USER EXPERIENCE WITH MEDICATION ADHERENCE TECHNOLOGY: DETERMINING USABILITY BY CAPABILITIES

by

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Author's Declaration

This thesis consists of material all of which I authored or co-authored: see Statement of Contributions included in the thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Statement of Contributions

Bincy Baby was the sole author of Chapters 1, 3, 4, 5, 6, 7, and 8, which were written under the supervision of Dr. Tejal Patel.

This thesis also includes one manuscript written for publication. Exceptions to sole authorship are as follows:

Research presented in Chapter 2:

The research was conducted at the University of Waterloo by Bincy Baby under the supervision of Dr. Tejal Patel. Bincy Baby completed the searches and data analysis with assistance from Dr. Tejal Patel. Caitlin Carter assisted in the searches. Jessica Ivo and Catherine Lee assisted in data analysis. Sadaf Faisal drafted the manuscript, and each author provided intellectual input on manuscript drafts.

Bincy Baby and Dr. Tejal Patel directed and contributed to all aspects of this manuscript. Caitlin Carter developed the search strategy and conducted searches in various databases. Hawa Patel and Sadaf Faisal contributed to title and abstract screening. Annette McKinnon, Kirk Patterson, and Rishabh Sharma contributed to full-text screening and data extraction. All authors read and approved the final manuscript.

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Abstract

Background: As populations worldwide grow older, the prevalence of chronic conditions and the complexity of managing multiple medications significantly increase. This challenge is further complicated by a range of barriers older adults face, including physical limitations, cognitive impairments, sensory issues, motivational challenges, and non-supportive environments. Such barriers can lead to a decline in capacity to self-manage medications, resulting in poor adherence to prescribed medication regimens, which in turn can cause increased hospitalizations and a decrease in quality of life. Medication Adherence Technologies (MATech), which range from simple electronic devices to more complex smart devices with connectivity and real-time monitoring capabilities, are recognized as one of the solutions to these challenges. However, the design and features of these technologies vary significantly, influencing how they are used by different users. Usability varies widely; some older adults may find certain features of these devices challenging to use due to their barriers. Hence, it is crucial to ensure that MATech are accessible and user-friendly for all older adults, regardless of their individual challenges. This study aims to identify the most suitable MATech for older adults with various physical, cognitive, sensory, motivational, and environmental limitations, tailored to their unique needs and abilities.

Objectives: The primary objectives of this study were to evaluate the usability and user experience (UX) of thirteen MATech devices among older adults facing various barriers to medication self-management and to gather comprehensive feedback on the usability and features of these technologies. Secondary objectives included determining how different barriers affect the usability outcomes of these technologies and identifying design features that best meet the needs of this demographic to enhance their independence and well-being.

Methods: The study used a mixed-methods approach to evaluate the usability of MATech. Eighty older adults, aged 60 and older, were recruited through convenience, purposive, and snowball sampling methods from various settings across Ontario, including academic and residential facilities. Data collection was conducted in three steps after obtaining informed consent from the participants. The first step involved measuring barriers to medication self-management using various scales such as the Self-Medication Assessment Tool (SMAT) for physical, cognitive, and vision barriers; the Whisper Test for hearing barriers; the Self-Efficacy for Medication Adherence Scale (SEAMS) for motivational barriers; and the Martin and Park Environmental Demands (MPED) Questionnaire for environmental barriers. The second step involved usability and user experience testing of three smart devices and ten electronic devices, to measure various performance-based metrics (task success rate, total task completion time, efficiency, error rate) and perception-based usability metrics (System Usability Scale (SUS) score, NASA-TLX workload score, Single Ease of Use Question (SEQ), and Subjective Mental Effort Question (SMEQ)). The third step consisted of in-depth qualitative interviews to explore feedback regarding the features of various MATech tested. Quantitative data were statistically analyzed using descriptive statistics and univariate and multivariate regression to assess usability across various devices, while qualitative responses were analyzed using inductive thematic analysis.

Results:

Quantitative Results: Cognitive impairments were identified in 20% of participants, physical limitations in 33.75%, hearing impairment (both ears) in 60%, and vision impairments in 11.25%. Backward stepwise multivariate regression analysis identified critical predictors for task success rates, including 'SEAMS score' ($p<0.001$) which measures motivational barrier positively influencing outcomes, whereas 'Low vision score' negatively affected success rates ($p<0.001$). Moreover, Old 'age' ($p<0.001$) and 'number of subtasks for product' ($p<0.001$) notably extended the total task completion times, and 'physical score' ($p<0.001$) increased error rates, suggesting necessary improvements in MATech design for better usability. While no predictors significantly impacted the SUS scores, the NASA TLX identified 'old age', 'vision impairment', and the ‘number of products tested’ as significant factors in perceived task load, particularly noting that using multiple products increased task load considerably, underscoring their profound impact on user experience and workload management. Predictive models were also developed to determine each participant's ability to successfully complete subtasks. For example, the model for a participant characterized by significant cognitive, physical, hearing, motivational and environmental impairments, but with high vision capacity, indicated high success probabilities for visually intensive subtasks such as "scroll the screen options" (92%) and "locate and touch an icon on a screen" (87%). Conversely, tasks requiring more physical interaction like "flip device" showed much lower success probabilities (45%).

Qualitative Findings: Five themes were identified: (1) the practicality of device design, (2) the impact of technological complexity, (3) the necessity for inclusivity in device functionality, which includes considerations for impairments, security, and privacy, (4) the influence of socio-economic and environmental factors, and (5) the importance of feedback for iterative design.

Discussion: The findings from this study underscore the critical importance of designing MATech that are not only functional but also tailored to the unique needs of older adults who face multiple barriers to effective medication management. Key findings from the regression analyses highlighted the importance of addressing physical and sensory impairments in MATech design, as these significantly influence user performance and error rates. Additionally, factors such as age and the complexity of device operations significantly influence usability and workload, suggesting the need for simpler, more intuitive designs that minimize cognitive and physical strain. Overall, the research emphasizes the need for a user-centered design approach in developing MATech, emphasizing simplicity, accessibility, and personalization to better support older adults in managing their medications effectively. This approach not only aids in improving medication adherence but also contributes to the broader goal of facilitating a more independent, quality life for older adults.

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Dedication

To my father, Baby Joseph, and my mother, Gracy, for their relentless support and encouragement in my pursuit of this master's degree. These past two years have been a challenging journey, made possible by their unwavering belief in my dreams and their endless sacrifices.

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List of Abbreviations

CHAS	Comprehensive Health Activities Scale
CSMS	Cognitive Screen for Medication Self-Management
CVLT	California Verbal Learning Test
DLTV	Daily Living Tasks associated with Vision
DRUGS	Drug Regimen Unassisted Grading Scale
DSB	Digit span backward
ETDRS	Early Treatment Diabetic Retinopathy Study eye chart
FCCHL	Functional, Communicative and Critical Health Literacy scale
FOME	Fuld Object-Memory Evaluation
HCP'S	Health Care Professionals
HMS	Hopkins Medication Schedule
LTMBSES	Long-Term Medication Behavior Self-Efficacy Scale
MASES	Medication Administration Self-Efficacy Scale
MATech	Medication Adherence Technologies
MCI	Mild cognitive impairment
MedMaIDE	Medication Management Instrument for Deficiencies in the Elderly
MeDS	Measure of Drug Self Management
MMC	Medication Management Capacity
MMSE	Mini-Mental State Examination
MOCA	Montreal Cognitive Assessment
MPED	Martin and Park Environmental Demands Questionnaire
MSPSS	Multidimensional Scale of Perceived Social Support

MSSS	Medication-Specific Social Support Questionnaire
MTS	Medication-transfer screen
NASA -TLX	The NASA Task Load Index
NEI VFQ-25	National Eye Institute Visual Function Questionnaire-25
NVS	The Newest Vital Sign
PASS	Performance Assessment of Self-care Skills
PR test	Pelli–Robson test
PSS-Fa	Perceived Social Support from Family
PSS-Fr	Perceived Social Support from Friends
RAT	Self-medication Risk Assessment Tool
REALM	Rapid Estimate of Adult Literacy in Medicine
SBT	Short Blessed Test
SEAMS	Self-efficacy for appropriate medication use scale
SEQ	Single Ease Question
SMAT	Self-medication Assessment Tool
SMEQ	Subjective Mental Effort Questionnaire
S-TOFHLA	Short Test of Functional Health Literacy in Adults
SUS	System Usability Scale
TMT	Trail-Making Test
TOFHLA-R	Test of Functional Health Literacy in Adults
WCST	Wisconsin Card Sorting Test
WHO	World Health Organization

1 Chapter 1: Introduction

According to Statistics Canada, approximately 25% of Canadians will be over the age of 65 by 2036.[1] This demographic shift not only signifies a significant portion of the population entering senior years, but also necessitates a re-evaluation of societal structures and support systems to ensure the well-being and quality of life of older adults.[2] In light of this, the concept of aging successfully takes on added importance. In order to age successfully, it is important that one maintains his or her independence.[3] Aging in place is one of the most effective ways to accomplish this goal.[3] Literature defines aging in place broadly as the ability to remain in one's own home as one ages.[4,5] According to a recent study (July 2020) by the National Institute of Ageing (NIA), 91 percent of Canadians of all ages intend to live safely and independently in their own homes for as long as possible.[6]

Despite the fact that many older adults wish to remain in their own homes as they age, they face a number of challenges in achieving this goal.[3] Of the various challenges they encounter, the two primary concerns that prevent older adults from aging in their homes and communities are chronic diseases and related disabilities.[3] The likelihood that a person will experience at least one chronic medical problem increases with age.[7] According to a report by the National Council on Aging, approximately 92 percent of older adults suffer from at least one chronic disease and 77 percent suffer from at least two chronic diseases.[8] Medical conditions such as hypertension, heart disease, diabetes, strokes, and cancer are particularly prevalent among the elderly and are often linked to various disabilities.[9] The concern with these conditions lies in their long-term and interrelated nature, which often leads to progressive physical and cognitive decline.[8,9] This decline can significantly impair an individual’s ability to perform everyday tasks independently, thereby challenging their capability to age in place.[4,5] Chronic diseases often require ongoing medical management, which can affect mobility, sensory abilities, and mental cognition—key components needed to maintain independence at home.[3-5] Pharmacotherapy remains the primary treatment pathway for managing these chronic conditions.[3,4] Continuous medication management is essential to control symptoms and slow disease progression, yet it introduces its own set of challenges.[3,7,9] As individuals age, they are more likely to be prescribed multiple medications simultaneously, a practice known as polypharmacy.[3,9] This high prevalence of polypharmacy among the elderly increases the risk of medication-related problems (MRPs). MRPs can include inappropriate prescriptions, drug-drug interactions, adverse side effects, and issues with adherence to medication regimens.[3,4] A study exploring medication use among community-dwelling older adults reported that a substantial proportion (44.2%–57.7%) take at least five different drugs regularly, and many (39.2%–27%) are prescribed ten or more drugs.[10] These complex medication schedules can exacerbate the risk of MRPs, complicating the management of their health conditions and further hindering their ability to live independently.

The increase in the prevalence of chronic conditions also contributes to greater functional limitations and disabilities.[11] Researchers found that older adults with more than three chronic conditions are 2-3 times more likely to have low performance in activities of daily living (ADLs) and instrumental activities of daily living (IADL) than older adults with no chronic conditions.[12] A decline in functional ability due to multimorbidity can also negatively affect the ability of older adults to manage their medications on their own.[13,14] Independent medication management requires cognitive and physical abilities.[15] As a result of chronic diseases, cognitive abilities, including memory, spatial orientation, processing speed, and physical abilities, such as a hand grip, fine motor skills, hand dexterity, and visual acuity, can be diminished, making it difficult to take medications.[16,17] This can result in non-adherence, hospitalizations, medication errors, and adverse drug reactions.[17] For example, researchers examined the ability of patients with rheumatoid arthritis to open tablets and unit dose packs and found that most of the participants were not able to open the containers due to arthritis-related deterioration of hand function.[18] As well as multiple comorbid conditions, aging and cognitive decline further impair older patients' ability to take medication correctly and efficiently.[19]

1.1 Medication Adherence

Medication adherence is defined by the World Health Organization (WHO) as "the degree to which the person's behavior corresponds with the agreed recommendations from a health care provider."[20] Though compliance and adherence are sometimes considered to be synonymous, compliance differs from adherence.[20] Patients' compliance is the degree to which their behavior matches their prescriber's advice and implies patient obedience to the prescriber’s authority.[21] However, the term adherence refers to the patient and prescriber working together to improve the patient's health by integrating the prescriber’s clinical opinion with the patient's lifestyle, values, and preferences.[22] Adherence to medication is a crucial part of patient care and typically consists of 3-phases: initiation of the treatment, implementation of the prescribed regimen, and discontinuation of the pharmacotherapy.[23]

Non-adherence to medications is widely recognized as a common problem, especially among older adults.[22] As discussed earlier, higher comorbidity results in a higher level of complexity and volume in medication regimens, which makes it more likely that they will not adhere to their medication regimens.[20] Non-adherence not only increases morbidity and mortality but can also result in higher healthcare costs.[21] According to a WHO report, medication non-adherence accounts for five percent of hospital admissions and five percent of doctor's visits, totaling $4 billion in additional costs.[23]

There are two types of non-adherence:[24]

1. **Intentional or active medication non-adherence** where patients choose to deviate from the prescribed treatment regimen for a number of reasons, including personal beliefs, concerns, side

effects, and/or considering taking the medication but not as prescribed.[24]

2. **Unintentional or passive medication non-adherence** where patients wish to take medication but are not able to comply with the regimen due to physical or cognitive limitations, complex treatment regimens, or inaccessibility due to financial or accessibility reasons.[24]

1.1.1 Factors Influencing Medication Adherence

According to WHO, there are five categories of factors that can influence medication adherence: [20,23,25]

Table 1-1: Factors Influencing Medication Adherence

Category	Examples
Patient-related factors	• Physical and sensory functioning (e.g., dexterity, vision) • Cognitive abilities (e.g., memory, comprehension) • Knowledge about the disease and treatment • Beliefs about medication and illness • Therapy expectations • Confidence in healthcare provider • History of medication use • Self-care practices • Mental health • Motivation
Condition-related factors	• Presence or absence of symptoms • Severity of symptoms • Change in clinical condition • Disease-related disabilities • Duration of the disease
Therapy-related factors	• Complexity of regimen • Polypharmacy • Accessibility of medication container/packaging • Drug-food interactions • Actual or perceived adverse events • Duration of treatment • Effectiveness of treatment

Social/economic factors	• Social support network • Employment and living conditions • Health insurance and medication cost • Education and health literacy
Health system-related factors	• Accessibility of healthcare • Provider-patient communication and relationship • Provision and clarity of education from care provider about drugs and diseases • Number of prescribers

With an understanding of whether the non-adherence is intentional or unintentional, and what factors have led to it, it is possible to improve the medication-taking behavior (self-management of medication or medication management capacity, non-adherence, misusing medication, obtaining medication) of each patient by tailoring individualized interventions.[22]

1.2 Medication Management Capacity (MMC)

Maddigan et al. refers to medication management capacity (MMC) as the "cognitive and functional ability to comply with a medication regimen, when it is the individual's wish or desire to follow a medication regimen as prescribed" and identify it as an important aspect of adherence.[15] In terms of MMC, deviations from adherence are the result of a lack of ability, and they are unintentional.[15]

Self-management is a fundamental component of optimal medication management.[25] In order to self-manage medications effectively, functional skills are required, including identifying the correct medication, opening the container, taking the correct dosage, and timing its administration.[26] An innovative conceptual framework called 'medication self-management' was developed by Bailey et al. (2013) based on evidence from the field of health literacy.[27] The authors define patients' medication self-management as "the extent to which a patient takes medications as prescribed, including not only the correct dose, frequency and spacing, but also its continued, safe use over time."[27]

Concerns about medication management capacity (MMC) are particularly significant among older adults due to their high medication intake and characteristics that increase their risk of medication-related issues.[16,28] The ability of older adults to manage complex medication regimens is vital for sustaining their independence as they age.[28] A decline in MMC is associated with non-adherence to medications, medication errors, adverse drug events, increased hospitalizations, and even transitions to nursing homes.[16,29–31] Research has shown that older adults living alone are at a higher risk of medication errors and non-adherence due to the absence of someone to assist or remind them about their medications.[28]

1.2.1 Barriers to MMC

The physical and cognitive limitations of older adults can make it difficult for them to take their medications in accordance with their prescriptions.[32,33] According to the WHO, approximately 46% of people over the age of 60 suffer from some form of disability, with visual impairment, hearing impairment, cognitive limitations, and osteoarthritis being the most common causes.[34] These limitations can impair the ability of older individuals to manage complex medications and, as a consequence, limit their independence.[34]

It is possible to categorize the barriers that prevent older adults from adequately managing their medications at home as follows:[35]

Figure 1-1: Barriers to Medication Management Capacity [35]

Physical

Grip strength, Speed of performance, Flexibility of joint, Hand-eye coordination, Retention in hand movement

Cognitive

Working memory, Spatial cognition, Selective attention, Semantic fluency, Reasoning, Numeracy and representational fluency

Sensory

Vision: Visual acuity/ accommodation, Color vision, Contrast detection, Dark adaptation, Glare

Audition: Auditory acuity, **Touch sensation**

Motivation

Trust in own ability, Efficiency in seeing benefits, Techno literacy, Health literacy, Self confidence in using wearables, Integration of functions during daily activities

Enviornmental

Social factors, Cost of healthcare, Home environment, Caregiver burden

1.2.1.1 *Cognitive Barriers*

Cognitive function refers to how we process information specifically in terms of orientation, attention, calculation, immediate and recent memory, language, and motor skills.[28] It is a crucial component for medication self-management. With aging, there is a decline in certain cognitive abilities, such as processing speed, and certain memory, language, visuospatial, and executive function abilities.[33] In addition to age-related memory decline, certain other conditions, such as dementia, also contribute to cognitive decline.[7] According to estimates, 12 million people worldwide suffer from dementia, and this number is expected to rise to 25 million by 2040.[32] The ability to manage medicines safely can be adversely affected by cognitive impairment.[36]

Consequently, there is an increased risk of unintentional non-adherence to medications, medication errors, preventable hospital admissions related to medications, and dependence on family caregivers or community nursing services.[7,33,34]

1.2.1.2 Physical Barriers

Physical impairments due to aging such as decline in grip strength, dexterity, coordination, and mobility of hands and arms, can affect the capability of older adults to manage their medications.[35] Between 31 and 64 percent of older adults living at home have difficulty opening medication containers due to hand function problems, and childproof containers pose the greatest challenge.[36,37] Additionally, conditions such as osteoarthritis and rheumatoid arthritis can impair hand dexterity, further impairing elders' ability to manage medications and use medication administration aids.[38]

1.2.1.3 *Sensory Barriers*

Sensory refers to the ability to see, hear, or become aware of something through the senses.[39] Older adults may suffer from sensory changes, especially loss of sight, hearing, and touch. The visual functions which decline with age are the ability to resolve detail, the ability to focus on close objects, the ability to discriminate between colors, the ability to detect contrast, the ability to adapt to darker conditions, and susceptibility to glare.[40] A study involving 156 patients above the age of 65 years aimed to compare issues relating to medication self-management between older people with and without visual impairment, and reported that about 29% of individuals with visual impairment needed help managing their medications, despite using visual aids.[40] Moreover, age-related eye diseases such as cataracts, age-related macular degeneration, glaucoma, and diabetic retinopathy can also deteriorate the vision functions of elders.[38]

Age related decline in auditory function and touch sensations can also affect the senior’s ability to use medication administration devices.[35] Older people may, for example, have difficulty hearing sound frequencies over 2 kHz, localizing sounds, and discriminating short-duration acoustic signals.[38] When there is a loss of touch sensation and fine motor control, it may be difficult to manipulate the buttons, knobs and levers of devices that are used to administer medications.[38]

1.2.1.4 *Motivational Barriers*

For successful self-management of medications various motivational factors are crucial. Adequate knowledge about medications and use of adherence technologies (health literacy and technology literacy), trust in own ability (self-efficacy), efficiency in seeing benefits from treatment, confidence to properly take medications (self-confidence), and integration of functions during daily activities are some of the motivational challenges older adults encounter with medication self-management at home.[35]

1.2.1.5 *Environmental Barriers*

The ability to independently take medications is directly affected by factors related to one's community and home environment and resources.[41] Support from care partners such as family members and friends, cost of medication and medication administration devices, as well as barriers within the home environment are paramount in determining a person's ability to manage medications.[42,43] Family members and friends can provide necessary reminders and assistance with managing complex medication regimens, which is especially crucial for those with cognitive impairments or physical limitations.[42] The cost of medications and any necessary devices for administration can also be a barrier, potentially limiting adherence to prescribed treatment plans if financial resources are strained.[41]

Moreover, practical barriers within the home environment, such as poor lighting and cluttered spaces, can impede the safe handling and organization of medications.[43] Inadequate lighting increases the risk of errors in medication identification and dosing, while a lack of clear counter space can lead to disorganization that complicates medication schedules.[43]

1.2.2 Assessment of Barriers to MMC

The relationship between functional impairments and the declining ability to manage medications has been well established in the literature, leading to increased recognition of the importance of assessing older patients' MMC.[12,15,44] A number of instruments have been developed to assess an individual's functional and cognitive capacity to manage medications.[13,46-48] A recent review identified 26 instruments designed to assess medication self-management capacity in older adults.[49] Instruments that measure physical, cognitive, and sensory abilities to manage medications were identified in this review.[49] DRUGS, MedMaIDE, the Hopkins Medication Schedule, and the Medication Management Ability Assessment (MMAA) are the tools most recommended by various reviewers based on the medication management skills measured, administration time, scoring scale, type of medication regimen used, and psychometric properties.[34-37] It is important to note that while various tools exist, most are designed to identify cognitive and physical barriers to successful medication administration, and none are considered gold standard measures.[46-4934-36] Furthermore, considering that motivational and environmental factors significantly influence an individual's medication-taking behavior, it is crucial to incorporate these factors when assessing MMC to recommend appropriate interventions.[42,50]

1.3 **Interventions to improve medication adherence and MMC**

Interventions aimed at enhancing medication adherence and MMC in older adults encompass a broad range of strategies.[51-55] These strategies are designed to address the complex needs of this demographic, which often faces challenges such as polypharmacy, cognitive and physical decline, and the need for assistance from non-professional carers.[51,52] Effective interventions can significantly impact the health outcomes and quality of life of older adults by ensuring that medications are taken as prescribed, thereby reducing the risks associated with non-adherence and poor medication management.[51-54] The following are several interventions for improving medication adherence and/or medication taking behavior.[51-56]

1.3.1 **Educational Interventions**

Educational interventions aim to increase patients' and caregivers' knowledge of medications, their proper use, potential side effects, and the importance of adherence to prescribed regimens. These interventions can significantly impact patients' ability to manage their medications effectively, especially when tailored to the individual's needs and learning preferences. Some examples are given below. [51-56]

- ***Group or Individual Sessions:*** Conducted by healthcare professionals to provide targeted information about medication management, disease-specific education, and strategies to overcome barriers to adherence.
- ***Diverse Educational Materials:*** Utilization of verbal instructions, written materials, audiovisual aids, and digital content to cater to different learning styles.
- ***Interactive Workshops:*** Sessions that encourage active participation, discussion, and problem-solving related to medication management.
- ***Empowerment and Self-Management:*** Educating patients on how to take an active role in their healthcare, including understanding when and how to take their medications.

1.3.2 Behavioral Strategies

Behavioral strategies are designed to modify patients' behavior related to medication adherence through various supportive tools and reminders. These interventions focus on making it easier for individuals to follow their prescribed medication regimens. Some examples are given below. [51-56]

- ***Reminder Systems:*** Use of alarms, beepers, or smartphone apps to remind patients to take their medications at the correct times.

- ***Pill Organizers:*** Devices that sort medications by day and time, simplifying the process of taking multiple medications.
- ***Simplification of Medication Regimens:*** Working with healthcare providers to reduce the frequency of doses or the number of medications, when possible.
- ***Habit Formation:*** Assisting patients in incorporating medication-taking into their daily routines.
- ***Adherence Monitoring:*** Regular check-ins or electronic monitoring of medication use, with feedback provided to patients.

1.3.3 Technology-based Interventions

Technology-based interventions make use of digital tools and platforms to support medication management and adherence. Some examples are given below. [51-56]

- ***Mobile Health Apps:*** Applications that provide medication reminders, track adherence, and offer educational content.
- ***Telehealth:*** Virtual consultations and follow-ups that enable healthcare providers to support medication management remotely.
- ***Electronic and Smart Pill Dispensers:*** Devices that dispense medications at preset times and can alert caregivers if a dose is missed.
- ***Web-Based Platforms:*** Online resources and support groups that provide information and peer support for managing health and medications.

1.3.4 Combinations of Interventions

Combining educational, behavioral, and technology-based interventions can offer a holistic approach to improving medication adherence and management.[51-56] This comprehensive strategy addresses various barriers to adherence by providing the knowledge, skills, and tools necessary for effective medication management.[51-56]

Research indicates that no single intervention is universally effective, suggesting a need for personalized approaches that consider the patient's preferences, capabilities, and barriers to adherence.[51,56]

1.4 Medication adherence technologies (MATechs)

Assistive electronic medication organization and dispensing technologies have increasingly gained interest as new interventions for supporting medication adherence and improving treatment outcomes.[57] With innovations in the integration of data processing, electronics and wireless communication, the number of MATech available on the market has grown phenomenally in the past few years.[57] A systematic review published in 2016 identified 80 electronic adherence devices available in Canada, while another review published in 2023 identified 114 'smart' products (connectivity and automaticity) designed to improve medication adherence.[57,58] "Connectivity" refers to the ability of these devices to connect to other devices or networks using technologies such as Wi-Fi, Bluetooth, or mobile data. This feature allows the devices to sync data with healthcare providers' systems, send reminders to patients via their smartphones or other connected devices, and even alert caregivers or family members if a dose is missed.[58] "Automaticity," on the other hand, pertains to the devices' capability to perform functions automatically without continuous manual input from the user.[58] This can include automatically dispensing medications at preset times, recording the time and amount of medication taken, and even adjusting doses based on real-time data from connected health monitoring devices. In terms of design, function, and features, there are some major differences between the technologies available today.[59]

According to a narrative review of current medication adherence monitoring technologies, the technologies can be classified into eight categories based on their technical designs and adherence monitoring functions.[59]

- ***Electronic pill bottles*** – consist of a standard size pill bottle and an electronic cap that contains a microchip. Data on adherence is collected based on the time and date when the bottle was opened. Its main limitation is that it can only store one type of medication at a time, and therefore is not appropriate for patients on complex multidrug regimens.[59] Example: MEMS (Medication Event Monitoring System) bottle caps
- ***Electronic pillboxes or bags*** - these devices are similar to electronic pill bottles; however, they are capable of storing a variety of medications in different compartments.[59] Their large size and associated risk to patient privacy are the principal drawbacks of this type of product.[59]
    - Example: Wisepill device
- ***Ingestible sensors / digital pills / digital ingestion monitoring*** - these consist of microsensors, an external monitor worn on the abdomen, and a mobile application.[60] A micro-ingestible sensor encapsulated with medication transmits a signal to the external monitor once it is in contact with gastric fluid. The data is then uploaded into a mobile application including the date and time.[59]
    - Example: MyTMed [60]
- ***Blister pack technology*** - consists of attachable adhesive labels containing a microchip and conductive wire pattern. When the patient removes the medication from the blister pack, a break in the label circuit occurs, and this information will be recorded by the microchip with a date and time. This allows real-time monitoring of medication adherence by

- transferring data to central servers accessible to healthcare professionals (HCPs) and caregivers.[59]
- Example: Jones Healthcare Group smart blister pack

- ***Electronic medication management systems (EMMS) -*** these devices are designed to assist patients in managing their medications effectively and documenting their medication adherence patterns.[59] An example is ReX (DosentRx Ltd), the talking pill bottle that assists visually or cognitively impaired patients with accessing recorded medication information.[61] There is a speaker on the bottle that plays recorded information from the pharmacist regarding the drug, what it is used for, the dose, frequency, duration, and side effects warnings.
- ***Patient self-report–based technology -*** by using phone calls, smart buttons, eDiaries, web-based platforms, and mobile apps, these technologies collect medication adherence information from patients.[59]
    - Example-TrackYourMed® (TYM) (mobile app)[62]
- ***Video-based technology -*** real time medication adherence data is captured by video recording of medication intake, which is later verified by HCPs.[59]
    - Example-Video-DOT (VDOT (directly observed therapy))
- ***Motion sensor technology -*** these are wearable sensors that look like wristwatches and are worn on the wrist. The devices contain motion sensors such as gyrometers and accelerometers that are used to detect a patient's behaviors when taking medication. Data regarding adherence is uploaded to databases for access by HCPs.[59]

Medication adherence devices like these may assist with medication self-management by providing appropriate medication information, education, organizing medications, dispensing and providing reminders for taking medications.[64] A qualitative study examining the role of MATechs in older adults with dementia found that evidence-based and user-centred technological solutions can address medication management challenges and help people with dementia make the best use of their medications.[65] Another single-blind randomized controlled trial examining a medication self-management app (called ALICE) in elderly patients with multimorbid conditions found that the application increased adherence, reduced forgetfulness and medication errors, and increased perceived independence in managing medications.[66]

1.5 Psychological principles of successful aging technologies

Many technology-based products are available to assist older adults in adhering to their prescribed medications.[61] Old age is associated with cognitive, sensory, and motor impairments; therefore, the design of technologies aimed at these individuals should take into consideration their evolving capabilities and limitations.[67–69] From the perspective of behavioral science, a technology that is designed for use by individuals must learn and adapt to their needs, habits, and preferences in order to be effective.[70] There are a number of behavioral principles that can serve as a guide for the development and evaluation of assistive technology.[67,71] Lindenberger *et al.* propose three criteria for designing and evaluating technologies for the elderly.[70] These include: (a) net resource release, or marginal resource benefit; (b) person specificity, and (c) proximal versus distal frames of evaluation.[69]

- ***Net resource release, or marginal resource benefit*** refers to the fact that physical and mental resources are both required for the use of technology.[70] If the operation costs associated with the technology are higher than the payoff associated with other changes in processing, the technology will not be adopted.[70] Based on this criterion, successful aging can be defined as maximizing gains and minimizing losses. It is also imperative to consider both subjective and objective factors when assessing net resource release. An individual's perception of technology use, for instance, is more likely to determine the actual use of a technology than objective factors, such as cost/benefit ratios.[70] Understanding human motivations, preferences, and social expectations, as well as understanding technology itself, can increase the likelihood of this outcome. [70]

- ***Person specificity*** refers to the unique characteristics of each individual and their ability to adapt. [70] For instance, people in their 50's and those in their 80's will have a different level of cognitive, sensory, and motor functioning. It is therefore crucial to take into consideration the average age of users when developing assistive technology. [70] The technology should also be adapted to meet the specific requirements, preferences, and competencies of each individual. [70]

- ***Proximal versus distal frames of evaluation*** refers to knowledge that previous exposure to the same technology or related technology can affect the net resource release in old age, and the short-term and long-term benefits of technologies may differ from individual to individual. [70] For example, using GPS-based spatial navigation in the short term can help with navigation behaviors, but its long-term use has the potential to have negative consequences by reducing the development of brain structures involved in spatial behavior. Technology can, however, provide long-term benefits by optimizing the balance between environmental support and self-initiated processing, uncovering latent potential. [70]

Integrating these criteria into usability and user experience design involves creating technology that is not only easy to use but also deeply satisfying and conducive to long-term well-being. [70] This approach ensures that aging adults are not only able to use these products effectively but are also more likely to adopt them as part of their daily lives, enhancing their independence and quality of life. These design principles are critical for ensuring that technologies truly meet the needs of older adults, promoting successful aging through supportive and adaptive tools.[70]

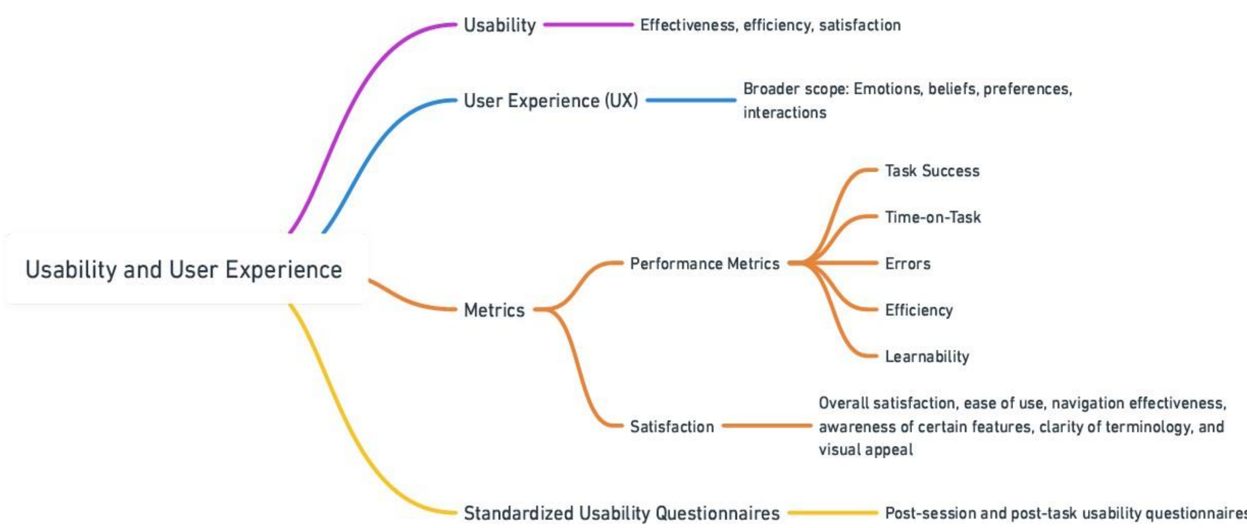
1.6 Usability and User Experience (UX)

Usability emerged in the 1980s as a concept to describe the ease with which products can be used.[72] Its evolution was marked by the formalization of definitions, such as Shackel's (1981) description of usability as the capability of a product to be used easily and effectively.[73] ISO 9241 part 11 (International Organization for Standardization (ISO) covering ergonomics of human-computer interaction) defines usability as "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use".[74] On the other hand, user experience (UX) broadens this scope, encompassing all aspects of the user's interaction with a product, system, or service.[75,76] It's a comprehensive view that includes emotions, beliefs, preferences, perceptions, physical and psychological responses, behaviors, and accomplishments that occur before, during, and after use. [75-77]

The terms usability and UX are often used interchangeably.[78] It is important to note that usability aims at effectiveness, efficiency, and satisfaction in accomplishing specific tasks, while UX considers the overall experience and emotional engagement with the product or service.[76] The importance of usability and UX cannot be overstated. Products that are not user-friendly and do not provide a positive experience are likely to be abandoned for alternatives.[76-79]

While assessing the usability of products for users of all ages is essential, it is particularly critical to evaluate it for older adults as cognitive, sensory, and motor impairments associated with aging can significantly affect how they interact with various technology.[67] Ensuring products are accessible and understandable can greatly enhance their ability to use technology effectively, supporting independence and quality of life. Usability and UX design for older adults must consider their specific needs and limitations to create products that are both functional and satisfying.[68-71]

Figure 1-2: Usability and User Experience Metrics[68-71]



1.6.1 User Metrics

Usability testing focuses on two critical aspects of the user experience: performance and satisfaction.[78,80] (Figure 1-2) These dimensions are essential for assessing how effectively and easily users can interact with these devices.[78,80,81]

1.6.1.1 *Performance-based Metrics*

Performance is assessed based on the user's interaction with the product, helping to identify the extent of usability through:[78,80]

- ***Task Success:*** Evaluates how effectively users are able to complete a given set of tasks. It can be measured using both binary success and levels of success.
- ***Time-on-Task:*** Measures the duration required to complete a task.

- ***Errors:*** Identifies mistakes made during task execution, which can highlight areas needing improvement.
- ***Efficiency:*** Measures the effort needed to accomplish a task, indicating how user-friendly the device is.
- ***Learnability:*** Assesses how user performance improves with time, reflecting the device's ease of learning.

1.6.1.2 *Satisfaction*

Satisfaction is determined by what the user says or thinks about their interaction with the product.[78,81] Many factors are examined, such as overall satisfaction, ease of use, navigation effectiveness, awareness of certain features, clarity of terminology, and visual appeal.[78] Standardized usability questionnaires can be used to collect this information.

1.6.1.3 *Perception-based Metrics*

To systematically measure perceived usability, standardized questionnaires are administered.[78,80] These questionnaires consist of a predefined set of questions, presented in a certain order, utilizing a specific format, with scores derived from users' responses.[80] These tools are categorized into two categories: post-task usability questionnaires and post-session usability questionnaires

1.6.1.3.1 Post-task Usability Questionnaires

These questionnaires assess user satisfaction and perceived usability at the task level immediately after task completion.[81] Table 0-2 provides details about some of the commonly used post-session usability questionnaires, along with their psychometric properties. [78,80,81]

Table 1-2: Post-Task Usability Questionnaires

Questionnaire	Description	Psychometric properties
After-scenario Questionnaire (ASQ)	A three-item questionnaire designed to assess overall ease of task completion, satisfaction with completion time, and satisfaction with support information. The overall score is the average of the responses to these items.	Reliability measures between 0.9 to 0.96. Significant correlation with successful scenario completion ($r(46) = -0.4$, $p < 0.01$) indicating concurrent validity. Factor analysis showed a clear association of ASQ factors with tasks, with the eight factors explaining almost all (94%) of the total variance.
Single Ease Question (SEQ)	A single-item questionnaire that asks participants to assess the overall ease of completing a task. A seven-point scale is recommended based on research on scale reliability and user preference.	Evidence of concurrent validity through significant correlations with performance efficiency metrics, the SMEQ, and the UME ($r > 0.94$), and with the SUS ($r = -0.6$, $p < 0.01$). Significant correlations also reported with completion times ($r = -0.9$) and number of errors ($r = 0.84$).
Subjective Mental Effort Question (SMEQ)	A single-item questionnaire with a scale from 0 to 150 and nine verbal labels to assess perceived mental effort of completing a task. Participants indicate their perceived effort by marking a point on the scale, with the SMEQ score being the marked number of millimeters above the baseline of 0.	Significant correlation with SEQ ($r = 0.94$, $p < 0.01$) and UME ($r = 0.845$, $p < 0.01$). Correlation with SUS scores ($r = -0.6$, $p < 0.01$), completion time, rates, and errors, providing evidence of concurrent validity.
Usability Magnitude Estimation (UME)	A method to measure usability enabling ratio measurement, where participants judge the intensity of a usability task against a baseline stimulus. It allows for assessing perceived difficulty in a manner that enables comparisons such as "twice as difficult" or "half as difficult".	Strong correlations with task completion time ($r = -0.91$, $p < 0.01$), the SMEQ, and the average of the first two items of the ASQ, indicating validity. However, it is noted that UME may be challenging to apply, especially in unmoderated testing.

1.6.1.3.2 Post-Session Usability Questionnaires

These questionnaires are designed to gather feedback from users after they have interacted with a product, system, or service.[80] Table 0-3 provides details about some of the commonly used post-session usability questionnaires, along with their psychometric properties. [78,80]

Table 1-3: Post-Session Usability Questionnaires

Questionnaire	Description	Psychometric Properties	
		Validity	Reliability
System Usability Scale (SUS)	A fast, effective, and low-cost tool with 10 items rated on a five-point scale, mixing positive and negative wording to assess usability and learnability. Scores range from 0 to 100.	Construct validity; evidence of sensitivity; emerging normative information.	>0.89
Usefulness, Satisfaction, and Ease of Use (USE) Questionnaire[83]	Consists of 30 items across four categories (Usefulness, Satisfaction, Ease of Use, and Learning Ease), rated on a seven-point Likert scale.	Construct validity.	0.98
Questionnaire for User Interaction Satisfaction (QUIS)[84]	Measures overall system satisfaction and nine specific interface factors, in five languages and two lengths, using nine-point bipolar scales.	Construct validity; evidence of sensitivity.	0.94
Post-Study System Usability Questionnaire (PSSUQ)	Assesses satisfaction with computer systems or applications via 16 items, yielding an overall score and three subscale scores. Scores range from 1 to 7, with lower scores indicating higher satisfaction.	Construct validity; concurrent validity; evidence of sensitivity; some normative information.	0.94
Computer System Usability Questionnaire (CSUQ)[85]	Similar to PSSUQ but with minor wording changes, designed for mail or online administration. It includes 19 statements rated on a seven-point scale.	Construct validity.	0.9575
Software Usability Measurement Inventory (SUMI)	A 50-item questionnaire with a Global scale and five subscales (Efficiency, Affect, Helpfulness, Control, and Learnability), featuring a mix of positive and	Construct validity; evidence of sensitivity; availability of norms.	0.92

	negative statements. Available in multiple languages.		
Usability Metric for User Experience (UMUX)	Designed to measure perceived usability similar to the SUS but with just four items, each rated from 1 (Strongly disagree) to 7 (Strongly agree).	Construct validity; concurrent validity; evidence of sensitivity.	>0.82

1.7 Usability and User Experience Testing of MATechs

As the design, function, and features of MATechs differ significantly, how they are being used by individuals also varies.[85,86] A prospective study evaluated the usability and user workload of 21 electronic medication adherence devices using two metrics: the System Usability Scale (SUS) and the NASA Task Load Index (NASA-TLX).[85] The findings revealed significant differences among the devices, with SUS scores ranging from 0 to 100, indicating varied levels of ease of use. Similarly, NASA-TLX scores ranged from 4.2 to 99.2, reflecting a broad range of user effort required to operate these devices. These scores highlight the diverse usability and workload experiences users may encounter with these products. These findings suggest the importance of usability testing for MATechs, particularly for older adults with diverse limitations.[85] For example, a person who is visually impaired may not be able to comprehend information from a pill bottle that produces a visual alert to take medication, but a device that produces an audio alert may be more effective. In a study that examined the link between cognitive status and the usability of a medication adherence product in older adults, a significant correlation was found between Mini-Mental State Exam (MMSE) scores and task success rates ($z = -2.03$, $p = 0.04$).[86] Participants without cognitive impairment (MMSE > 24) successfully completed an average of 69.0% of tasks, while those with cognitive impairment (MMSE < 24) had a performance rate of 34.7%. This indicates that older adults' ability to use a product and self-manage medications is therefore affected by the differences in usability of various products and diverse age-related barriers.[85,86]

A qualitative study that examined user experience with electronic medication adherence products generated two important themes: product factors (simplicity and product features, including availability and usability of alarms, portability, restricted access to medications, and storage capacity) and user factors (sentiment, affordability, physical and cognitive capability, and technology literacy and learnability).[58] The selection of a medication adherence product has to take into account both the product features as well as the characteristics of the user, such as the user's capabilities as well as their limitations.[58,67] Usability testing ensures that these technologies are designed to meet the unique needs of older adults by identifying usability issues and enhancing user experience.[78-81,85,86]

1.8 Thesis goal

The overall goal of this research is to identify the most suitable MATechs for older adults with various physical, cognitive, sensory, motivational, and environmental limitations, tailored to their unique needs and abilities. By evaluating the user experience and usability of different smart and electronic medication adherence devices in older adults with various challenges, this study aims to significantly improve medication self-management and adherence among this demographic. Consequently, it aims to improve independence and quality of life for older adults by helping them live safely, independently, and comfortably in their own homes including effective self-management of their medications.

To achieve this goal, this research addresses the following key objectives:

- To identify tools that measure physical, cognitive, sensory (vision, hearing, touch), motivational, and environmental barriers to medication self-management in older adults, and to understand the extent to which these tools assess various barriers.
- To develop a comprehensive classification system for MATechs based on an inventory of

characteristics and features of existing technology.

- To assess the usability and user experience of three smart and ten electronic medication adherence devices in older adults with physical, cognitive, sensory, motivational, and environmental barriers to medication taking
- To explore the feedback and experiences of older adults with diverse barriers to medication management regarding the usability and features of MATechs.

1.9 Thesis Outline

This thesis is comprised of the following chapters:

Chapter 1: A brief introduction of chronic conditions and complexity of medications among older adults, medication adherence, factors influencing medication adherence, medication management capacity, assessment of barriers to medication management capacity, interventions to improve medication adherence and medication management capacity, MATechs, psychological principles of successful aging technologies, and user experience and usability.

Chapter 2: A scoping review to identify tools to measure barriers to MMC among older adults. This chapter details the tools available to assess physical, cognitive, sensory, motivational, and environmental challenges that older adults face in managing their medications effectively. It uses a comprehensive methodology to examine the literature, employing Arksey and O'Malley's framework and the PRISMA extension for scoping reviews. The findings reveal the existence of 44 tools, each measuring different combinations of barriers, with none covering all five areas comprehensively. This chapter highlights the necessity of using multiple tools for a thorough assessment and highlights the need for further research to develop a more inclusive tool that encompasses all relevant barriers.

Chapter 3: Outlines the development of a comprehensive classification system for MATechs. This chapter details a methodical approach using the Taxonomy Development Method by Nickerson *et al.*, which includes stages of development, validation, and evaluation. The taxonomy categorizes medication adherence products based on seven key dimensions: Physical Features, Display, Connectivity, System Alert, Data Collection and Management, Operations, and Integration. These dimensions were refined through multiple iterations and validated using the Delphi consensus method, resulting in a taxonomy that includes 24 subdimensions and 314 characteristics. This structured framework is designed to improve the usability testing and selection of MATechs tailored to the unique needs of older adults, addressing a critical gap in the literature and enhancing the management of and adherence to medications in this population.

Chapter 4: Primary Research Project (study rationale and objectives) - User experience and Usability testing of MATechs among older adults who face physical, cognitive, sensory, motivational, and/or environmental barriers to medication self-management.

Chapter 5: Primary Research Project (methods) - details a prospective mixed-method research design to offer a comprehensive analysis of MATechs' usability across diverse user limitations.

Chapter 6: Primary Research Project (quantitative findings).

Chapter 7: Primary Research Project (qualitative findings).

Chapter 8: Discussion and Conclusion.

2 Chapter 2: Tools to Measure Barriers to Medication Management Capacity in Older Adults: A Scoping Review

This Chapter is published as follows:

Baby, B., McKinnon, A., Patterson, K., Patel, H., Sharma, R., Carter, C., Griffin, R., Burns, C., Chang, F., Guilcher, S. J., Lee, L., Fadaleh, S. A., & Patel, T. (2024). Tools to measure barriers to medication management capacity in older adults: a scoping review. *BMC Geriatrics*, *24*(1), 285.

2.1 Abstract

Background: Medication management capacity is a crucial component of medication adherence, particularly among older adults. Various factors, including physical abilities, cognitive functions, sensory capabilities, motivational, and environmental factors, influence older adults' ability to manage medications. It is, therefore, crucial to identify appropriate tools that allow clinicians to determine which factors may impact medication management capacity and, consequently, non-adherence to medications.

Purpose: 1) To identify tools that measure physical, cognitive, sensory (vision, hearing, touch), motivational, and environmental barriers to medication self-management in older adults, and 2) to understand the extent to which these tools assess various barriers.

Methods: The scoping review was conducted using Arksey and O'Malley's scoping review framework and the PRISMA Extension for Scoping Reviews checklist. In June 2022, the relevant literature was identified by searching PubMed (MEDLINE), Ovid Embase, Ovid IPA, EBSCOhost CINAHL, APA PsycINFO, and Scopus.

Results & Discussion: In total, 7235 studies were identified. Following the removal of duplicates, 4607 articles were screened by title and abstract, of which 4253 did not meet the inclusion criteria. Three reviewers reviewed the full texts of the remaining 354 articles; among them, 41 articles, 4 theses and 1 conference abstract met the inclusion criteria. From the included studies, 44 tools were identified that measured a combination of physical, cognitive, sensory, motivational, and environmental barriers (n=19) or only cognition (n=13), vision (n=5), environmental factors (n=3), auditory (n=1), and motivational factors (n=1). The review also examined the psychometric properties of the identified tools and found that most of them had reported validity and reliability

data. Several tools have demonstrated promise in assessing a combination of barriers with validity and reliability. These tools include the Self-Medication Assessment Tool (SMAT), ManageMed Screening (MMS), Self-Medication Risk Assessment Tool (RAT), HOME-Rx revised, and Medication Management Ability Assessment (MMAA).

Conclusion: This scoping review identified 44 validated tools to measure various challenges that older adults encounter with medication management. However, no tool measures all five barriers (physical, cognitive, sensory, motivational, and environmental) to medication-taking at home. Therefore, utilizing a combination of tools would be most appropriate to measure these different aspects comprehensively. Further research is needed to develop a new comprehensive tool that simultaneously measures various barriers to medication self-management.

2.2 Background

In individuals aged 60 years and above, there is a higher prevalence of multiple chronic conditions, including diabetes, hypertension, heart disease, stroke, and cancer, compared to younger age groups.[87] According to a report by the National Council on Aging, "approximately 92% of older adults have at least one chronic disease, and 77% have at least two chronic diseases".[88] These chronic diseases, along with associated disabilities, can result in complex medication regimens and an increased risk of functional impairment, presenting significant challenges in medication management capacity.[90] Additionally, the burden of handling medications, especially within the context of multi-morbidity and complex medications regimens, introduces an added layer of complexity to the day-to-day lives of older people, and these burdens can also influence their capacity to manage medications.[91,92]

Medication management capacity (MMC) refers to the "cognitive and functional ability to comply with a medication regimen, when it is the individual's wish or desire to follow a medication regimen as prescribed".[92] MMC encompasses factors such as understanding the purpose and importance of medications, being able to remember and follow prescribed dosages and administration instructions and having the necessary skills to handle medication containers and administer medications correctly.[92] Medication management capacity is closely linked to adherence.[50] Medication adherence refers to "the extent to which a person's medication-taking behavior corresponds with agreed-upon treatment recommendations from a healthcare provider".[93,94] If an individual lacks the necessary cognitive or functional abilities to manage their medications effectively, it can result in unintentional nonadherence.[50,92,94] Compared to younger patient groups, concerns regarding medication management capacity are particularly significant among older adults.[95] According to the World Health Organization (WHO), approximately 46% of people over the age of 60 suffer from some form of disability, with visual impairment, hearing impairment, cognitive limitations, and osteoarthritis being the most common causes.[96] These limitations can impair the ability of older individuals to manage complex medications and, as consequence, restrict their independence.[96]

The MOLD-US framework, with its focus on physical, cognitive, sensory, and motivational barriers affecting the usability of mobile health applications in older adults, serves as a valuable guide for understanding and categorizing challenges in medication self-management.[35] By considering impairments associated with aging and their consequences, this framework addresses the challenges involved in medication management in older adults.[35] Physical impairments associated with aging include a decline in grip strength, dexterity, coordination, and mobility of the hands and arms.[35] Research on rheumatoid arthritis patients revealed that hand function deterioration associated with arthritis hindered their ability to open tablet containers and unit dose packs.[97] Aging also leads to a loss of certain cognitive abilities, including processing speed as well as certain memory, language, visuospatial, and executive functions.[98,99] In addition, certain conditions, such as dementia, can worsen cognitive decline, which ultimately reduces medication management ability. [98,99] Visual functions that decline with age include the ability to resolve detail, focus on close objects, discriminate between colors, detect contrast, adapt to darker conditions, and increase susceptibility to glare.[41,100] A study involving 156 patients above the age of 65 compared issues related to self-management of medications among older individuals with and without visual impairment.[41] Despite using visual aids, approximately 29% of individuals with visual impairment required assistance managing their medications.[41] Moreover, age-related eye diseases such as cataracts, age-related macular degeneration, glaucoma and diabetic retinopathy can also deteriorate the vision functions of older individuals.[100] Motivational challenges that older adults encounter with medication self-management at home include inadequate knowledge about medications and the use of adherence technologies (health literacy and technology literacy), low self-efficacy, lack of confidence in taking medications properly, and integration of medication management during daily activities.[35] Additionally, research suggests that feedback from care partners and the environment in the home can impact the ability of older adults to self-administer medication.[57,101] Therefore, when assessing various barriers to medication-taking, it is important to take into account a variety of environmental factors, including social factors such as support from family and caregivers and home environment.[101,102]

Several studies have emphasized the importance of assessing the functional ability of older adults to medication management in clinical practice as it serves as a guiding factor for planning, applying, and monitoring interventions aimed at optimizing medication management, allowing healthcare professionals to tailor strategies to individual needs and challenges.[48,103-105] However, despite the significance of this assessment, standardized evaluations of functional ability in medication management or medication self-management are not routinely performed in clinical settings.[105] Often, judgments regarding medication management ability rely on the clinician's intuition or reports provided by the patient or caregiver, which have limitations in terms of knowledge, insight, and objectivity.[48] Instruments that measure instrumental activities of daily living and medication adherence are sometimes used to assess medication management capacity, but they are insufficient for evaluating the specific skills required for independent medication management.[48]

A number of instruments have been developed to assess an individual's functional and cognitive capacity to manage medications.[103-106] Drug Regimen Unassisted Grading Scale (DRUGS), Medication Management Instrument for Deficiencies in the Elderly (MedMaIDE), the Hopkins Medication Schedule (HMS), and the Medication Management Ability Assessment (MMAA) are the tools most recommended by various reviewers based on the medication management skills measured, administration time, scoring scale, type of medication regimen used, and psychometric properties.[48,103-106] It is important to note that while various tools exist, most are designed to identify cognitive and physical barriers to successful medication administration, and none are known to address all barriers to medication management.[48,103,104] Furthermore, considering that motivational and environmental factors significantly influence an individual's medication-taking behavior, it is crucial to incorporate these factors when assessing medication management capacity.[42,101] The integration of these diverse elements into a single tool enables healthcare professionals to acquire a comprehensive overview of an individual's medication management capacity. This comprehensive assessment facilitates targeted interventions that consider the interplay of physical, cognitive, sensory, motivational, and environmental factors, potentially resulting in more effective support and strategies to enhance medication management.

This review aims 1) to identify tools that measure physical, cognitive, sensory, environmental, and motivational barriers to medication self-management in older adults, and 2) to understand the extent to which these tools assess various barriers Although previous reviews have been conducted, this review aims to include any new tools that have emerged since then and to consider a broader range of barriers, including physical, cognitive, sensory, motivational, and environmental factors. By synthesizing the existing evidence and offering a consolidated resource, we aim to assist healthcare professionals in selecting appropriate tools for assessing medication management capacity in older adults and contribute to the advancement of knowledge in this field.

2.3 Methodology

This scoping review was informed by the guidance provided by the Arksey and O'Malley scoping study framework and the PRISMA Extension for Scoping Reviews checklist.[107,108] Based on the direction from these two sources, the scoping review included the following stages: (1) identifying the research question, (2) identifying relevant studies, (3) study selection, (4) charting the data, and (5) summarizing and reporting the results.

2.3.1 Stage 1. Identifying the research question

The research question was as follows: Which tools exist to measure physical, cognitive, sensory, environmental, and motivational barriers to medication taking in older adults?

For this study, we define "tools" as instruments, scales, or assessment methods specifically designed to measure, evaluate, or assess various factors, including physical abilities, cognitive functions, sensory capabilities, motivational factors, and environmental factors that can influence an older adult's capacity to manage medications.

The MOLD-US framework developed to evaluate barriers of older adults influencing usability of mobile health applications was used in this scoping review to guide the identification and categorization of barriers to medication taking in older adults.[35] Even though its primary purpose may differ, the framework allowed us to categorize the diverse barriers impacting older adults' medication self-management in a comprehensive manner as physical, cognitive, sensory, and motivational barriers. In addition to these barriers, we aimed to capture the broader contextual factors, including environmental factors such as social support and home environment (e.g., counter space, adequate lighting), that may influence medication-taking among older adults.[57,101,102]

2.3.2 Stage 2. Identifying relevant studies

Relevant articles were found by using a thorough search strategy consisting of both medical subject headings and keywords in 6 databases: PubMed (MEDLINE), Ovid Embase, Ovid International Pharmaceutical Abstracts, EBSCOhost CINAHL, APA PsycINFO, and Scopus. An experienced medical librarian (CC) constructed the database search strategies and conducted the search with input from the team. The search strategies contained synonyms for the following search concepts: medication, self-management, tools, functional impairment (e.g., impaired hearing, vision) and older adults. In each database, all keywords were limited to the title and abstract fields. All search strategy results were limited to the English language and the date range of 2002-2022. The final search strategies were run in each database on June 20th, 2022, and all results were exported to EndNote 20 (Clarivate Analytics, 20.2.1) for duplicate removal. Appendix A-1 contains the full search strategy utilized in each database. After duplicate removal, the remaining results were exported into Covidence (Veritas Health Innovation, 2022) for screening.

2.3.3 Stage 3. Study selection

Two team members (BB and HP) initially independently screened the titles and abstracts of 460 articles (10% of citations retrieved) based on the predetermined inclusion and exclusion criteria. The inter-rater reliability between the two researchers was determined (the Kappa coefficient was found to be 0.88). The remaining publications were screened by a single reviewer (BB) in view of this strong inter-rater reliability. Full-text screening of eligible studies was conducted by three team members (BB, AM, KP). One reviewer (BB) screened all the eligible studies, and the other two reviewers (AM, KP) screened 50% of the studies each. The bibliographies of the pertinent studies were also screened for additional relevant studies. Studies were included if they were (1) conducted in participants with a mean age of ≥60 years, (2) introduced or proposed tools designed to examine any of the physical, cognitive, motivational, and environmental barriers related medication taking, or tools to assess functional decline/capacity /limitation/independence/disability related to medication-taking, (3) tools for which psychometric evaluation (at least one of reliability, content validity, or construct validity) is available, (4) published between 2002 and 2022, (5) published in the English language, and (6) performed in the outpatient setting or after hospital discharge. The exclusion criteria were as follows: (1) studies performed in inpatients or assisted living residents, (2) editorials, comments, letters to the editor, guidelines, case series and case reports, (3) studies that reported on condition-specific tools (designed to be used in specific diseases only), (4) tools introduced to measure domains other than barriers to medication management, such as self-care or medication adherence, and (5) studies measuring physical, cognitive, sensory, motivational, and environmental barriers, but not related to medication-taking. Disagreements among the three reviewers were resolved through discussion and consensus. Where consensus was not achieved, a fourth team member (SA) was invited to assist with resolving the disagreement.

2.3.4 Stage 4. Charting the data

Data abstraction from the included studies was completed using a Microsoft R Excel R (Office 365 Version 1906) spreadsheet. The following data were abstracted for each included study: title, author, year of publication, journal, country, age and gender of participants, sample size, study objective, study design, study duration, study setting, inclusion criteria, exclusion criteria, assessment tools mentioned, and main outcomes. For the identified tools, the following data were abstracted: purpose, administration time, type of instrument (performance-based/self-reported), type of medication regimen used, barriers assessed, and psychometric properties (validity & reliability). Two reviewers (BB, RS) abstracted data from eligible studies, and the accuracy of the abstracted data was verified by two additional reviewers (AM, KP).

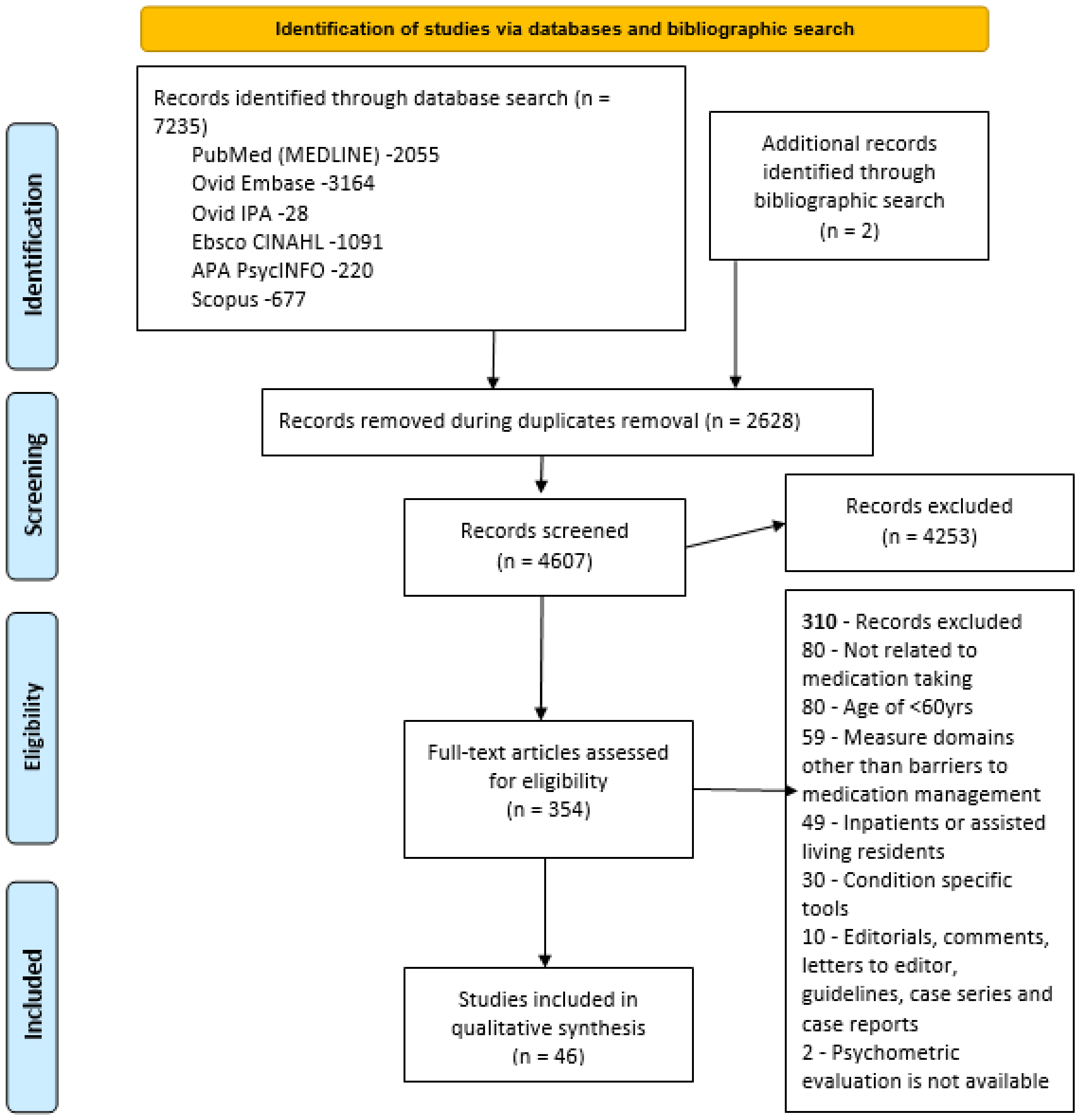
2.3.5 Stage 5: Summarizing and reporting the results

The general characteristics of the studies and properties of the tools were collected and summarized. The results were then categorized and summarized based on the type of tool, barriers assessed, medication management skills assessed, and psychometric properties.

2.4 Results

A total of 7235 studies were identified. After removing duplicates, two reviewers screened 4607 articles by title and abstract, of which 4253 did not meet the inclusion criteria. Therefore, 354 articles were included for full-text review. Of these, 39 articles, four theses, one conference abstract, and two articles identified from the manual search of bibliographies met the inclusion criteria. In the 46 papers included, 44 tools measuring various barriers to medication management capacity were identified. The flow chart in Figure 2-1 illustrates the screening process.

Figure 2-1: PRISMA flow diagram



2.4.1 Study Characteristics

Publication rates varied across decades, with sixteen articles published from 2002 to 2012 and thirty from 2013 to 2022. More than half of the studies (*n*=25) were conducted in the United States, 13 in Europe, 4 in Asia, 2 in Australia, and 2 in Canada. A variety of study designs were used: cross-sectional (*n*=30), pilot study (*n*=5), cohort study (*n*=2), scoping review (*n*=2), validity study (*n*=3), case–control study (*n*=1), mixed method study (*n*=1), systematic review (*n*=1), and randomized controlled trial (*n*=1). Most of the studies included both males and females, except for one study conducted on community-dwelling women aged 70 to 80 years. Twelve studies targeted older adults with specific conditions (coronary heart disease, Parkinson's disease, chronic obstructive pulmonary disease, hypertension, age-related macular degeneration), one study recruited pharmacists and pharmacy students to evaluate the validity of a medication assessment tool for older adults, and the remaining studies targeted community-dwelling older adults. A detailed description of the studies included is summarized in Table 2-1.

Table 2-1: Study Characteristics

Author, Year of Publication, Country	Tool(s)	Study design	Study Objective	Population description	Sample Size	Mean age of Participants	Gender	Study outcome
Advinha AM., et al.,[109] 2021 Portugal	Drug Regimen Unassisted Grading Scale (DRUGS) Self-Medication Assessment Tool (SMAT)	Observational study (Cross sectional)	To assess the ability of older people to self-manage their medication.	Community-dwelling residents over 65 years old	207	75.5 years	Female (75.4%) Male (24.6%)	The probability that an older individual would be able to manage medications with total accuracy (100%) increases exponentially with cognitive competence. The functional ability of older people to self-manage medications was found to be clearly associated with cognitive impairment.
Caffery DM., et al.,[110] 2007 US	Cognitive Screen for Medication Self-Management (CSMS) Test in Older Adults	Validity study	To evaluate specific identified psychometric properties of the CSMS.	Community dwelling individuals age from 72 to 95 and living independently	60	NR	Female (75%) Male (25%)	Established validity for cognitive status and age, Reliability measure, Internal consistency, -0.08-0.84.
Insel, K., et al.,[111] 2006 US	Mini-Mental State Examination (MMSE) Wisconsin Card Sorting Test (WCST) Digit span backward (DSB) California Verbal Learning Test (CVLT)	Observational study (cohort study)	To investigate the association between cognitive processes and medication adherence among community-dwelling older adults.	Older adults (67 years or older)	100	78 years	Female (78%) Male (22%)	Executive function and working memory tasks were the only significant predictor ($b = .44$, $p < .01$) of medication adherence. Assessments of executive function and working memory can be used to identify community-dwelling older adults who may be at risk for failure to take medicines as prescribed.
Kripalani, S., et al.,[112] 2006 US	Drug Regimen Unassisted Grading Scale (DRUGS) Rapid Estimate of Adult Literacy in Medicine (REALM)	Observational study (Cross sectional study)	To evaluate the effects of low literacy, medication regimen complexity, and sociodemographic characteristics on MMC.	Patients with CHD	435	65.4 years	Female (54.6%) Male (45.4%)	Total DRUGS scores increased with literacy level ($P=.001$), as did the ability to identify medications correctly ($P< .001$). Patients with inadequate literacy specifically struggled with identifying their medications by viewing the bottle exterior or label (P<

								.001, compared with higher literacy patients).
Lam, AY., et al.,[113] 2011 US	Mini-Cog Medi-Cog Medication-transfer screen (MTS)	Observational study (Cross sectional study)	To assess pillbox, fill accuracy and cognition among community-dwelling older adults.	Community-dwelling older adults > 60 years of age,	50	76.4 years	Female (58%) Male (52%)	All components of the cognitive screens except the clock draw portion of the Mini-Cog were significantly associated with PC. The Mini-Cog and MTS individually accounted for about 30% of the variance (P < 0.001); their combination into the Medi-Cog was the strongest predictor of PC, accounting for 44% of the variance (P < 0.001). Medi-Cog was the strongest predictor of PC.
Lubinga, SJ., et al.,[114] 2011 UK	Self-medication Risk Assessment Tool (RAT)	Observational study (Cross sectional study)	To determine scale reliability and validate the instrument against community pharmacists' assessment of patients' ability to manage their medicines.	Older adults who were at least 65 years old	37	Median age-76years	Female (48.6%) Male (51.4%)	Cronbach's alphas were 0.792, 0.679 and 0.813 for the 13-item, cognitive risk, and the physical risk sub-scales respectively. The total risk score and cognitive risk sub-scores were significantly worse among multi-compartment compliance aid users compared to the non-users.
Mortelmans, L., et al.,[115] 2021 Belgium	Medication Management Instrument for Deficiencies in the Elderly (MedMaIDE)	Observational study (Cross sectional study	To describe post-discharge medication self-management by geriatric patients with polypharmacy, to describe the problems encountered and to determine the related factors.	Older adults aged least 75 years old, used five or more prescribed medicines.	400	82 years	Female (52.5%) Male (47.5%)	After discharge, 70% did fully self-manage their medication, 27% received help with preparing their medication but self-administered their medicines and 3% received help with preparing and administering medicines at home. Approximately 90% of patients experienced at least one medication management deficiency after discharge. Most deficiencies were related to medication knowledge (mean 3.1 [SD 1.8]).
Kim, JS., et al.,[116] 2013 South Korea	Mini-Mental State Examination (MMSE) Montreal Cognitive Assessment (MoCA)	Observational study (Cross sectional study	To evaluate the correlation between ability to manage medication and cognitive functioning in patients with PD.	PD patients	208	66.4 years	Female (55.29%) Male (44.71%)	Correlations between PillQ scores and scores on the MMSE and MoCA approached moderate strength. Among the MMSE subscales, orientation (-0.403 p<0.001) and memory registration (-0.314 p<0.001) were

								most strongly related to scores on the PillQ. The orientation (-0.363 p<0.001) and visuospatial subscales (-0.375 p<0.001) of the MoCA were strongly correlated with PillQ scores.
Anderson, RE., et al.,[29] 2016 US	Short Blessed Test (SBT) Montreal Cognitive Assessment (MOCA) Trail-Making Test (TMT)	Observational study (prospective)	To determine whether cognitive dysfunction, in particular impaired executive function, may be a risk factor for early readmission in older adults independently managing their medications.	Individuals aged 65 and older	452	74.7 years	Female (59.1%) Male (40.9%)	For participants managing medications themselves, adjusted 30-day odds of readmission increased 13% on average with each point decrease in SBT score (P = .003) and 9% on average with each 0.01 decrease in TMT-B score (P = .02).
Risser, J., et al.,[117] 2007 US	Self-efficacy for appropriate medication use scale (SEAMS) Rapid Estimate of Adult Literacy in Medicine (REALM)	Experimental study	To develop a self-efficacy scale for medication adherence in chronic disease management that can be used in patients with a broad range of literacy skills.	Patients with documented coronary heart disease (CHD) who presented to the clinic	436	63.8 years	Female (55.7%) Male (44.3 %)	The final 13-item scale had good internal consistency reliability (Cronbach's α 0.89). Test-retest reliability of the 21-item scale was moderate (Spearman's ρ 0.62, p 0.0001). Self-efficacy as measured by the scale was strongly correlated with medication adherence as assessed by the Morisky scale (Spearman's ρ 0.51, p .0001).
Castel-Branco, M., et al.,[118] 2015 Portugal	Mini-Mental State Examination (MMSE)	Observational study (Cross sectional study	To identify the elements required for an appropriate medication self-management in elderly in order to create a Good Practice Guideline for home visits to isolated polypharmacy elderly.	Patients with 65 or more years old, living alone	34	NR	NR	From a total of 37 seniors, only 62 % were considered non-adherents although 87 % knew when to take their medication, and 85 % reported using different memory strategies, such as associating the administration with a specific activity, pillboxes, or the location of the medicine at home.
Marks, TS., et al.,[119] 2020 US	Mini-Cog Medi-Cog-R Medication-transfer screen-revised (MTS-R)	Observational study (Cross sectional study	To examine whether a combined cognitive and performance-based medication management measure would be able to better classify an individual's functional cognitive status and potential for instrumental activities of daily living (IADL)	Community-dwelling adults	185	70.68 years	Female (76.2%) Male (23.8 %)	The Mini-Cog, the MTS-R, and the Medi-Cog-R all show discriminant validity, but the combined measure demonstrates greater sensitivity and specificity than either component measure alone in identifying IADL impairment.

			impairment than either measure alone.					
O'Conor, R., et al.,[120] 2019 US	Short Test of Functional Health Literacy in Adults (S-TOFHLA) Trail Making Test (TMT) Mini Mental State Exam (MMSE)	Observation study (cohort study)	To assess the association between health literacy and cognitive abilities with self -management behaviors in patients with COPD.	Adults with COPD	388	68 years	Female (58.3%) Male (41.7 %)	Compared with individuals with adequate health literacy, participants with limited health literacy were less likely to be adherent to their COPD medicines (23.3% vs. 46.0%, p < 0.001), demonstrate correct MDI (57.8% vs. 71.9%, p = 0.02) or DPI (40.0% vs. 56.7%, p = 0.04) technique, or have one healthcare provider regularly manage their COPD. Global cognitive ability was predictive of correct MDI and DPI technique.
Son, YJ., et al.,[121] 2017 South Korea	Self-Efficacy for Appropriate Medication Use Scale (SEAMS)	Observational study (Cross sectional study	To examine the mediating role of self-efficacy in the relationship between depression and medication adherence among older patients with hypertension.	Older adults patients with hypertension	255	73.89 years	Female (48.2%) Male (51.8%)	Depression was significantly negatively correlated with self-efficacy (r = −.26, P < .001) and medication adherence (r = −.24, P < .001), while self-efficacy was significantly positively correlated with medication adherence (r = .53, P < .001), depression significantly predicted self-efficacy (β = .20, P = .002) and medication adherence (β = −.28, P < .001).
Wajda, B., et al.,[122] 2014 US	National Eye Institute Visual Function Questionnaire-25 (NEI VFQ–25)	Observational study (Cross sectional study-prospective)	To determine whether personality traits influence self-reported functional vision in patients with age-related macular degeneration (AMD).	Patients with AMD	182	84.1 years	Male (29%) Female (71%)	For near functional vision, visual acuity [95% confidence interval {CI} 0.46, 0.20]; p 0.001), and education [95% CI 0.01, 0.15]; p 0.03) were statistically significant predictors. For distance functional vision, only visual acuity [95% CI – 0.69, – 0.29]; p 0.001) was statistically significant predictor.
Yang, C., et al.,[123] 2021	Medication-Specific Social Support Questionnaire (MSSS)	Protocol for a randomised controlled trial	To implement an evidence-based, theory-informed, and nurse-led medication self-management intervention among	Community-dwelling older patients with multimorbidity.	NR	NR	NR	NR

China	The Self-Efficacy for Appropriate Medication Use Scale (SEAMS)		older patients with multimorbidity and examine its effects in community settings.					
Smith, SG., et al.,[124] 2015 US	The Rapid Estimate of Adult Learning in Medicine (REALM) Test of Functional Health Literacy in Adults (TOFHLA-R) The Newest Vital Sign (NVS) Comprehensive Health Activities Scale (CHAS)	Observational study (Cross sectional study	To investigate the relationship between literacy and numeracy and their association with health task performance.	English-speaking adults ages 55 to 74	304	63.2 years	Female (74.7%) Male (25.3%)	Literacy and numeracy were both significantly associated with performance on all tasks (literacy range, b = 0.23–0.45, all ps < 0.001; numeracy range, b = 0.31– 0.41, all ps < 0.001).
Curtis, LM., et al.,[125] 2016 US	The Rapid Estimate of Adult Learning in Medicine (REALM) Test of Functional Health Literacy in Adults (TOFHLA-R) The Newest Vital Sign (NVS) Comprehensive Health Activities Scale (CHAS)	Observational study (Cross sectional study)	To determine the prevalence of various forms of cognitive decline over a 3-year period, and to examine associations with requisite health literacy and self-management skills.	English-speaking adults ages 55 to 74	545	66 years	Female (69%) Male (31%)	Decline in long term memory was associated with poorer self-management skills (beta -3.26, 95%CI -4.96, -1.55; p < 0.001). Cognitive decline was not associated with performance on the REALM or the NVS assessments.
Sluggett, JK., et al.,[99] 2020 Australia	Drug Regimen Unassisted Grading Scale (DRUGS) Self-Efficacy for Appropriate Medication use Scale (SEAMS)	Non-randomized pilot and feasibility study	To determine the feasibility of a multi-component intervention to simplify medication regimens for people receiving community-based home care services.	Older adults	25	79 years	Female (64%) Male (36%)	The DRUGS assessment showed most participants were able to self-manage their medications, participants who received intervention did so with a high degree of protocol adherence and acceptability. Simplification was possible for 14 participants (56%) and implemented for 7 (50%) at follow-up.

Beckman, A., et al.,[126] 2005 Sweden	Mini-Mental State Examination (MMSE)	Observational study (Cross sectional study)	To investigate elderly people's ability to open medicine containers, and how this ability correlates to some common disorders that may cause functional or cognitive impairment.	Older adults aged 75 years or older,	604	86.7 years	Male (22.4%) Female (77.6%)	14% were unable to open a screw cap bottle, 32% a bottle with a snap lid, and 10% a blister pack. Female gender, higher age, living in an institution, Parkinson's disease, rheumatoid arthritis, cognitive impairment and impaired vision were all associated with a decreased ability to open the containers.
Somerville, E., et al.,[102] 2019 US	HOME–Rx-revised Medication Management Instrument for Deficiencies in the Elderly (MedMaIDE) Medication Management subscale of the *Performance* Assessment of Self-care Skills (PASS)	Observational study (Cross sectional study)	To further develop the HOME–Rx, an in-home medication management assessment, by modifying scoring metrics, improving clinical utility, and establishing psychometric properties.	Older adults	Phase 1: 4 Phase2: 30	Phase1-73.8 years Phase2-75.8 years	Phase1-Female (50%) Male (50%) Phase2-Female (73.3%) Male (26.7%)	Phase 1- Administration time was reduced from an average of 65 to 75 min to 25 to 35 min. Phase2: The PASS was positively correlated with the HOME–Rx Performance and Safety subscales; the MedMaIDE was negatively correlated with the HOME–Rx Performance subscale and positively correlated with the Barriers subscale. Interrater reliability was excellent (ICCs = .87–1.00).
Murphy, MC., et al.,[127] 2017 US	HOME–Rx	Validity study	To develop a novel, performance-based medication adherence assessment.	Older adult	12 Content expert participants 7 Older adult 5	75.6 years	Female (60%) Male (40%)	Content experts were in agreement that the overall instrument was valid for measuring medication management (scale-level CVI 5 .95). Older adult participants reported the instrument was relevant, acceptable, and easy to understand.
Hutchison, LC., et al.,[128] 2006 US	Medication Management Ability Assessment (MMAA) Drug Regimen Unassisted Grading Scale (DRUGS) Mini-Mental State Examination (MMSE)	Observational study (Cross sectional study)	To compare the Medication Management Ability Assessment (MMAA) and the Drug Regimen Unassisted Grading Scale (DRUGS) as standardized tools to assess medication management skills in elderly patients with a range of cognitive function.	Individuals with Alzheimer's disease and a control group	52	75.8 years	Female (69%) Male (31%)	The 49 participants who took the MMAA had a mean (SD) score of 19.4 (6.1), with a range of 0 to 25. The 46 participants who took the DRUGS had a mean (SD) score of 91.6 (24.7), with a range of 0 to 100.The MMAA and the DRUGS correlated with one another (P = 0.000).

Miller, DJ., et al.,[129] 2022 US	The National Eye Institute Visual Function Questionnaire (NEI-VFQ-25) Functional Health Literacy Scale (FHL)	Pilot study Prospective, single-arm pilot study with a pre post design.	To investigate whether demographic, clinical, or psychosocial factors act as moderators of change in medication adherence in the Support, Educate, empower (SEE) program.	Glaucoma patients	39	63.9 years	Female (44%) Male (56%)	There were no significant differences in the slopes of adherence for better-eye MD, visual acuity, number of comorbidities, visual function measured by the NEI-VFQ-25 score, FHL or GMSE in response to medication reminders ($P > 0.05$) for all comparisons.
Advinha, AM., et al.,[103] 2016 Portugal	Self-medication Assessment Tool (SMAT)	Pilot study	To assess elderly's medication management ability using the Self Medication Assessment Tool – Portuguese Version (SMAT-PT) and to correlate the performance between standard and real therapeutic regimens.	Portuguese community-dwelling elders	150	74.73 years	Female (74.7%) Male (25.3%)	The SMAT-PT standard regimen mean scores were 20.92 (±6.83) in functional ability and 38.75 (±5.92) in cognitive ability. Significant correlations between medication recall and standard regimen items were found. Cognitive measures were directly correlated with medication management ability.
Alosco, ML., et al.,[130] 2012 US	Mini Mental State Examination (MMSE) Trail Making Test (TMT)	Observational study (Retrospective observational analyses)	To examine whether cognitive functioning predicts instrumental ADL performance in persons with HF.	HF population	122	68.49 years	Female (35.2%) Male (64.8%)	In each case, poorer neuropsychological test performance was associated with poorer instrumental ADL function. Poorer cognitive test basic performance was associated with reduced independence in medication management
Bailey, S., et al.,[131] 2015 US	Measure of Drug Self-Management (MeDS)	Observational study (Cross sectional study)	To develop and evaluate a comprehensive yet brief Measure of Drug Self-Management (MeDS) for use in research and clinical settings among diverse patient groups.	Diagnoses of diabetes and hypertension	193	61.1 years	Female (60.1%) Male (39.9%)	MeDS demonstrated adequate internal consistency with a Cronbach's α of 0.72. The scale was significantly correlated with the Morisky Medication Adherence Scale ($r= -0.62$; P,0.001), low-density lipoprotein cholesterol ($r= -0.27$, $P<0.001$) and diastolic blood pressure ($r= -0.18$, $P=0.01$).
McCann, RM., et al.,[41] 2012 Australia	Daily Living Tasks associated with Vision (DLTV)	Observational study (case–control study)	To compare issues relating to medication self-management between older people with and without VI.	Individuals aged ≥65 years,	Visually impaired-156, Control-158	Visually impaired-81 years Control-77.8 years	Visually impaired-Male (35.9%) Female (64.1%) Control-\ Male-(38.6 %) Female -(61.4 %)	Significantly more with VI (29%), compared to controls (13%) (OR = 2.8 [95% CI = 1.6 to 5.0]; age-adjusted OR = 2.6 [95% CI = 1.4 to 4.7]) relied on help to take their medication each day or to sort it into a compliance aid (a container holding usually seven daily

								aliquots of medication, each within separate sections).
Raehl, CL., et al.,[132] 2002 US	Med Take test Whisper test Mini-Mental State Examination (MMSE)	Observational study (Cross sectional study)	To quantify how seniors' ability to take oral prescription drugs safely may correlate with age, sex, socioeconomic status, education, cognitive impairment, depression, and drug self-management.	Older adults	57	79.49 years	Female (72%) Male (28%)	Significant predictors of the outcome MedTake test score, adjusted for age and sex, were MMSE (b = 0.393, p=0.002) and Medicaid assistance in last 10 years (b = -0.302, p=0.021).
Creech, CL., et al.,[133] 2016 US	Self-Efficacy for Appropriate Medication use Scale (SEAMS) Newest Vital Sign (NVS)	Pilot study	To determine whether a brief, low-HL tailored intervention on common medication management issues could affect immediate changes in the dependent variables of knowledge and self-efficacy (SE).	Independently living older adults (Greater than 65 years)	14	84.06 years	Female (92.8 %) Male (7.2 %)	Post-test knowledge scores were significantly higher than pre-test scores for all participants (M = 8.43, Mdn = 9.00, SD =1.651 versus M = 3.93, Mdn = 4.00, SD = 1.817; p < .001). Change in knowledge and SE scores were not related to age, educational attainment, or baseline HL status.
Chin, J., et al.,[134] 2021 US	Rapid Estimate of Adult Literacy in Medicine (REALM)	Observational study (Cross sectional study)	To examine how health literacy and its components (processing capacity and knowledge about illness) influence memory for medication purposes.	Individuals with diagnosis of type II diabetes mellitus	674	63.6 years	Female (55.2%) Male (44.8 %)	Health literacy was associated with memory for medication purposes, with processing capacity and health knowledge partly mediating this association. (F (5,665) = 18.97, p < .001, adjusted R2 = 0.12, SE = 0.94).
Sumida, CA.,[135] et al., 2019 US	Medication Management Ability Assessment (MMAA)	Observational study (Cross sectional study)	To examine the performance of healthy older adults' (HOA) and individuals with amnestic mild cognitive impairment (aMCI) on the medication management abilities assessment's original scoring criteria and derived error process measures.	Healthy older adults and individuals with amnestic mild cognitive impairment (aMCI)	50 Healthy older adults-25 Individuals with aMCI-25	HOAs-70.68 aMCI- 70.80	HOAs- Female-(68%) Male (32%) aMCI- Female (80%) Male (20%)	Individuals with aMCI performed more poorly than HOAs on the MMAA score and process error measures. The aMCI group showed significantly poorer performance on measures of total overtaking error (η2 = .169), total undertaking error (η2 = .099), the magnitude error score (η2 = .291) and the MMAA score (η2 = .258).
Thuy LT., et al.,[136] 2020 Thailand	Multidimensional Scale of Perceived Social Support (MSPSS) Short Test of Functional Health Literacy in Adults	Observational study (Cross sectional study)	To examine the factors of medication regimen complexity, physical function, social support, health literacy, patient-provider communication, health belief, and self-efficacy in explaining	Individuals aged 60 years or older; being diagnosed with HTN and undertaking antihypertensive	300	68.11 years	Female (42%) Male (58%)	Five variables (medication regimen complexity, health literacy, patient-provider communication, health belief, and self-efficacy) were significantly associated with medication

	(S-TOFHLA)		medication adherence of older people with hypertension.	drug for at least 6 months;				adherence. Physical function and social support were not significantly related to medication adherence (-.136*, -.114*).
Windham, BG., et al.,[137] 2005 UK	*Hopkins Medication Schedule* (HMS) Pelli-Robson letter sensitivity chart (PR test) Randot Circles (stereovision) Early Treatment Diabetic Retinopathy Study eye chart (ETDRS)	Observational study (Cross sectional study)	To assess relationships between vision (Contrast sensitivity, stereopsis, visual acuity) and a performance-based measure of ability to implement new medications.	Community-dwelling women aged 70 to 80 years	335	76.8 years	only female	Each vision measure was positively associated with Pillbox Ratio scores and varied with cognition and time to completion. Better visual acuity, contrast sensitivity, and stereopsis were each associated with better performance in women with poor cognition who filled the pillbox quickly.
Robnett, RH., et al.,[138] 2007 US	ManageMed Screening (MMS) *Hopkins Medication Schedule* (HMS)	Observational study (Cross sectional study)	To introduce ManageMed and complete initial reliability and validity analyses on the ManageMed Screening.	Volunteer participants, aged 65 and over.	67	76 years	NR	Adequate reliability and concurrent validity were established. Internal consistency, Cronbach's Alpha of 0.89 (42 items). Interrater reliability on individual questions ranging from 0.859 to 0.965. A moderate correlation was attained between ManageMed total score and the total Cognistat score (0.696, p = 0.01), indicating that the results for both tests are similar (concurrent validity).
Russell, AM., et al.,[139] 2018 UK	Rapid Estimate of Adult Literacy in Medicine (REALM)	Observational study (Cross sectional study)	To explores patient preferences for functionality in a smartphone application (app) that supports medication self-management among older adults with multiple chronic conditions.	English-speaking older adults (55 and older) who owned smartphones and took five or more prescription medicines	46	65 years	Female-70% Male-30%	Desired features included (1) a list and consolidated schedule of medications, (2) identification and warning of unsafe medication interactions, (3) reminder alerts to take medicine, and (4) the ability record when medications were taken.
Irvine-Meek, J., et al.,[140] 2010	Self-Medication Assessment Tool (SMAT)	Observational study (Cross sectional study)	To evaluate the face validity of the SMAT and to determine its acceptability among pharmacists.	Pharmacists and pharmacy students	20	NR	NR	Participants rating the SMAT; 70% (14/20) for usefulness, 35% (7/20) for ease of use, 60% (12/20) for thoroughness, and 55% (11/20) for willingness to use. Pharmacists and

Canada								pharmacy students working in hospital settings were more willing to use the SMAT than those working in community settings (p = 0.08, effect size = 0.17).
Haus, CS., et al.,[98] 2003 US	Mini-Mental State Exam (MMSE) Martin and Park Environmental Demands Questionnaire (MPED) Long-Term Medication Behavior Self-Efficacy Scale (LTMBSES) Perceived Social Support from Friends (PSS-Fr) and the Perceived Social Support from Family (PSS-Fa)	Observational study non-experimental descriptive-correlational research design	To describe factors and medication strategies used by community dwelling elderly persons who live alone.	Older adults living alone	60	77.4 years	Females (90%) Males (10%)	No significant association was found between the outcome and the 7 predictor variables (MMSE, GDS-S, SS-Fa, SS-Fr, MSE, MPED-routine, MPED-busyness) (Wilks' lambda is .822 (x2 = 10.637; p = .154))
Visscher BB., et al.,[141] 2020 Netherland	Functional, communicative and critical health literacy scales (FCCHL)	Observational study Two-phase qualitative study	To explore the needs of people with low health literacy and DM2 regarding medication self-management and to explore the preferences for medication self-management support.	People with DM2 and low health literacy	18	NR	Female- (39%) Male- (61%)	The participants preferred to be supported with reliable and easily understandable Information, adequate interactive communication with health care professionals and fellow people with diabetes and tools for medication self-management support.
Klymko , KW., et al.,[142] 2008 US	Fuld Object-Memory Evaluation (FOME)	Pilot study	To examine the prevalence of selected cognitive impairments and explore the relationships among cognitive function, hypertension related self-care, and blood pressure in African American older adults.	African American men and women aged 60 and older	39	70 years	Female (69%) Male (31%)	46% African American elders had a high prevalence of cognitive impairments. A strong positive association was found between cognition(memory) and HTN related self-care (correct medication use) ($r=0.59$ $p<0.05$).

Westerbotn, M., et al.,[143] 2008 Sweden	Mini-Mental State Examination (MMSE)	Descriptive study	To describe how older people living at home experienced the management of their own medication regimen from their own perspective.	Individuals aged ≥85 years, living at home	25	89.8 years	Female (64%) Male (36%)	Most participants managed their medicines by themselves and were very content with this. Most important components for older people were to have good cognitive ability, to be independent and to get support with their medicines from a close person as a backup.
Deupree JP, et al.,[144] 2011 UK	Test of Functional Health Literacy in Adults (TOFHLA-R) Medication Administration Self-Efficacy Scale (MASES)	Mixed method study	To explore how community dwelling adults ages 60 to 74 self-manage five or more daily prescription medications.	Community dwelling older adult	15	71.27 years	Female (87%) Male (13%)	Regardless of the health literacy level or the number of daily prescribed medications, participants demonstrated high accuracy of self-management for their medications.
Kapoor A., et al.,[145] 2018 UK	Show back	Observational study (Cross sectional study)	To develop and test a comprehensive simulation which assesses older adult medication self-management proficiency.	English-speaking individuals aged 65+	9	76 years	NR	Inter-rater agreement- high proficiency across all five domains (83%–100%).

2.4.2 Tool properties

Among the 44 tools, two broad categories were identified: performance-based (*n*=30) and self-report measures(*n*=14). Performance-based measures involved asking older adults to complete different tasks related to medication management or different instrumental activity tasks, while self-reported measures are based on subjective information provided by individuals as part of surveys and offer insights into aspects of their own lives that are not directly observable. Of the included tools 19 measured a combination of various barriers, while others assessed only cognition(*n*=12), vision (*n*=5), motivational (*n*=4), environmental (social support) (*n*=3), or auditory (*n*=1) factors. A detailed description of the tools identified is summarized in Appendix A-2 and Table 2-2 illustrates the type and extent of barriers assessed by these tools.

2.4.3 Psychometric properties

There was at least one validity (content and construct)and one reliability (inter-rater, test-retest, internal consistency)data reported for most of the tools we reviewed. For MedTake, Medi-cog, and MTS, only validity data(both content and construct) were reported. Construct validity was shown through association with cognitive function and correctly filled pills for MTS and Medi-cog. The MedTake test was validated for construct validity using cognitive function (MMSE) and educational level. For the ETDRS eye chart, the psychometric properties were measured in terms of accuracy (-0.12*0.14) and test-retest variability (-0.23*0.17). Sensitivity - 100% (95% CI: 96-100) and specificity - 87% (95% CI: 80-92) were reported for the whisper test as psychometric measures. Appendix A-2 contains a detailed description of the psychometric properties of each tool identified

Table 2-2: Tools and type of barriers assessed

Tools	Physical					Cognitive						Sensory								Motivational						Environmental	
	Speed of performance	Flexibility of joints	Hand - eye coordination	Retention in hand movement	Grip strength	Working Memory	Spatial cognition	Dynamic /selective attention	Phonemic/semantic fluency	Reasoning	Numeracy and representational fluency	Vision	Visual acuity/accommodation	Color Vision	Contrast detection	Dark adaptation	Glare	Audition	Auditory acuity	Trust in own ability	Efficiency in seeing benefits	Techno literacy	Health literacy	Shift in responsibilities from provider to patient not preferred	Integration of activities during daily activities	Social factors	Home environment
MMS		X	X	X	X	X	X	X	X	X	X	X		X						X	X		X				
RAT		X	X	X	X	X	X	X		X	X	X	X							X	X						
CSMS	X	X	X	X	X	X	X	X	X	X	X	X	X	X									X				
MMAA	X	X	X	X	X	X	X	X		X	X			X												X	
SMAT	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X								X	
HOME - Rx revised		X	X	X	X	X	X	X	X	X	X									X							X
MedMaIDE		X	X	X	X	X	X	X		X	X												X			X	
Show Back		X	X	X	X	X	X	X															X				
MedTake test	X	X	X	X	X	X	X	X		X	X												X				
HOME - Rx		X	X	X	X	X	X	X	X	X	X									X							
HMS	X	X	X	X	X	X	X	X		X	X												X				
PASS - IADL						X	X	X				X						X					X				
DRUGS					X	X	X	X	X	X	X																
S - TOFHLA						X		X	X														X				
TOFHLA - R						X					X												X				
CHAS						X	X	X		X	X											X	X				
FCCHL						X	X	X		X	X										X		X				
LTMBSES																				X					X	X	
SEAMS																				X			X	X		X	
MMSE						X	X	X	X	X	X																

WCST						X																					
DSB						X																					
CVLT						X																					
Mini - Cog						X	X	X																			
Medi - Cog						X	X	X																			
MTS						X	X	X	X																		
MOCA						X	X	X	X	X	X																
SBT						X	X	X	X																		
TMT						X																					
MeDS						X																					
FOME						X			X																		
NEI VFQ–25												X		X													
DLTV												X	X	X	X	X	X										
PR test															X												
Randot Circles																											
ETDRS												X	X														
Whisper test																		X	X								
NVS																							X				
REALM																							X				
MASES																				X							
MPED																									X		
MSSS																										X	
MSPSS																										X	
PSS - Fr& PSS - Fa																										X	

2.5 Discussion

For older adults, managing multiple health conditions with complex medication regimens can be quite challenging, potentially affecting their quality of life.[50] Assessment and identification of specific limitations in medication management capacity can promote a deeper understanding amongst healthcare providers of how these challenges influence adherence to treatment as well as implementation of appropriate strategies to mitigate the impact on adherence.[13,44-47,56,109,128,135] We aimed to identify a tool that comprehensively evaluates various barriers to medication self-management, including physical, cognitive, sensory, motivational, and environmental domains. Although we found 44 tools that assess these barriers either separately or together, no single tool collectively addressed all five barriers.

2.5.1 Assessment domains and promising tools

There are significant differences in the type and extent to which physical, cognitive, sensory, motivational, and environmental barriers are assessed in the tools we identified. While there are several instruments that exist to measure various aspects of physical and cognitive barriers, sensory components such as color vision, dark adaptation, and auditory factors, along with socioeconomic factors including cost considerations and the home environment, are less frequently or thoroughly addressed. Instruments such as the Self-medication Assessment Tool (SMAT),ManageMed Screening(MMS), Self-medication Risk Assessment Tool (RAT),HOME-Rx revised, Medication Management Ability Assessment (MMAA), Medication Management Instrument for Deficiencies in the Elderly (MedMaIDE), and MedTake test stand out for their degree of assessment, each assessing between 11 to 16 of the 29 components.[43,109,114,128,135,140,144] However, it is important to highlight that the tools predominantly assess physical and cognitive domains. Previous studies by Farris and

Phillips, Elliot and Marriott, and Badawoud et al. have also confirmed the effectiveness of tools like DRUGS, MedMaIDE, MedTake test, MMAA, and HMS in determining physical and cognitive abilities for independent medication management.[46-48] This focus on physical and cognitive barriers underscore a significant gap in the assessment of other critical domains, especially sensory and socio-economic factors. Sensory components, such as visual and auditory factors, are essential for accurately identifying and managing medications, yet they are often not considered in current assessment tools. Socio-economic factors, including affordability and the suitability of the home environment for medication management, also play a significant role in an individual's ability to adhere to medication regimens but are similarly under addressed. The limited emphasis given to sensory, motivational and environmental barriers highlights the necessity for further research.

2.5.2 Psychometric properties of assessment tools

It is important to establish psychometric properties of tools as they highlight each tool's validity and reliability in clinical and research settings. If a tool lacks sufficient validity , the outcomes derived from the use of the tool cannot be confidently relied upon. Our review highlights a mixed picture regarding the psychometric properties of these tools. Instruments, such as the Self-medication Assessment Tool (SMAT) and Medication Management Ability Assessment (MMAA),demonstrate good psychometric properties through the assessment of their content and construct validity and with high scores in various reliability measures such as inter-rater reliability, test-retest reliability, and internal consistency.[114,128,135] However, other tools like the Cognitive Screen for Medication Self-Management(CSMS) showed potential issues with reliability, indicated by its low internal consistency scores.[110] Similarly, MedTake test only has only validity measures with a lack of various reliability measurements.[132] This variability indicates that while many tools have undergone some level of psychometric evaluation, there remains a gap in the comprehensive validation of these instruments. Future research should focus on addressing these gaps, particularly by expanding validation studies to include larger and more diverse populations, examining test-retest reliability, inter-rater reliability, and internal consistency more consistently, and exploring the practical implications of these tools in everyday clinical use.

2.5.3 Clinical utility and implementation challenges

While identifying tools that are comprehensive is important, implementing such tools in clinical settings presents its own set of challenges. Most of the promising tools we identified are performance-based assessments, which healthcare professionals are responsible for administering. However, implementing these assessments in busy clinical environments can be challenging. Given that the administration times for these tools vary widely from 5 minutes to 60 minutes, integrating them effectively into busy clinical workflows can be a hindrance to implementation. This is especially true when considering the average physician visit lasts approximately 15.7 minutes.[179] Consequently, use of comprehensive tools may be impractical within a clinical setting. However, clinicians can make use of these findings to selectively determine which tools are most suitable for the specific needs of the patients under their care.

2.5.4 Limitations and real-world applicability of assessments

While the measurement of MMC provides valuable insights into an individual's ability to handle medications effectively, it's essential to recognize its limitations.[43,45-48,110,114,128,135] This assessment doesn't offer a comprehensive prediction of real-world medication-taking behavior.[178-180] Medication non-adherence can be intentional or unintentional.[15,23,50,94] Intentional medication non-adherence, where individuals may consciously choose to deviate from prescribed regimens due to personal beliefs, concerns, or experiences with side effects, is not examined by these measurements.[180] However, incorporating MMC assessments into routine clinical practice allows clinicians to identify those who are unintentionally non-adherent and may benefit from person specific assistance in managing their medications.[44-48] Such tailored interventions include patient education, simplified medication regimens, cognitive-behavioural therapy, and technology-based solutions to help manage medications.[50] Addressing barriers to MMC in older

adults has the potential for long-term health benefits by improving overall well-being, reducing hospitalizations and complications associated with chronic conditions, while concurrently addressing the burden associated with managing medications.[9,11,47,48,90,91,96]

2.5.5 Strengths and limitations

One of the main strengths of this scoping review is the involvement of patient partners in the full text review and data extraction stages. Their valuable input not only provided insights into the needs and concerns of older adults regarding medication self-management, but also contributed to the identification of tools that were considered crucial for measuring diverse medication management components, drawing upon their personal lived experience with managing medications. Furthermore, by comprehensively identifying and comparing various tools that measure barriers to MMC, this scoping review contributes to the advancement of knowledge in the field of medication management in older adults. It serves as a reference point healthcare professionals can use for selecting tools to assess their patient's MMC. Researchers can use this information to select appropriate tools for their studies and to develop new tools that address specific barriers to MMC.

A limitation of this study is that it was limited to English language studies published between 2002 and 2022. There may be important studies that were excluded from this study due to language and time restrictions. Future research should consider including studies published in other languages to increase the comprehensiveness of the review. Additionally, although we searched six different databases using well-constructed search strategies, it is still possible that relevant studies were missed.

2.6 Conclusion

This scoping review identified several validated tools to measure various challenges that older adults encounter with medication management. However, no one tool measures all five barriers (physical, cognitive, sensory, motivational, and environmental) to medication-taking at home. Therefore, a combination of tools is recommended to comprehensively measure these different aspects. The study's findings can aid healthcare professionals and researchers in selecting appropriate tools for assessing medication management capacity in older adults and enhancing the quality of care for this population. Nonetheless, despite the valuable insights from this review, the development of a comprehensive tool that addresses all these barriers is still necessary. Further research and development in this area is needed to provide healthcare professionals with a more efficient and holistic approach to assess medication management capacity.

3 Chapter 3: Medication Adherence Technologies: A Classification Taxonomy Based on Features

3.1 Abstract

Background: The high prevalence of comorbid conditions among older adults frequently leads to complex medication regimens, increased risk of functional impairments, and non-adherence to medications. MATech have emerged as a solution to these issues. However, the usability of these technologies, which is significantly impacted by their features as well as the capabilities of the older adult users, remains largely unknown. Classifying medication adherence products based on their unique features and characteristics is essential for effectively assessing their usability, enabling the tailored selection of devices that meet the specific needs of older adults.

Objective: The aim of this study is to develop a comprehensive classification system for MATech based on an inventory of characteristics and features of existing technology.

Methods: Using a three-stage approach methodology—development, validation, and evaluation—the study adopted the Taxonomy Development Method by Nickerson *et al*. In the development stage, MATech were defined, end users were identified, and a meta- characteristic was determined, using both empirical-to-conceptual and conceptual-to-empirical approaches dimensions and characteristics were identified. The taxonomy was validated through the Delphi consensus approach and evaluated by classifying 20 sample medication adherence products.

Results: After undergoing six iterations, which included incorporating feedback from a Delphi consensus survey, the final taxonomy is comprised of 7 dimensions, 24 subdimensions, and 314 characteristics. These key dimensions encompass Physical Features, Display, Connectivity, System Alert, Data Collection and Management, Operations, and Integration. The taxonomy is considered complete and valuable once all pre-established ending conditions are met, and its applicability and

comprehensiveness were verified by comparing various MATech

Conclusion: This study successfully establishes the first comprehensive classification system for medication adherence technologies based on attributes, addressing a critical gap in the literature. By providing a structured framework for categorizing and evaluating diverse technologies, it assists in usability testing and the selection of appropriate devices tailored to the unique needs of older adults. This taxonomy not only aids in improving medication management and adherence but also serves as a framework for the comparison of evolving technologies.

3.2 Background

Globally, according to the World Population Prospects 2022 by United Nations, the proportion of the population that is over 65 years of age is expected to increase from 10% in 2022 to 16% in 2050.[181,182] These changes in demographics call for a global reorientation towards addressing the healthcare and medical requirements of the aging population.[183] Aging is associated with a decline in several body functions, such as the ability to swallow, motor skills, vision, hand-eye coordination, hearing, cognition, health literacy, and self-care ability.[184,185] Moreover, the prevalence of chronic conditions increase with age.[186] As reported by the 2017–2018 Canadian Community Health Survey (CCHS), more than one out of three seniors experience multimorbidity (coexistence of two or more chronic conditions) , with the prevalence increasing with age.[187] Over one-third of men and women aged 65 and older have at least two chronic conditions, and nearly half (48%) of those aged 85 and older have two or more chronic conditions.[187]

Among older adults, the high prevalence of multimorbidity and age-related changes contributes to functional limitations, associated disabilities, complex medication regimens, and a high risk of polypharmacy.[11,3,188] The likelihood of older adults with over three chronic conditions having limitations in basic activities of daily living (ADLs) and instrumental activities of daily living (IADLs) is 2.2 to 2.9 times higher than that of those with no chronic illnesses.[12] Polypharmacy, often defined as the simultaneous use of five or more medications, is common among patients with multimorbidity.[189,190] A number of adverse health outcomes are associated with it, including a higher mortality rate, falls, drug interactions, non-adherence, hospitalization, and higher healthcare costs.[190,191] Furthermore, multimorbidity and related functional disabilities, complex medication regimens, polypharmacy, and age-related changes can negatively affect older adults' ability to manage their medications.[15,178192,193] The challenges presented by these factors also increase the risk of medication errors, adverse drug reactions, hospitalization, and medication non-adherence.[16,17] Medication non-adherence, when a patient fails to take a prescribed medication or follow the healthcare provider's instructions for its administration, can often result from challenges in managing medications due to a lack of ability.[194] Medication non-adherence not only prevents the achievement of treatment goals, quality of life, and productivity, but also elevates healthcare costs due to avoidable hospitalizations, with the added risk of mortality.[50,51,195-197]

Several strategies have been designed to address medication taking and non-adherence in older adults.[51,52] Among the various solutions, assistive electronic medication adherence technologies are emerging as one of the key interventions to address medication-taking issues and enhance adherence in older adults, offering potential improvements in treatment outcomes.[56,59] With innovations in the integration of data processing, electronics, and wireless communication, the number of medication adherence technologies available on the market has grown phenomenally in the past few years.[56,59,198] A systematic review published in 2016 identified 80 electronic adherence devices available in Canada, while another review published in 2023 identified 114 'smart' products (defined as those with both connectivity and automaticity) designed to improve medication adherence.[57,58] These devices assist with medication self-management by organizing and dispensing medications as well as by providing reminders for taking medications.[64]

Various cognitive, sensory, and motor impairments associated with aging can significantly affect how older people interact with medication organizing and dispensing devices.[67-69] User testing with older individuals is a vital step to ensure these devices are designed to meet the diverse needs of older individuals and to identify potential challenges resulting from aging-related limitations.[69,85] Usability testing is the process of understanding how a product can be used to achieve a desired goal, while taking the user's needs and capacity into consideration.[56] Since various medication adherence technologies available on the market differ significantly in their design and features, their usability can vary from individual to individual.[37] An inefficient or ineffective medication adherence product that is not user-friendly, complicated to use, socially unacceptable, inefficient, or has limited learnability may negatively affect adherence rather than improve it.[79] For example, a person who is visually impaired may not be able to comprehend information from a pill bottle that produces a visual alert to take medication, but a device that produces an audio alert may be more effective. From the perspective of behavioral science, the selection of a medication adherence product has to take into account both the product features as well as the characteristics of the user, such as the user's capabilities as well as their limitations.[67,49]

Classification, a key cognitive process, involves organizing objects based on their characteristics.[199] Taxonomy, a type of classification, is crucial in both research and practical applications.[200,201] It structures concepts and their interrelations, aiding in understanding diverse research outcomes.[199,202] In various fields, including biology, management science, and health information systems, taxonomy plays a crucial role in categorizing objects based on similarities and differences.[199-202] This method of classification helps in describing, comprehending, and analyzing relevant objects.[200-204] In case of medication adherence technologies, although numerous products with diverse and unique design, function, and features are being developed and marketed, there is no widely accepted definition of medication adherence technology; electronic reminder systems, electronic monitoring systems, digital health, wearable sensors, and ingestible sensors have all been included in technological interventions for adherence.[200-207] Moreover, medication organization and dispensing products are often identified as automated dispensers, pill boxes, smart vials or vial caps, blister packaging, or storage boxes, but no system of classification by which these devices may be differentiated for use by older adults has been developed.[59,208] Applying the principles of classification and taxonomy to MATech means systematically organizing these devices based on a range of features and characteristics. This structured approach is particularly beneficial when considering the specific needs of different user groups, such as older adults. For instance, older adults might benefit more from devices with simple interfaces, large buttons, or clear auditory reminders, considering potential challenges such as reduced vision, hearing, or manual dexterity.[35,100] Moreover, this classification system could aid in focused usability testing, allowing for a more in-depth understanding of how these devices function in practical settings. The combination of systematic classification and practical testing ensures the selection of technologies which are not only theoretically suitable but also user-friendly and effective in everyday use. Therefore, the objective of this project is to develop a classification system for MATech based on an inventory of characteristics and features of existing technology.

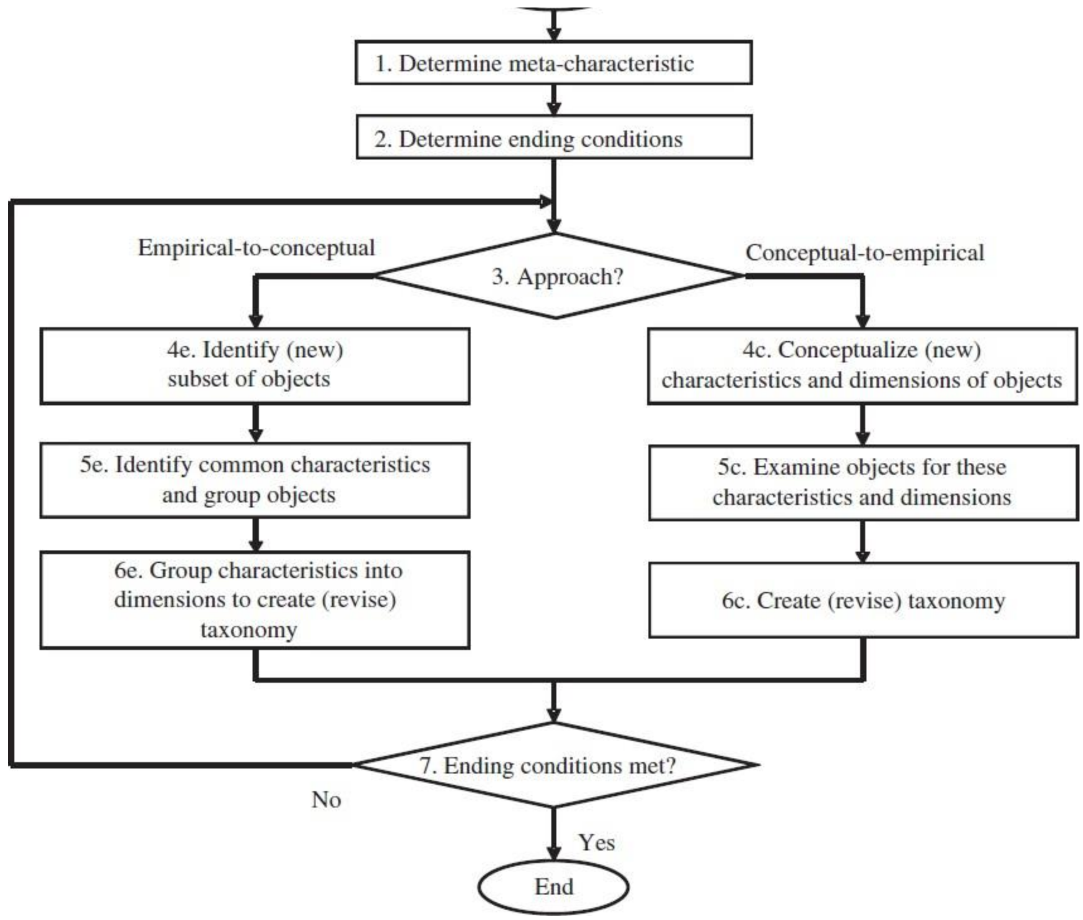
3.3 Methods

To develop a classification system for MATech we used a three-stage approach: taxonomy development, taxonomy validation, and taxonomy evaluation.[209]

3.3.1 Stage 1: Taxonomy development

A taxonomy is a classification system that groups similar objects within a domain based on distinctive characteristics and provides a set of decision rules.[199,201,202] The Taxonomy Development Method by Nickerson *et al*. was employed in this study,[200,201] as it is formal, systematic, and straightforward, and has been used successfully for building taxonomies in health information technologies and patient portals.[209-211] Various steps involved in this method are given in Figure 3-1. Nickerson et al. has defined Taxonomy as "a set of n dimensions each consisting of mutually exclusive and collectively exhaustive characteristics such that each object under consideration has only one set of characteristics for each dimension ."[201]

Figure 3-1: The taxonomy development method



(Note: Nickerson R, Varshney U, Muntermann J. A method for taxonomy development and its application in information systems, European Journal of Information Systems. 2013;22:3, 336-359, © copyright # [2013],reprinted by permission of Informa UK Limited, trading as Taylor & Taylor & Francis Group, http://www.tandfonline.com)

Following the methodology, a core research team (consisting of four graduate students, four undergraduate students, and one researcher) and a wider research team (consisting of two older adult knowledge users, four researchers, one physician, and one system design engineer) conducted a series of steps. Initially, the core research team defined "Medication Adherence Technologies."

Subsequently, core research team determined the users of the taxonomy and identified the meta-characteristic. The core team then established the ending conditions to guide our process.

Following this, we initiated the development of the taxonomy, using both an empirical-to-conceptual and a conceptual-to-empirical approach. An iterative process was employed within each stage, ensuring thorough examination and refinement. This iterative approach was maintained until it was determined that no further revisions were necessary. The number of iterations varied across different stages and is detailed in the results section. After evaluating the need for taxonomy revisions, we confirmed the fulfillment of all ending conditions.

Listed below is a detailed description of these steps:

Step 1: Define "Medication Adherence Technologies"

As there is no well accepted definition for MATech the core research team defined MATech before initiating the steps involved in the taxonomy development method. We defined Medication Adherence Technology as "any device, software or equipment that can support patients in organizing and taking their oral medications as agreed upon by their provider.

Step 2: Determine who are the users of the taxonomy

Nickerson *et al.*'s method requires a precise definition of the end users of the taxonomy. Hence, we determined the intended users of our taxonomy as the patient, caregiver, and healthcare provider, defined as follows:

- ***Patient*** – The person living with an acute, chronic, or advanced illness[212] requiring medication
- ***Caregiver*** – A person who gives care to people who need help taking care of themselves[213]

- ***Healthcare provider*** – A health professional that a person sees or talks to when they need care or advice about their health. This can include a family doctor or general practitioner, pharmacist, medical specialist, nurse practitioner[214]

Step 3: Determine the meta-characteristic

Meta-characteristic is the most comprehensive characteristic that will serve as the basis for the choice of characteristics in the taxonomy.[201] It is derived from the purpose and target users of the taxonomy and all dimensions and characteristics must be a logical consequence of the meta-characteristic.[201,215] The core research team determined our meta characteristics as the definition of medication adherence technologies; "any device, software or equipment that can support patients in organizing and taking their oral medications as agreed upon by their provider."

Step 4: Determine ending conditions

Considering that the method of developing the taxonomy is iterative, it requires both subjective and objective conditions to determine the end of the process. One of the most important objective conditions for a taxonomy is that it must be based on dimensions with mutually exclusive and collectively exhaustive characteristics.[201] Table 3-1 provides a list of other objective ending conditions for our study. The subjective conditions are a set of minimum requirements that must be met in order to terminate the development process.[201] The ending conditions were established based on the objective and subjective criteria outlined in the taxonomy development method by Nickerson et al. In Table 3-2, we have listed the subjective ending conditions for the end of this study.

Table 3-1: Objective ending conditions[201]

Conditions
All objects or a representative sample of objects have been examined
All medication adherence technologies fall into one characteristic within a dimension
No new dimensions or characteristics were added in the last iteration

No dimensions or characteristics were merged or split in the last iteration
Every dimension is unique and not repeated (i.e., there is no dimension duplication)
Every characteristic is unique within its dimension (i.e., there is no characteristic duplication within a dimension)
Each cell (combination of characteristics) is unique and is not repeated (i.e., there is no cell duplication)

Table 3-2: Subjective ending conditions[201]

Condition	Description
Concise	Ensure that the number of dimensions is sufficient for the taxonomy to be meaningful without becoming too large or over complex.
Robust	Ensure that the dimensions and characteristics of the objects are sufficient to differentiate them from each other. Derive meaningful insights about sample objects by analyzing their characteristics.
Comprehensive	Verify that all objects within the domain of interest or a sample of objects within the domain areclassified. Confirm the identification of all dimensions of the objects of interest.
Extendible	Ensure that the addition of a new dimension or a new characteristic to an existing dimension is an easy process.
Explanatory	Ensure that dimensions and characteristics give adequate explanation about an object.

Step 5: Creation of Taxonomy

We employed a combination of two approaches in creating the classification system: the empirical- to-conceptual and conceptual-to-empirical approaches. The empirical-to-conceptual approach is suitable when the researcher has limited domain understanding but ample data about the objects.[201] In our case, we applied this approach to identify common characteristics of 20 MATech in our lab, which are listed in Table 3-3.[215] This approach began with identifying a subset of well-documented technologies and selecting their common characteristics, which are inherently linked to a defined meta-characteristic, ensuring that these characteristics distinctly differentiate the technologies.

Conversely, the conceptual-to-empirical approach is preferred when little data are available, but the researcher possesses significant domain understanding.[201] We conducted a scoping review to understand the additional characteristics and features of devices available on the market.[58] This review identified 114 Smart Medication Adherence Products (SMAPs), noting a wide range in their hardware, software, data management features, and cost. This review helped us in clarifying the dimensions of our taxonomy based on our theoretical understanding of what features are crucial, followed by empirical validation of these conceptual dimensions against real-world data.

Subsequently, we classified characteristics identified from both approaches into dimensions and subdimensions to create the taxonomy. This dual approach facilitated the creation of a comprehensive taxonomy, integrating both practical and conceptual aspects of MATech .[201]

Table 3-3: Sample Medication Adherence Devices Classified

Medication Adherence Devices
1. GMS Med-e-lert Automatic Pill Dispenser
2. LiveFine Automatic Pill Dispenser and Reminder
3. MedReady 1700 Automated Medication Dispenser
4. MedSmart Med-Reminder and Dispensing System
5. e-pill MedTime Station Automatic Pill Dispenser with Tipper
6. e-pill Accutab Weekly Pill Dispenser
7. VitaCarry Advanced Pill Case
8. Nishiki Round Pill Box with Alarm
9. MedGlider System 1 with Talking Reminder
10. Patterson Medical TabTime Super 8
11. 100-Hour Pill Reminder
12. Med-Q Smart Pillbox
13. e-pill MedGlider Home Medication Management System
14. MedCentre System
15. Pillbox with Digital Timer Instructions
16. TimerCap Travel Size
17. eNNOVEA Weekly Planner with Advanced Auto Reminder
18. Jones medication adherence system
19. Spencer Medication Dispenser
20. EllieGrid Smart Pill Box

3.3.2 Stage 2: Taxonomy Validation

To validate the developed taxonomy of MATech , we implemented the Delphi consensus method, involving a panel of five field experts including system design engineers, physicians, pharmacists, and patient partners (wider research team).[216] This approach is renowned for its effectiveness in achieving consensus through structured communication.[216,217] Participants in our Delphi panel were invited to assess the identified characteristics, dimensions, and subdimensions through a survey using a 4-point Likert scale: strongly disagree, disagree, agree, and strongly agree.

Survey items that achieved more than 70% agreement (agree and strongly agree) were retained within the taxonomy. Those receiving more than 70% disagreement (strongly disagree and disagree) were either modified or removed, following a thorough review and consensus among the expert panel. For items that did not meet these agreement or disagreement thresholds, a second round of surveys was conducted. This iterative process allowed for further refinement and reevaluation of the taxonomy based on expert feedback.

In addition to rating the items, participants were given the opportunity to provide suggestions and feedback on how to improve the taxonomy, ensuring that all relevant perspectives were considered. The survey data were collected and analyzed using the Qualtrics XM Platform,Qualtrics 2023, ensuring robust data management and analysis.

After conducting necessary revisions and considering all feedback from the panel, we reviewed whether the taxonomy met the predefined ending conditions as listed in Tables 3-1 and 3-2. Upon confirmation that all ending conditions were satisfied, the taxonomy development process was concluded.

3.3.3 Stage 3: Taxonomy evaluation

The first two stages of the study yielded a preliminary taxonomy which described the dimensions and characteristics of medication adherence devices. In the third stage, we focused on validating the appropriateness of each dimension and characteristic that had been identified in the previous step. As part of this verification process, the 20 samples of MATech in our lab were categorized based on the predefined dimensions and characteristics. Members of the core research team met multiple times to thoroughly examine and discuss the attributes and features of each device. These sessions allowed the team to apply the taxonomy directly, ensuring that each device fit into a specific dimension within our framework. During these meetings, team members discussed the features of each device, collaboratively determining their adherence to the taxonomy's dimensions and characteristics after reaching a consensus.

3.4 Results

3.4.1 Stage 1: Taxonomy Development

First Iteration: The initial taxonomy, created after examining 20 products in our lab (Table 3-3), comprised 10 dimensions and multiple characteristics (Table 3-4). This was based solely on the empirical-to-conceptual approach. However, ending conditions were not met, prompting a second iteration.

Second Iteration: Recognizing the unmet ending conditions, the team revised the classification, renaming the dimension "Retrieval/Medication Access" to "Operation Method" and introducing a new dimension, "Data Collection Method" with characteristics of "Manual" and "Automatic" (Table 3-4). These changes did not meet the ending conditions. Subsequently, a conceptual-to-empirical approach was adopted, and a scoping review was conducted, whose results have been published separately.[58]

Third Iteration: Building upon findings from the conceptual-to-empirical approach, we added a new subdimension, "Portability," under the dimension "Physical Features." We also refined characteristics such as the spacing between buttons, classified displays as "Product Display," "Setting Display," and "Electronic Display," and introduced a new dimension, "Ease of Use," which merged the dimensions "Instruction," "Operation Method," and "Customization." Another new dimension, "Data Collection and Management," combining the dimensions of "Data Collection" and "Tracking," was created (Table 3-4).

3.4.2 Stage 2: Taxonomy Validation

Fourth Iteration: During the validation process, we used the Delphi consensus method and sent out a Qualtrics survey to wider research team comprising of experts in the field. The first Delphi survey showed less than 70% agreement with some subdimensions such as power source (within Dimension 1: Physical features), instructions (within Dimension 4: Operation), and connected (within Dimension 5: Connectivity) (Table 3-4).

Table 3-4: First Delphi survey – percentage agreement

Dimension	Percentage Agreement
Dimension 1: Physical Features	
Shape	80%
Portability	100%
Size	100%
Button	80%
Power source	60%
Compartment	100%
Locking feature	80%
Dimension 2: Display	
Nonelectronic	80%
Electronic	83.34%
Dimension 3: System Notification	
Internal alert	80%
External alert	80%
Dimension 4: Operations	
Number of steps	100%
Instructions	60%
Dispensing	80%
Access	80%
Dimension 5: Connectivity	
Standalone	100%
Connected	60%
Dimension 6: Data Collection and Management	
Method	75%
Monitoring	100%
Reporting	100%
Data accessibility	100%
Dimension 7: Integration	
Device	75%
Support	60%

Based on feedback, the following modifications were made:

- Removing weight (from Dimension 1: Physical features)
- Reclassifying display- non-electronic display to product display and settings display
- Introducing a new dimension "Operations"
- Adding a subdimension "Reporting of Medication Intake"

Fifth Iteration: The second survey (n=4) resulted in more than 70% agreement with all changes (Table 3-5). However, minor suggestions were received, leading to further changes of dimension “Display” to "Transmissive," "Emissive," and "Reflective" display types were added, and "Screen Size" was added.

Table 3-5: Second Delphi survey – modifications and percentage agreement

Changes	Agree
Added new subdimensions	
• Holdable - “Physical Features “	75%
• Added more characteristics	
• Electronic - "Display"	100%
• Method - "Data Collection & Management”	100%
• Data Accessibility - "Data Collection & Management”	100%
Modified subdimension	
• Internal Alert - "System Notification"	100%
• External Alert - "System Notification"	75%
• Instructions - "Operations"	100%
• Connected - "Connectivity"	100%
• Power Source - "Physical Features"	75%
• Support - "Integration"	75%

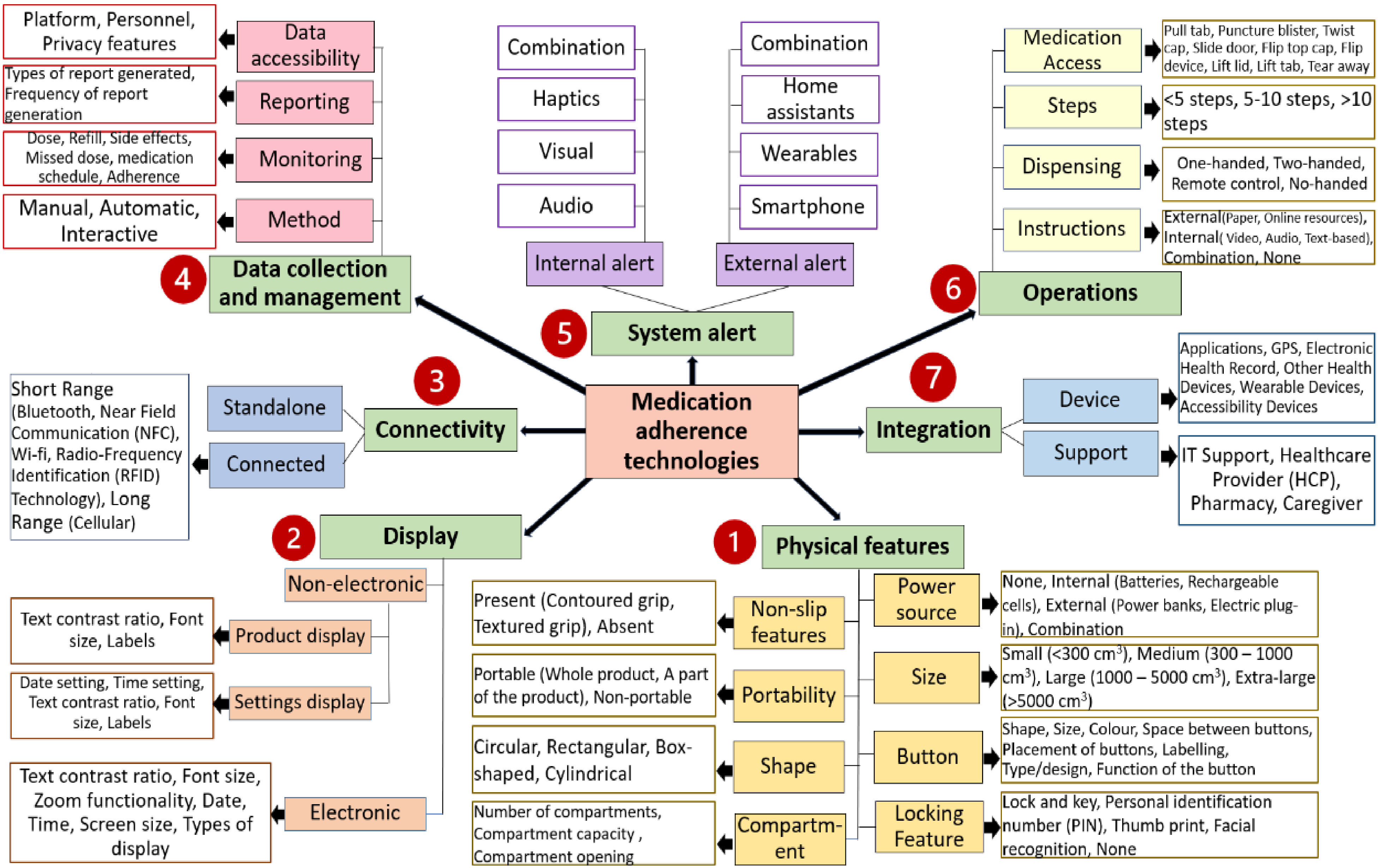
3.4.3 Stage 3: Evaluation of taxonomy

Sixth Iteration: To evaluate the taxonomy, the 20 sample products were classified based on the developed taxonomy (Appendix B-2). No new characteristics were found, and there were no alterations in dimensions required. By classifying real medication adherence devices, iteration six evaluated each characteristic's appropriateness. Through this process, we were able to prove that real medication adherence devices met all specified characteristics. It was also demonstrated that all devices examined fit into a single characteristic within a subdimension, and no device fell into multiple characteristics. To ensure the completeness of our taxonomy, we thoroughly examined all ending conditions. Based on the examination of all medication adherence devices in our sample, the taxonomy can be regarded as collectively exhaustive and mutually exclusive. In the final version, no dimension or characteristic was separated, combined, or introduced. Therefore, we can infer that our taxonomy satisfies all predetermined objective ending criteria. The subjective ending conditions were also examined in order to ascertain the usefulness of our taxonomy.

The taxonomy contains seven dimensions, offering a limited yet sufficient number of dimensions and characteristics to distinguish medication adherence devices. Following a scoping review of different medication adherence devices in the market and analyzing 20 devices in our lab, all dimensions and characteristics were successfully identified. Therefore, our taxonomy appears comprehensive. Lastly, the dimensions and characteristics identified provide a comprehensive understanding of medication adherence devices, making the taxonomy explanatory. This results in the taxonomy meeting all predetermined objective and subjective ending conditions, and it can be considered final and helpful. Appendix B-1 provides a detailed description of all dimensions and characteristics.

The final taxonomy for Medication Adherence Devices includes seven key dimensions: “Physical Features, Display, Connectivity, System Alert, Data Collection and Management, Operations, and Integration,” each with its own subdimensions and characteristics (Figure 3-2). Under Physical Features, we consider aspects such as non-slip elements, portability, shape, and locking mechanisms. The Display dimension distinguishes between electronic and non-electronic types, while Connectivity differentiates standalone from connected devices. Data Collection and Management explores methods of monitoring, reporting, and accessibility. System Alert categorizes various alert types, and Operations examines instructions, dispensing, and medication access methods. Lastly, the Integration dimension takes into account the way in which these devices integrate with external systems or support networks, including pharmacists and caregivers.

Figure 3-2: Overview of the final classification system for medication adherence technologies



3.5 Discussion

In this study, we successfully developed, to our knowledge, the first classification system for MATech, providing a structured framework based on the characteristics and features of existing technologies. The classification system introduced in this study fills a critical gap in the literature by providing a structured way to understand and categorize the multitude of medication adherence devices on the market.

This classification system was developed using a rigorous methodology, employing the Taxonomy Development Method by Nickerson *et al*.[201] This systematic and formal approach emphasized precision in defining the end users, meta-characteristics, and ending conditions. A similar method was adopted in developing taxonomies for complex emerging technologies, mobile applications, and patient portals.[200,209,218] This comprehensive methodology facilitated an iterative process that combined empirical-to-conceptual and conceptual-to-empirical approaches to ensure the inclusion of relevant features and characteristics. Nickerson *et al*. also employed this dual approach in creating a taxonomy for mobile applications, combining existing data with theoretical frameworks.[200] Furthermore, the validation stage of our taxonomy involved the participation of a panel of experts using the Delphi consensus method.[216] This approach adds a layer of validity to the taxonomy, ensuring alignment with expert opinions in the field. The Delphi approach is widely recognized and has been effectively used in various domains, including program planning, healthcare interventions, policy planning, and MATech.[216,217]

In contrast to taxonomies designed for different purposes, our taxonomy, tailored for MATech, offers a distinctive approach.[200,209,218,219] It comprises 7 dimensions, 24 subdimensions, and 314 characteristics, in contrast from other taxonomies. For instance, the taxonomy for patient portals includes 20 dimensions and 49 characteristics, while a mobile application taxonomy features seven dimensions and fifteen characteristics.[200,209] The extensive inclusion of subdimensions and characteristics in our taxonomy is justified by the complex and diverse aspects of MATech, which require a more comprehensive framework to capture their varying functionalities and user-specific needs. Diverging from the taxonomy for smart healthcare technologies by Chaudhary *et al*., which categorizes technologies based on application areas, our taxonomy specifically categorizes MATech based on their characteristics and features.[219] It emphasizes user needs and detailed features crucial for user interaction and technology adaptability, providing a comprehensive and user-centric framework tailored to this specific domain.

MATech are typically categorized based on their type, such as electronic pill bottles, smart pill dispensers, mobile apps, or wearable devices.[59,208] While this classification provides a broad overview of the technology's form, it does not delve into its usability aspects, and previous research has found that these technologies frequently fail to consider the diverse needs and constraints of specific user groups, like older adults who may have cognitive, sensory, or motor impairments.[59] Our study addressed these issues by introducing a taxonomy that comprises multiple dimensions and covers a wide range of characteristics and features of MATechThis multidimensional approach results in a classification system that is more comprehensive than exiting classifications.

This classification system for medication adherence technology can be a valuable tool in various contexts, especially when considering the specific needs and limitations of older adults. Healthcare providers, caregivers, and patients can use this classification system to compare different MATech. For example, they can assess which devices have features like large buttons and clear auditory reminders for individuals with reduced vision or hearing. They can also compare devices based on the availability of Wi-Fi connectivity, which might be crucial for remote monitoring, adherence tracking, and data synchronization. Additionally, the classification system allows users and healthcare providers to identify devices that align with the specific needs of a unique user. For instance, if an older adult has limitations in manual dexterity, they can search for devices categorized under the "Physical Features" dimension that offer easy-to-hold options. Alternatively, if a person is managing multiple medications, they can look for devices that have a greater number of compartments with larger compartment capacity, which is covered under the "Compartment" subdimension. This personalized approach to technology selection aligns with the principles of patient-centered care, where the individual's needs and preferences play a key role in the decision-making process.

Usability testing guided by the taxonomy can also provide a systematic approach for researchers and developers to evaluate MATech among older adults. Test scenarios can be created that align with the taxonomy's dimensions, allowing them to assess crucial aspects such as user interface navigation, clarity of reminders, adaptability to different dosing regimens, and the impact of connectivity features like Wi-Fi. By doing so, they can uncover potential usability challenges and areas for improvement specific to older users, ensuring that the technology is tailored to their unique needs ultimately leading to more effective and user-friendly solutions for medication management in this demographic. Furthermore, as new MATech continue to emerge, this classification system can serve as a framework for evaluating and categorizing these innovations. It enables researchers to analyze how these new technologies fit within the existing technological environment and whether they address the unique challenges faced by older adults. Healthcare providers can engage in patient-centered discussions about medication management by using the classification system. They can involve older adults and their caregivers in the decision-making process, taking into account their preferences, capabilities, and limitations, and selecting the most suitable technology accordingly. With the rapid expansion ofMATech , a standardized taxonomy based on characteristics and features becomes increasingly relevant for both addressing the current gap as well as setting the stage for future advancements in the field.

Even though our study contributes to a better understanding and categorization ofMATech , it is not without limitations. The inclusion of a larger group of subject matter experts at various stages may have improved the quality of the study by providing even more complete and in-depth information. Moreover, as technology continues to evolve and new devices are introduced, the classification system may require periodic updating. Moreover, the study focused on MATech for older adults, and further study should be conducted to determine whether the classification system can be applied to other populations or age groups.

3.6 Conclusion

This study provides the first comprehensive classification system for MATech for older adults, filling a significant gap in the literature. It provides a structured framework for categorizing and evaluating diverse technologies based on the unique challenges faced by the aging population. By combining the Taxonomy Development Method with Delphi consensus method, the classification ensures precision and validity. With its multidimensional structure that encompasses physical features, display characteristics, system alerts, operations, connectivity, data management, and integration with devices and other supports, it provides a valuable tool for assessing usability tailored to the unique needs of older adults. Apart from its immediate applications, this taxonomy can also serve as a benchmark for objective comparisons of evolving technologies and support informed decision-making among healthcare stakeholders.

4 Chapter 4: Study Rationale & Objectives

User Experience and Usability Testing of Medication Adherence Technologies Among Older Adults with Diverse Barriers to Medication-Taking

4.1 Rationale for the study

The aging population is increasingly burdened with chronic conditions that necessitate polypharmacy with resulting complex medication regimens, presenting significant challenges for older adults in managing their medications effectively.[3-10] The complexity of such regimens, combined with a variety of barriers to effective medication management—including physical limitations like reduced manual dexterity, cognitive issues such as memory decline, sensory impairments, motivational challenges, and non-supportive environmental factors—often increases the risk of medication non-adherence.[11-16] This non-adherence and declining ability to self-manage medications can lead to negative outcomes such as increased hospitalizations, the necessity for assisted living arrangements, escalated healthcare costs, and a marked decrease in the autonomy and quality of life of older adults.[15,17-27] Such challenges not only compromise the ability of older adults to maintain their independence but also prevent aging in place.[28,34] The complex interplay of chronic conditions, medication management challenges, and their resultant outcomes highlight the critical need for targeted interventions that can empower older adults to self-manage their medications and maintain their independence.[32-34]

MATech have emerged as one of the solutions to the challenges of medication management, particularly for older adults with chronic conditions and with complex medications.[56] These technologies range from simple electronic devices to advanced 'smart' systems that incorporate connectivity and automatic features to enhance medication adherence.[56-59] A systematic review conducted in 2016 highlighted the availability of 80 electronic adherence devices in Canada with another review published in 2023 identifying 114 'smart' products designed with features such as medication reminders as well as real-time monitoring of medication dispensing.[57,58]

The effectiveness of MATech in improving medication management and adherence has been the subject of various studies.[64-66] A qualitative analysis focusing on older adults with dementia found that user-centered and evidence-based technological solutions significantly alleviate the challenges of medication management, enabling better management of medications.[65] Furthermore, a single-blind randomized controlled trial examining the impact of a medication self-management app, named ALICE, on elderly patients with multimorbid conditions, demonstrated promising outcomes.[66] The application not only increased medication adherence but also reduced forgetfulness and medication errors, ultimately enhancing the users' perceived independence in managing their medications.[66] These findings underscore the potential of MATech to significantly improve medication self-management, offering solutions that extend beyond simple reminders to comprehensive support systems.[64-66]

Usability and user experience (UX) are foundational concepts in the design and evaluation of technology products, including MATech.[72-77] Usability focuses on how easily and effectively a product can be used and aims at ensuring products are straightforward to use, thereby enhancing effectiveness, efficiency, and satisfaction in accomplishing specific tasks.[73,74] On the other hand, UX takes a broader view, including all aspects of the user's interaction with a product or service.[75- 77] It includes emotions, perceptions, beliefs, preferences, physical, and psychological responses, behaviors, and accomplishments before, during, and after use, thus addressing the overall experience and emotional engagement with the product.[75-77]

Usability and UX is particularly important in the context of using MATech for older adults.[67] The diversity in the design, function, and features of MATech available today directly influences their use by various individuals, especially older adults who may face a range of limitations, including physical, cognitive, sensory, motivational and environmental limitations.[67-71] These limitations necessitate a thoughtful approach to the development and selection of MATech, one that takes into account the evolving capabilities and needs of the aging population.[68-79] Principles of behavioral science offers a foundation for understanding how technologies can be designed and evaluated to meet the needs of older individuals effectively.[67,70,71] These principles emphasize making MATech simple, tailored to each user, and designed to offer both immediate help and long-term health benefits without harming users' mental or physical abilities over time.[70] A device that may be perfectly suitable for one individual could pose significant challenges for another due to differences in sensory capabilities, cognitive function, or physical dexterity.[67-71] For example, older adults with visual impairments might find devices with visual alerts for medication intake less useful than those that employ auditory alerts. Similarly, older adults with limited mobility or physical dexterity may struggle with devices that require fine motor skills for operation, such as small buttons or touchscreens that necessitate precise touch and devices that rely heavily on manual interaction could be less accessible to individuals with arthritis or hand tremors.

Considering the wide range of MATech designs and functionalities, as well as the diverse ways in which older adults with various limitations use these technologies, the need for devices that can be tailored to fit the unique abilities and preferences of each user becomes evident.[66-69,85,86] Usability testing of MATech among older adults with physical, cognitive, sensory, motivational, and environmental barriers to medication management is crucial and instrumental in identifying the difficulties and challenges this demographic faces while using various MATech, thereby enhancing the user experience for older adults.[85,86]

This study will assess the usability and user experience of three smart and ten electronic medication adherence devices among older adults with physical, cognitive, sensory, motivational, and/or environmental barriers to medication management. It will also explore the feedback and experiences of older adults with diverse barriers to medication management regarding the usability and features of MATech. By conducting usability and UX testing and exploring the feedback and experiences of older adults with diverse medication management barriers, the study aims to identify the most suitable MATech for older adults with various physical, cognitive, sensory, motivational, and environmental limitations, tailored to their unique needs and abilities. By doing so, it ensures that products are not only functional but also satisfying and supportive of older adults' independence and well-being, thereby contributing to the broader goal of designing, developing, and selecting MATech that matches to the unique needs of older adults. This approach has the potential to promote successful aging and enable older adults to maintain their independence and age in place through technology-assisted medication self- management.

4.2 Objectives

The primary objectives of this research are:

- To assess the usability and UX of three smart and ten electronic medication adherence devices in older adults with physical, cognitive, sensory, motivational, and environmental barriers to medication taking.
- To explore the feedback and experiences of older adults with diverse barriers to medication management regarding the usability and features ofMATech .

The secondary objectives of this research are:

- To assess how cognitive, physical, sensory, motivational, and environmental barriers influence the usability outcomes of various MATech
- To investigate if specific design features of medication adherence devices affect usability outcomes differently for older adults facing diverse barriers.
- To identify which design features best support the needs of older adults with different profiles of barriers.

5 Chapter 5: Research Methodology

5.1 Study design

A prospective mixed method research design was used for this study. Mixed method research is the type of research in which a researcher uses a combination of qualitative and quantitative research components to answer a research question.[220] An advantage of such an approach is that it enables a more complete and synergistic use of data than separate quantitative and qualitative data collection and analysis.[221] Incorporating a mixed method design in this study helped to generate a more comprehensive understanding of *what a user is experiencing or will experience when using a product.*

5.2 Study Setting

The research took place at several different locations, listed as follows:

- The University of Waterloo's School of Pharmacy, situated in Kitchener, Ontario.
- Various Schlegel Villages located throughout Ontario: Schlegel Villages is a network of retirement and long-term care communities in Ontario, designed to provide a home-like environment for older adults through a unique neighborhood design that fosters a caring community.
    - The Village of Taunton Mills in Whitby.
    - The Village of Tansley Woods in Burlington,
    - The Village of Riverside Glen in Guelph.

5.3 Study participants

5.3.1 Sampling Strategy

For this study various sampling methods were used as described below:[222]

- ***Convenience sampling* -** sampling of subjects for reasons of convenience (e.g., easy to recruit, close at hand, likely to respond)
- ***Purposive sampling* -** non-random method of sampling, which aims to identify a group of individuals or settings with a particular characteristic
- ***Snowballing* -** from an initial group of respondents, researchers recruit others in the target group (e.g., friends and family recruited by existing respondents, or health professionals and members of relevant patient groups may be asked for patients in the relevant category)

5.3.2 Eligibility criteria

Participants included in this study were:

- Aged $\geq$ 60 years
- Able and willing to provide consent

The research excluded participants if they were:

- Not able to speak or read English

5.4 Sample size

The sample size was determined in collaboration with a statistician and the total estimated minimum sample size required for the study was 100 participants. This calculation was guided by statistical principles and practical considerations.[223,224] The research involved examining six types of limitations as independent variables—physical, cognitive, vision, hearing, motivational, and environmental. According to Green's formula for regression analysis (N > 50 + 8m, where m is the number of independent variables), ideally, the sample size for six independent variables would be calculated as 50 + 8*6 = 98.[224] This guideline suggests a larger sample might be preferable for comprehensive analysis.[224,225] However, due to time constraints, the recruitment was stopped at 80 participants.

5.5 Screening and recruitment

Participants for the study were recruited from various locations from June 2023 to February 2024. Various sources from which participants are recruited are given below:

- Waterloo Research in Aging Participant pool at the University of Waterloo
- Waterloo Seniors Fair - November 2023
- Schlegel Villages
- University of Waterloo School of Optometry clinic patient list
- Snowballing

A diverse range of methods was used to inform potential participants about the study including telephone calls, emails, outreach presentations, as well as the distribution of informational materials such as flyers, and the use of digital platforms like websites and social media. Interested participants were screened to assess their eligibility based on predefined inclusion and exclusion criteria. Eligible participants were provided with detailed information about the study including the study's objectives, methodologies, potential benefits, and any associated risks. Furthermore, participants were encouraged to ask questions or express any concerns regarding their participation in the study. Participants were also provided with a patient information sheet to review, ensuring they had all the necessary information to make an informed decision about their participation. If an individual agreed to participate, formal informed consent was obtained during the study visit, confirming that the individual had a comprehensive understanding of the study. If any individual declined to participate, their decision was respected, and they were not enrolled in the study. In instances where a potential participant was unable to give informed consent due to being dependent on caregivers for daily activities, caregivers were approached to provide consent on behalf of the patient. Furthermore, several procedures were adopted to facilitate participants with communication or visual difficulties in obtaining consent. Considering the minimal/low-risk nature of the study, individuals with visual impairments were allowed to sign and consent without the presence of a separate witness or caregiver, provided they had the capacity to consent. However, they were given the option to have someone present to witness their consent if they chose. Study materials were also adjusted for accessibility purposes as needed, such as using larger font sizes. Appendix C-1 contains the Screening Questions, and the Patient Information Letter.

5.6 Data Collection

All participant data was collected during the study visit, consisting of data obtained from three main steps:

- Step 1: Measurement of barriers to medication management capacity
- Step 2: Usability testing
- Step 3: Qualitative interview

A detailed description of various steps, along with the questionnaires and tools used, is provided below.

5.6.1 Step 1: Measurement of Barriers to Medication Management Capacity

To measure diverse physical, cognitive, vision, hearing, motivational and environmental barriers to medication self-management, various tools identified from the scoping review conducted previously (Chapter 2) were used. Appendix C-2 contains various scales used to measure barriers to medication management capacity.

5.6.1.1 *Self-Medication Assessment Tool (SMAT) - Physical, Cognitive, and Vision Barriers*

The Self-Medication Assessment Tool (SMAT) is a detailed tool designed to identify deficits in medication self-management among older adults, aiming to enable targeted interventions.[226] It encompasses five distinct scales that evaluate necessary skills for proper and safe medication self-management[44,109,140,226]

- ***Functional Scale:*** Comprising 22 items, each scored on a 2 or 3-point scale, this scale assesses sensory, perceptual, and physical capabilities required for medication management.
- ***Cognitive Scale:*** Also containing 22 items but scored on a 3-point scale, it evaluates cognitive functions such as judgment, information manipulation, and instruction interpretation abilities.
- ***Recall Scale:*** This involves 4 items for each medication, with a 2-point score for each, assessing recall of medication names, purposes, dosing schedules, and the patient's own regimen, thus determining if the patient initially understood and remembered medication instructions.
- ***Purposeful Non-Adherence Scale:*** With 3 items scored on a 4-point scale, it examines experiences with side effects, beliefs about medication's health benefits, and history of medication discontinuation.
- ***Self-Reported Adherence Scale:*** This scale has 4 items per medication, scored on a 2-point scale, reflecting the patient's evaluation of their adherence to their medication regimen.

As the aim of this study was to evaluate the usability of MATech in older adults with various barriers and not an assessment of actual medication management, only the functional and cognitive scales were used. Total scores from each scale were further categorized as follows,

- **Cognitive Scale (X/44):**
    1. High Cognitive Scores (90% or greater).
    2. Relatively High Cognitive Scores (80% or greater).
    3. Moderate Cognitive Scores (70% to 80%).
    4. Low Cognitive Scores (approximately 69% or less).
- **Physical Score (X/12):**

1. High Physical Scores (90% or greater).
2. Moderate Physical Score (85% to 89%).
3. Moderate to Low Physical Score (76% to 84%).
4. Low Physical Score (approximately 75% or less).

- **Vision Score (X/16):**
    1. High Vision Scores (90% or greater).
    2. Moderate Vision Score (85% to 89%).
    3. Moderate to Low Vision Score (76% to 84%).
    4. Low Vision Score (approximately 75% or less).

Participants with moderate to low and low scores across all categories were considered to have an impairment present.

5.6.1.2 Whisper test – Hearing Barrier

The Whispered Voice Test stands out as a straightforward and effective method for detecting hearing impairments, remarkable for its unique advantage of requiring no equipment.[227] The procedure involves the examiner whispering a sequence of three numbers and letters, such as "4- K-2," from an arm's length away behind the seated patient. This positioning is crucial to prevent the patient from lip-reading, aiming to purely assess their hearing ability. Before whispering, the examiner should exhale fully to achieve the quietest whisper possible, ensuring the test's integrity. If the patient fails to repeat the sequence accurately, the examiner repeats the test with a new set of numbers and letters. A key criterion for passing this screening test is the correct repetition of at least three out of six possible characters, equating to a 50% success rate. The test is conducted separately for each ear. The non-test ear is temporarily disabled by occluding the auditory canal with a finger and rubbing the tragus, allowing for an accurate assessment of the ear under examination with a different number and letter combination.[132,227] If both ears fail the hearing test, it is considered a 100% impairment; if only one ear fails, it is considered a 50% impairment; and if both ears pass, there is no impairment.

5.6.1.3 The Self-Efficacy for Medication Adherence Scale (SEAMS) – Motivational Barrier

The Self-Efficacy for Medication Adherence Scale (SEAMS) is a specialized tool designed to assess patients' confidence in their ability to adhere to medication regimens. With a focused purpose of evaluating self-efficacy regarding medication adherence, this instrument is particularly useful in clinical settings and research studies that aim to understand and improve patients' medication management behaviors.[99,117,121,123,133] The SEAMS comprises 16 items. Each item on the scale is rated by the patient, reflecting their level of confidence in adhering to their medication regimen under various circumstances (1 not confident, 2 somewhat confident, and 3 very confident). The total score, derived from this rating scale, reflects the patient's overall self-efficacy in medication management. The lowest possible score of the 16-item questionnaire is 16 and the highest possible score is 48. Higher scores indicate that the patients are more confident about taking medication accurately.[99,117,121,123,133] A score below 40 on the SEAMS taken as low self-efficacy, which points to a motivational barrier in medication adherence. Conversely, a score of 40 or above taken as high self-efficacy. These cutoff points were established based on initial data collected in the absence of standardized thresholds.

5.6.1.4 The Martin and Park Environmental Demands (MPED) Questionnaire - Environmental Barrier

The Martin and Park Environmental Demands (MPED) Questionnaire is a tool designed to assess self-reported environmental demands, focusing on the events within an individual's daily life, especially in relation to forgetfulness in taking medications. It comprises two subscales: Busyness and Routine.[7,173] This questionnaire uses a 5-point Likert scale for each item within both subscales.

- ***Routine Subscale:*** This consists of four items designed to measure the regularity with which an individual follows a daily routine. It assesses the frequency of engaging in daily activities at consistent times, such as waking up, going to bed, eating meals, and participating in home activities. The overall score for this subscale ranges from 4 to 20, with higher scores indicating a more established daily routine.

- ***Busyness Subscale:*** This includes seven questions that assess the density of events in an individual's daily life, measuring how often someone feels busy or rushed across various settings. The subscale's total scores range from 7 to 35. Higher scores on this subscale reflect greater busyness.

For the study, environmental barriers were identified based on specific cutoff points: a Busyness Subscale score of 15 or higher indicates significant busyness, and a Routine Subscale score of less than 16 suggests a lack of routine. These cutoff points were established based on initial data collected in the absence of standardized thresholds.

5.6.2 Step 2: User Experience and Usability Testing

5.6.2.1 Medication Adherence Products

In this study, three smart and 10 electronic MATech were evaluated for usability and user experience. Smart medication adherence products were provided by Custom Health, Jones Healthcare Group, and the 3rd product EllieGrid was purchased (Table 5-1). The 10 electronic products used were chosen from 22 that the research lab has already tested on older adults (Table 2) in a previous study.[215] This selection was guided by the diversity of their features, as detailed in Chapter 3 on the classification of MATech. In stage 3 of taxonomy development, the core research team classified the available medication adherence products based on various attributes. After this classification, 10 products were selected that exhibited a broad range of features. These selection criteria ensured that the chosen products varied significantly in terms of their operational mechanisms and user interface elements. These variations included differences in opening mechanisms, the number of compartments, locking mechanisms, button size, portability, and other relevant features. This approach aimed to comprehensively assess and understand the utility and user-friendliness of different types of MATech in supporting older adults.

In the study, each participant was encouraged to test up to four different medication adherence products. However, the actual number of products tested by each participant varied, depending on individual preferences and choices. No formal training was provided to the participants on how to use these products. This approach was intentional to simulate a real-world scenario where individuals purchase devices from the market and use them at home without prior training. Instead of training, participants were given all the instructional materials that typically come with the devices, aiming to assess how intuitive and user-friendly these products are when used without additional guidance.

Initially, medication adherence products were allocated to participants randomly. After reaching 50 participants, the assignment strategy was revised to ensure that each product was tested by an equal representation of participants across all six diverse limitations. This adjustment aimed to ensure a consistent number of individuals for each type of barrier were testing each product. However, since recruitment was halted at 80 participants due to time constraints, the target of having 5 participants with each type of limitation testing each product in the 13-product list was not achieved.

Table 5-1: List of smart medication adherence products tested

Manufacturer	Medication Adherence Product	Description
Custom Health	spencer Automatic Pill Dispenser	The spencer device serves as a daily medication reminder system by providing users with pre-packaged medications in accordance with a predetermined dosing schedule. As a means of communication, spencer uses wireless technology and an electronic display. Among the device's features are the ability to view name, strength, picture, and description for each type of medication, the option to adjust the volume of an alert tone (sound intensifies as dispenses escalate), the frequency at which the light flashes increase as dispense escalates, and the display color changes from blue (normal) to amber (escalated) to red (missed).[228,229]
Jones Healthcare Group	Jones Smart Blister Pack	The Smart Blister Pack consists of a plastic blister, aluminum foil substrate, and paperboard with printed conductive circuits that record dosage events. A pharmacist pre-fills the package. Each blister cavity on the back of the package is numbered in the order that medications should be taken. Days of the week and times of the day may also be indicated on the packaging. Notifications and reminders are sent to a mobile phone (via SMS messaging) or an email address. To use the device, the patient pierces the cavity barrier with an index finger after identifying a blister cavity. They then pull the barrier out of the package by pinching the number on the card between his/her thumb and index finger. Medicine is easily accessible once the barrier has been removed.[230,231]
EllieGrid	EllieGrid Smart Pill Organizer	EllieGrid is an advanced smart pill box designed to simplify medication management through its seamless integration with a mobile app. This device is engineered to enhance medication adherence by providing timely reminders, dosage instructions, and tracking user compliance. Measuring 7.7 by 4 inches, EllieGrid is lightweight, wireless, and features a durable plastic construction. It features seven compartments capable of holding a full bottle of small pills or approximately seven larger pills each. Users can set alarms for medications outside the box through the app with specific medication details and schedules. Alarms are indicated both by sound and push notifications, and the device requires physical interaction to silence, ensuring active engagement with medication schedules.[232,233]

Table 5-2: List of electronic medication adherence products tested[215]

• GMS Med-e-lert Automatic Pill Dispenser
• MedReady 1700 Automated Medication Dispenser
• Pill Box with Digital instruction
• VitaCarry Advanced Pill Case
• MedGlider System 1 with Talking Reminder
• 100-Hour Pill Reminder
• MedQ Smart PillBox
• MedCentre System
• eNNOVEA Weekly Planner with Advanced Auto Reminder
• e-pill Multi-Alarm Pocket XL

5.6.2.2 Mock Medication Regimen

This study used a mock medication regimen designed to mimic the complexity of medication schedules often managed by older adults. The regimen was developed in-house and is intended for use in evaluating the effectiveness of medication adherence products. Participants in this study were provided with a mock medication regimen that included placebo tablets, candy, and placebo capsules, representing a variety of medications typically taken by older adults for chronic conditions. The purpose of using a mock medication regimen was to safely simulate the experience of managing a real medication schedule without the risk of ingesting actual medications.

The mock medication regimen includes placebo representations of the following medications:

- Warfarin: 2 mg once daily on Monday, Wednesday, and Friday, and 3 mg once daily on Tuesday, Thursday, Saturday, and Sunday.
- Pantoprazole: 20 mg twice daily.
- Phenytoin: 100 mg, with one capsule in the morning and two capsules in the evening.
- Propranolol: 20 mg, with half a tablet once daily for the first two days, followed by one tablet daily thereafter.

5.6.2.3 User Experience (UX) Metrics

Various performance-based and perception-based usability metrics were used to measure the usability and UX of various products.

5.6.2.3.1 Performance-based Metrics

Cognitive Walkthrough

Cognitive walkthrough is a method used in user interface design to understand how new users interact with a product by simulating the process of exploring its functionality for the first time.[78,80,81] It is a task-based approach that focuses on evaluating the product's ease of use and learnability, particularly for users who may not have prior experience or knowledge of the product. The objective is to identify usability issues that could hinder the user's ability to complete tasks efficiently and effectively.[78,80,81] To conduct a cognitive walkthrough, a participant information sheet and an evaluation sheet were prepared (Appendix C-3). The participant information sheet outlines specific tasks for users to perform with the product. These tasks are designed to cover a range of functions and features of various products, ensuring a comprehensive assessment of their usability. The tasks ranged from basic setup procedures like inserting batteries and unlocking the device, to more complex interactions such as setting up the current time, filling a tray with medication for a week, setting alarms, locking the device, and removing medication after an alarm. The evaluation sheet documented each task's outcome, marking them as unassisted success, assisted success, or failure. Additionally, the sheet recorded task errors, indicating whether multiple attempts were required for a successful completion or if tasks were accomplished on the first try, and the time spent to complete each task. The evaluation sheet helps in systematically recording observations and measuring the effectiveness of the product's design in facilitating user interaction.

Task Success Rate

Task success is a measure of the level to which users are able to successfully complete tasks using a particular product, indicating the usability and learnability of the product.[81] Task success was measured by determining if users could complete tasks required to use a product without assistance, with assistance, or not at all. In the study, success criteria for each task were defined prior to data collection. Task success could be categorized as either unassisted or assisted, while task failure occurred if the task couldn't be completed even with the evaluator's help.[80]

$$\boldsymbol{Task\ sucess\ rate\ unassisted\ only}\ (\%) = \frac{\boldsymbol{Number\ of\ tasks\ completed\ unassisted}}{\boldsymbol{Total\ number\ of\ tasks\ required\ to\ use\ the\ product}} \times \mathbf{100}$$

Time on Task

Time on task, also referred to as task completion time or simply task time, is the total amount of time users spend on a given task.[81] Most of the time, the quicker a user can complete a task, the better the experience will be. In products where users perform the same task repeatedly, this metric is particularly significant.[81]

For each product, the time elapsed between the start and end of a task was recorded using a OnePlus smartphone clock app. This metric highlights how quickly and efficiently a product can be used, which is crucial for assessing user satisfaction and product effectiveness.

Efficiency

Efficiency can be measured by the amount of time spent on a task or by examining the amount of effort required to complete a task.[81] This metric reveals how effortlessly a user can operate the product, emphasizing the product's ability to facilitate smooth and effective user interactions. In this study, efficiency was defined as task success per unit of time and measured using the following equation.[81]

$$\boldsymbol{Efficiency\ \ unassisted} = \frac{\left(\frac{\boldsymbol{Number\ of\ steps\ completed\ successfully\ unassisted}}{\boldsymbol{total\ number\ of\ steps\ required\ to\ set\ up\ product}}\right)}{\boldsymbol{Total\ time\ spent\ on\ completing\ steps}(\boldsymbol{minutes})}$$

Error Rate

In the study, "error" was defined as any unintentional action, mistake, or oversight made by a user while performing a task.[80] Error criteria were established before data collection and categorized as either present (indicating one or more additional attempts were needed for task completion) or absent (if the task was completed on the first attempt). This percentage quantifies the mistakes made during task performance, providing insight into potential complexities and user challenges within the product's design.

In this study, errors provide excellent insight into why participants with different limitations are failing tasks and can be correlated with the usability of the product.

$$\boldsymbol{Error\ rate}(\%) = \frac{\boldsymbol{Number\ of\ errors\ encountered}}{\boldsymbol{Total\ number\ of\ tasks\ required\ to\ use\ the\ product}} \times \mathbf{100}$$

5.6.2.3.2 Perception-based Metrics

In this study two post-task and one post-session usability questionnaire were used to measure and to gather insights into participants' experiences and satisfaction with the medication adherence products tested. Both questionnaires were administered immediately after completing each task. To measure the workload associated with using devices, the NASA Task Load Index (NASA TLX) questionnaire was used.

Post-Task Usability Questionnaires

<u>Single Ease Question (SEQ)</u>

The Single Ease Question (SEQ) is a scale used to measure the overall ease of completing a task, using a seven-point scale where 1 indicates "extremely difficult" and 7 signifies "very easy."[8]

<u>Subjective Mental Effort Questionnaire (SMEQ)</u>

The SMEQ (Subjective Mental Effort Questionnaire), also known as the Rating Scale for Mental Effort (RSME), features a single-item scale from 0 to 150, with 0 indicating "Not at all hard to do" to 150 being "Tremendously hard to do." Participants indicate perceived mental effort by marking a point on a 150 mm line, with the score determined by the distance in millimeters from the baseline of 0.[81]

Post-Session Usability Questionnaires

In this study, one validated usability questionnaire, the System Usability Scale (SUS) was used to measure and compare the usability of various medication adherence products. This was administered at the end of testing each product (after completing all the tasks associated with a product) before any other discussion.

System Usability Scale (SUS)

SUS is a reliable, robust, quick, low-cost scale for assessing the usability of systems at the end of a test and correlates well with other subjective measures of usability.[78,80] A total of 10 items are included in the test, half of which are worded positively and half of which are worded negatively. Each agreement is measured on a five-point scale. It has two factors: eight of the questions reflect a usability factor and two reflect a learnability factor.[80]

The SUS score is calculated by adding up the score contributions from each item. The score contribution of each item will range from 0 to 4. Score contributions are calculated by subtracting 1 from the scale position for items 1, 3, 5, 7, and 9. For items 2, 4, 6, 8 and 10 the contribution is computed by subtracting the scale position from 5. To obtain the overall value of system usability, the sum of the scores is multiplied by 2.5. In the event that a respondent cannot respond to a particular item, they should mark the center point on the scale. Overall scores range from 0 to 100, with higher scores indicating more usability.[78]

The following criteria can be used to interpret SUS scores.[234]

- <50: Not acceptable
- 50–70: Marginal
- >70: Acceptable

Workload

To measure workload associated with using medication adherence devices, the NASA Task Load Index (NASA TLX) was used. This was administered after the two post-session usability questionnaires.

NASA Task Load Index (NASA TLX)

NASA TLX is a tool that is designed to measure and conduct subjective mental workload (MWL) assessments.[235] Using this tool, the MWL of a participant can be determined while they are carrying out a task.[235] The scale consists of six subscales as follows:

- ***Mental demand*** - the amount of thinking, deciding, or calculating required to accomplish the task.
- ***Physical demand*** - the amount and intensity of physical effort required for the task to be completed.

- ***Temporal demand*** – the time pressure associated with completion of the task.
- ***Effort*** – the level of effort the participant has to put forth to maintain their performance
- ***Performance*** - the extent to which a task has been completed successfully.
- ***Frustration level*** - the level of insecurity, discouragement, or security or contentment that the participant felt during the activity.

Each subscale is scored on an interval scale ranging from low (1) to high (20). The scale was rated by participants shortly after the usability questionnaire has been administered. Based on the ratings of the six items, an overall workload score was calculated. The lower the score, the less work is involved.

The questionnaires used to measure usability, user experience, and workload can be found in Appendix C-4.

5.6.3 Step 3: Qualitative interview

In order to explore the experiences of older adult participants with diverse barriers to medication management regarding the usability and features of MATech , a semi- structured interview was conducted. Participants were interviewed once they have completed the usability testing process. This interview consisted of screening questions to understand participants' daily medication routines and any aids used, as well as in-test questions to delve deeper into the usability and features of the tested products. The interview aimed to gather comprehensive feedback on the ease of use, learning curve, satisfaction, and potential improvements for the MATech tested, assessing both the positive and negative aspects to better understand user needs and preferences. The details for the interview guide are available in Appendix C-5.

5.7 Data Analysis

5.7.1 Statistical Analysis for Quantitative Data

Statistical analysis of the quantitative data was conducted with the assistance of a PhD statistics student using R Studio Version 4.3.3 (2023.12.1 Build 402) by Posit Software, PBC, and SAS Studio Version 9.4 from SAS Institute Inc. Descriptive statistics, the Shapiro-Wilk test, Levene's test, and the Kruskal-Wallis test were performed using SAS Studio. R Studio was used for Dunn's Post-Hoc Test, univariate regression analysis, multivariate regression analysis, and binomial regression modeling. The statistical methods used are described below.

- Descriptive statistics were utilized to provide a fundamental understanding of the central tendency, dispersion, and distribution shape for both performance-based and perception-based usability measures. The mean reflected the central tendency of each measure, while the standard deviation offered insights into the variability of the data around that central value. The range highlighted the breadth of the data by showcasing the difference between the highest and lowest observed values. The median and interquartile range (IQR) were particularly insightful for skewed distributions, offering a more resistant measure of central tendency and spread by focusing on the middle 50% of the data.
- The Shapiro-Wilk test was applied to assess the normality of the distribution of each measure. Instances where this test yielded significant p-values indicated deviations from the normal distribution, suggesting the need for non-parametric statistical techniques.
- Levene's test was also conducted to evaluate the homogeneity of variances across different groups to decide between non-parametric and parametric statistical techniques.
- Kruskal-Wallis Test was used to compare outcome measures across different MATech, identifying if there are statistically significant differences between the median scores of various products.
- Dunn's Post-Hoc Test was employed for pairwise comparisons between different MATech outcome measures after a Kruskal-Wallis test has indicated significant differences, pinpointing which products differ significantly.
- Univariate Regression Analysis was used to assess the impact of individual predictor variables (like age, SEAMS score, and MPED busyness score) on various outcome measures, identifying how each predictor influences the outcome measure with medication adherence devices.
- Multivariate Regression Analysis was used to evaluate the collective influence of several predictor variables on the outcome measure, determining how variables together affect the outcome measure.
- Binomial Regression Modeling was used to estimate the probability of success in various subtasks for older adults with diverse limitations

5.7.2 Data Analysis for Quantitative Data

Data from the semi-structured interviews were analysed using the inductive thematic analysis method. Inductive thematic analysis is a qualitative research method where researchers start without prior knowledge of theoretical frameworks or constructs.[236] Instead, they begin with provisional topics, allowing themes to emerge naturally from the data. This process involves coding the data inductively, where initial observations lead to the development of categories and themes. As the analysis progresses, these observations evolve into a continuously evolving codebook. This codebook reflects the researchers' increasing understanding of the data, facilitating a grounded analysis that is closely tied to the data itself. This approach allows for a flexible and responsive analysis, where themes are directly derived from the data, rather than being imposed on it from existing theories.[236-238] This method is commonly used for analyzing and making inferences from text and other qualitative data such as interviews, focus groups, open-ended survey questions, documents, and videos. [236-238]

Various steps involved in this analysis process are given below:

- ***Initial Individual Coding of Interviews:*** The process began with two researchers, GE and BB, independently coding the first five interviews.
- ***Comparison and Discrepancy Resolution:*** After independently coding the interviews, GE and BB compared codes to identify and resolve any discrepancies.
- ***Calculation of Percentage Agreement:*** To ensure consistency of coding between the two researchers, a percentage agreement was calculated. The agreement was 85% allowing us to proceed with individual coding of the remaining interviews.
- ***Development of an Initial Codebook:*** An initial codebook was created, which included the name of each code, a description, and quotes from the interviews that were representative of each code.
- ***Division and Analysis of Remaining Interviews:*** The remaining interviews were then analyzed by BB.
- ***Creation of a Final Codebook:*** Upon completing the analysis of interviews until data saturation, a final codebook was created. This document finalized the list of codes and included their names, descriptions, and representative quotes from the data. The final codebook served as a key reference throughout the analysis process.
- ***Organizing Codes:*** The codes were organized by grouping them based on a "typical" similarity that could be generalized across them, despite their detailed variations.
- ***Comparing Codes:*** In this step, codes were reviewed to revise them, identify negative

cases, and link codes together.

- ***Labeling Codes:*** Codes were sorted into groups of similar meaning, and labels were assigned to each group. These labels helped to clarify the main ideas and themes developing from the data.
- ***Defining Themes:*** Finally, themes were defined based on the organized and labeled codes. This involved synthesizing the data to identify overarching themes that reflected the interviewees' experiences and perspectives.

5.8 Ethics clearance

The Office of Research Ethics at the University of Waterloo granted this research project ethical clearance under the reference number ORE##45203 (detailed information can be found in Appendix C-6). Throughout the recruitment phase, all participants willingly provided signed informed consent to participate in the study.

6 Chapter 6: Quantitative Results

6.1 Demographic and Clinical Characteristics of Study Participants

As of February 2024, a total of 80 participants enrolled in this study. The average age of participants was 75.6 years, with ages ranging from 61 to 95 years. The study population was predominantly female (67.5%). In terms of medication use, 90% of the participants were taking medications, with 10% not on any medications. The self-reported medical conditions varied, with cardiovascular diseases being the most prevalent (56.25%), followed by metabolic and endocrine disorders (35%), and musculoskeletal diseases (27.5%). To manage their medications, 61.25% of the participants placed containers in a specific location and took medications in association with meals or bedtime, 47.5% used a pillbox, 10% relied on an alarm beeper, 6.25% had someone else remind them to take their medications, 5% used a blister pack, and 1.25% used a medication calendar. Table 6-1 provides a comprehensive overview of the demographic characteristics, clinical status, medication usage, and medication management methods of the study participants.

Table 6-1: Demographic and Clinical Characteristics of Study Participants

Variable	(N=80)	
Age		
Mean ± SD	75.6 ± 7.17	
Range	61-95	
Gender	n	Percent
Female	54	67.5
Male	26	32.5
Level of education		
Masters/doctoral/professional	24	30
Bachelors	22	27.5
Non-university diploma	14	17.5
High school	20	25
Place of residence		
Home	67	83.75
Retirement home	13	16.25
Current medications		
No	8	10
Yes	71	90
Self-reported Number of medications		
0 medication	8	10
1-2 medications	20	25
3-5 medication	33	41.25
6+ medications	19	23.75
Self-reported Medical Conditions		
Cardiovascular diseases	45	56.25
Metabolic and endocrine	28	35
Musculoskeletal diseases	22	27.5
Oral and gastrointestinal	15	18.75
Eye related conditions	9	11.25
Respiratory diseases	7	8.75
Mental health conditions	6	7.5

Renal and urogenital	6	7.5
Neurological diseases	6	7.5
Cancer and neoplasms	5	6.25
None	5	6.25
Hematological diseases	3	3.75
Stroke	3	3.75
Inflammatory and immune system	2	2.5
Ear related conditions	1	1.25
Infections	1	1.25
Injuries and accidents	1	1.25
Reproductive health	1	1.25
Skin diseases	1	1.25
Medication Management Strategies		
Placing containers in a specific location and taking medications in association with meals or bedtime	49	61.25
Pillbox	38	47.5
Alarm beeper	8	10
Someone else reminds me	5	6.25
Blister pack	4	5
Others	2	2.5
Medication calendar	1	1.25

6.2 Barriers to Medication Self-Management Among Participants

For this study, we recruited participants with diverse barriers to medication self-management. Cognitive barriers (defined as low or moderate cognitive score; see table 6-2 for categories) and physical barriers (defined as low or moderate to low physical score; see table 6-2 for categories) as determined with the use of SMAT were identified in 20% and 33.75% of participants, respectively (Table 6-2). Vision barriers (defined as low or moderate to low physical score) were also prevalent, with 11.25% of participants scoring low or moderate to low on the vision scale. Hearing barrier was notably common, affecting 60% of participants to varying degrees. Additionally, motivation and environmental challenges were reported by over 30% of the group.

Table 6-2: Barriers Among Participants

Barriers	n	Percentage
Cognitive barrier - Self-Medication Assessment Tool (SMAT)		
High Cognitive Scores (90% or greater)	60	75.00
Relatively High Cognitive Score (80% or greater)	4	5.00
Moderate Cognitive Score (70% to 80%)	6	7.50
Low Cognitive Score (approx. 69% or less)	10	12.50
Physical barrier- Self-Medication Assessment Tool (SMAT)		
High Physical Scores (90% or greater)	53	66.25
Moderate to Low Physical Score (76% to 84%)	8	10.00
Low Physical Score (approx. 75% or less)	19	23.75
Vision barrier- Self-Medication Assessment Tool (SMAT)		
High Vision Scores (90% or greater)	71	88.75
Moderate to Low Vision Score (76% to 84%)	4	5.00
Low Vision Score (approx. 75% or less)	5	6.25
Hearing barrier - Whisper test		
Impairment in One Ear	12	15.00
Impairment in Both Ears	36	45.00
Motivation barrier - Self-Efficacy for Appropriate Medication Use Scale (SEAMS)	25	31.25

Environmental barrier - Martin & Park Environmental Demands (MPED) Questionnaire	27	33.75
No Barrier	8	10.00
*SEAMS: total score <40 low self-efficacy: motivational barrier present *MPED: busyness subscale score ≥ 15 - greater busyness, routine subscale score < 16 - less routine: environmental barrier present		

6.3 Distribution of Participant Barriers Across 13 Tested Products

There was a lack of homogeneity in the number of times products were tested by participants with various barriers (Table 6-3). Product SM 001 was tested a higher number of times across all barriers. There was a noticeably low number of participants with vision barrier involved in testing across all products.

Table 6-3: Distribution of Participant Barriers Across 13 Tested Products

Products	Cognitive	Physical	Vision	Motivation	Environmental	Hearing		No impairment
						50%	100%	
PBA 001	4	7	2	4	5	1	10	2
PBA 002	4	7	0	3	6	2	7	2
PBA 003	4	3	3	7	7	3	9	2
PBA 004	4	6	2	6	8	5	7	1
PBA 005	3	8	2	9	7	3	12	0
PBA 006	4	5	2	6	8	3	8	1
PBA 007	3	3	4	7	11	4	10	2
PBA 008	2	7	3	9	10	4	13	2
PBA 009	3	9	2	7	5	5	7	2
APD 001	3	12	2	9	5	4	5	2
APD 002	6	7	0	5	9	2	12	3
SM 001	8	15	4	9	13	5	21	3
SM 002	8	12	4	11	11	6	11	1

[1]PBA-001: MedQ Smart PillBox, PBA-002: MedGlider System 1 with Talking Reminder, PBA-003: VitaCarry Advanced Pill Case, PBA-004: e-pill Multi-Alarm Pocket XL, PBA-005: 100-Hour Pill Reminder, PBA-006: eNNOVEA Weekly Planner with Advanced Auto Reminder, PBA-007: Pillbox with digital timer instructions, PBA-008: MedCentre System, PBA-009: EllieGrid Smart Pillbox, APD-001: MedReady 1700 Automated Medication Dispenser, APD-002: GMS Med-e-lert Automatic Pill Dispenser, SM-001: Spencer automatic pill dispenser, SM-002: Jones healthcare blister pack

6.4 Outcome Measures

In this study, we categorized the outcome measures into two types: performance-based measures and perception-based measures (Table 6-4). Performance-based measures objectively assess task completion and include metrics such as task success rate unassisted, total error rate, efficiency unassisted, total task completion time, time on task, and subtask success rate. Perception-based measures, on the other hand, evaluate users' subjective experiences and include the System Usability Scale (SUS) score, the NASA Task Load Index (NASA TLX), and task-specific SEQ and SMEQ scores.

Table 6-4: List of Predictor Variables and Outcome Measures

Predictor Variables	Outcome Measures

Continuous	Performance-based usability measures
• Age	1. Task success rate unassisted
• SMAT Cognitive score	2. Total error rate
• SMAT Physical score	3. Total task completion time
• SMAT Vision score	4. Efficiency for unassisted
• SEAMS score	5. Time on Task
•]MPED Busyness subscale score	6. Proportion of subtask success
• MPED Routine subscale score	
• Number of subtasks for product	Perception-based usability measures
• Number of medications	1. System Usability Scale (SUS) score
• Number of medical conditions	2. NASA task load index (NASA TLX)
• Categorical	3. Task SEQ score
• Gender	4. Task SMEQ score
• Level of education	
• Medication aid use	
• SMAT Cognitive score category	
• SMAT Physical score category	
• SMAT Vision score category	
• Hearing impairment category	
• Number of products tested	

The results are presented through descriptive statistics for performance-based measures followed by univariate and multivariate regression analyses. Similar data treatment follows for the perception-based measures.

6.5 Performance-based usability measures

The first four performance-based usability measures—task success rate unassisted, total error rate, total task completion time, and efficiency for unassisted—are presented together along with their descriptive statistics, univariate, and multivariate regression analyses. Following this, descriptive statistics for “Time on task" provide a focused look at the duration participants spend on each task. Descriptive statistics for "Proportion of subtask success" and subsequent Binomial regression modeling of these rates for older adults with diverse limitations offer detailed insights into specific subtask components and predictive factors of subtask success.

6.5.1 Task Success Rate Unassisted, Total Task Completion Time, Efficiency for Unassisted and Total Error Rate

Table 6-5 presents detailed descriptive statistics of various performance-based metrics for various medication adherence devices tested, including a task success rate unassisted, total task completion time, efficiency for unassisted tasks, and total error rate, followed by p-values from Kruskal-Wallis and Dunn's tests to determine statistical significance.

On average, tasks across all devices were completed successfully at a rate of 77.9%, with a higher median success rate of 83.33%, suggesting that half of the tasks exceeded this success rate. However, the broad standard deviation of 18.78 and a full range from 0 to 100% in success rates highlights the variability in performance among the devices. Among the various devices MedGlider System 1 with Talking Reminder (PBA-002) and Spencer automatic pill dispenser (SM-001) showed the highest mean success rates of 86.97% and 86.84%, respectively.

The total completion times averaged 11.07 minutes, yet it varied significantly, from 2.15 to 31.77 minutes. The Spencer automatic pill dispenser (SM-001) demonstrated remarkable completion time, significantly outperforming others with an average completion time of just 4.53 minutes and exhibiting a notably higher average efficiency score of 22.87.

The efficiency for unassisted task completion, with a mean of 9.95 and a median of 7.31, indicated a positive trend in performance efficiency. SM-001's (Spencer automatic pill dispenser) efficiency was significantly higher than other devices and the subsequent Dunn's test revealed significant differences with other products, such as MedReady 1700 Automated Medication Dispenser (APD-001) and EllieGrid Smart Pillbox (PBA-009).

In regard to error rates, the average across devices was 16.80%, with a median 11.76% indicating more than half the tasks had error rates below this average. VitaCarry Advanced Pill Case(PBA-003), was most prone to errors, suggesting areas for potential improvement.

Figure 6-1 displays a box plot that illustrates various performance metrics such as assisted task success rate, total task completion duration, efficiency for assistance, and total error rate. These plots represent overall values across all products.

Figure 6-1: Box Plot of Various Performance-based Metrics by Product tested

Table 6-5: Descriptive Statistics of Performance Based Measures - Average Task Success Rate Assisted, Total Task Completion Time, Efficiency for Assisted and Total Error Rate

	Task Success Rate Unassisted (%)	Total Task Completion Time (minutes)	Efficiency for Unassisted	Total Error Rate (%)
Overall N	288	288	288	288
Overall Mean	77.90	11.07	9.95	16.80
Overall Median	83.33	10.63	7.31	11.76
Overall Std Dev	18.78	5.42	8.16	16.09
Overall Range	0 - 100	2.15-31.77	0-46.51	0-100

		Task Success Rate Unassisted (%)					Total Task Completion Time (minutes)					Efficiency for Unassisted					Total Error Rate (%)				
Product tested	N	Mean	Med	Q1	Q3	p-value	Mean	Med	Q1	Q3	p-value	Mean	Med	Q1	Q3	p-value	Mean	Med	Q1	Q3	p-value
APD-001	20	71.30	73.91	54.35	91.30	<.0001	15.38	15.38	11.30	18.59	<.0001	5.40	4.55	3.19	7.27	<.0001	17.39	8.70	4.35	26.09	0.003
APD-002	24	77.26	83.33	72.92	87.50		14.95	14.63	12.63	16.28		5.86	5.77	4.67	7.09		15.97	12.50	8.33	18.75	
PBA-001	19	66.82	65.22	56.52	86.96		14.54	13.07	11.60	14.00		5.27	4.84	3.12	6.75		20.14	13.04	8.70	34.78	
PBA-002	21	86.97	89.47	84.21	94.74		11.68	11.17	9.62	13.15		7.97	8.27	6.21	9.85		14.79	10.53	5.26	15.79	
PBA-003	21	71.73	68.75	56.25	87.50		15.58	15.37	10.30	19.33		5.57	5.09	3.02	6.82		26.19	25.00	18.75	37.50	
PBA-004	20	74.93	82.35	71.57	88.24		10.27	9.62	8.05	12.52		7.96	7.20	5.33	10.75		18.43	11.76	7.87	20.59	
PBA-005	20	75.00	80.00	60.00	90.00		5.76	5.01	3.79	7.67		16.18	14.01	7.83	23.74		20.00	10.00	5.00	30.00	
PBA-006	19	77.17	82.61	69.57	91.30		12.53	13.13	9.00	15.65		6.82	6.08	5.30	8.82		17.34	17.39	8.70	26.09	
PBA-007	21	80.95	84.62	69.23	100.00		11.17	9.33	8.30	13.25		8.47	9.45	5.22	11.05		21.98	23.08	7.69	30.77	
PBA-008	26	79.40	87.50	64.29	89.29		13.29	12.84	10.95	15.20		6.34	5.98	4.95	7.47		12.09	8.93	3.57	14.29	
PBA-009	23	73.49	70.97	64.52	80.65		11.22	10.63	8.58	12.43		7.17	6.75	5.29	9.07		10.52	9.68	6.45	12.90	
SM-001	38	86.84	94.74	84.21	100.00		4.53	4.08	3.27	5.50		22.87	22.69	14.08	27.86		12.47	10.53	0.00	10.53	
SM-002	16	83.33	86.67	70.00	100.00		6.54	5.79	4.68	8.32		15.28	13.98	10.12	17.18		17.08	13.33	6.67	20.00	

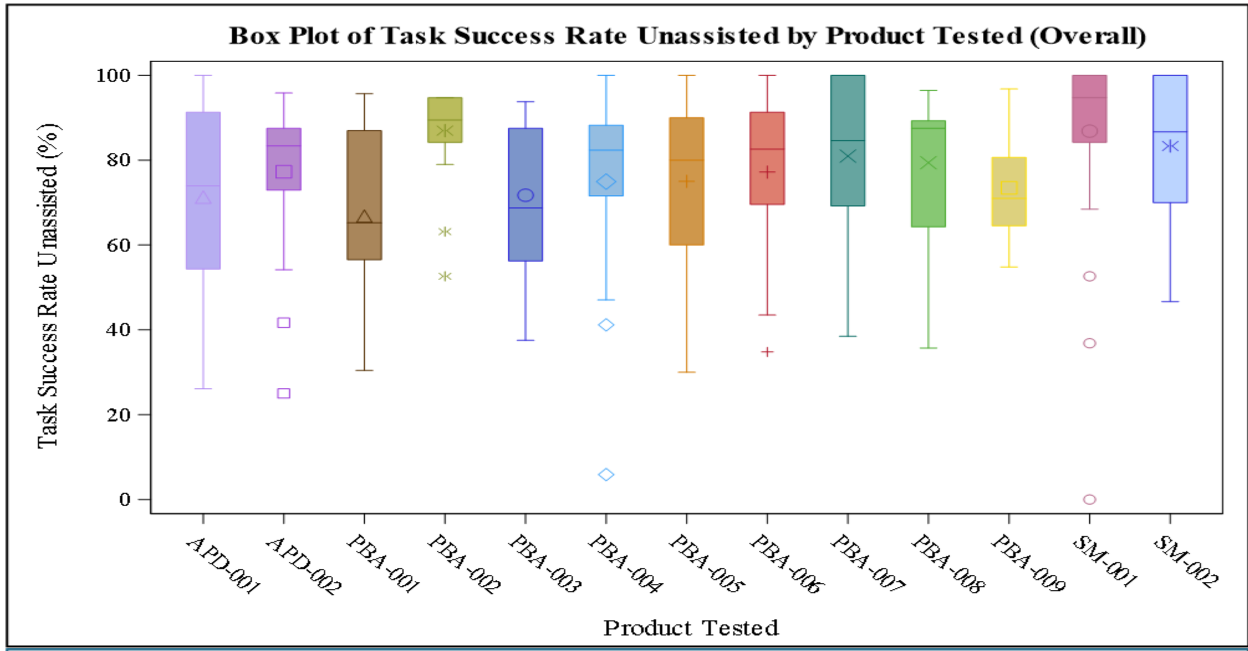
	Comparison	Adjusted p-value	Comparison	Adjusted p-value	Comparison	Adjusted p-value	Comparison	Adjusted p-value
Dunn's Test	PBA-001 - SM-001	0.000351	APD-002 - SM-001	1.41993E-14	APD-001 - SM-001	1.14E-10	PBA-003 - SM-001	0.000573
	PBA-009 - SM-001	0.001513	PBA-003 - SM-001	1.57007E-12	PBA-001 - SM-001	2.19E-10	PBA-003 - PBA-008	0.005644
	PBA-003 - SM-001	0.002658	APD-001 - SM-001	3.2528E-12	PBA-003 - SM-001	3.16E-10	PBA-003 - PBA-009	0.006385
	APD-001 - SM-001	0.015785	PBA-008 - SM-001	7.32865E-12	APD-002 - SM-001	7.74E-10		
	PBA-001 - PBA-002	0.025463	PBA-001 - SM-001	1.72468E-10	PBA-008 - SM-001	5.51E-09		

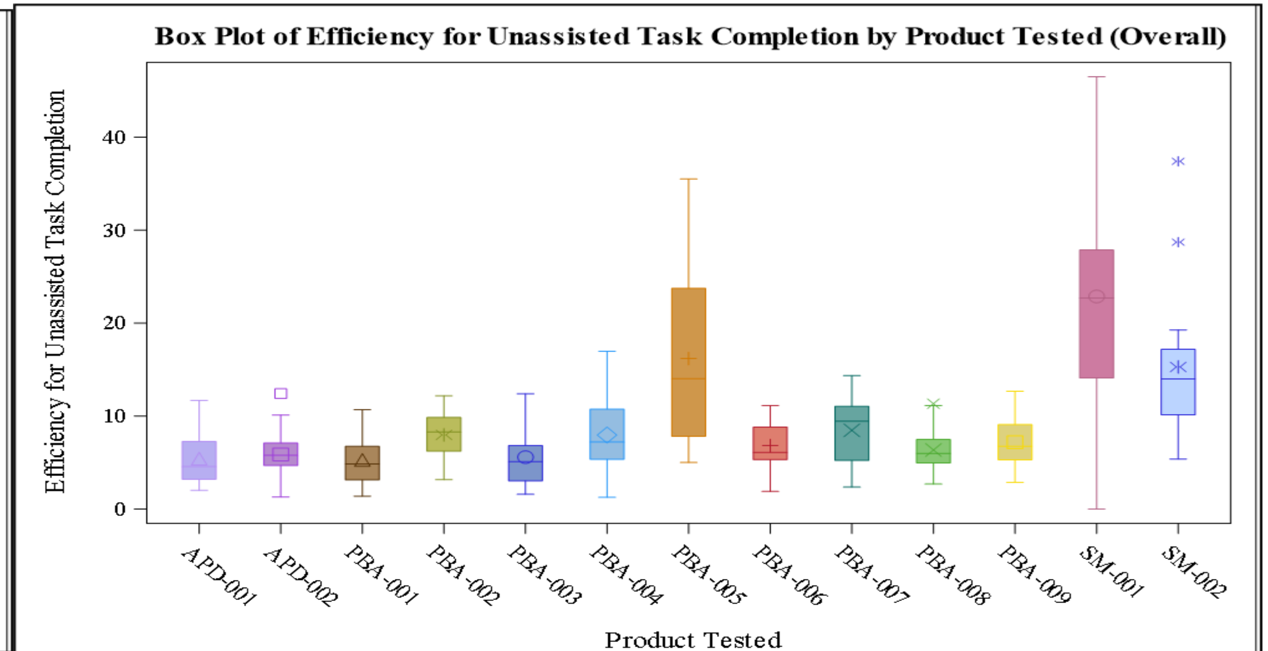
[1]*Products tested - APD-001: MedReady 1700 Automated Medication Dispenser, APD-002: GMS Med-e-lert Automatic Pill Dispenser, PBA-001: MedQ Smart PillBox, PBA-002: MedGlider System 1 with Talking Reminder, PBA-003: VitaCarry Advanced Pill Case, PBA-004: e-pill Multi-Alarm Pocket XL, PBA-005: 100-Hour Pill Reminder, PBA-006: eNNOVEA Weekly Planner with Advanced Auto Reminder, PBA-007: Pillbox with digital timer instructions, PBA-008: MedCentre System, PBA-009: EllieGrid Smart Pillbox, SM-001: Spencer automatic pill dispenser, SM-002: Jones healthcare blister pack*

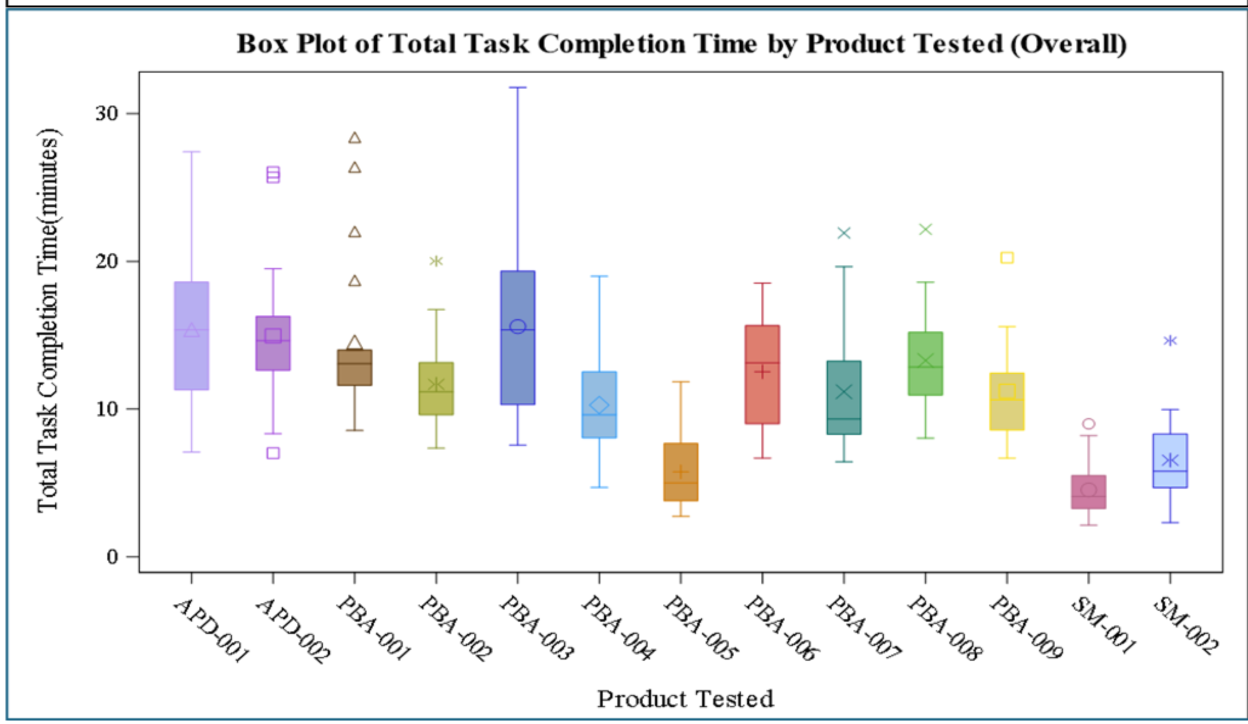
[2]*Statistics presented: N, Mean, Standard deviation, Range, Med-Median, Q1-lower quartile, Q3-upper quartile*

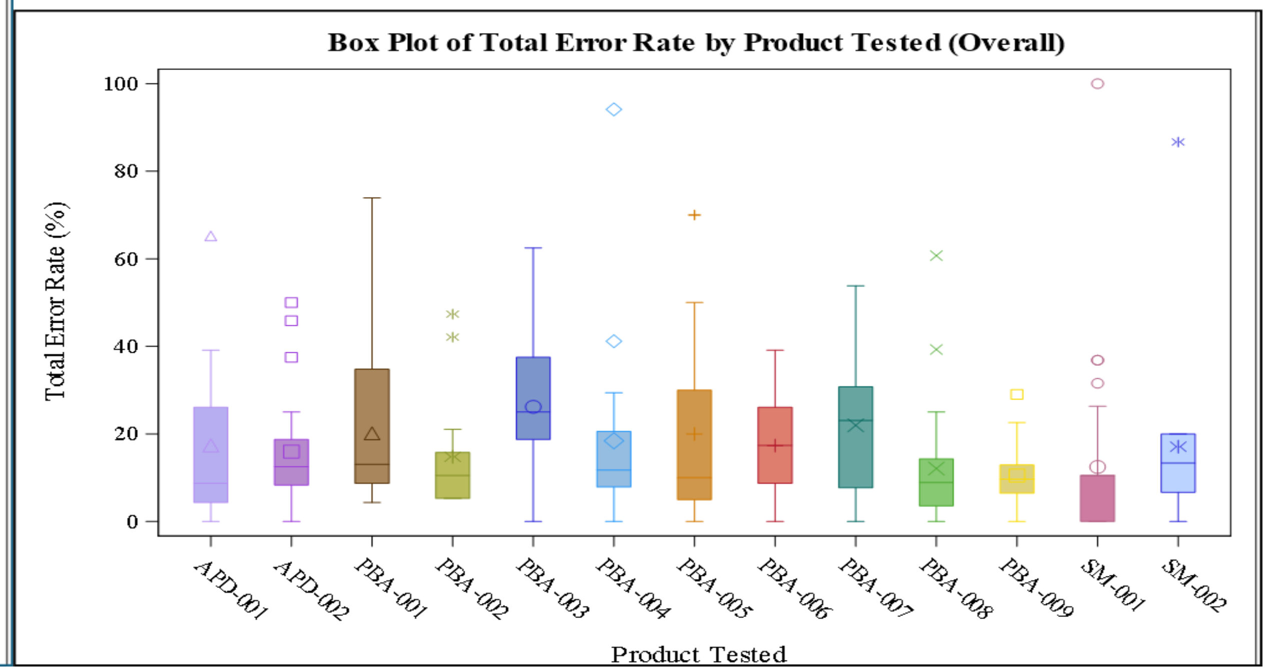
[3]*Statistical tests performed: Kruskal-Wallis test (p-value), Dunn's test (adjusted p-value), Significance level p<0.05*

[4]*Bonferroni correction for multiple testing in Dunn's test, E - exponent*


Box Plot of Task Success Rate Unassisted by Product Tested (Overall)
Task Success Rate Unassisted (%)
Product Tested
APD-001
APD-002
PBA-001
PBA-002
PBA-003
PBA-004
PBA-005
PBA-006
PBA-007
PBA-008
PBA-009
SM-001
SM-002


Box Plot of Efficiency for Unassisted Task Completion by Product Tested (Overall)
Efficiency for Unassisted Task Completion
Product Tested
APD-001
APD-002
PBA-001
PBA-002
PBA-003
PBA-004
PBA-005
PBA-006
PBA-007
PBA-008
PBA-009
SM-001
SM-002


Box Plot of Total Task Completion Time by Product Tested (Overall)
Total Task Completion Time(minutes)
Product Tested
APD-001
APD-002
PBA-001
PBA-002
PBA-003
PBA-004
PBA-005
PBA-006
PBA-007
PBA-008
PBA-009
SM-001
SM-002


Box Plot of Total Error Rate by Product Tested (Overall)
Total Error Rate (%)
Product Tested
APD-001
APD-002
PBA-001
PBA-002
PBA-003
PBA-004
PBA-005
PBA-006
PBA-007
PBA-008
PBA-009
SM-001
SM-002

When analyzing performance metrics across different barriers, individuals with vision and cognitive barriers generally faced the most significant challenges. Those with vision barriers had the lowest task success rate at 64.97% and the highest error rate at 25.74%, highlighting difficulties related to visual perception. Cognitive barriers resulted in the longest task completion times, averaging 12.12 minutes, and the lowest efficiency, suggesting difficulties in task processing and completion.

Individuals with physical barriers performed better than those with vision or cognitive challenges but not as well as those with environmental barriers, achieving a success rate of 70.1%. However, this group also showed variability in performance. Those with motivational barriers displayed a balanced performance with a high average success rate of 73.59%, indicating effective task completion despite motivational challenges. In contrast, those facing environmental barriers excelled, consistently achieving the highest success rates, efficiency scores, and the shortest completion times, while also maintaining the lowest error rates.

Table 6-6 provides a detailed breakdown of performance metrics including average task success rate, total task completion time, efficiency, and error rates across various barriers, highlighting the differences in how cognitive, physical, vision, hearing, motivation, and environmental impairments affect task completion.

Table 6-6: Task Success Rate Unassisted, Total Task Completion Time, Efficiency for Unassisted and Total Error Rate in the Presence of Various Barriers

	Barrier Type	N	Mean	Median	Std Dev	Range	
						Min	Max
Task Success Rate Unassisted (%)	Cognition	51	69.43	70	21.04	0	100
	Physical	97	70.1	73.68	20.97	0	100
	Vision	28	64.97	68.59	25.93	0	92.31
	Hearing	172	75.77	82.61	20.5	0	100
	Motivation	87	73.59	77.42	22.09	0	100
	Environmental	99	82.55	89.29	16.71	25	100
Total Task Completion Time (minutes)	Cognition	51	12.12	11.17	6.56	2.22	31.77
	Physical	97	11.97	11.68	5.89	2.18	27.42
	Vision	28	10.79	8.61	7.2	2.32	31.77
	Hearing	172	11.19	10.33	6.22	2.22	31.77
	Motivation	87	11.14	10.5	5.63	2.15	31.77
	Environmental	99	10.28	9.1	4.84	2.15	23.27
Efficiency for Unassisted	Cognition	51	8.43	5.73	7.8	0	42.74
	Physical	97	8.78	5.93	8.55	0	43.39
	Vision	28	8.8	7.48	7.81	0	37.41
	Hearing	172	10.2	7.33	8.41	0	43.17
	Motivation	87	9.06	6.19	8.13	0	46.51
	Environmental	99	11.19	8.91	8.8	1.28	46.51

Total Error Rate (%)	Cognition	51	21.77	16.67	19.31	0	100
	Physical	97	17.08	10.53	17.59	0	100
	Vision	28	25.74	17.27	26.49	0	100
	Hearing	172	16.49	11.76	16.18	0	100
	Motivation	87	19.1	12.5	21.51	0	100
	Environmental	99	14.31	10.53	12.5	0	53.85

[1]*Statistics presented: N, Mean, Standard deviation, Range*

The Appendix D-1, D-2, D-3 and D-4 includes descriptive statistics and box plots for performance metrics like task success rate assisted, total task completion time, efficiency for assisted, and total error rate respectively by product across different limitations, supplemented by Kruskal-Wallis test results to evaluate differences across devices and barriers.

6.5.2 Impact of Single Predictor Variables on Task Success Rate Unassisted, Total Task Completion Time, Efficiency for Unassisted and Total Error Rate

In the univariate regression analysis examining the impact of various continuous and categorical predictor variables on the usability metrics for medication adherence devices, significant findings were found. Age notably decreases the task success rate ($p=0.000007$) and increases the total task completion time ($p=0.0016$), with a decrease in efficiency for unassisted tasks ($p=0.0365$), although it does not significantly affect error rates ($p=0.265$). Higher cognitive scores significantly improve the task success rate ($p=0.000009$)and reduce error rates ($p=0.005$), highlighting the benefits of cognitive capabilities in enhancing task performance and minimizing mistakes. Similarly, higher physical and vision scores positively influence task success rates, with better vision significantly reducing error rates ($p<0.0001$), underscoring the importance of visual acuity. Among categorical variables, variations in education level, particularly a high school education ($p=0.008$), significantly diminish task success rates, while lower cognitive($p<0.0001$) and physical scores ($p<0.0001$) decrease these rates, indicating the substantial role of cognitive and physical abilities in task success. Moreover, lower vision scores also result in poorer task success rates ($p=0.005$) and higher error rates($p=0.021$), indicating the critical impact of visual skills. The number of products tested significantly affects all metrics except for efficiency and time, with more product tests leading to higher task success rates and significantly lower error rates, possibly reflecting a learning effect or greater adaptability. **Table 6-7** presents a detailed regression analysis exploring the influence of various continuous and categorical predictor variables on four performance-based usability metrics.

Table 6-7: Task Success Rate Unassisted, Total Task Completion Time, Efficiency for Unassisted and Total Error Rate - Summary of Univariate Regression Models for Each Predictor

	Task Success Rate Unassisted (%)		Total Task Completion Time (minutes)		Efficiency for Unassisted		Total Error Rate (%)	
Continuous Predictor Variables	Est.	p-value	Est.	p-value	Est.	p-value	Est.	p-value
Age	-0.68	7.80E-06	0.15	0.0016	-0.14	0.0365	0.20	0.265
Cognitive score	0.76	9.60E-06	-0.04	0.429	0.10	0.17	-0.42	0.005
Physical score	2.92	4.00E-07	-0.28	0.1051	0.50	0.074	0.57	0.264
Vision score	3.46	6.00E-08	0.04	0.85	0.43	0.30	-3.02	2.00E-07
SEAMS score	0.48	0.0248	0.03	0.639	0.04	0.67	-0.33	0.066
MPED busyness score	0.42	0.146	0.01	0.893	0.11	0.40	-0.36	0.147
MPED routine score	0.58	0.127	0.14	0.205	-0.14	0.387	-0.31	0.344
Number of subtask for product	-0.22	0.254	0.29	2.00E-07	-0.43	2.00E-07	-0.48	0.0037
Categorical Predictor Variables	Est.	p-value	Est.	p-value	Est.	p-value	Est.	p-value
Gender (male)	-4.52	0.055	0.06	0.935	0.71	0.492	3.57	0.078
Medication Aid Use (yes)	-5.46	0.013	0.52	0.412	-0.34	0.728	0.95	0.616
Education level								
• Masters/doctoral/professional (Ref)								
• Bachelors	-0.68	0.812	-0.45	0.594	1.09	0.386	-1.33	0.787
• Non-university diploma	2.79	0.523	-1.08	0.499	2.03	0.315	-0.08	0.978
• High school	-8.56	0.008	0.77	0.499	-1.25	0.386	5.11	0.094
Cognitive score category								
• High Cognitive Scores (ref)								
• Relatively High Cognitive Score	3.36	0.491	1.67	0.332	-0.78	0.720	-3.64	0.394
• Moderate Cognitive Score	-3.07	0.491	2.30	0.140	-2.74	0.304	4.31	0.332
• Low Cognitive Score	-14.60	8E-05	0.78	0.454	-1.37	0.512	6.78	0.055
Physical score category								
• High Physical Scores (ref)								
• Moderate to Low Physical Score	-8.22	0.029	2.23	0.073	-2.08	0.223	3.86	0.378
• Low Physical Score	-13.06	5E-07	1.04	0.167	-1.65	0.218	-0.83	0.711
Vision score category								
• High Vision Scores (ref)								
• Moderate to Low Vision Score	-13.98	0.0059	-0.85	0.852	-0.61	0.787	9.08	0.038
• Low Vision Score	-14.67	0.0058	0.22	0.883	-1.95	0.578	10.73	0.021
Hearing impairment category								
• No impairment (Ref)								
• Impairment in one ear	-10.14	0.003	0.15	0.872	-0.01	0.993	2.31	0.414
• Impairment in both ears	-3.57	0.1347	0.33	0.872	0.84	0.639	-1.85	0.414
Number of product tested								
• 1 product (Ref)								
• 2 products	63.73	0.0011	12.51	0.099	5.36	0.706	-69.67	1.91E-05
• 3 products	71.73	0.0002	7.62	0.298	7.69	0.685	-80.61	3.00E-07
• 4 products	80.75	3E-05	5.26	0.332	10.89	0.685	-84.93	1.00E-07
[1]*Statistical test performed: Univariate regression, Significance level p<0.05*								
[2]*P-values were adjusted according to the Benjamini-Hochberg (BH) method to control the false discovery rate*								
[3]*Est.-Parameter Estimate*								
[4]*DF=1 for all variables*								
[5]*Dummy Variables were created for all categorical predictor*								

6.5.3 Impact of Multiple Predictor Variables on Task Success Rate Unassisted, Total Task Completion Time, Efficiency for Unassisted and Total Error Rate

A backward stepwise multivariate regression analysis was conducted to identify key predictors impacting the task success rate unassisted, total task completion time, efficiency for unassisted and total error rate. The final model, incorporating statistically significant variables, provides crucial insights into factors enhancing task performance and error management.

For the task success rate unassisted, 'SEAMS score' (p=0.001) and 'Low Vision Score' (p=0.00002) were among the significant variables, with 'SEAMS score' having a notably positive impact, while 'Low Vision Score' negatively influenced success rates. The total task completion time was significantly affected by 'Age' (p=0.0004) and the 'Number of subtasks for product,' (p=0.0000001) where a higher number of subtasks led to longer completion times. 'Physical score' (p=0.0002) significantly increased the total error rate, and a 'Low Physical Score'(p=0.0006) indicated higher error rates, highlighting areas for potential intervention and support in device design and user interaction.

Table 6-8 summarizes the final regression model, detailing the parameter estimates, standard errors, t-values, and adjusted p-values.

Table 6-8: Final Multivariate Regression Model Summary - Task Success Rate Unassisted, Total Task Completion Time, Efficiency for Unassisted and Total Error Rate

Task Success Rate Unassisted					
Variable	Estimate	Std. Error	t value	Pr(>|t|)	Adj.P.value
(Intercept)	-5.65	23.06	-0.24	0.807	0.807
Age	-0.22	0.16	-1.39	0.166	0.240
Cognitive score	0.35	0.17	2.10	0.036	0.079
Vision score	2.01	0.81	2.48	0.014	0.045
SEAMS score	0.72	0.19	3.77	0.000	0.001
MPED busyness score	0.60	0.27	2.23	0.026	0.068
Number of subtask for product	-0.27	0.17	-1.60	0.110	0.205
Gender (male)	-6.93	2.09	-3.32	0.001	0.004
Moderate to Low Vision Score	-1.35	3.56	-0.38	0.705	0.764
Low Vision Score	-11.76	2.42	-4.86	0.000002	2.58E-05
Number of Products tested					
2 products	19.41	20.91	0.93	0.354	0.418
3 products	22.78	20.92	1.09	0.277	0.360
4 products	31.01	20.90	1.48	0.139	0.226
Total Task Completion Time					
Variable	Estimate	Std. Error	t value	Pr(>|t|)	Adj.P.value
(Intercept)	-29.90	10.53	-2.84	0.005	0.021
Age	0.19	0.05	4.15	4.38E-05	0.0004
Cognitive score	0.64	0.31	2.08	0.039	0.094
SEAMS score	-0.12	0.06	-1.93	0.055	0.106
MPED busyness score	0.12	0.08	1.39	0.166	0.235
Number of subtask for product	0.30	0.05	5.99	6.71E-09	1.00E-07
Bachelors	-1.23	0.77	-1.58	0.114	0.195
Non-university diploma	-0.95	0.88	-1.08	0.280	0.340

High school	1.23	0.86	1.44	0.152	0.235
Relatively High Cognitive Score	5.85	2.21	2.64	0.009	0.027
Moderate Cognitive Score	9.05	3.47	2.61	0.010	0.027
Low Cognitive Score	11.17	5.83	1.92	0.056	0.106
Moderate to Low Vision Score	-4.58	1.59	-2.88	0.004	0.021
Low Vision Score	-1.75	1.50	-1.17	0.243	0.318
Number of Products tested					
2 products	0.49	7.52	0.06	0.948	0.948
3 products	-2.52	7.02	-0.36	0.719	0.764
4 products	-4.67	7.03	-0.66	0.507	0.575
Efficiency for Unassisted					
Variable	Estimate	Std. Error	t value	Pr(>|t|)	Adj.P.value
(Intercept)	18.78	9.52	1.97	0.049	0.223
Age	-0.11	0.06	-1.68	0.095	0.284
Number of subtask for product	-0.44	0.08	-5.55	1.00E-07	6.00E-07
Bachelors	1.43	1.17	1.22	0.222	0.332
Non-university diploma	1.69	1.35	1.25	0.213	0.332
High school	-1.41	1.24	-1.13	0.258	0.332
Number of Products tested					
2 products	4.92	8.07	0.61	0.543	0.543
3 products	5.75	7.70	0.75	0.456	0.513
4 products	8.84	7.66	1.15	0.249	0.332
Total Error Rate					
Variable	Estimate	Std. Error	t value	Pr(>|t|)	Adj.P.value
(Intercept)	68.36	24.50	2.79	0.006	0.014
Physical score	6.35	1.44	4.40	1.57E-05	0.0002
Vision score	-6.45	2.14	-3.01	0.003	0.014
MPED busyness score	-0.68	0.24	-2.81	0.005	0.014
Number of subtask for product	-0.41	0.15	-2.80	0.006	0.014
Gender (male)	3.68	1.88	1.96	0.051	0.076
Moderate to Low Physical Score	10.27	3.83	2.68	0.008	0.017
Low Physical Score	25.03	6.27	3.99	8.51E-05	0.0006
Moderate to Low Vision Score	-11.64	7.96	-1.46	$0.145	$0.182
Low Vision Score	-25.08	11.85	-2.12	$0.035	$0.059
Impairment in one ear	3.85	2.64	1.46	$0.146	$0.182
Impairment in both ears	-4.06	1.85	-2.20	$0.029	$0.054
Number of Products tested					
2 products	4.10	26.76	0.15	$0.878	$0.941
3 products	-0.63	27.26	-0.02	$0.982	$0.982
4 products	-7.18	27.23	-0.26	$0.792	$0.914

[1]*Statistical test performed: Backwards stepwise multivariate regression process prioritized by the Akaike Information Criterion (AIC)*

[2]*P-values were adjusted according to the Benjamini-Hochberg (BH) method to control the false discovery rate*

[3]*Significance level p<0.05*

6.5.4 Time on task (Seconds)

A task refers to a specific action required to manage and operate a medication adherence device. These actions are vital for the setup, use, and maintenance of the device to ensure it dispenses medication accurately and timely. Tasks might include inserting batteries, setting up times and dates, filling trays with medications, and setting alarms. Various tasks involved in using different devices were coded from A to U. Table 6-9 presents the codes and a list of tasks.

Table 6-9: Tasks for Using Various Devices

Codes	Tasks
A	Put batteries in
B	Unlock the device
C	Set up the time and date
D	Fill tray with medications
E	Set alarm
F	Lock the device
G	Remove medication after alarm sounds
H	Turn the carousel
I	Open an app and touch on an icon /button
J	Press “add new pill” and add first pill to the app.
K	Set alarm /alert volume for medication on the app/device
L	Respond to the questions in the app/ device
M	Load a new medication cartridge into the device
N	Adjust the alert volume for medication reminders on the device screen
O	Wait for a medication reminder and dispense the scheduled dose
P	Open the medication package and retrieve medication
Q	Shut down the device
R	Connect a blister pack to the device
S	Ensure blister pack is connected correctly to the device by checking the display
T	Follow notification and remove the medication from the blister pack
U	Remove the blister pack from the device

Table 6-10 provides information on the time spent on various tasks both overall and under various limitations.

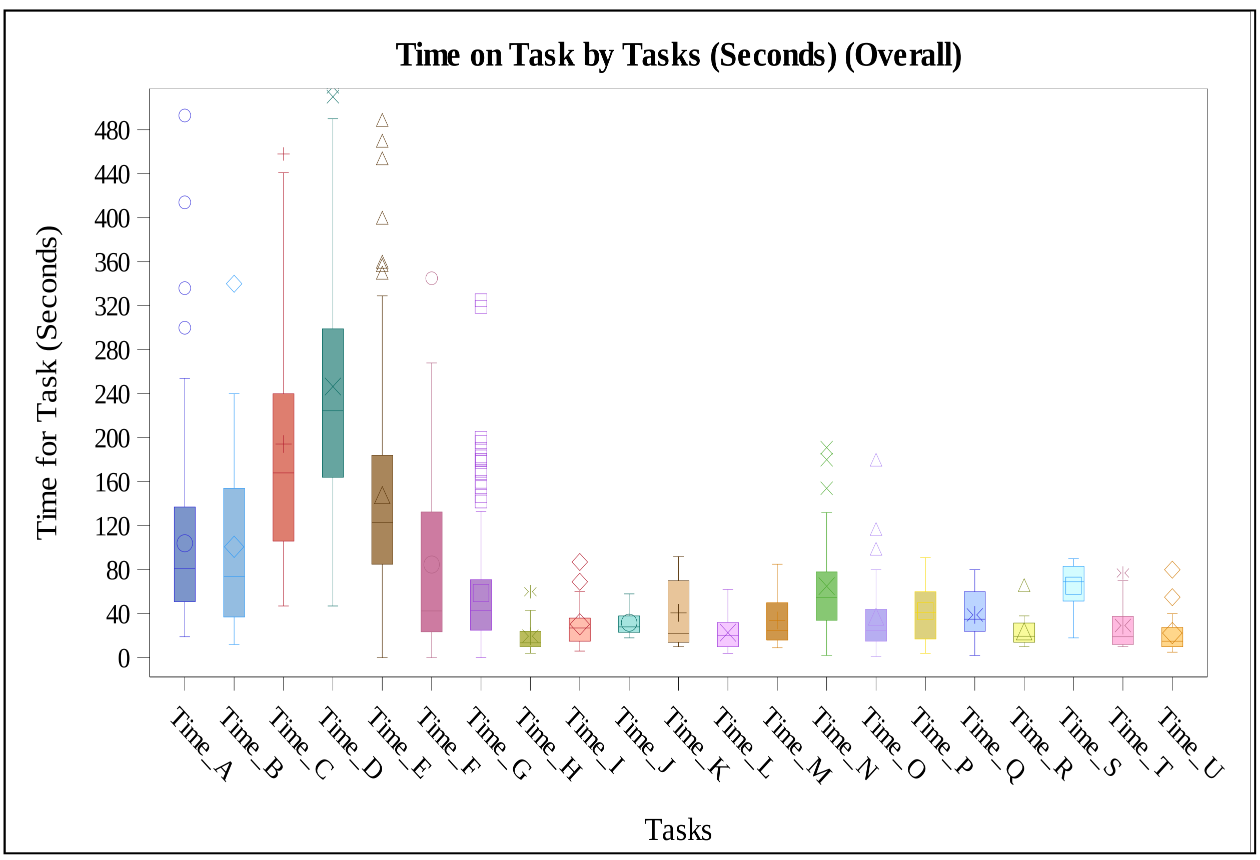
The analysis of time on task for medication adherence technologies involved measuring how long participants engaged with each task until they either failed, gave up, or successfully completed it. Overall, the average time spent on various tasks was 120.47 seconds, with a standard deviation of 114.40 seconds, a median of 81 seconds, and an interquartile range from 34 to 180 seconds. In terms of specific barriers, cognitive barriers lead to the longest average task time of 132.73 seconds, while environmental barriers result in the shortest, at 116.75 seconds. Physical, vision, and hearing barriers show moderately higher average times than the overall mean, at 126.23, 125.72, and 125.74 seconds respectively. The spread of times, as indicated by the standard deviations, is fairly consistent across all barriers, suggesting a uniform variability in how different barriers impact task duration.

Among various tasks significant variability in task completion times was observed, as highlighted by a Kruskal-Wallis test ($p<0.001$) indicating a substantial difference across tasks. Overall, the task "Task D-Fill tray with medications" required the most time on average at 246.53 seconds, suggesting it as the most time-consuming or complex task for participants. In contrast, simpler tasks such as "Task H-Turn the carousel" (19.56 seconds) and "Task U-Remove the blister pack from the device"(22.38) required significantly less time.

In terms of various barriers, the time spent on tasks for medication adherence technologies reveals significant differences ($p<0.001$). Similar to overall time on task, Task D-"Fill tray with medications," consistently required the most time across almost all categories, indicating its complexity and potential difficulty for users with different limitations. In contrast, tasks perceived as simpler, such as Task H, "Turn the carousel," and Task U, "Remove the blister pack from the device," required significantly less time.

Figure 6-2 shows box plot that visualizes the distribution of time taken (in seconds) for different tasks (labeled A through U) related to medication adherence technologies.

Figure 6-2: Box Plot for Distribution of Time Taken (in seconds) for Different Tasks Overall (labeled A through U)



The Appendix D-5 includes descriptive statistics and box plots for time spent on various tasks across different barriers, supplemented by Kruskal-Wallis test results to evaluate differences across tasks

Table 6-10: Time (seconds) spent on various tasks overall and under various barriers

	Overall					Cognitive Barrier			Physical Barrier			Vision Barrier			Hearing Barrier			Motivational Barrier			Environmental Barrier		
N	1471					264			503			134			862			439			496		
Mean	120.47					132.73			126.23			125.72			125.74			120.80			116.75		
Std Dev	114.40					126.13			121.42			138.26			123.93			115.37			111.82		
Med	81					86.5			83			74			80			81			80		
IQR	34 -180					40 - 191			36 - 182			30 - 190			35 - 180			34 - 180			31 - 180		
Task	N	Mean	Q1	Med	Q3	N	Mean	Med	N	Mean	Med	N	Mean	Med	N	Mean	Med	N	Mean	Med	N	Mean	Med
A	150	104.03	51	81	137	27	115.3	85	49	130.78	125	12	131.58	96	84	106.19	78.5	43	121.42	105	50	88.16	72.5
B	44	100.8	37	74	154	9	146.22	159	19	88.68	45	2	47.5	47.5	23	116.22	120	14	91.14	61.5	14	136.07	137
C	191	194.27	106	168	240	34	223.32	175	58	201.78	180.5	18	210.94	193.5	110	209.85	182	56	185.91	165	69	178.39	177
D	234	246.53	164	224	299	40	271.5	248.5	75	266.07	240	22	277.82	237.5	137	259.29	236	72	238.28	214	81	242.74	228
E	211	147.82	85	123	184	37	166.43	130	66	160.86	147	20	130.1	94.5	125	151.61	124	65	143.43	120	76	142.97	114
F	44	84.68	23.5	42.5	132	9	63.22	40	19	122.05	86	2	38	38	23	85.35	35	14	104.43	89.5	14	46.79	27
G	233	58.8	25	43	71	40	76.6	52	74	71.11	51	21	60	45	136	64.14	45	72	61.76	38	80	47.58	33
H	18	19.56	10	13.5	24	4	9.75	8.5	4	20.25	17.5	1	10	10	10	20.5	13	6	23.5	12.5	7	18.14	12
I	23	30.35	15	27	36	3	48	60	9	31.89	30	2	11	11	12	33.75	30	7	32.86	30	5	30.2	30
J	23	31.78	23	28	38	3	23.67	21	9	32	24	2	22	22	12	33.17	29	7	33.57	32	5	29.6	26
K	23	40.74	14	22	70	3	78.33	73	9	54.44	68	2	69	69	12	48.33	67	7	56.71	68	5	51.6	66
L	23	22.74	10	20	32	3	20	10	9	25	18	2	10	10	12	25	21	7	25.43	26	5	19.4	10
M	38	33.84	16	24.5	50	8	29	20	15	33.47	24	4	32.5	20	26	33.62	30	9	31.67	22	13	41.54	25
N	38	65	34	54.5	78	8	50.25	44	15	54.33	42	4	80	94.5	26	63.42	47	9	48.33	39	13	67	60
O	38	37.26	15	24.5	44	8	25	21.5	15	38.33	26	4	37.25	15.5	26	31.69	25	9	43.44	24	13	35.38	25
P	38	42.37	17	41	60	8	47.25	49	15	47.4	48	4	25.5	23	26	44.42	45	9	35	35	13	37.23	34
Q	38	38.89	24	35	60	8	25.25	24	15	38.93	36	4	33.5	31	26	38.85	36	9	18.33	15	13	33.46	30
R	16	23.94	14	19.5	31.5	3	15	15	7	25.29	23	2	41.5	41.5	9	22.78	17	6	33	29.5	5	27.6	20
S	16	65.44	51.5	69	83	3	81	77	7	58.71	57	2	65	65	9	61.89	55	6	61.33	55	5	71.6	87
T	16	29.25	12	19	37.5	3	21	18	7	30.71	29	2	16.5	16.5	9	25.33	15	6	30.83	23	5	30.2	20
U	16	22.38	10	15	27.5	3	18.33	10	7	26.43	14	2	5	5	9	17.67	15	6	35.5	33.5	5	15.6	16

[1]Statistics presented: N, Mean, Med-Median, Q1-lower quartile, Q3-upper quartile

[2]Statistical test performed- Kruskal-Wallis Test – significant difference present between time for various tasks $p<0.0001$ (overall and in case of all limitations)

[3]Statistical test performed - Dunn's test - Task A - Task C (2.38e-10), Task A - Task E (5.03e-03), Task B - Task C (4.75e-05), Task D - Task E(2.06e-11), Task A - Task D(2.80e-25), Task C - Task F(7.93e-10), Task B - Task D(1.85e-11), Task D - Task F (3.82e-18), Task C - Task D(1.79e-02),Task E - Task F(9.61e-05)

6.5.5 Proportion of Subtask Success

A subtask is a discrete, individual action that forms part of a larger task, specifically designed to achieve a step in the overall process. It involves precise activities, such as inserting a battery or setting a date, that are essential for the successful operation of a device.

Different subtasks associated with device usage were assigned alphabetical codes and a total of 32 subtasks were developed. These are listed in the table 6-11.

Table 6-11: Subtasks for Using Various Devices

Code	Subtask
A1	Locate the battery/cartridge compartment/medication cavity
A2	Put/ insert the battery correctly
A3	Lift/ close battery compartment door
A4	Slide in out/out battery compartment door
A5	Slide a tab/button
A6	Check /ensure/verify the device is on or the lock is placed on position/Follow instructions/ Ensure indicator light flashes for 3 seconds
B1	Flip device
B2	Insert key and rotate
B3	Press and rotate the lid
B4	Open the lid by lifting
C1	Press and hold a button on a device
C2	Press a button on a device
D1	Open pill box or compartment by rotating the lid
D2	Open pill box or compartment or tray or door by sliding
D3	Pick up the correct pillbox/pill organizer/open correct compartment
D4	Insert/fill/place medication in compartment/ pillbox/pill organizer
D5	Close lid
D6	Put stickers on pillbox dividers
G1	Remove the medication
G2	Grab/hold the device
G3	Place hand over open slot
H1	Rotate the carousel three days from today’s date
I1	Locate and touch on a icon/ button on an app or screen
I2	Enter/ type any data in an app/screen
I3	Scroll the screen options
M1	Align and insert cartridge into the designated slot
P1	Tear the package
R1	Rotate retaining clips at each end of the device in an open/close position
R2	Align connectors to one another and gently push card into the device
T1	Pierce cavity barrier
T2	Pinch number printed on card and pull out
U1	Pull the blister packs away from the device

The proportion of subtask success for participants was calculated using the below equation.

$$Proportion\ of\ subtask\ success = \frac{Number\ of\ times\ subtask\ present\ in\ device\ usage - Number\ of\ times\ participants\ failed}{Number\ of\ times\ subtask\ present\ in\ device\ usage}$$

Table 6-12 displays the descriptive statistics for the proportion of subtask success overall and in the presence of various barriers, highlighting that on average, 89% of subtasks were completed successfully. Cognitive and physical barriers led to a slightly lower success proportion, at 85% and 84% respectively, with vision barriers presenting the most significant challenge at 80%. In contrast, environmental barriers had the least impact, with the highest average proportion of success at 91%. Despite the challenges, the median value consistently reached 100%, indicating that the majority of attempts were fully successful.

Among subtasks G2, R2, T1 and T2 have the highest recorded mean success proportions at 1.00 across most barriers. In contrast, subtask D6 exhibits the lowest mean success proportion at 0.26 overall, 0.25 for cognition and 0 for physical and vision barriers. Moreover, certain subtasks were not performed by individuals with vision, as indicated by the absence of data for these specific barrier in the respective subtask categories.

Figure 6-3 presents box plot of proportion of success for subtasks for various subtasks for overall

Figure 6-3: Box Plots for Proportion of Success for Subtasks Overall

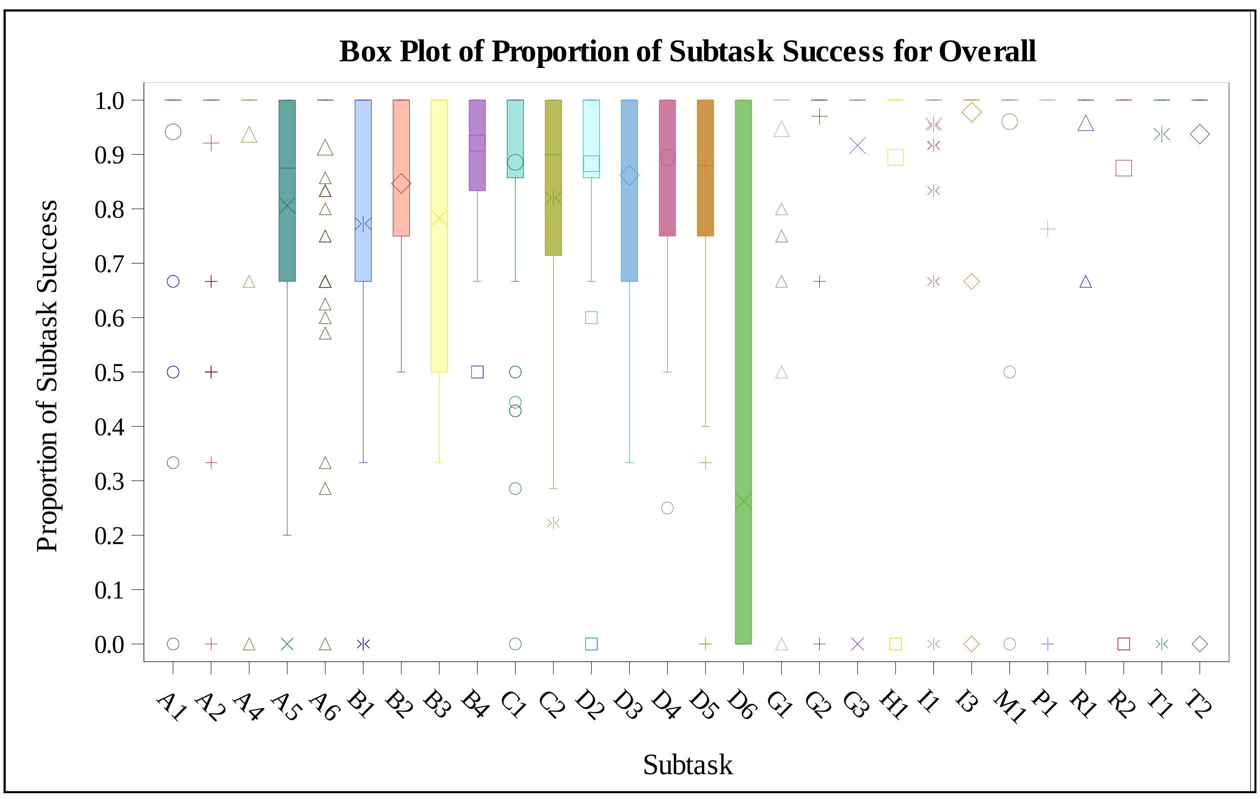


Table 6-12: Descriptive Statistics of Proportion of Subtask Success - Overall and in the Presence of Various Barriers

	Overall		Cognitive		Physical		Vision		Hearing		Motivation		Environmental	
N	1366		256		482		129		799		411		459	
Mean	0.89		0.85		0.84		0.80		0.87		0.87		0.91	
Std Dev	0.24		0.28		0.28		0.33		0.26		0.26		0.22	
Min	0		0		0		0		0		0		0	
Max	1		1		1		1		1		1		1	
Q1	0.9		0.75		0.75		0.71		0.83		0.83		1	
Median	1		1		1		1		1		1		1	
Q3	1		1		1		1		1		1		1	
Subtasks	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean
A1	80	0.94	16	0.88	27	0.90	9	0.80	48	0.94	25	0.90	27	1.00
A2	78	0.92	15	0.97	26	0.81	8	1.00	46	0.91	24	0.94	26	0.99
A4	37	0.94	6	0.94	12	0.89	2	0.50	19	0.88	8	0.88	13	0.97
A5	65	0.81	10	0.66	19	0.78	7	0.72	38	0.79	19	0.82	21	0.90
A6	80	0.91	16	0.85	27	0.82	9	0.87	48	0.89	25	0.90	27	0.94
B1	44	0.77	9	0.59	19	0.82	2	0.50	23	0.84	14	0.67	14	0.62
B2	44	0.85	9	0.83	19	0.83	2	1.00	23	0.82	14	0.84	14	0.79
B3	20	0.78	3	0.89	12	0.72	2	0.83	8	0.71	9	0.78	4	0.75
B4	77	0.92	13	0.89	26	0.94	7	0.93	45	0.92	22	0.89	27	0.93
C1	54	0.89	10	0.87	22	0.83	4	0.96	27	0.87	17	0.90	17	0.90
C2	79	0.82	15	0.73	26	0.76	8	0.71	47	0.77	24	0.80	27	0.88
D2	53	0.88	8	0.92	18	0.86	5	0.77	29	0.91	17	0.80	18	0.92
D3	50	0.86	7	0.88	13	0.73	5	0.70	31	0.88	17	0.82	21	0.87
D4	79	0.89	15	0.93	26	0.88	8	0.83	47	0.90	24	0.88	27	0.90
D5	79	0.88	15	0.89	26	0.87	8	0.80	47	0.86	24	0.84	27	0.92
D6	19	0.26	4	0.25	5	0.00	2	0.00	11	0.09	6	0.50	8	0.38
G1	80	0.95	16	0.83	27	0.92	9	0.79	48	0.95	25	0.92	27	0.95
G2	45	0.97	9	1.00	16	0.92	2	1.00	26	0.99	12	0.92	14	1.00
G3	24	0.92	6	0.83	7	0.71	0	0.00	15	0.87	5	1.00	10	1.00
H1	19	0.89	4	1.00	5	0.60	2	0.50	11	0.82	6	1.00	8	0.88
I1	60	0.96	11	0.88	23	0.92	6	0.81	37	0.95	16	0.89	18	0.99
I3	60	0.98	11	0.91	23	0.94	6	0.83	37	0.96	16	0.94	18	1.00
M1	38	0.96	8	0.81	15	0.93	4	0.63	26	0.94	9	0.83	13	1.00
P1	38	0.76	8	0.63	15	0.67	4	0.75	26	0.73	9	0.78	13	0.69
R1	16	0.96	3	0.89	7	0.90	2	1.00	9	0.93	6	1.00	5	1.00
R2	16	0.88	3	1.00	7	0.71	2	1.00	9	0.78	6	1.00	5	1.00
T1	16	0.94	3	1.00	7	1.00	2	1.00	9	0.89	6	1.00	5	0.80
T2	16	0.94	3	1.00	7	1.00	2	1.00	9	0.89	6	1.00	5	0.80

[1]*Statistics presented: N, Mean, Standard deviation, Range Med-Median, Q1-lower quartile, Q3-upper quartile*

[2]*Subtaks with 100% success rates are highlighted*

The Appendix D-6 includes descriptive statistics and box plots for proportion of success for subtasks across different barriers, supplemented by Kruskal-Wallis test results to evaluate differences across subtasks.

6.5.6 Identifying suitable subtasks for older adults with diverse limitations

To identify which subtasks are challenging for individuals with diverse barriers, a comprehensive data analysis was performed by a statistics student, employing a range of statistical methods. These methods include data manipulation and standardization, randomization and selection of participants, calculation of the cosine similarity metric, binomial regression modeling, and prediction based on personalized models.

Data Manipulation and Standardization: Initially, the dataset was cleaned and prepared, with numerical variables such as age, number of medications, cognitive scores, physical scores, vision score, SEAMS score and MPED scores standardized to ensure that the variables are on the same scale, allowing for accurate comparisons and analyses across participants.

Randomization and Selection of Participants: Three participants were randomly selected from the initial dataset and to serve as the predicting dataset. This randomization process is crucial for reducing bias and ensuring that the predictive models are tested on data that were not used in their development, thus simulating a real-world scenario where the model's performance can be evaluated on unseen data. The IDs of these participants were noted (31, 79, and 51 in this case), and they were referred to as Participant X, where X = 1, 2, 3 for each of the three randomly selected participants.

Cosine Similarity Metric Calculation (CSM): To personalize the analysis to each participant's specific profile, the cosine similarity metric was calculated between a given participant (referred to as Participant X) and each of the participants in the training data (77 participants). This metric, ranging between -1 and 1, measures the cosine of the angle between two vectors, where a value of 1 indicates maximum similarity and -1 denotes minimum similarity. Following the computation of these metrics, the participants in the training data were sorted in descending order by their similarity scores relative to each of the participants selected for prediction. Specifically, the first 80% of the training data, sorted by decreasing cosine similarity, were selected. Table 6-13 illustrates the list of 80% participants most similar to the participants in the predicting data.

Table 6-13: List of 80% Participants Most Similar to the Participants in the Predicting Data

Predicting data	80% of training data by decreasing cosine similarity
P31	34 46 12 11 29 26 3 18 25 47 74 41 76 71 13 16 27 21 30 56 40 38 62 78 1433 2 80 53 6 20 36 42 60 75 49 52 4 65 63 7 66 37 70 9 10 28 19 77 32 44 48 24 39 8 67 72 57 50 64 54 73
P79	62 13 32 11 33 27 15 80 9 47 17 52 56 54 72 68 19 76 77 28 36 39 18 73 45 24 53 50 49 1 2 48 37 43 25 57 30 75 34 10 38 42 74 65 7 40 63 60 29 20 21 16 46 14 6 78 12 35 66 70 55 71
P51	56 36 44 75 18 80 28 47 62 39 74 29 27 12 9 52 48 42 53 78 58 19 14 40 77 73 76 10 69 33 26 23 70 1 17 22 30 41 34 72 5 68 49 46 71 54 3 16 24 45 15 21 57 25 38 32 43 50 35 59 4 65

Binomial Regression Modeling: For each participant in the predicting data, a binomial regression model was created to estimate the probability of success in various subtasks. The outcome variable was proportion of success for a subtask and the predictors include standardized measures of medication number, medical history number, cognitive, physical, and vision scores, and variables for gender, motivational impairment, environmental barriers, and hearing impairment. Age was excluded from the model due to its non-significant impact, as evidenced by prior analyses.

- Model 1 - 80% of training participants most similar to Participant 31: This model was created based on the subset of data representing the top 80% of training participants most similar to Participant 31.
- Model 2 - 80% of training participants most similar to Participant 79: Similarly, for Participant 79, a customized model was fitted using data from the most similar 80% of

training participants. This model highlights different predictors' contributions to predicting subtask success.

- Model 3 - 80% of training participants most similar to Participant 51: The final personalized model for Participant 51 again uses the most similar 80% of training participants, highlighting the unique factors influencing this participant's subtask success rates.

Table 6-14 presents a detailed comparison of binomial regression model outcomes

Table 6-14: Personalized binomial regression models for predicting subtask success of medication adherence devices

Predictor Variables	Model 1 - 80% data similar to Participant 31					Model 2 - 80% data similar to Participant 79					Model 3 - 80% data similar to Participant 51				
	Estimate	Std. Error	z value	Pr(>|z|)	Sig	Estimate	Std. Error	z value	Pr(>|z|)	Sig	Estimate	Std. Error	z value	Pr(>|z|)	Sig
Gender (Male)	-0.41	0.12	-3.55	0.00039	***	-0.28	0.11	-2.46	0.01411	*	-0.43	0.12	-3.59	0.00033	***
Number of medication (std)	-0.22	0.06	-3.36	0.00079	***	-0.19	0.07	-2.87	0.0041	**	-0.28	0.07	-4.05	5.11E-05	***
Medical history number (std)	0.19	0.05	3.68	0.00023	***	0.2	0.05	3.93	8.51E-05	***	0.38	0.07	5.15	2.57E-07	***
Cognitive score (std)	0.2	0.05	3.65	0.00026	***	0.27	0.06	4.39	1.16E-05	***	0.19	0.07	2.7	0.00696	**
Physical score (std)	0.25	0.05	5.22	1.82E-07	***	0.25	0.05	5.43	5.74E-08	***	0.39	0.06	7.06	1.63E-12	***
Vision score (std)	0.41	0.06	6.36	2.01E-10	***	0.39	0.07	5.85	4.98E-09	***	0.53	0.11	4.83	1.34E-06	***
Motivation score (std)	-0.41	0.11	-3.76	0.00017	***	-0.27	0.11	-2.47	0.01363	*	-0.49	0.12	-3.99	6.69E-05	***
Environmental impairment	0.53	0.11	4.58	4.64E-06	***	0.49	0.11	4.38	1.17E-05	***	0.36	0.12	3.05	0.0023	**
Hearing impairment	-0.32	0.12	-2.74	0.00611	**	-0.19	0.12	-1.63	0.10243		-0.19	0.12	-1.59	0.11198	
Subtasks A2	-0.85	0.5	-1.71	0.0879	.	-0.6	0.49	-1.22	0.22331		-0.77	0.51	-1.49	0.13534	
Subtasks A4	-0.5	0.71	-0.7	0.48323	***	-0.35	0.7	-0.5	0.6195		-0.35	0.72	-0.49	0.62727	
Subtasks A5	-1.85	0.41	-4.47	7.98E-06		-1.55	0.4	-3.89	0.0001	***	-1.76	0.42	-4.18	2.97E-05	***
Subtasks A6	-0.86	0.43	-2	0.04504	*	-0.71	0.41	-1.71	0.08676	.	-0.59	0.45	-1.32	0.18732	
Subtasks B1	-1.87	0.49	-3.79	0.00015	***	-1.92	0.48	-4.04	5.37E-05	***	-2.15	0.48	-4.43	9.53E-06	***
Subtasks B2	-1.58	0.47	-3.35	0.00081	***	-1.62	0.45	-3.57	0.00036	***	-1.5	0.48	-3.09	0.00199	**
Subtasks B3	-2.03	0.51	-3.99	6.68E-05	***	-1.92	0.52	-3.69	0.00022	***	-1.56	0.61	-2.58	0.00982	**
Subtasks B4	-0.41	0.47	-0.88	0.38006	***	-0.31	0.45	-0.68	0.49392		-0.42	0.47	-0.88	0.38121	
Subtasks C1	-1.59	0.44	-3.64	0.00027		-1.42	0.43	-3.34	0.00085	***	-1.66	0.46	-3.63	0.00029	***
Subtasks C2	-1.78	0.39	-4.57	5.00E-06	***	-1.61	0.37	-4.36	1.28E-05	***	-1.68	0.4	-4.22	2.45E-05	***
Subtasks D2	-0.85	0.47	-1.81	0.07085	.	-0.76	0.45	-1.69	0.09169	.	-0.97	0.47	-2.05	0.04009	*
Subtasks D3	-1.4	0.46	-3.03	0.00248	**	-1.12	0.45	-2.52	0.01191	*	-1.27	0.47	-2.71	0.0068	**
Subtasks D4	-1.15	0.44	-2.65	0.00815	**	-0.95	0.42	-2.27	0.02346	*	-1.01	0.45	-2.25	0.02456	*
Subtasks D5	-1.06	0.44	-2.38	0.01734	*	-0.85	0.43	-1.98	0.04773	*	-0.87	0.46	-1.89	0.05819	.
Subtasks D6	-4.59	0.77	-5.98	2.25E-09	***	-4.31	0.69	-6.2	5.51E-10	***	-4.41	0.72	-6.15	7.62E-10	***
Subtasks G1	0.1	0.51	0.19	0.85092		0.36	0.5	0.72	0.46957		0.14	0.52	0.27	0.78489	
Subtasks G2	-0.41	0.65	-0.63	0.52927		-0.23	0.64	-0.36	0.71749		13.64	351.88	0.04	0.96908	
Subtasks G3	-1.21	0.86	-1.41	0.15756		-1.11	0.85	-1.3	0.19294		-0.33	1.11	-0.3	0.76252	
Subtasks H1	-1.01	0.88	-1.15	0.25077		-0.8	0.86	-0.93	0.35484		-0.25	1.12	-0.23	0.82131	
Subtasks I1	0.24	0.45	0.54	0.59114		0.64	0.44	1.43	0.15269		0.46	0.48	0.97	0.33479	
Subtasks I3	0.84	0.74	1.13	0.25903		1.03	0.73	1.41	0.16009		0.86	0.82	1.06	0.28945	
Subtasks M1	0.68	0.82	0.83	0.40439		0.81	0.81	0.99	0.32109		1.22	1.08	1.13	0.26037	
Subtasks P1	-1.84	0.59	-3.13	0.00173	**	-1.75	0.58	-3.04	0.00238	**	-1.73	0.59	-2.94	0.00332	**
Subtasks R1	-0.12	0.82	-0.15	0.88481		0.03	0.82	0.03	0.97312		-0.42	0.83	-0.51	0.61326	
Subtasks R2	-1.35	0.87	-1.56	0.11952		-1.22	0.87	-1.41	0.1582		-0.87	1.13	-0.77	0.44282	
Subtasks T1	-0.56	1.11	-0.5	0.61785		-0.41	1.12	-0.37	0.70999		-0.87	1.13	-0.77	0.44282	
Subtasks T2	-0.56	1.11	-0.5	0.61785		-0.41	1.12	-0.37	0.70999		-0.87	1.13	-0.77	0.44282	

[1]*Statistical test performed – Binomial Regression, E-exponential*

[2]****: high level of statistical significance with a p-value < 0.001, **:strong level of statistical significance with a p-value < 0.01 but >= 0.001, *: statistical significance with a p-value < 0.05 but >= 0.01*

Prediction and Personalization: The final step in our analysis involved making predictions using the three personalized models (model 1, model 2, and model 3) for the participants selected for the predicting dataset. This predictive analysis aims to estimate the success probability of performing each subtask, taking into consideration of the unique characteristics of each participant.

- Predictions for Participant 31: Using model 1, predictions were made for Participant 31, considering their specific demographic and limitations characteristics. The model estimated the probability of success across various subtasks, indicating that subtasks like I3, M1, I1 and G1 have the highest predicted success rates, with probabilities over 85%. This personalized prediction helps in identifying which subtasks Participant 31 is most likely to succeed at, considering their unique profile.
- Predictions for Participant 79: Similarly, for Participant 79, model 2 provided predictions based on their characteristics, indicating that subtasks like I3, M1, I1 and G1 have the highest predicted success rates, with probabilities over 96%.
- Predictions for Participant 51: Finally, predictions for Participant 51 were made using model 3. This participant showed a unique pattern, with the subtask G2 having a predicted success probability of 100%, a difference from the other participants. This again highlights the importance of personalized modeling in predicting subtask success, as it can identify specific areas where individuals are likely to achieve success.

Table 6-15 demonstrates the predicted success proportions for each subtask, arranged in descending order for the three participants within the predicting dataset.

Table 6-15: Predicted success proportions for each subtask for the three participants within the predicting dataset

Characteristics	Participant 31	Participant 79	Participant 51
Gender	Male	Male	Male
Number of medications	29	4	3
Medical history number	3	2	4
Cognitive impairment	Present, low cognitive score (approx.69% or less)	Absent, high cognitive score (90% or greater)	Absent, high cognitive score (90% or greater)
Physical impairment	Present, low physical score (approx.75% or less)	Absent, high physical score (90% or greater)	Absent, high physical score (90% or greater)
Vision impairment	Absent, high vision score (90% or greater)	Present , low vision score (approx.75% or less)	Absent, high vision score (90% or greater)
Motivation impairment	Present	Absent	Absent

Environmental impairment	Present			Present			Absent		
Hearing impairment	Both ear present			Both ear present			Both ear present		
	Subtask	Log Odds	Probability	Subtask	Log Odds	Probability	Subtask	Log Odds	Probability
	I3	2.493	0.924	I3	3.966	0.981	G2	18.267	1.000
	M1	2.338	0.912	M1	3.748	0.977	M1	5.846	0.997
	I1	1.898	0.870	I1	3.576	0.973	I3	5.490	0.996
	G1	1.752	0.852	G1	3.303	0.965	I1	5.085	0.994
	A1	1.657	0.840	R1	2.968	0.951	G1	4.767	0.992
	R1	1.538	0.823	A1	2.940	0.950	A1	4.626	0.990
	G2	1.251	0.777	G2	2.710	0.938	H1	4.372	0.988
	B4	1.246	0.777	B4	2.631	0.933	G3	4.292	0.987
	A4	1.158	0.761	A4	2.591	0.930	A4	4.278	0.986
	T1	1.101	0.750	T2	2.525	0.926	B4	4.210	0.985
	T2	1.101	0.750	T1	2.525	0.926	R1	4.204	0.985
	D2	0.806	0.691	A2	2.339	0.912	A6	4.032	0.983
	A2	0.804	0.691	A6	2.232	0.903	A2	3.858	0.979
	A6	0.795	0.689	D2	2.180	0.898	R2	3.758	0.977
	H1	0.649	0.657	H1	2.144	0.895	T1	3.758	0.977
	D5	0.600	0.646	D5	2.091	0.890	T2	3.758	0.977
	D4	0.503	0.623	D4	1.989	0.880	D5	3.752	0.977
	G3	0.444	0.609	G3	1.831	0.862	D2	3.653	0.975
	R2	0.309	0.577	D3	1.817	0.860	D4	3.613	0.974
	D3	0.259	0.564	R2	1.717	0.848	D3	3.356	0.966
	B2	0.082	0.520	C1	1.517	0.820	B2	3.130	0.958
	C1	0.070	0.517	A5	1.392	0.801	B3	3.063	0.955
	C2	-0.121	0.470	C2	1.329	0.791	C1	2.969	0.951
	P1	-0.182	0.455	B2	1.324	0.790	C2	2.949	0.950
	A5	-0.192	0.452	P1	1.186	0.766	P1	2.900	0.948
	B1	-0.208	0.448	B3	1.021	0.735	A5	2.870	0.946
	B3	-0.371	0.408	B1	1.021	0.735	B1	2.479	0.923
	D6	-2.936	0.050	D6	-1.368	0.203	D6	0.212	0.553

6.6 Perception-based usability measures

Perception-based measures in the study include the system usability scale (SUS) and NASA task load index (NASA TLX), both applied after product testing to assess usability and cognitive load, with results presented using descriptive and regression methods. Task-specific SEQ and SMEQ scores are gathered post-task to evaluate immediate usability perceptions and mental effort, respectively, and are summarized using descriptive statistics.

6.6.1 System Usability Scale (SUS) Score and NASA task load index (NASA TLX) Score

The descriptive statistics for the SUS score and NASA TLX scores reveal varied responses both overall and across limitations. For SUS, the mean scores slightly vary with the lowest average seen under vision limitations (42.87), suggesting that visual constraints may affect usability perceptions. In contrast, the NASA TLX scores are higher across all limitations compared to the overall mean (55.33), particularly for vision (65.93) and physical (61.44) limitations, indicating increased task load under these specific conditions. This comprehensive data provides crucial insights into how different limitations can impact user experience and task performance.

Across products, the SUS and NASA TLX scores vary significantly($p<.0001$), indicating different levels of usability and task load associated with each product. The SUS scores range from a low of 32.5 for APD-002 to a high of 64.38 for SM-001, suggesting varying degrees of user-friendliness among the products. Similarly, NASA TLX scores highlight differences in perceived task load, with SM-001 showing the lowest mean score (34), indicating ease of use, while APD-001 ranks highest (77.6), suggesting greater cognitive demand.

Table 6-16 presents detailed descriptive statistics of various perception-based metrics for various medication adherence devices tested, including System Usability Scale score and NASA task load index score, followed by p-values from Kruskal-Wallis and Dunn's tests to determine statistical significance.

The Appendix E-1 and Appendix E-2 includes descriptive statistics and box plots for the System Usability Scale (SUS) Score and NASA task load index (NASA TLX) Score across different barriers, supplemented by Kruskal-Wallis test results to evaluate differences across devices.

Table 6-16: Descriptive Statistics of Performance Based Measures - System Usability Scale (SUS) score and NASA task load index (NASA TLX)-Overall and under Various Limitations

	System Usability Scale (SUS) score							NASA task load index (NASA TLX)						
	Overall	Cognitive	Physical	Vision	Hearing	Motivation	Environmental	Overall	Cognitive	Physical	Vision	Hearing	Motivation	Environmental
N	283	50	94	27	170	87	96	282	49	94	27	170	86	96
Mean	47.24	47.45	46.76	42.87	45.88	44.91	46.38	55.33	56.63	61.44	65.93	57.24	62.44	56.32
Std Dev	23.35	25.21	24.87	26.23	22.62	23.36	23.88	30.59	34.9	32.86	33.44	31.38	29.63	27.67
Minimum	0	2.5	0	2.5	0	0	0	0	5	0	17	0	7	0
Maximum	100	100	100	90	100	100	100	120	120	120	120	120	120	115
Q1	30	30	30	27.5	30	27.5	27.5	29	24	35	36	30	38	34.5
Median	45	43.75	42.5	40	45	42.5	45	54.5	59	63.5	72	59	63.5	58.5
Q3	62.5	62.5	60	70	60	60	63.75	78	86	91	95	81	84	77.5

Product tested	N	Mean	Std Dev	Min	Max	Q1	Med	Q3	p-value	N	Mean	Std Dev	Min	Max	Q1	Med	Q3	p-value
APD-001	19	35.13	18.59	0	82.5	25	32.5	45		20	77.6	32.68	18	116	49	90.5	101.5	
APD-002	24	32.5	19.17	0	70	21.25	31.25	46.25		24	69.71	23.68	15	104	55.5	74.5	88.5	
PBA-001	19	40.66	17.12	2.5	62.5	25	45	52.5		19	61.16	22.7	23	108	49	59	73	
PBA-002	21	46.07	25.75	0	90	30	45	60		21	49.62	32.34	5	120	24	50	81	
PBA-003	21	39.52	20.96	0	75	27.5	42.5	50		21	71.71	25.04	19	108	59	72	91	
PBA-004	20	45.38	22.74	7.5	92.5	28.75	42.5	60	<.0001	20	53.2	27.73	6	117	35.5	49.5	74	
PBA-005	20	44	20.67	2.5	100	31.25	41.25	55		20	58.8	29.69	7	120	37	61	75	<.0001
PBA-006	18	44.72	22.85	7.5	80	30	41.25	70		17	59.53	31.91	14	110	34	51	84	
PBA-007	20	47.88	24.09	0	100	30	48.75	63.75		20	54.4	35.57	4	120	23.5	53.5	86	
PBA-008	26	50.29	25.32	5	100	32.5	47.5	70		24	53.29	33.39	0	103	22	57	82	
PBA-009	23	56.09	22.43	10	100	45	60	67.5		23	45.26	25.31	9	93	19	45	69	
SM-001	36	64.38	22.2	20	100	48.75	62.5	78.75		37	34	24.34	0	120	14	33	48	
SM-002	16	55.47	18.82	22.5	87.5	40	55	71.25		16	46.88	27.53	8	97	22.5	44	69.5	

	Comparison	adj. p-value	Comparison	adj. p-value	Comparison	adj. p-value
Dunn's Test	APD-002 vs SM-001	2.19E-05	APD-002 vs SM-001	1.41993E-14	APD-002 vs PBA-005	1.91841E-08
	APD-001 vs SM-001	0.000406	PBA-003 vs SM-001	1.57007E-12	PBA-006 vs SM-001	5.29479E-08
	APD-002 vs PBA-009	0.012247	APD-001 vs SM-001	3.2528E-12	PBA-003 vs PBA-005	2.47722E-07
	PBA-003 vs SM-001	0.01475	PBA-008 vs SM-001	7.32865E-12	APD-001 vs PBA-005	3.31486E-07
	PBA-001 vs SM-001	0.043105	PBA-001 vs SM-001	1.72468E-10	PBA-002 vs SM-001	7.47977E-07

[1]*Products tested - APD-001: MedReady 1700 Automated Medication Dispenser, APD-002: GMS Med-e-lert Automatic Pill Dispenser, PBA-001: MedQ Smart PillBox, PBA-002: MedGlider System 1 with Talking Reminder, PBA-003: VitaCarry Advanced Pill Case, PBA-004: e-pill Multi-Alarm Pocket XL, PBA-005: 100-Hour Pill Reminder, PBA-006: eNNOVEA Weekly Planner with Advanced Auto Reminder, PBA-007: Pillbox with digital timer instructions, PBA-008: MedCentre System, PBA-009: EllieGrid Smart Pillbox, SM-001: Spencer automatic pill dispenser, SM-002: Jones healthcare blister pack*

[2]*Statistics presented: N, Mean, Standard deviation, Range, Med-Median, Q1-lower quartile, Q3-upper quartile*

[3]*Statistical tests performed: Kruskal-Wallis test (p-value), Dunn's test (adjusted p-value), Significance level p<0.05*

[4]*Bonferroni correction for multiple testing in Dunn's test, E - exponent*

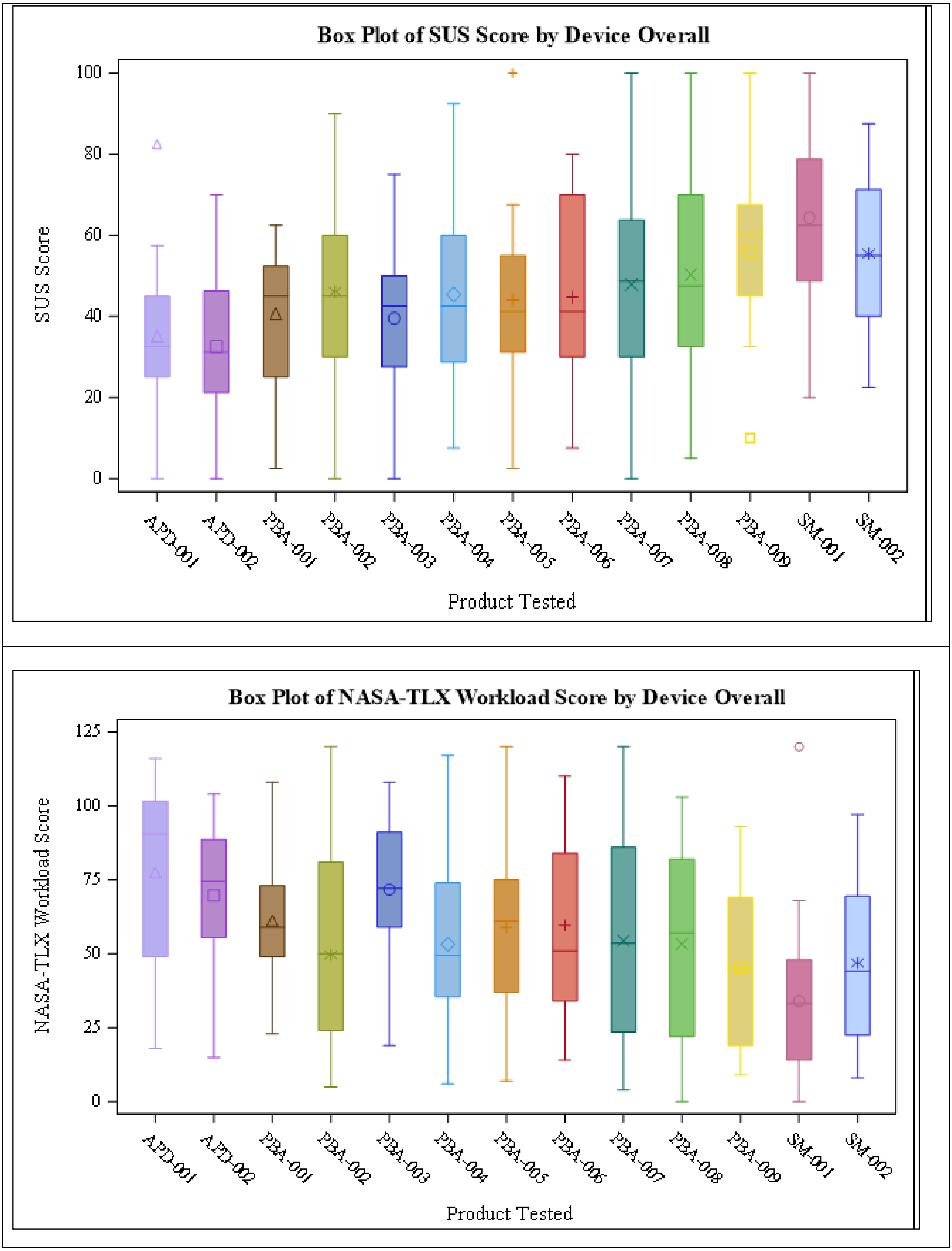


Figure 6-4: Box plot of Various Perception-based Metrics SUS and NASA-TLX Workload Score by Product Tested (Overall)

6.6.2 Impact of Single Predictor Variables on System Usability Scale (SUS) score and NASA task load index (NASA TLX)

The impact of individual predictor variables on the System Usability Scale (SUS) and the NASA Task Load Index (NASA TLX) was examined through univariate regression analyses. Each predictor variable is analyzed separately to determine its direct relationship with the outcome measures.

Among various predictors, a moderate to low vision score significantly impacted both SUS (p=0.041) and NASA TLX (p=0.009) scores, indicating the crucial role of visual capability in both usability and task load perception. Additionally, for the NASA TLX, age (p=0.033) and SEAMS score (p=0.008) also emerged as significant predictors, further highlighting specific factors that can influence task workload management.

Table 6-17 displays the parameter estimates and p-values for each predictor variable examined.

Table 6-17: System Usability Scale (SUS) score and NASA task load index (NASA TLX)- Summary of Univariate Regression Models for Each Predictor

Predictor Variables	System Usability Scale (SUS) score		NASA task load index (NASA TLX)	
Continuous Predictor Variables	Est.	p-value	Est.	p-value
Age	-0.19	0.342	0.61	0.033
Cognitive score	-0.07	0.748	-0.08	0.780
Physical score	0.76	0.318	-1.98	0.044
Vision score	0.58	0.507	-1.69	0.142
SEAMS score	0.41	0.123	-0.92	0.008
MPED busyness score	0.69	0.060	-0.16	0.740
MPED routine score	0.81	0.085	-0.69	0.266
Number of subtask for product	0.04	0.886	0.01	0.974
Categorical Predictor Variables	Est.	p-value	Est.	p-value
Gender (male)	-4.73	0.111	4.89	0.208
Medication Aid Use (yes)	-2.84	0.308	7.03	0.053
Education level				
• Masters/doctoral/professional (Ref)				
• Bachelors	1.83	0.613	-5.03	0.289
• Non-university diploma	4.56	0.546	-6.85	0.272
• High school	-2.62	0.613	6.74	0.272
Cognitive score category				
• High Cognitive Scores (ref)				
• Relatively High Cognitive Score	5.67	0.732	4.22	0.606
• Moderate Cognitive Score	2.64	0.851	9.95	0.350
• Low Cognitive Score	-0.63	0.890	-3.28	0.606
Physical score category				
• High Physical Scores (ref)				
• Moderate to Low Physical Score	0.88	0.858	9.20	0.156
• Low Physical Score	-1.35	0.858	9.14	0.050
Vision score category				
• High Vision Scores (ref)				
• Moderate to Low Vision Score	-14.13	0.041	23.01	0.009
• Low Vision Score	5.18	0.433	-0.44	0.959
Hearing impairment category				
• No impairment (Ref)				
• Impairment in one ear	-7.85	0.085	8.43	0.179

• Impairment in both ears	-1.81	0.549	3.49	0.381
Number of product tested				
• 1 product (Ref)				
• 2 products	-2.19	0.930	-64.50	0.058
• 3 products	5.60	0.930	-58.17	0.058
• 4 products	8.13	0.930	-66.98	0.056
[1]*Statistical test performed: Univariate regression, Significance level p<0.05*				
[2]*P-values were adjusted according to the Benjamini-Hochberg (BH) method to control the false discovery rate*				
[3]*Est.-Parameter Estimate*				
[4]*DF=1 for all variables*				
[5]*Dummy Variables were created for all categorical predictor*				

6.6.3 Impact of Multiple Predictor Variables on System Usability Scale (SUS) score and NASA task load index (NASA TLX)

A backward stepwise multivariate regression analysis was conducted to identify key predictors impacting the SUS and NASA TLX scores. The final model, incorporating statistically significant variables, provides crucial insights into factors enhancing system usability and task load management.

Table 6-18 summarizes the final regression model, detailing the parameter estimates, standard errors, t-values, and adjusted p-values.

In the final regression model for the SUS score, none of the predictors reached statistical significance, indicating that no clear influences on usability were statistically validated in this analysis. For the NASA TLX score, however, several predictors such as 'Age' (p=0.008), 'Vision score' (p=0.008), and the number of products used demonstrated significant impacts, suggesting these are critical factors in perceived task load. Specifically, the use of multiple products (3 or 4) showed a substantial increase in task load, highlighting their profound effect on workload.

Table 6-18: Final Multivariate Regression Model Summary - System Usability Scale (SUS) score and NASA task load index (NASA TLX)

System Usability Scale (SUS) score					
Variable	Estimate	Std. Error	t value	Pr(>|t|)	Adj. P.value
(Intercept)	26.97	10.11	2.67	0.008	0.048
MPED busyness score	0.80	0.37	2.18	0.030	0.089
MPED routine score	0.72	0.48	1.51	0.131	0.158
Gender (male)	-4.67	3.02	-1.55	0.123	0.158
Moderate to Low Vision Score	-12.40	6.41	-1.93	0.054	0.108
Low Vision Score	2.85	6.80	0.42	0.676	0.676
NASA task load index (NASA TLX)					
Variable	Estimate	Std. Error	t value	Pr(>|t|)	Adj. P.value
(Intercept)	10.09	47.41	0.21	0.832	0.832
Age	0.83	0.28	2.95	0.004	0.008
Vision score	14.15	4.67	3.03	0.003	0.008
Bachelors	-0.94	0.37	-2.58	0.010	0.019
Non-university diploma	-7.30	4.70	-1.56	0.121	0.157
High school	-5.57	5.23	-1.07	0.288	0.312
Medication Aid Use (yes)	6.21	4.95	1.25	0.211	0.249
Moderate Cognitive Score	6.75	3.63	1.86	0.064	0.092
Low Cognitive Score	49.54	16.83	2.94	0.004	0.008

Number of Products Tested					
2 products	62.66	25.30	2.48	0.014	0.023
3 products	-204.60	57.55	-3.56	0.000	0.003
4 products	-197.38	58.36	-3.38	0.001	0.004
[1]*Statistical test performed: Backwards stepwise multivariate regression process prioritized by the Akaike Information Criterion (AIC)*					
[2]*P-values were adjusted according to the Benjamini-Hochberg (BH) method to control the false discovery rate*					
[3]*Significance level p<0.05*					

6.6.4 Task SEQ and Task SMEQ Score

After completing each task, participants were asked a single ease-of-use question for each product used, designed to measure ease of task on a scale from 1 to 7, where 1 indicates "very difficult" and 7 indicates "very easy." Additionally, the Subjective Mental Effort Questionnaire (SMEQ) was applied to assess the perceived mental effort of users. This questionnaire consists of a single question, scored on a scale ranging from 0 to 150, to assess the mental workload associated with completing each task.

The various tasks involved in using the various products were coded A to U. The details of each task are given in Table 6-9 Section 6.5.4

Table 6-19 provides descriptive statistics for the Single Ease-Of-Use Question (SEQ) scores and Subjective Mental Effort Questionnaire (SMEQ) scores, both overall and across various barriers such as cognitive, physical, vision, hearing, motivation, and environmental factors.

The SEQ score, with an overall mean of 4.65, indicates a moderate level of ease across all tasks, with scores slightly lower for individuals facing cognitive (4.44), physical (4.39), and vision (mean 4.32) limitations. This suggests these particular limitations may impact the perceived ease of use more than hearing (4.49), motivation (4.53), and environmental factors (4.63). In terms of mental effort, the overall mean score is 29.71, with higher scores indicating greater effort required. Individuals with cognitive limitations reported a higher mean effort score (34.02), closely followed by those with physical (33.57), and vision (34.83) limitations. These findings highlight that tasks demanding more mental effort are perceived as more challenging for users with cognitive, physical, and visual barriers. Median scores for SEQ and SMEQ remained consistent at 5 (moderately easy) and 20 (a bit hard to do), respectively, across all limitations, suggesting a median user experience that is moderately easy and does not require excessive mental effort.

Across various tasks, Task U- Remove the blister pack from the device, with the highest SEQ mean score of 6.69 and the lowest SMEQ score of 2.50, is considered the easiest and least mentally demanding. On the other end, Task B-Unlock the device shows significant difficulty, having the lowest SEQ mean score of 3.23 and the highest SMEQ score of 59.77, indicating that it is perceived as the most challenging and mentally demanding. Tasks H- Turn the carousel and Task I-Open an app and touch on an icon /button also stand out with high SEQ mean scores of 6.56 and 6.26, respectively, along with very low SMEQ scores, suggesting that while they are considered easy, they require minimal mental effort.

Figure 6-5: Box plot of Various Perception-based Metrics SEQ and SMEQ Score by Product Tested (Overall)

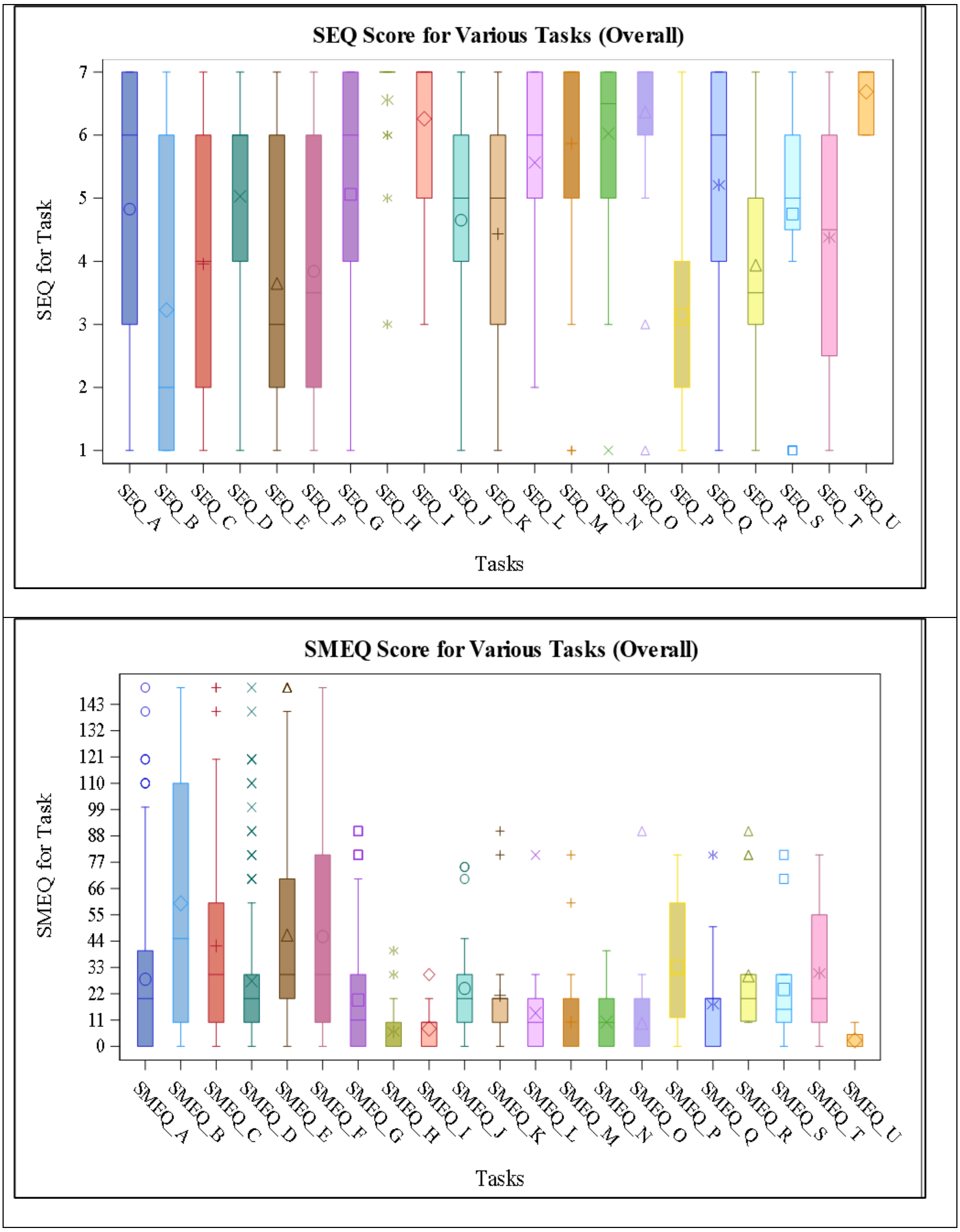


Table 6-19: Descriptive Statistics of Task Single Ease-Of-Use Question(SEQ) Score and Subjective Mental Effort Questionnaire (SMEQ) Score - Overall and under Various Barriers

	Single Ease-Of-Use Question (SEQ) Score							Subjective Mental Effort Questionnaire (SMEQ) Score						
	Overall	Cognitive	Physical	Vision	Hearing	Motivation	Environmental	Overall	Cognitive	Physical	Vision	Hearing	Motivation	Environmental
N	1470	264	502	133	861	439	495	1470	264	502	133	861	439	495
Mean	4.65	4.44	4.39	4.32	4.49	4.53	4.63	29.71	34.02	33.57	34.83	32.08	31.31	29.72
Std Dev	2.09	2.13	2.29	1.99	2.13	2.10	1.99	34.34	37.83	37.65	35.16	36.32	34.49	30.68
Q1	3	3	2	3	3	3	3	0	10	10	15	10	10	10
Median	5	5	5	5	5	5	5	20	20	20	20	20	20	20
Q3	7	6	7	6	6	6	6	40	55	50	50	40	40	40

Tasks	N	Mean	Std Dev	Min	Max	Q1	Med	Q3	p-value	N	Mean	Std Dev	Min	Max	Q1	Med	Q3	p-value
Task A	150	4.83	2.22	1	7	3	6	7		150	28.07	36.37	0	150	0	20	40	
Task B	44	3.23	2.41	1	7	1	2	6		44	59.77	51.38	0	150	10	45	110	
Task C	191	3.96	2.03	1	7	2	4	6		191	41.99	38.58	0	150	10	30	60	
Task D	233	5.03	1.83	1	7	4	6	6		233	27.34	30.63	0	150	10	20	30	
Task E	211	3.65	2.04	1	7	2	3	6		211	46.49	40.18	0	150	20	30	70	
Task F	44	3.84	2.39	1	7	2	3.5	6		44	45.91	45.92	0	150	10	30	80	
Task G	233	5.06	1.92	1	7	4	6	7		233	19.34	21.78	0	90	0	11	30	
Task H	18	6.56	1.04	3	7	7	7	7		18	6.11	11.95	0	40	0	0	10	
Task I	23	6.26	1.18	3	7	5	7	7		23	7.39	8.64	0	30	0	10	10	
Task J	23	4.65	1.47	1	7	4	5	6		23	24.22	21.98	0	75	10	20	30	
Task K	23	4.43	1.78	1	7	3	5	6	< 2.2e-16	23	21.30	22.01	0	90	10	20	20	<.0001
Task L	23	5.57	1.59	2	7	5	6	7		23	13.91	17.25	0	80	0	10	20	
Task M	38	5.87	1.77	1	7	5	7	7		38	10.13	16.95	0	80	0	0	20	
Task N	38	6.03	1.35	1	7	5	6.5	7		38	10.13	9.90	0	40	0	10	20	
Task O	38	6.37	1.22	1	7	6	7	7		38	9.61	16.12	0	90	0	0	20	
Task P	38	3.16	1.75	1	7	2	3	4		38	33.45	26.38	0	80	12	30	60	
Task Q	38	5.21	1.77	1	7	4	6	7		38	17.50	16.67	0	80	0	20	20	
Task R	16	3.94	1.73	1	7	3	3.5	5		16	29.50	27.59	10	90	10.5	20	30	
Task S	16	4.75	2.02	1	7	4.5	5	6		16	23.81	22.13	0	80	10	15.5	30	
Task T	16	4.38	1.93	1	7	2.5	4.5	6		16	30.63	28.16	0	80	10	20	55	
Task U	16	6.69	0.48	6	7	6	7	7		16	2.50	4.47	0	10	0	0	5	

	Comparison	adj. p-value	Comparison	adj. p-value	Comparison	adj. p-value	Comparison	adj. p-value
Dunn's Test	SEQ A - SEQ B	1.94E-03	SEQ D - SEQ E	9.08E-09	SMEQ A - SMEQ B	3.53E-03	SMEQ D - SMEQ E	9.37E-06
	SEQ A - SEQ C	1.86E-03	SEQ B - SEQ G	1.43E-04	SMEQ A - SMEQ C	2.01E-04	SMEQ B - SMEQ G	1.26E-03
	SEQ B - SEQ D	4.36E-04	SEQ C - SEQ G	6.63E-06	SMEQ B - SMEQ D	4.75E-02	SMEQ C - SMEQ G	6.58E-06
	SEQ C - SEQ D	5.24E-05	SEQ E - SEQ G	6.19E-10	SMEQ C - SMEQ D	8.40E-03	SMEQ E - SMEQ G	7.55E-10
	SEQ A - SEQ E	2.77E-06	SEQ A - SEQ H	3.63E-02	SMEQ A - SMEQ E	1.86E-07	SMEQ B - SMEQ H	1.61E-05

[1]*Statistics presented: N, Mean, Standard deviation, Range, Med-Median, Q1-lower quartile, Q3-upper quartile*

[2]*Statistical tests performed: Kruskal-Wallis test (p-value), Dunn's test (adjusted p-value), Significance level p<0.05*

Bonferroni correction for multiple testing in Dunn's test, E - exponent

The Appendix E-3 and Appendix E-4 includes descriptive statistics and box plots for the Single Ease-Of-Use Question (SEQ) score and Subjective Mental Effort Questionnaire (SMEQ) score across different barriers, supplemented by Kruskal-Wallis test results to evaluate differences across devices.

7 Chapter 7: Qualitative Report

Out of the 80 individuals who participated in the study, 60 completed one-on-one interviews. Data analysis was conducted using inductive thematic analysis; initially, two researchers independently coded the first five interviews, and a percentage agreement of 85% was calculated. Based on this percentage agreement, the remaining interviews were coded by one researcher. Among the 25 interviews coded, data saturation was achieved in several categories: 7 for cognition, 8 for physical barriers, 8 for hearing, 10 for motivation, and 7 for environmental factors; however, saturation was not reached for vision impairment, indicating a need for further exploration in this area. The qualitative data analysis revealed five main themes and 15 sub-themes, which are detailed in the **Figure 7-1**. A complete codebook with detailed descriptions of these codes is available in **Appendix F.** A Word cloud of most frequently reported user insights on medication management devices is given in **Figure 7-2**.

Figure 7-1: List of themes and sub-themes

Theme 1: Design and Usability

- Sub-theme 1: Device Size and Portability
- Sub-theme 2: Device Capacity and Compartment Features
- Sub-theme 3: Alarm Features and Preferences
- Sub-theme 4: Design,Ease of Use and Accessibility
- Sub-theme 5: Operational Challenges
- Sub-theme 6: Durability and Visibility

Theme 2: Technological Adaptation, Support and Familiarity

- Sub-theme 7: Technological Concerns and Preferences
- Sub-theme 8: Adaptation and Preference for Traditional Methods
- Sub-theme 9: Technology Familiarity and Comfort
- Sub-theme 10: Instructional Support and Learning Curve
- Sub-theme 11: Support and Organizational Needs

Theme 3: Inclusivity for Impairments, Security, and Privacy

- Sub-theme 12: Challenges due to Functional impairments
- Sub-theme 13: Security and Privacy

Theme 4: Socio-Economic and Environmental Considerations

Theme 5: Feedback and Iterative Design

- Sub-theme 15: Critique of Design Process

Figure 7-2: Word cloud of user insights on medication management devices

Various themes and sub-themes emerged from the analysis are described below.

7.1 Theme 1: Design and Usability

This theme addresses the critical elements of medication management devices' design and operational ease.

7.1.1 Sub-theme 1: Device Size and Portability

The sub-theme "Device Size and Portability" encapsulates participants' preferences for medication management devices that are both compact and easy to transport. Participants often highlighted the drawbacks of larger devices, frequently describing them as "cumbersome" and "awkward" due to their impracticality for regular use. The frequent remarks about these devices being "too big" and that they "take up a whole lot of space" reflect a common frustration with their presence in living spaces. For instance, one participant's negative reaction was clearly stated:

" The first thing I thought was. Oh, no. Like, it's too huge. Yeah. Where would you put it? Where the heck will we put it?" (PT-003), pointing out the substantial negative impact of device size on user satisfaction.

In contrast, smaller devices were preferred for their perceived user-friendliness and minimal spatial requirements, which made them more appealing. Participants expressed a clear preference for compactness, as one noted,

"If I had to choose one, it would be this, because it's small, easy to figure out." (PT-010)

This preference is closely linked to the devices' ease of use and the convenience of storing smaller units without occupying much space.

Additionally, the aspect of portability was crucial in shaping participants' preferences. Devices that were easy to carry and suitable for use outside the home were highly valued. Comments such as *"It just seems awkward carrying that big thing around; it wouldn't work very well" (PT-006)*

,illustrate the practical limitations of larger, non-portable devices.

Devices featuring detachable components for enhanced portability were particularly praised. Such features allow users to take only necessary parts of the device for short trips or daily outings, thus supporting more active lifestyles. A participant explained the benefit of this design:

"I can take these come in little tubs, and if I go somewhere, I can take whichever one I want. Put the lid on it and take it, put it in my pocket for the day. One for one meal or whatever" (PT-008)

This flexibility in medication management is highly regarded, underscoring the value placed on devices that accommodate the mobility needs of users.

7.1.2 Sub-theme 2: Device Capacity and Compartment Features

The sub-theme "Device Capacity and Compartment Features" highlights participants' concerns and preferences regarding the physical capacities and design functionalities of medication management devices.

Participants frequently expressed a preference for devices with larger overall capacities, which they felt would simplify their routines by reducing the need to frequently refill the device. One participant articulated this preference by stating,

"I would prefer still the two weeks. I'd rather drag this along than be filling daily," (PT-007), highlighting the convenience of managing medications over extended periods without the need for constant attention.

However, devices with smaller capacities were often criticized, particularly when they failed to accommodate the needs of users with extensive medication regimens. As one participant pointed out,

"No, the small capacity of the pill boxes required her to fill two of them daily. This setup wouldn't be suitable for a cancer patient or anyone who needs to take a large number of pills. Managing

three pills in one go was manageable, about five or six total, but any more than that, not going to work." (PT-024)

This indicates the challenges posed by insufficient capacity, which complicates medication management for users with higher needs.

The capacity of individual compartments also emerged as a critical factor, especially for those who take larger pills or multiple doses at specific times. Issues were highlighted by comments such as, *"Well, sometimes these compartments aren't large enough to hold all the necessary medications. It can get confusing," (PT-003)* and *"Um, yeah. I mean, I think that one, the compartments can be a little bigger. Especially if you have trouble with your fingers." (PT-012)*

These remarks underscore the need for compartments that are both large enough to handle various medication types and easily accessible to accommodate physical limitations.

Structured compartment divisions with clear time-of-day labels were another highlighted feature, greatly appreciated for their role in preventing medication errors. One user explained,

"I guess it would be helpful if it was labeled for the for the day... I think it is. And you need it when you're older, you need to have something that says, yeah, this is Sunday." (PT-001)

Conversely, the absence of such divisions was a significant point of contention, as evidenced by another user's comment:

"No, I still don't like all the pills in one day together... I would not touch them." (PT-008)

Slide-out compartment designs were noted for their potential risks in causing medication mix-ups, with one participant noting the ease of accidental openings:

"It's so easy to push it a little too much. The first thing I did when I opened it was that the first two compartments came out with just a slight push. I thought, 'Oh, that's no good."(PT-012)

Finally, the practicality of the width and depth of compartments was also critiqued. Participants pointed out that narrow or overly deep compartments make it difficult to organize and retrieve medication, complicating the use process significantly. As one participant mentioned,

"…like when you are trying to take out or when you're organizing your medication... the depth of these compartments, it's like a little too deep." (PT-022)

In summary, the sub-theme "Device Capacity and Compartment Features" collectively demonstrates the importance of device capacity and compartment features in the effective management of medications.

7.1.3 Sub-theme 3: Alarm Features and Preferences

The sub-theme "Alarm Features and Preferences" precisely captures participants' discussions surrounding the different alarm types and reminder mechanisms that aid in managing their medication regimens.

Vibration alerts are favored for their discretion and ability to provide reminders without drawing public attention. Participants noted that vibration is effective because it is less likely to be ignored and can be felt even in noisy environments. One user mentioned,

"*The way off is the pitch versus the volume. And you know, especially when you're carrying something around with you, it kind of like to be discreet having it go off in an elevator and everyone say, hey, what's that? I'm going to be bombed, you know, So it's but then, you know, if it's discreet, you might not be able to hear it. So that may be where on the spectrum it is to the vibration that could worked as well. You keep that in your pocket. At least you could feel it." (PT-007)*

Visual alerts, such as flashing lights, are crucial for those with hearing impairments. These alerts make it easier to notice reminders visually, ensuring that the user does not miss important medication times due to inability to hear audio alarms. A participant emphasized,

"The light if I saw it. Yeah, that helps. The flashing light helps. Since I don't hear so." Another

stated that, *“…I think it's important because we don't all hear as well as you think you can see; I can't hear behind me as well as you know. So, I think it's important to have a flashing light reminder.” (PT-010)*

The ability to customize alarm volume, tone, and frequency was highlighted as a key feature that enhances user experience. Adjustable settings allow users to tailor their medication reminders to their specific environmental needs and personal preferences.

"...setting the alarm times, tones…well there sometimes you need a louder one, you need adjusting," (PT-017) shared one participant.

The concept of a portable alarm was appreciated for its convenience, particularly for users who travel or are often away from home.

"And something that would be good is something that you could carry the reminder with you, and it would vibrate. Otherwise, if you're nowhere near the alarm, the alarm could go off forever." (PT-010) indicates the usefulness of alarms that can be carried along.

Participants also expressed a preference for alarms that correspond to each medication compartment and those that utilize an AM/PM format rather than a 24-hour clock, which can be confusing for some.

"This one I like because it would have alarms going off for every compartment," (PT-005) a participant explained.

Another user expressed dislike for 24-hour format by saying,

“Well, don't do 24-hour formats because that confuses people. I think older people, are not used to. So, I think you need to have a good size, AM/PM, but pretty well, like I don't know anybody who can't tell the difference between 2 a.m. and 2 p.m. That's pretty straightforward. Is that like. Like my. I got things. I got a microwave. Yeah. You know, they want me to put on AM or PM . Well,

I think I know if it's two in the morning, or two in the afternoon. But for sure not the 24-hour thing. So, I think that that's difficult" (PT-017)

Moreover, the discussion extended to alternative reminder methods such as smart devices and visual cues, which integrate technology into daily routines. As a participant recommended,

"I highly recommend Alexa or a similar thing to any senior"(PT-014) ,highlighting the integration of technology in daily medication management.

Overall, the sub-theme, "Alarm Features and Preferences" addresses the diverse, personalized approaches that participants favor for receiving timely and effective medication reminders, highlighting the critical role of alarm features in enhancing adherence and simplifying the management of medication regimens.

7.1.4 Sub-theme 4: Design, Ease of Use and Accessibility

The sub-theme "Design, Ease of Use, and Accessibility" encapsulates the key concerns and preferences expressed by participants regarding the operational aspects of medication management devices.

Participants stressed the importance of user-friendly designs that are easy to understand and operate without extensive reference to instructions. For example, one user stated this preference clearly:

"It was as user-friendly as any of them was. I think it'd be easier to figure it out." (PT-001)

This reflects a broad desire for devices that are intuitive, thereby minimizing the cognitive load and making them accessible to users regardless of their tech-savviness.

The ease of battery insertion was another point of discussion. Participants expressed mixed feelings about this feature. Some found it cumbersome, impacting their overall satisfaction negatively:

"The battery was a little bit annoying." (PT-001)

Others appreciated devices that provided ease in this aspect, indicating that the physical interaction with the device significantly affects user experience.

Setup processes presented significant challenges, especially when configuring alarms and device settings, which could lead to user frustration. One participant noted:

"I didn't like this one at all. I guess because I really struggled getting it hooked up or whatever. Like, I'm not very, very savvy with electronic stuff." (PT-001)

This highlights the need for straightforward, intuitive setup procedures that accommodate users with limited technical skills.

Button design was a critical area of focus. Small, hard-to-press buttons presented difficulties, particularly for users with physical limitations such as arthritis. Complaints about tiny buttons that required additional tools like pens for operation were common:

"Oh, my gosh, no. There's little tiny writings and those little, tiny, tiny buttons that are like a millimeter, you know, less than a size is horrible." (PT-003)

This underscores the need for ergonomically designed buttons that are easy to manipulate and well-spaced to prevent accidental presses.

Participants also expressed a preference for simplicity in device design, avoiding unnecessary complexity that could confuse or overwhelm, especially those with cognitive impairments. One user explained:

"Though, they want it really big, and fancy and they figure, Oh, wow, this does this and this and the people will love it. But you know what? Sometimes you don't need something so complicated. The less complicated, the better." (PT-008)

This sentiment was echoed across responses, indicating a strong preference for devices that streamline medication management without adding extra hurdles.

Display size was another important factor, with a call for larger screens to aid those with visual impairments:

"Well, I suppose larger is better just because it's easier to see." (PT-012)

Conversely, small screens were criticized for their difficulty in use, highlighting the need for displays that accommodate reduced vision capabilities.

Interactive features like talking devices were highlighted for their benefits to users with visual impairments, providing audible instructions and reminders which enhance the usability of the device:

"... it tells you when your next alarm is going to go off and, I guess as long as you have it set up properly, it would be very helpful." (PT-009)

In summary, the sub-theme "Design, Ease of Use, and Accessibility" reflects the comprehensive discussion on how the physical and operational design of medication management devices should cater to the ease of use and accessibility needs of diverse users. This includes everything from the tactile feedback of buttons to the audio-visual features that assist users with sensory impairments, emphasizing a design approach that promotes inclusivity and user-friendliness.

7.1.5 Sub-theme 5: Operational Challenges

The sub-theme "Operational Challenges" effectively captures the range of practical difficulties that participants reported while using medication management devices.

Many participants struggled with compartments and medication packages that were difficult to open, a significant barrier for users with physical limitations like arthritis. One participant voiced this concern, saying,

"However, the little pill packets that go with it were the worst. You know. Because they were too hard to open." (PT-024)

This challenge highlights the necessity for medication management devices to be designed with ergonomic considerations that cater to the needs of users who may have limited strength or dexterity.

On the other hand, the value of easily accessible compartments was underscored repeatedly, illustrating a critical need within the user base. As articulated by one participant,

"If I have arthritis and I do get arthritis and then I can't even hold a knife or fork. So, the compartments have to be easy to open." (PT-024)

This comment reflects a widespread call for designs that enable independence and ease of use, particularly for those who struggle with common physical impairments.

The time-consuming nature of setting up, filling, and learning to use these devices also emerged as a significant concern. Devices that require extensive time to understand and use can deter consistent use, especially among older users who prefer simplicity. Statements like

"I think these ones here with the cups and you got to unscrew the cups. Kind of time-consuming," (PT-005) and

"I don't think I'd even bother trying. I wouldn't even try it. Yeah, that's a fair assessment, right? The amount of time it takes to learn it isn't worth," (PT-018)

highlight the frustration and discouragement felt by users when faced with complex operational procedures.

Furthermore, the effort and stress associated with using these devices were frequently cited as major drawbacks. Many participants found the process not only time-consuming but also physically and mentally demanding. This sentiment is encapsulated in the quote,

"Not that retired people have a lot to do but no it just yeah it's just a lot of effort as opposed to the other ones where you just open it. They're all there," (PT-001)

which highlights the need for device designs that prioritize straightforward, stress-free interactions. Overall, the sub-theme "Operational Challenges" reflects the focus on the functional difficulties encountered by users. It highlights the critical need for medication management devices to be designed with considerations that minimize the time, effort, and stress involved in their daily use, thereby enhancing the overall user experience and adherence to medication regimens.

7.1.6 **Sub-theme 6: Durability and Visibility**

The sub-theme "Durability and Visibility" addresses the concerns surrounding the physical durability and visual accessibility of medication management devices, highlighting how these factors are essential for the longevity of the device and accurate medication usage by individuals. Durability is a key concern for users who fear that materials like "flimsy plastic" or cardboard might not endure the rigors of daily use or accidental mishaps. This concern is expressed by one participant who criticized the use of inferior materials:

"*Yeah, about this? Not the best idea to use cardboard for that. Really, it's not smart. You've got this plastic part that could've been engraved, which means it wouldn't wear out because you're not directly touching it. But with cardboard, the moment I open it and accidentally touch it, the whole thing shifts. Suddenly, it's showing a completely different day, and I didn't even notice." (PT-024)*

Such comments underscore the need for manufacturers to select materials that are not only durable but also capable of maintaining the integrity of the device's functionality over time, preventing issues that could complicate medication adherence.

Visibility within the device is equally critical. The ability to easily see and identify the contents of a medication compartment ensures that users can manage and administer their medications correctly.

“So I guess the fact that you could see the pills and so on, like you could see them sort of in front of you, whereas with this device and the package and all that, you couldn't really see what you were taking, I guess.” (PT-012)

This statement points to the importance of clear compartments and well-designed packages that support users in their medication management routines.

In summary, the sub-theme "Durability and Visibility" illustrates the significance of the participants' feedback regarding the physical and visual attributes of medication management devices. It demonstrates that enhancing the durability of the materials used and ensuring the visibility of medication within these devices are crucial for effective and safe medication management. These aspects not only contribute to the longevity of the device but also significantly impact the ease and accuracy with which users can follow their medication regimens.

7.2 Theme 2: Technological Adaptation, Support and familiarity

This theme explores the challenges and opportunities related to adopting technology in medication management, focusing on user familiarity, support mechanisms, and the balance between high-tech features and user-friendly design.

7.2.1 Sub-theme 7: Technological Concerns and Preferences

The sub-theme "Technological Concerns and Preferences" explores the concerns and preferences that users have regarding the integration of technology in medication management devices.

Many users expressed significant worries about the reliability of technologically advanced medication devices, especially the risks associated with potential technological failures that could lead to critical medication errors. As one participant aptly put it,

"It's all technology. What happens if like with your computer it goes down. You don't know about the failure. You miss your pills. And what happens if the button start beeping at 4:00 and you were supposed to take your medication at 3:00." (PT-003)

This concern underscores the critical need for dependable technology in devices designed to manage something as crucial as medication.

Moreover, the integration of technology often presents a steep learning curve, particularly for older adults who might not be as familiar with digital tools. This lack of technological literacy can significantly hinder their ability to utilize these devices effectively. Reflecting on this, one user explained,

"No. Everything is far too advanced for me mentally. I'm not all that, so I can't even use a cell phone properly. So, I need something simple like this. That's the one with the lid that comes up. I could never handle that machine." (PT-013)

Another user added,

“I'm old. I just think we're going too far with technology. I prefer sort of a hands on, like the dosette. ...I was not raised with technology, so that makes a big difference. I think, you know, for people my age, none of them work. They're too techy.” (PT-016)

These statements reveal the challenges and frustrations faced by users as they interact with new technological solutions.

Despite these hurdles, some participants recognized the advantages of technology in improving the convenience and accuracy of medication management. A user commented on the potential benefits of mobile applications:

"Yeah, I think mobile applications to remind you take medication. I think that would be the best because you could have it set up. So now it depends on once again, the individual." (PT-020)

This reflects a segment of the user base that values the enhancements technology can provide, balancing the scales between technology’s benefits and its challenges.

Privacy concerns related to the handling of sensitive medical data were also a significant issue. One user expressed unease about data security:

"I'm a little touchy on the privacy side, and too many people seems can get into that kind of thing… Kind of scary," (PT-007)

highlighting the importance of robust security measures to protect personal health information.

Lastly, the dependency on reliable internet connectivity emerged as a barrier, particularly in regions with inconsistent internet service. This limitation was pointed out by a participant who noted the practical issues with connected devices:

"Yeah. I find I go to places where there is no internet... So that would be, I know the only one I would consider in any way would be that electronic one," (PT-008)

which highlights the challenges faced by users in technology-based medication management scenarios.

Thus, the sub-theme "Technological Concerns and Preferences" effectively addresses the breadth of issues and preferences associated with the technological aspects of medication management devices. It highlights both the concerns about the incorporation of technology in these devices and the potential it has to significantly enhance user experience, provided the challenges can be appropriately addressed.

7.2.2 Sub-theme 8: Adaptation and Preference for Traditional Methods

The sub-theme "Adaptation and Preference for Traditional Methods" effectively encapsulates the range of user attitudes towards traditional versus technologically advanced medication management methods.

Many users exhibit a strong preference for traditional, familiar methods of medication management and display considerable resistance to adopting new technological tools. This resistance is often rooted in comfort with established routines and a reluctance to disrupt these practices. For example, one user plainly stated,

"You got the pill bottle. That's what you need. That's all you need. I don't need any of this. Yeah, I just need the pill bottle." (PT-003)

Another user expressed their hesitance to deviate from their routine:

"For me, I find that as I get older, I've become set in my ways. I do my laundry on Monday, not on Tuesday; it has to be Monday. I don't want to change. Please, don't make me change." (PT-003)

These comments reflect a general sentiment among some users who find solace and simplicity in the familiarity of traditional methods and are cautious, or even adverse, to introducing new complexities into their routines.

Additionally, age-related challenges in learning new technologies play a significant role in shaping preferences. As users age, their ability to adapt to and learn new systems can diminish, making the shift to technologically advanced devices more daunting. This is captured by the observation that *"you know, you get to a certain age or not everybody ages the same, but some people may find it really challenging to learn a new system. Right." (PT-003)*

This statement acknowledges the diversity in aging experiences and the impact it has on technological adoption.

Despite the preference for traditional methods by many, there is also an acknowledgment of the benefits that technologically enhanced devices can offer, especially for managing complex medication regimes. These devices can significantly simplify the medication-taking process for users who must navigate multiple medications across different times. One user highlighted the utility of such systems:

"So, if you think about it, if you have to take medication four times a day and they're different medications, it gets complicated. For example, you might take a red pill at one time, an orange pill at another, and two white pills at yet another time. It can all become too much. So, this system really simplifies the whole process, I think." (PT-005)

This illustrates that while traditional methods are favored for their simplicity and familiarity, the structured support offered by newer devices can be appealing for its ability to reduce the complexity inherent in extensive medication schedules.

Overall, the sub-theme "Adaptation and Preference for Traditional Methods" highlights the dual perspectives on medication management—the comfort found in traditional, well-understood methods versus the potential benefits of embracing new technological solutions. It reflects the diverse decisions users make based on their personal experiences, capabilities, and the complexity of their medication needs.

7.2.3 Sub-theme 9: Technology Familiarity and Comfort

The sub-theme "Technology Familiarity and Comfort" captures how users' familiarity with and comfort level regarding technology significantly influence their preferences for and ease of adoption of medication management devices.

The ease with which users transition to using new medication management technologies can be greatly enhanced if these devices resemble other familiar tools from their daily lives. One participant made a relatable comparison that underscored this point, saying,

"I have to laugh because of my second career in life was a professional cat sitter…So, anyway, so I looked at it and I thought, it looks like an automatic feeder because some my clients had an automatic feeder. Right. Same thing. And it just dispenses...So it's kind of like that. Very, very much like that. Like, here's your meds for the day. Same. The same thing. Same principle." (PT-003)

This comparison between a medication dispenser and an automatic pet feeder illustrates how familiarity with similar technologies can reduce the learning curve and enhance user comfort.

Additionally, the importance of regular interaction with technology to maintain proficiency is another critical aspect of this sub-theme. Just as skills can diminish without practice, infrequent use of technologically advanced medication devices can lead to challenges in operation. A participant highlighted the importance of routine in maintaining technological skills:

"Although sometimes I know people that, you know, they'll send a picture, they'll send a picture on email, but then they don't do it for a month. 'How do I send a picture?' You know, you just, you know, it's a whole new you if you don't do a lot. I think it's true for everybody. But if you don't do it a lot, you get rusty, it's not as easy to do." (PT-017)

This comparison to the common task of sending pictures via email emphasizes how continuous engagement with technology can help keep users adept and confident.

Overall, the sub-theme "Technology Familiarity and Comfort" reflects the understanding that users' pre-existing familiarity with technology and their ongoing interaction with it are key factors in how effectively they can adopt and use new medication management devices. It stresses the need for device designs that consider the user's technological background and provides an environment where they can easily learn and feel comfortable with new tools.

7.2.4 Sub-theme 10: Instructional Support and Learning Curve

The sub-theme "Instructional Support and Learning Curve" highlights how users navigate the instructional materials of medication management devices and the challenges they encounter in understanding and using these aids effectively.

Several participants expressed frustration with instructional materials that were not provided in a language they could understand, which significantly impeded their ability to use the devices. One user’s comment encapsulates this difficulty:

"Well, I thought that all there was Chinese. Like wrong language." (PT-003)

This highlights the critical need for instructions to be accessible in the user's native language to avoid alienating users and complicating the learning process.

Unclear and incomplete instructions also posed substantial barriers to effective device usage. For instance, one user mentioned,

"it doesn't say AM and PM, you got to figure that out yourself. Okay. So that would confuse me as an older person." (PT-005)

Another user pointed out problems with the visual quality of instructional materials:

"On this one you can barely see some of the photos and the reproduction are so grey that you can't really see what it's pointing at or where it is on the device. Like this line on device. How do I find that here?" (PT-024)

These experiences illustrate the necessity for clear, complete, and well-presented instructions to ensure users can operate devices without additional confusion or errors.

Many users expressed a preference for straightforward, step-by-step instructions that guide them through the process of setting up and using their devices. One user described their ideal instruction format:

"The description of the whole module identified exactly which number each section was. And then it went on to tell you what number, what button to press. So, once you realized that that was number seven, then, you know, I think it would be really easy to learn to use." (PT-020)

This preference underscores the value of clear and concise instructions in helping users overcome initial difficulties.

While some users struggled with external online or video instructions due to their lack of technological proficiency, others found that these resources could be beneficial once the initial barriers were overcome. A participant reflected,

"But you'd have to have a separate video for this, right? Like on your phone or whatever. Yeah, I guess it'd be handy. But don't you see? As soon as that happens, you'd need to have a certain level of technical expertise, which a lot of people, especially older people, don't have. So right off, you just think, 'Oh, I can't do this." (PT-012)

This illustrates the dual-edged nature of digital instructions, which can either facilitate or complicate the learning process depending on the user's tech skills.

Furthermore, many users showed a strong preference for receiving personal instruction from healthcare providers or pharmacists. They valued the direct interaction and tailored guidance that could be provided by a professional:

"They're starting to just use pictures, which is not always somebody's strength. But what I do find is that, you know, you have alternatives, you know, you can go to your pharmacist and ask them if you bought it through a pharmacy or wherever you purchased from. And most people know how to operate them. And I'm much better if somebody shows me first because I'm more patient in terms of how I learn things." (PT-005)

This preference for personalized, face-to-face instructional support further highlights the need for adaptable learning resources that accommodate various learning styles and capabilities.

Overall, the sub-theme "Instructional Support and Learning Curve" effectively describes the challenges and preferences related to the instructional aspects of medication management devices. It emphasizes the need for clear, accessible, and user-friendly instructional content that can help users navigate the initial difficulties and enhance their long-term experience with these technologies.

7.2.5 Sub-theme 11: Support and Organizational Needs

The sub-theme "Support and Organizational Needs" delves into the types of support systems and organizational aids that users find essential for managing their medications effectively.

Many users find the technical aspects of modern medication devices challenging and often depend on assistance from family members or healthcare professionals to set up and manage these systems. This dependence is underscored by one user's experience:

"They're (devices) too techy, and unless they had a child that would come and set it for them. My grandson probably can set that. But for me, no." (PT-016)

This reflects a common scenario where the complexity of the devices necessitates external support, emphasizing the importance of user-friendly design that accommodates all levels of technical skill.

Additionally, some users prefer to have their medications pre-organized by professionals to minimize the risk of mistakes. One participant highlighted the value of this approach:

"They're filled by the pharmacist, and all you have to do is plump them out. So, organization is key because that is what someone else is taking over that function. That's right. I rather have somebody else do that. So, I'm sure I don't make a mistake." (PT-003)

This preference not only ensures accuracy but also relieves users from the burden of managing complex medication schedules themselves.

The availability of technical help and customer support is another critical element within this theme. Users appreciate being able to reach out for help similar to other technology support systems:

"I think so. I mean, it's like a computer. You know, you have to call the help line. That's all right." (PT-010)

Access to reliable support can alleviate concerns about using new devices and is crucial for addressing any issues that may arise during their use.

Moreover, many users show a strong preference for devices that come pre-filled or pre-packaged with medications from the pharmacy. This setup significantly simplifies the medication management process by eliminating the need to manually organize pills:

"And you didn't have to do anything on your own yet. You didn't have to organize your pills. Yeah. You don't have to do any of that. I mean, it comes from the pharmacy, right? Yeah." (PT-008)

However, the limitation of these systems to include over-the-counter (OTC) medications remains a concern, as noted by one user:

"But also, when you take several over-the-counter meds that wouldn't be included in that. So that would just be a bigger problem." (PT-026)

This highlights the need for systems that can accommodate a full range of prescription and non-prescription medications to truly meet the needs of users with complex regimens.

To summarize, the sub-theme "Support and Organizational Needs" captures the fundamental aspects of how support from others and well-structured organizational systems are crucial for many users in effectively managing their medication. These elements reduce the likelihood of errors, enhance ease of use, and ensure that medication management can be as efficient and stress-free as possible.

7.3 Theme 3: Inclusivity for Impairments, Security, and Privacy

7.3.1 Sub-theme 12: Challenges Due to Functional Impairments

The sub-theme "Challenges Due to Functional Impairments" addresses the various difficulties that individuals with physical, vision, memory, hearing, and touch impairments encounter when using medication management devices.

Physical impairments, especially conditions like arthritis, significantly impact users' ability to interact with medication management devices. The difficulty in performing tasks requiring fine motor skills, such as pressing small buttons or opening tight compartments, is a common issue. One user described the challenge:

"Yeah, just to rotate it and open it. I mean. Yeah, you have to really have a lot of dexterity. And for older people, myself included don't have that. I think it wasn't set up for older people." (PT-012)

Another expressed frustration with devices not suited for those with tremors:

"...I can't imagine how it could be. No, because if you are shaking or have tremor, you're really likely to make mistakes. Yes. Also, with the time and the tiny buttons. And then when you have to take the medication, well, dump it. Too difficult." (PT-022)

Vision impairments create challenges in reading small fonts or discerning details on devices without sufficient contrast. Users with poor vision require devices with large, clear displays to ensure they can interact correctly with their medication regimens. A participant highlighted the importance of visual clarity:

"Yeah, maybe if you had a bit of a vision problem, more than I have, it would be more difficult. For me, I can't see what they are - I can see that there's something there." (PT-012)

High contrast is also crucial, as another user pointed out:

"But you know, like I'm fairly early stages macular at this point, and one eye is not as bad as the other. But I do have cataracts that are developing as well. So, I need I like to have contrast. That is a good contrast from here. Just because of the light background and the black lettering." (PT-005)

Memory impairments necessitate devices that are simple to use and provide effective reminders. The complexity of operating modern devices can add cognitive strain, making it difficult for users to manage their medication schedules. One user expressed dissatisfaction with a device's usability for those with memory issues:

"This thing? way too small. It's just not going to work for someone older, or anyone who's got trouble remembering things. Like, who cares about the exact hour for taking meds if you can't even remember what day it is, right?" (PT-024)

Voice reminders were suggested as a helpful feature, reinforcing medication schedules through audible cues:

"If there was some way you could record a voice in and the voice said, Thank you. Take your 10:00 am pills. And if the pills had not been removed in five minutes, like, take your 10:00 am pills again…. I can set that same message every two minutes if I want." (PT-014)

Touch impairments such as neuropathy also complicate interactions with device interfaces, as affected users may struggle with the tactile feedback necessary to operate them effectively:

"Yeah, with neuropathy, it's hard to tell if you're pressing hard enough." (PT-016)

Lastly, hearing impairments require alternative alert systems, such as visual or vibrating alerts, to ensure that users do not miss important reminders. A user with hearing challenges described adapting technology for personal use:

"What I use is very simple. I use my cell phone for keeps, for texting. My family. I don't hear too well. I use the phone because it connects directly to my ears. My hearing aids. Yeah. So, I can hear much better. I use it to control my hearing aids and for a few other little things, but for pill taking, not sure might be complex." (PT-008)

In summary, the sub-theme "Challenges Due to Functional Impairments" effectively captures the diverse and significant issues that arise from various physical and sensory limitations. It emphasizes the need for medication management devices to be designed with features that address these challenges, ensuring accessibility and usability for all users.

7.3.2 Sub-theme 13: Security and Privacy

The sub-theme "Security and Privacy" examines the security and privacy concerns associated with medication management devices, particularly emphasizing the challenges and preferences related to locking mechanisms which are crucial for safeguarding the user's medications.

A significant issue is the use of physical keys in medication devices, which can pose practical challenges for seniors who might easily lose small items or have difficulty using them due to physical impairments. As one user vividly described their frustration with such systems:

"You couldn't get the key to work. I couldn't get it open... I thought, what? you have to have a key to get in. But a senior could easily lose things like that is just an awful, awful device." (PT-003)

Another user expressed similar concerns about the impracticality of keys:

"It can get lost so easily. I'm old, I drop it, it goes under the stove, it goes under the table, I can't get it, therefore I can't get up my pills for the day. So yeah, that key is definitely no. I understand why it's there, but I don't think it's necessary." (PT-024)

There is a strong preference for simpler locking systems that do not complicate the opening process. Users advocate for security mechanisms that are easy to operate, indicating that while security is necessary, it should not hinder usability:

"So I could see having a lock or having some way to open it. But I don't think it has to be quite that difficult." (PT-019)

This sentiment is further supported by suggestions to improve design, such as placing the lock on the top of the device to avoid the need to manipulate the device awkwardly:

"First of all, if it could be locked from the top so that you don't have to turn it upside down like that, it just adds another barrier, trying to juggle how you hold it to open." (PT-019)

Despite these challenges, the necessity for a locking mechanism is acknowledged by some users as essential for preventing accidental or unauthorized access, particularly in households with multiple people:

"Well, I think you have to have some security. Because otherwise, if somebody was frustrated and thought they hadn't taken their pills or whatever, they might accidentally open it and take things they shouldn't be taking." (PT-017)

Alternative locking options such as codes or electronic tags are seen as potentially easier to manage than physical keys and could accommodate a wider range of users:

"Well, code would be good. But I would maybe remember it, but maybe somebody else might not," (PT-008) suggesting that innovative solutions could better meet user needs.

Additionally, there are concerns about making devices childproof without making them overly difficult for adults to use, reflecting a need for balance in design:

"Well, our grandchildren come in and look at them saying, Oh, those look colorful. It can be an issue. But to make it childproof, it's a bit much. Or if you're going to do that, then have it someplace where it's easier to access, you know." (PT-017)

Overall, the sub-theme "Security and Privacy" effectively addresses the complex interplay between ensuring secure storage of medications and maintaining easy access for intended users, particularly those with physical or cognitive impairments. This theme highlights the importance of designing medication management devices that safeguard privacy and security without adding unnecessary complexity or burden.

7.4 Theme 4: Socio-Economic and Environmental Considerations

This theme delves into the socio-economic and environmental factors influencing the adoption and operation of medication management devices, highlighting the impact of device costs, insurance coverage, and the environmental impact of device manufacturing and disposal.

7.4.1 Sub-theme 14: Environmental and Financial Considerations

The sub-theme "Environmental and Financial Considerations" addresses the broader context in which medication management devices operate, focusing on the environmental impacts of these devices, user preferences for their power sources, concerns over the costs of these technologies, and the challenges posed by lack of government or insurance coverage.

Environmental concerns are a significant issue for many users who are worried about the sustainability of the devices they use, especially those that involve disposable components or use non-recyclable materials. One user expressed their discomfort with the environmental impact of such devices:

"Well, it seemed like a lot of environmentally unfriendly stuff. Like each time you get your pills, you've got this little plastic packet and we're trying to cut back on packaging. I can see where a lot of people, me included, would not be happy with those." (PT-012)

This statement reflects a growing awareness and concern about the ecological footprint of medical products and the desire for more sustainable solutions.

Power source efficiency and the ongoing costs associated with electronic medication devices are also major concerns. Users are particularly wary of devices that require frequent battery changes, which can become expensive and inconvenient. A user highlighted these concerns, saying,

"But then you have to think like you're using battery power, right? So how many batteries in there? You know, it takes more power, right? What happens when you need a battery and you got to put it in. It's probably a $50 for battery." (PT-003)

This comment underscores the need for energy-efficient designs that minimize long-term operational costs.

The cost of medication management devices themselves, along with insufficient government or insurance support, poses significant barriers to accessibility, especially for seniors on fixed incomes. The high upfront costs, coupled with ongoing expenses such as subscription fees for connected services, make these devices unattainable for many. A user articulated this barrier:

"Um, I just don't think it's practical. I know that this is going to be an expensive piece of machinery to have in my house. It's the subscription fee I think of. You know what? Seniors don't like parting with money. Believe me, $50 a month, It wouldn't happen." (PT-024)

Despite these financial hurdles, there is still a willingness among some users to invest in reliable medication management devices if they substantially reduce the complexity and burden of managing medications. One user expressed their readiness to pay for such convenience:

"And I would pay what I pay $100 a month for that. Because if I knew that it was very, very important to take the pills when they're supposed to be taken in, in great quantities. And it, it would all be set up, it would be sort of worry-free. I think it would be worth it." (PT-017)

Overall, the sub-theme "Environmental and Financial Considerations" captures the dual challenges of ensuring environmental responsibility and economic feasibility in the use of medication management devices. It highlights the need for devices that are both ecologically and economically sustainable, enabling wider accessibility and adherence to medication regimens without imposing undue financial or environmental concerns.

7.5 Theme 5: Feedback and Iterative Design

This theme focuses on the critical examination of the design process for medication management devices, highlighting the necessity for a user-centered approach that integrates direct feedback from end-users, particularly those with impairments or elderly users.

7.5.1 Sub-theme 15: Critique of Design Process

The sub-theme "Critique of Design Process" addresses concerns about the methodologies used in developing medication management devices, specifically pointing out the frequent neglect of a user-centered approach in the design phase.

There is a significant concern among users that many medication management devices lack a user-centered design, often featuring elements that are not suitable for all users, especially those with physical limitations. This issue is compounded by the use of small buttons and complex interfaces that can be challenging for users with larger hands or those with physical disabilities. One user expressed their difficulty with the device interfaces:

"The second thing I noticed with almost all the devices was the menu layout. It is a concerns for people with larger fingers or hands. It seemed like most devices weren't designed with them in mind. I felt that if my fingers were larger or if I had pudgy hands, I would struggle to set or use these devices." (PT-024)

Another user lamented the oversight in user-focused design:

"They're difficult to take out medication, the designers aren't thinking about the end user as much as they should sometimes," (PT-017)

These comments highlight the frustrations with designs that do not consider the ergonomic needs of a diverse user base.

Additionally, the critique extends to the recognition that user needs vary widely, and yet, many medication management systems lack the necessary flexibility to accommodate this diversity effectively. Devices often do not offer enough customization options to address individuals' unique medication schedules or physical capabilities, which can limit their usefulness. A user pointed out the limitations of such a one-size-fits-all approach:

"Well, it depends on the individual. For me this would actually work, this would be the easiest to work with because I only take one pill twice a day and the rest is just singles. But for someone who is taking, you know, multiple pills at specific times of day, then this may not be useful." (PT-020)

This statement underscores the need for device designs to be adaptable to accommodate the full spectrum of user requirements and preferences.

Overall, the sub-theme "Critique of Design Process" reflects the critical perspective users have towards the development of medication management devices, stressing that designs should be more inclusive and attentive to the varied needs of all potential users.

8 Chapter 8: Discussion And Conclusion

8.1 Discussion

This study examines the usability and user experience of medication adherence technologies (MATech) for older adults facing various barriers such as physical, cognitive, sensory, motivational, and environmental challenges. Using both quantitative and qualitative data, this study provides an evaluation of how these technologies perform across diverse users. It identifies the most suitable devices based on usability metrics, assesses how different demographic and barrier factors affect these metrics, and identifies features of MATech that are most appropriate for older adults with diverse needs. Findings from the qualitative component delve into the practical aspects of MATech, highlighting the features that users find most and least beneficial, exploring the challenges they encounter while using them, and their preferences regarding the design and functionality of the devices.

8.1.1 Medication Usage and Chronic Conditions Among Older Adults

In our study, 90% of participants reported using medications, reflecting the high rates of medication use among Canadian seniors as reported by the Canadian Institute for Health Information (CIHI).[239] Specifically, 41.25% of our seniors were taking between three and five medications, and 23.75% were managing more than six, which aligns with the 27% polypharmacy rate found in the 2008 Canadian Survey of Experiences with Primary Health Care.[241,242] This similarity underscores the widespread and complex medication management needs within this demographic. Additionally, our findings on chronic conditions mirror national trends: while the National Council on Aging notes hypertension and high cholesterol as the most prevalent conditions affecting nearly 60% and over 50% of older adults respectively, our study identified cardiovascular diseases as the most common at 56.25%, followed by metabolic and endocrine disorders at 35%.[242] This correspondence highlight consistent healthcare challenges and the necessity for targeted management strategies for aging populations in Canada.

8.1.2 Use of Medication Management Aids and Strategies

In examining the use of medication management aids among community-dwelling older adults, our study found that a significant majority (61.25%) relied on placing pill bottles in a specific location and taking medications in association with meals or bedtime to manage their medications. This is reflective of findings from Marek and Antle, who emphasize the importance of structure and routine in preventing nonadherence, a major factor contributing to hospital admissions and decreased quality of life among the elderly.[28] Similarly, the use of pillboxes in our study (47.5%) aligns with evidence suggesting that such aids significantly enhance medication adherence and management, a crucial aspect considering the vulnerability of older adults to adverse drug reactions and the complexity of their medication regimens.[243,244]

Our findings also revealed a notable reliance on alarm beepers (10%) and assistance from others (6.25%) for medication management. This indicates an effective approach among older adults incorporating both technology and social support to ensure adherence, highlighting the complex nature of effective medication management strategies recommended in the literature.[28,243-246] However, the use of blister packs and medication calendars was notably low in our study (5% and 1.25%, respectively), despite evidence suggesting their effectiveness in simplifying complex regimens and improving adherence.[28]

8.1.3 Measuring Barriers to Medication Management in Older Adults: Tools, Challenges, and Implications

In our comprehensive assessment of barriers to medication management among older adults, we used a variety of measurement tools to assess physical, cognitive, vision, and hearing impairments, as well as motivational and environmental challenges. These tools, identified through an extensive scoping review presented in Chapter 2, included the Self-Medication Assessment Tool (SMAT) for cognitive, physical, and vision barriers; the Whisper Test for hearing impairments; the Self-Efficacy for Medication Use Scale (SEAMS) for motivational barriers; and the Martin and Park Environmental Demands (MPED) Questionnaire for environmental factors. Each of these tools offered unique insights into the complex nature of medication management challenges faced by the elderly, while also highlighting the inherent complexities in accurately measuring these barriers within clinical and research settings.

The Self-Medication Assessment Tool (SMAT) was employed to measure cognitive, physical, and vision barriers, providing a detailed view of the participants' abilities to manage their medication regimes effectively.[109,140,147,226] The cognitive component of the SMAT was validated against the Mini Mental State Examination (MMSE), showing a significant positive correlation (Pearson correlation coefficient = +0.36, $p < 0.05$).[140] This confirms that higher cognitive capabilities, as assessed by the MMSE, are associated with better performance on the SMAT's cognitive scale.[140] The psychometric properties of the SMAT further underscore its reliability. The functional scale demonstrated good internal consistency with a Cronbach's alpha of 0.81, while the cognitive scale demonstrated excellent consistency with a Cronbach's alpha of 0.92.[140,147] Despite its comprehensive approach and strong psychometric properties, the performance-based nature of the SMAT, combined with its long administration time, restricts its practicality in clinical settings. Using this tool, we identified that 20% of participants faced cognitive barriers, 33.75% encountered physical barriers, and 11.25% had vision issues. These figures give a comprehensive view of the impairment landscape among the older adults in our study population. Comparing these findings to previous global data, such as the report that over 46% of older persons experience some form of disability, our results reflect similar challenges but with distinct prevalence rates in specific categories.[247-251]

The Whisper Test used for assessing hearing barriers, revealed a significant finding: 60% of participants exhibited varying degrees of hearing impairment, a finding consistent with general disability statistics among the elderly.[132,227,248,252] Whisper test, a simple, equipment-free method, while beneficial for its ease of use, faces limitations due to potential examiner bias, thus affecting the reliability of its outcomes although this method has demonstrated a sensitivity of 100% (95% CI: 96-100) and a specificity of 87% (95% CI: 80-92).[227] Despite this, the high incidence of hearing impairments identified highlights a critical area for healthcare intervention, particularly in developing audible and vibration-based medication reminders that can accommodate this widespread need.

The Self-Efficacy for Medication Use Scale (SEAMS) offered a deeper understanding of the motivational barriers affecting participants, with 31.25% reporting challenges.[33,117,121] While SEAMS effectively measures confidence in medication management, it overlooks crucial motivational factors such as techno-literacy and health literacy, suggesting a gap in our understanding of all the elements that influence medication adherence.

The Martin and Park Environmental Demands (MPED) Questionnaire provides insights into how daily routines and environmental demands impact medication management.[173] It measures the effects of busyness and routine on forgetfulness in medication intake, highlighting the role of external factors in medication adherence.[7,173] While the MPED offers valuable data, it does not cover all potential environmental influences, such as cost and living conditions, which were reported as significant factors influencing medication self-management. Our findings on the impact of environmental factors affecting 33.75% of participants are consistent with previous research findings discussing how external factors, including social support, financial resources, and living conditions, significantly influence the self-management of older adults with impairments.[43,248,249]

The diversity of measurement tools necessary to cover the spectrum of barriers underscores the complexity of assessing medication management challenges. The practical difficulties associated with employing multiple tools, such as participant fatigue and time constraints, can compromise the quality and reliability of data. This limitation points to a significant gap in the field: the lack of a comprehensive, standardized tool for assessing medication management barriers among older adults. Despite our best efforts to cover a wide range of barriers, our study was limited by the lack of comprehensive measures and the practical constraints of using multiple tools in clinical research. Furthermore, global trends highlighted by sources like the United Nations and several studies on the functional decline of older adults point to an increasing elderly population and a corresponding rise in disability rates.[247,253] These trends are anticipated to significantly increase healthcare demands and resource utilization, underscoring the critical need for well-directed healthcare strategies. Our findings related to impairments provide detailed insights into which impairments are most widespread in our sample of older adults. This information can be crucial for developing targeted interventions that address the medication management challenges faced by older adults with specific impairments thereby enhancing their quality of life and reducing the burden on healthcare systems.

8.1.4 Challenges in Recruiting Participants with Impairments for Product Testing

The distribution of participant impairments across 13 tested products in our study highlights significant gaps in testing participation, especially concerning those with vision and cognitive impairments. Certain products, notably identified as PBA 002 and APD 002, show missing data points where no participants with vision impairments were involved. This pattern suggests challenges in recruiting participants with these specific impairments for user experience studies. Similar challenges are discussed in previous research, which points to systemic barriers that prevent the full participation of people with impairments in health and usability research.[254] These barriers include logistical challenges in reaching out to and engaging with people with specific impairments. Addressing recruitment challenges necessitates inclusivity through targeted outreach and partnerships with organizations supporting people with impairments, to ensure diverse and representative research outcomes.

8.1.5 Task Success Rates and User Limitations: Implications for MATech Accessibility and Usability

In evaluating MATech, the task success rate serves as a key performance based objective indicator of usability. This metric is crucial as it directly relates to the user's ability to manage their medication regimen effectively, which is of paramount importance for older adults who often struggle with multiple prescriptions.[78,80,81] High success rates suggest that users can interact with these devices effectively, potentially leading to better medication adherence and health outcomes.

Our findings reveal an overall mean unassisted task success rate of 77.90% and a median of 83.33%, indicating that participants generally performed well on the tasks unassisted, with more than half achieving above-average success. However, an IQR of 67-99 points to variability in individual performance, ranging from 0 to 100%, which suggests differences in participants' abilities or task understanding. It is important to note that being able to complete 80% of the tasks required to effectively use these products does not necessarily mean participants can use them without assistance. For example, missing even a crucial 20% of the steps required for proper medication management could still prevent effective use.

When compared to the results of a prior study focused on the usability and workload of similar medical technology, which reported an overall average unassisted task success rate of 55.3%, our study reveals a significantly higher average of 77.90%.[85] However, examining individual products reveals a notable decline in success rates in our study as opposed to the same products in earlier research. For instance, the MedGlider System 1 with Talking Reminder (PBA-002) reported an 86.97% unassisted success rate in our study—commendable, yet short of the previously reported 95%. Conversely, the MedQ Smart PillBox (PBA-001) exhibited a markedly reduced unassisted success rate of 66.82%, a sharp fall from the earlier study's 85%. Furthermore, the 100-Hour Pill Reminder's success rate dropped from 96% in the previous study to 75% in ours. Such variances may be attributed, in part, to the impairments present among our study participants. Additionally, the previous study included clinicians and care providers, did not recruit people with impairments, and had a much smaller sample size.[85] Challenges like vision or hearing loss, diminished manual dexterity, or cognitive challenges can significantly impact an individual's interaction with technology, potentially decreasing their ability to use these devices without help. These findings suggest that while the design and functionality of medication adherence products are essential, the specific abilities and needs of the users must be a core consideration.

Additionally, the high overall mean unassisted success rate observed in our study could be attributed to the inclusion of three smart medication adherence technologies (MATech), contrasting with the previous study that examined only one such device. This difference highlights the significance of smart medication adherence devices. Smart medication adherence devices, with their user-friendly interfaces, voice prompts, and smartphone integration, can considerably improve the user experience. They make interactions more intuitive, particularly beneficial for individuals facing limitations. For example, SMA-001, an automated medication dispenser used in our study, achieved an unassisted success rate of 86.84%, showcasing the capabilities of these innovative devices.

Examining the unassisted task success rates among participants with various limitations reveals a pronounced decline in the presence of various barriers. Cognitive limitations result in a mean success rate of 70.43%, with physical limitations close behind at 67.96%. Vision limitations appear to have a more significant impact on unassisted use, with a mean success rate dropping to 64.73%. Hearing limitations are less problematic, with a mean of 77.45%, which is below the overall unassisted mean of 77.90% but still relatively high compared to other limitations. Motivational limitations lead toa mean success rate of 74.83%, and environmental limitations, once again, show the least impact on the unassisted task success rate with a mean of 81.45%.

These findings emphasize the need for MATech to be not only effective in their core functions but also accessible and user-friendly to ensure high success rates across all user groups, regardless of individual limitations.

8.1.6 Task Completion Time: Implications for MATech Practicality and Accessibility

The total task completion time of MATech is a significant performance metric, essentially reflecting the time spent by users interacting with these devices.[78,80,81] This metric encompasses not only the successful completion of tasks but also unsuccessful attempts or completing tasks with assistance.[78,80,81] In evaluating the utility and practicality of MATech, this metric is crucial as devices that enable users to manage their medication quickly and effortlessly are more likely to be adopted and used consistently, which is particularly vital for older adults who may be on complex medication regimens.

In our study, on average, users spend a mean time of 11.07 minutes interacting with these technologies. This time includes all aspects of use, from navigating the device to actually dispensing medication, and is a vital indicator of the ease with which users can manage their medication regimen. This study findings also highlight notable disparities in the total task completion times across various MATech. The smart devices, which incorporate advanced features, tend to facilitate quicker task completion. This is demonstrated by Spencer Automatic Pill Dispenser (SM-001), which demonstrated the shortest mean completion time of 4.53 minutes.

This time is notably shorter compared to other smart medication devices such as the Jones Healthcare Blister Pack (SM-002) and the EllieGrid Smart Pillbox (PBA-009) but also in comparison with other electronic devices. However, it is important to note that with the EllieGrid (PBA-009) and most electronic devices, users were required to fill their medications into the device, which may contribute to longer completion times.

When comparing the findings from this study to those of the previous one, most devices showed a reduction in total task completion time compared to the previous study. For instance, the MedReady 1700 Automated Medication Dispenser (APD-001) showed a substantial decrease in mean total task completion time from 26.15 minutes in past studies to 15.38 minutes in our current research. Similarly, the GMS Med-e-lert Automatic Pill Dispenser (APD-002) has seen a reduction from 17.24 minutes to a current average of 14.95 minutes. However, it is also crucial to consider that shorter completion times may sometimes result from users not completing tasks or completing tasks with assistance.

When limitations are present, the total task completion time for medication adherence technologies also varies significantly, reflecting the diverse needs and challenges faced by users. Among cognitive, physical, and vision limitations, cognitive limitations resulted in the highest mean total task completion time of 12.12, indicating the most significant challenge in navigating and interacting with medication adherence technologies independently. Physical limitations followed closely behind with a mean completion time of 11.97, suggesting comparable difficulties in device use. These findings underscore the necessity of designing medication adherence technologies that accommodate various limitations, ensuring accessibility and usability for all users.

8.1.7 Efficiency of MATech: Understanding User Performance and Device Effectiveness

Efficiency is a critical attribute of MATech, reflecting how effectively and quickly users can accomplish tasks with these devices.[78,80,81] High efficiency in these devices allows users to complete necessary tasks swiftly and with minimal effort, reducing the cognitive load and physical strain associated with medication management.[85] This is especially crucial in promoting the consistent and independent use of these technologies among the elderly, who may be managing complex medication schedules and given the potential cognitive, physical, and sensory challenges they may face. Furthermore, efficiency serves as a metric that incorporates both task success and time, providing a comprehensive measure that assesses the effectiveness of these technologies in real-world scenarios.

Our findings revealed an overall mean efficiency score for unassisted use was relatively low at 9.95, with a median of 7.31, indicating moderate usability challenges across the tested devices. The wide range of scores from 0 to 46.51, along with a standard deviation of 8.16, underscores a significant disparity in user capabilities and experiences, suggesting that many participants struggled with operating these devices independently. This variability emphasizes the need for user-centered design improvements in MATech to enhance accessibility and ease of use.

Among the devices tested, (SM-001), an automatic medication dispenser, distinguished itself by achieving the highest mean efficiency score of 22.87. This performance significantly outpaced other electronic devices, such as Automated Medication Dispenser (APD-001) (0.015) and MedQ Smart PillBox (PBA-001)(p=0.0003), which logged lower mean scores of 5.40 and 5.27, respectively. This difference was further validated by Dunn’s Test, confirming statistically significant efficiency advantages for automatic medication dispensers over electronic products.

Efficiency scores also varied significantly among users with different impairments. Participants with hearing impairments demonstrated the highest mean efficiency score of 10.2, possibly suggesting that these devices are better tailored to users with auditory challenges or that hearing impairments do not drastically affect the use of these technologies. Conversely, those with cognitive impairments experienced more substantial difficulties, reflected in a lower mean efficiency score of 8.43, likely due to difficulties understanding or remembering how to operate the technologies without help.

8.1.8 Variability in Error Rates of MATech: Implications for Usability and Safe Use

Error rates in medication adherence technologies (MATech) usability testing are vital for assessing a device's reliability and user-friendliness.[78,80,81] A high error rate may lead to medication mismanagement, posing significant risks, especially for older adults or those with complex medication schedules. Our study highlights an overall mean total error rate of 16.80%, with a range up to 100% and a standard deviation of 16.09%. This indicates considerable variability in error rates across different devices, reflecting the varying quality of design and user interface complexity among the tested products.

For specific products, the VitaCarry Advanced Pill Case (PBA-003) exhibited the highest error rate at 26.19%, significantly more than the 20% reported in previous studies.[85] Conversely, the MedCentre System showed one of the lowest error rates at 12.09%, closely aligning with the 10% previously reported. These differences might be attributed to variations in user demographics, such as cognitive, physical and sensory abilities, or differing levels of technological familiarity among the study participants. These findings underscore the importance of manufacturers considering both user interface design and user abilities to minimize errors. Making products intuitive and straightforward is essential to reduce the risk of errors, crucial for better health outcomes through improved medication adherence.

The total error rates among participants with specific impairments provide key insights into how disabilities impact making mistakes while using MATech. Participants with cognitive limitations experienced a mean error rate of 20.62%, indicating that devices are often not designed to accommodate users with memory, problem-solving, or attention challenges. Those with physical limitations had an error rate of 17.57%, suggesting issues with device ergonomics such as hard-to-press buttons or poorly designed interfaces for those with reduced manual dexterity. Vision limitations showed the highest error rate at 24.79%, pointing to inadequate visual designs that fail to cater to users with impaired sight, such as small text or poor screen contrast. Interestingly, hearing limitations had a minimal impact on error rates, suggesting that auditory features are less crucial in the current device designs but that enhancements in visual and tactile feedback could be beneficial. Error rates for motivational and environmental limitations were 18.35% and 14.39%, respectively, highlighting the influence of both motivation and the operating environment on device error rate. These insights emphasize the importance of inclusive design in MATech to improve safety, effectiveness, and user satisfaction, catering to a broad spectrum of user needs and conditions.

8.1.9 Understanding MATech Usability Through SUS Scores

The System Usability Scale (SUS) scores provide valuable insights into the usability and user satisfaction of medication adherence technologies.[81] In our study, we observed significant variability in SUS scores across the tested devices, ranging from 32.50 to 64.38. This wide range suggests that not all devices are perceived equally by users in terms of usability, highlighting the importance of understanding user preferences and needs when designing such technologies.

It's essential to recognize that SUS scores are subjective measures, reflecting users' personal experiences and preferences when interacting with the devices. While higher SUS scores generally indicate better usability, it's crucial to interpret them in the context of individual user needs and expectations. Factors such as device complexity, ease of use, and aesthetic appeal can influence users' perceptions and ultimately impact SUS scores.

The Kruskal-Wallis test results confirmed significant differences in SUS scores among the tested products, indicating that usability varied significantly between different medication adherence technologies. Among the devices tested, Spencer automatic pill dispenser (SM-001) (the highest SUS score of 64.38, indicating a better usability and user acceptance compared to other devices even though the score itself is not particularly high. This suggests that Spencer may have incorporated features or design elements that resonate well with users, leading to higher satisfaction levels. Conversely, devices such as GMS Med-e-lert Automatic Pill Dispenser (APD-002) scored lower on the SUS scale, indicating potential usability issues that need to be addressed to improve user experience.

Comparing SUS scores from our study with previous research findings revealed both improvements and declines in usability across devices.[85] For example, while some devices showed increased SUS scores compared to previous studies, others demonstrated lower scores. For instance, the SUS score for MedReady 1700 Automated Medication Dispenser (APD-001) increased from 28.63 to 35.13, while the SUS score for GMS Med-e-lert Automatic Pill Dispenser (APD-002) decreased from 40.75 to 32.5.

Moreover, when considering limitations such as cognitive, physical, and vision impairments, SUS scores varied significantly. Cognitive limitations resulted in the highest mean SUS score, indicating that users with cognitive impairments may perceive certain devices as more usable compared to those with physical or vision impairments. However, vision impairments (SMAT) yielded the lowest SUS scores, suggesting potential challenges in usability for users with visual disabilities.

These findings underscore the importance of designing medication adherence technologies that cater to the diverse needs and limitations of users. By prioritizing usability and incorporating features that enhance accessibility, manufacturers can improve user satisfaction, adherence rates, and overall health outcomes. Additionally, ongoing usability testing and user feedback are essential to iteratively refine and optimize medication adherence technologies for maximum effectiveness and user acceptance.

8.1.10 Workload Assessment of Medication Adherence Technologies: Understanding User Experience and Barriers

The NASA Task Load Index (NASA TLX) is an essential metric used to evaluate the perceived workload associated with the operation of technological devices, including factors such as mental, physical, and temporal demands, as well as overall effort and frustration levels.[235] This index is particularly critical when assessing the usability of Medication Adherence Technologies (MATech) for older adults, who are the primary users of these devices. A lower NASA TLX score is desirable, indicating that the device is easier to manage and imposes less cognitive and physical strain on its users, which is crucial for promoting independent and consistent use among elderly individuals dealing with complex medication schedules.

Our study's comprehensive evaluation using the NASA TLX revealed a mean score of 55.33 across all tested devices, with scores ranging from 0 to 120. This wide range underscores the varying degrees of workload experienced by users, which can significantly impact their interaction with MATech. The standard deviation of 30.59 points to a broad diversity in user experiences, highlighting the importance of individualized considerations in device design and function.

In regard to barriers, physical and vision impairments were associated with the highest mean workload scores, 61.44 and 65.93 respectively, suggesting that these users face considerable challenges in interacting with MATech. Devices requiring significant physical interaction or clear visual outputs may be particularly difficult for users with these impairments, potentially exacerbating the cognitive load and physical strain involved. Conversely, hearing barriers showed a slightly lower mean score of 57.24, indicating that while challenges persist, these may be somewhat less obstructive compared to physical and vision limitations.

Among the various products tested, the MedGlider System 1 with Talking Reminder (PBA-002) and Spencer (SM-001) registered the lowest mean NASA TLX scores of 49.62 and 34, respectively. These scores suggest that these devices are perceived as less burdensome and more user-friendly, possibly due to more intuitive interfaces or more effective communication of information. On the other hand, the MedReady 1700 Automated Medication Dispenser (APD-001) and VitaCarry Advanced Pill Case (PBA-003) recorded higher scores of 77.6 and 71.71, highlighting a perceived higher workload and suggesting a need for design improvements to reduce user strain.

Comparison of our findings with prior studies reveals notable shifts in user workload perceptions that may be due to our study's inclusion of participants with various impairments.[85] For instance, the MedReady 1700 Automated Medication Dispenser demonstrated an increase in its mean workload score to 77.6, up from a previously 72.92. Similarly, the VitaCarry Advanced Pill Case showed a current mean score of 71.71, which is higher compared to its earlier mean of 46.11. This rise suggests its user interface may not have kept pace with the needs of its users, particularly those with impairments.

The significant variation in NASA TLX scores across different devices and user impairments underscores the need for manufacturers to focus on reducing cognitive and physical demands. By developing MATech with intuitive, accessible interfaces that accommodate the specific needs of the elderly, developers can help mitigate the risks of medication management errors, improve adherence, and support independent living.

8.1.11 Understanding the Impact of Cognitive, Physical, Sensory, and Motivational Barriers on MATech Usability Among Older Adults

The main objective of this study was to assess how cognitive, physical, sensory, motivational, and environmental barriers impact the usability outcomes of various medication adherence technologies (MATech) among older adults. Using univariate and multivariate regression analyses, we explored significant predictors affecting MATech's performance and perception-based usability metrics.

In terms of performance-based metrics, cognitive capabilities emerged as a significant predictor of usability especially in case of task completion (p-value-0.027) further confirming previous findings that cognitive decline is a major challenge to effective medication management.[35,38,86,255] As cognitive function encompasses processes such as memory, attention, and problem-solving, its significant association with total task completion time underscores the complexity of interacting with MATech. Aging naturally impacts these cognitive functions, leading to increased challenges in navigating technological interfaces, and executing the actions required by these technologies.[255] This aligns with previous studies that have documented the barriers faced by older adults due to cognitive impairments, emphasizing the need for MATech designs that accommodate a range of cognitive abilities.[65,86]

Physical and sensory capabilities were also identified as critical factors influencing MATech usability. The significant negative impact of low vision scores on task success rate and the positive association of physical score with total error rate(p-value<0.001) highlight the essential role of these sensory and motor abilities in the effective use of MATech. Similarity low vision scores were also found to be reducing task success rate (p-value<0.001) and increasing error rates (p-value-0.014). These findings are consistent with existing research that underscores the challenges posed by physical and sensory impairments on medication management.[35,38,256] For example, difficulties opening medication containers, accurately dispensing doses, and even reading medication labels are often aggravated by declines in fine motor skills, grip strength, and visual acuity. [35,38] Our study adds quantitative evidence to these observations, emphasizing the necessity for MATech that is designed with ergonomic considerations and visual clarity to minimize these barriers.

Interestingly, our study did not find a significant association between hearing impairments and MATech usability metrics. This contrasts with previous studies that highlighted hearing as a crucial factor in technology use among older adults.[35,38] It suggests that current MATech may not heavily rely on auditory feedback or that the devices tested do not adequately cater to the auditory capabilities of the older adult population. This gap indicates an area for further research and development, ensuring that future MATech can effectively communicate with users across the sensory spectrum.

The number of subtasks per product was another key factor that influenced usability. An increase in the number of subtasks was associated with longer task completion times and reduced efficiency, demonstrating the complexity and cognitive load imposed on users. This emphasizes the need for simplification in MATech design to ensure they do not overwhelm the user, the main principle that usability research emphasizes, the need for clarity and simplicity in technology designed for older adults.

Age itself proved to be a critical factor; as age increased, so did the total task completion time, which aligns with the general understanding that aging is accompanied by a general slowdown in physical and cognitive processes.[35,38,65,85,86,255,256] Additionally, the significant association of the SEAMS score with task success rate underscores the impact of motivational barriers. Motivation and self-efficacy are crucial for older adults to engage successfully with MATech. A higher SEAMS score, reflecting better self-efficacy, was associated with improved task success rates, suggesting that users who believe in their ability to use MATech are more likely to succeed.[85]

Looking at the perception-based usability metrics, the SUS scores in this study revealed no significant predictors, suggesting that the cognitive, physical, sensory, motivational, and environmental barriers assessed do not directly impact the usability scores of MATech. This finding is particularly intriguing when compared to broader UX research, where SUS is often used as a reliable measure of usability.[78,80,81,257] Literature suggests that SUS provides a global view of subjective assessments of usability, which contrasts with our findings where specific impairments and user characteristics did not alter usability perceptions significantly.[80] This suggests that while SUS scores are grounded in user perceptions, they might not fully capture the practical usability challenges faced by distinct user groups, particularly older adults or those with varied physical, sensory, or cognitive impairments. Such individuals might encounter difficulties that generalized usability queries fail to accurately document.

In contrast, another perception-based usability metric, the NASA-TLX scores showed significant relationships with age and vision, indicating that higher mental workload is associated with older age and poorer vision. This aligns with previous studies where mental workload was influenced by user demographics and functional capabilities.[235,258,259] The negative coefficients for educational levels (bachelor's degree and below) suggest that higher education reduces perceived workload, potentially due to better cognitive strategies or familiarity with technology. An additional consideration is the influence of the number of products evaluated. The significant relationship between this variable and NASA-TLX scores demonstrates how testing multiple products can intensify perceived mental workload. The rise in workload with an increase in the number of products tested highlights the complexity and cognitive demand required to manage multiple technologies, thereby influencing user experience and workload perception.

Our study findings highlights that incorporating both subjective and objective measures will likely provide a more comprehensive understanding of a system's usability across diverse user groups. It is particularly crucial in the context of health technologies like medication adherence tools, where ease of use directly impacts the effectiveness and adoption of the technology. By acknowledging the limitations of perception-based measures and strategically integrating more diverse testing methodologies, developers can better accommodate the unique needs of older adults and individuals with various limitations. Moreover, the findings also underscores the need for user-centered design and development approaches in creating MATech for older adults. By focusing on reducing the cognitive load and accounting for the physical and sensory limitations of the user, designers can improve the effectiveness, efficiency, and satisfaction with which older adults use these technologies. The importance of such an approach is particularly evident given the heterogeneous nature of the older adult population, which encompasses a wide range of capabilities and preferences.

8.1.12 Reflexivity in Qualitative Analysis: Examining the Role of Researcher Identity

Incorporating reflexivity into this study required a thorough examination of how my personal and professional background influenced the research process and outcomes. As a pharmacist with a focus in neurology, my experiences have inevitably shaped the questions posed during the study and my interpretation of participants' responses. This perspective may have introduced a bias towards emphasizing practical usability concerns that affect medication adherence. Furthermore, my identity as a younger female researcher also played a critical role. The age difference between myself and the predominantly older participants might have affected the dynamics during usability testing, potentially influencing how participants responded to the technology and to me as a tester. Additionally, being a woman could have impacted both the manner in which I conducted the interviews and my analysis of the data, as gender-related experiences might frame one's interpretative lens. Addressing these reflections has been pivotal in understanding the specifics of my interactions with the participants and the consequent thematic analysis.

8.1.13 Clinical Implications of the Study

This study addresses a critical need in healthcare by focusing on the usability and effectiveness of MATech for older adults, a demographic increasingly burdened by complex medication regimes. As populations age and the prevalence of chronic diseases rises, the demand for effective solutions to support medication management becomes essential. This research provides invaluable insights that can assist technology developers in improving products to meet the specific needs of elderly users. By identifying the features that enhance usability and adherence based on diverse barriers older adults face, developers can target improvements that make these technologies more accessible and effective for this demographic.

For older adults and their healthcare providers, the study offers evidence-based guidance on selecting the most suitable MATech features. This is particularly beneficial in clinical settings where tailored healthcare solutions are essential for optimizing treatment outcomes. By choosing the right technology, healthcare providers can enhance their patients' ability to manage their own medications, thereby improving overall health outcomes and patient autonomy.

Moreover, the study's findings can influence the development of environments that support aging in place. By integrating effective MATech into the homes of older adults, it is possible to create living spaces that not only promote independence but also mitigate the risks associated with complex medication regimens. This can have a profound impact on reducing medication errors, optimizing healthcare resource utilization, and lowering hospitalization rates due to non-adherence. Additionally, by decreasing the incidence of medication errors and enhancing adherence, these technologies can manage healthcare costs more effectively. Reducing unnecessary hospital admissions and optimizing treatment regimes can lead to significant financial savings for healthcare systems, making this study's implications highly relevant not only to patient care but also to the broader economic aspects.

8.1.14 Strengths and Limitations

This study on the usability and user experience of MATech for older adults presents several strengths that significantly contribute to the field of geriatric care and healthcare technology. One of its main strengths is the use of a mixed-methods approach, which incorporates both quantitative and qualitative data to provide a comprehensive analysis of how these technologies serve the elderly facing various barriers. This method allows for an in-depth understanding of both the measurable outcomes of device use and the subjective experiences of the users, offering a holistic view of the effectiveness of these technologies.

Another significant strength is the study's focus on a variety of barriers that can affect medication adherence. By addressing not only physical and cognitive impairments but also sensory, motivational, and environmental factors, the research provides a broad view of the challenges faced by older adults. This extensive scope is crucial for developing MATech that is truly inclusive and effective. Furthermore, the real-world applicability of the study is enhanced by its detailed examination of how specific features of MATech can meet the needs of older adults, directly informing the design and implementation of these technologies in clinical settings. Additionally, the use of assessment tools with strong psychometric properties significantly enhances the study's validity. Instruments such as the Self-Medication Assessment Tool (SMAT), Whisper Test, and others are well-established measures that yield reliable data on the barriers to medication self-management. This rigorous methodology ensures that the study's conclusions are grounded in solid empirical evidence, which can be confidently used to advance medication adherence technologies.

Another major strength of the study is its comprehensive evaluation of both electronic and smart medication adherence devices. This inclusive approach allows for a detailed comparison of traditional and advanced technologies, illuminating the specific benefits and drawbacks of each in terms of enhancing medication adherence among older adults. The inclusion of smart devices, which typically feature user-friendly interfaces, voice prompts, and integration with mobile technology, provides a modern perspective on how medication management can be optimized with cutting-edge technology.

Despite these strengths, the study also faces several limitations that could affect the generalizability and interpretation of its findings. A major limitation is the sample size; although initially calculated to require 100 participants to ensure a representative test of each product by individuals with varied barriers, the study recruited only 80 participants. This shortfall not only challenges the statistical power of the study but also limits the ability to fully represent each barrier type in the testing of every product, potentially skewing the results towards those barriers and products that were adequately sampled.

Furthermore, the use of mixed methods, while a strength, also presents a limitation as it did not converge to produce a unified set of findings that incorporate both qualitative and quantitative elements effectively. This lack of convergence might lead to differing interpretations of how MATech works in real-life scenarios, reducing the practical applicability of the results. Additionally, the varied findings across the different usability metrics could complicate the overall conclusions that can be drawn about the effectiveness and usability of the technologies evaluated.

Another significant limitation is related to the scope of testing environments and demographic representation. The study's settings may not adequately reflect the typical daily environments where these devices would be used, which can influence the performance and perceived usability of the devices. Additionally, the demographic variability of the participant group, including factors such as background, technological literacy, and health status, could introduce biases that were not fully accounted for, impacting the applicability of the findings to the general population of older adults.

Overall, while the study provides valuable insights into the usability and effectiveness of MATech for older adults, the limitations regarding sample size, methodological integration, and testing environment need to be addressed in future research to enhance the validity and relevance of the findings. These improvements could help better tailor medication adherence technologies to meet the diverse needs of the aging population.

8.1.15 Future Recommendations

Taking into consideration the findings of this study on MATech for older adults, there are several potential areas for future research that could further enhance the usability and effectiveness of these tools.

One promising area for further investigation is the development of a clinical decision-making tool that incorporates the diverse barriers and usability metrics identified in this study to tailor medication management solutions more effectively. This advanced decision-support system would integrate specific barriers to medication management—such as cognitive, sensory, physical, motivational, and environmental limitations—with individual patient profiles. Healthcare providers could input user-specific information to receive targeted recommendations, simplifying the selection process and potentially increasing patient adherence by offering personalized solutions.

Additionally, there is a need to modify and expand the measurement tools used to assess barriers to medication management. While this study used several effective tools, the development of a more comprehensive, standardized measurement tool could provide deeper insights and more consistent data about various barriers to medication self-management. Future research should aim to develop and validate such a tool, possibly incorporating diverse spectrum of challenges which impacts medication management in older adults.

Further investigations could also explore the long-term impacts of using MATech in diverse settings, including at-home use, retirement homes or assisted living facilities. Longitudinal studies would provide valuable data on the sustainability of these technologies and their effects on health outcomes over time. This would also allow researchers to assess the long-term benefits of personalized MATech and its influence on reducing healthcare costs through improved medication adherence.

Moreover, there is an opportunity to expand the scope of research to include a broader demographic, examining the effectiveness of MATech across different cultural and age groups. This would ensure that the developed technologies are accessible and effective for a wider range of users, addressing differences in healthcare accessibility and promoting equity in health outcomes.

Future research on medication adherence technologies can also examine the learnability aspect, focusing on how quickly older adults can master these tools and the progression of their interaction over time. It is also essential to analyze long-term user engagement and determine if "technology fatigue" affects sustained use. Longitudinal studies are vital to understand the prolonged impact of MATech on health outcomes like medication adherence, hospitalization rates, and overall quality of life.

Through these recommendations, future research can build on the current study's findings to enhance the practical application of MATech, ultimately contributing to more effective, efficient, and personalized healthcare solutions for the aging population.

8.2 Conclusion

This study on the user experience and usability of medication adherence technologies (MATech) provides key insights into improving healthcare outcomes for older adults through tailored technological solutions. By assessing the specific usability needs and preferences of this demographic, the research emphasizes the importance of choosing technologies based on the specific needs of older adults to improve healthcare effectiveness and promote senior independence. The insights gained from this study not only guide the selection of appropriate device features for older adults but also set the stage for future advancements in MATech that can support effective medication self-management. With an aging population and the increasing prevalence of chronic diseases, thoughtful selection and development of innovative MATech are essential to enhancing patient autonomy, optimizing healthcare resources, and improving overall community health outcomes.

9 References

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10 Appendix

10.1 Appendix A: Scoping Review

10.1.1 Appendix A-1: Full Database Search Strategies

PubMed(MEDLINE):

(medication therapy management[mesh] OR patient compliance[mesh] OR prescription drugs[mesh] OR prescription*[tiab] OR medication*[tiab] OR drug*[tiab] OR medicine*[tiab]) AND (self administration[mesh] OR self management[mesh] OR self efficacy[mesh] OR self care[mesh] OR "self administrat*"[tiab] OR "self manag*"[tiab] OR "self efficacy"[tiab] OR "self care"[tiab] OR “self treatment”[tiab] OR "self medicat*"[tiab]) AND (tool*[tiab] OR instrument*[tiab] OR framework*[tiab] OR assess*[tiab] OR surveys and questionnaires[mesh] OR survey*[tiab] OR questionnaire*[tiab] OR scale*[tiab] OR screen*[tiab] OR measur*[tiab] OR psychometrics[mesh] OR psychometric*[tiab]) AND (mental competency[mesh] OR competenc*[tiab] OR capacity[tiab] OR skill*[tiab] OR aptitude[mesh] OR aptitude[tiab] OR abilit*[tiab] OR hearing loss[mesh] OR auditory perception[mesh] OR “hearing loss”[tiab] OR “hearing impairment”[tiab] OR “impaired hearing”[tiab] OR “loss of hearing”[tiab] OR “hearing difficult*”[tiab] OR hypoacusis[tiab] OR hypacusia[tiab] OR hypacusis[tiab] OR hypoacousia[tiab] OR “transitory deafness*”[tiab] OR “transitory hearing loss”[tiab] OR “auditory acuity”[tiab] OR “hearing sensitivity”[tiab] OR “auditory perception”[tiab] OR deaf*[tiab] OR vision disorders[mesh] OR “vision disorder*”[tiab] OR “visual disorder*”[tiab] OR visual acuity[mesh] OR “visual acuity”[tiab] OR “vision impairment*”[tiab] OR “vision disturbance”[tiab] OR “visual disturbance”[tiab] OR “visual impairment*”[tiab] OR “visually impaired”[tiab] OR blind*[tiab] OR hemianopsia*[tiab] OR hemianopia[tiab] OR “vision defect*”[tiab] OR “colour blind*”[tiab] OR colourblind*[tiab] OR “color blind*”[tiab] OR colorblind*[tiab] OR diplopia[tiab] OR “double vision”[tiab] OR “seeing double”[tiab] OR photophobia[tiab] OR scotoma[tiab] OR “low vision”[tiab] OR “vision loss”[tiab] OR “poor vision”[tiab] OR “subnormal vision”[tiab] OR amblyopia[tiab] OR “lazy eye”[tiab] OR cataract[mesh] OR cataract*[tiab] OR “contrast detection”[tiab] OR “contrast sensitivity”[tiab] OR “sensory impairment”[tiab] OR “sensory loss”[tiab] OR “sensory dysfunction”[tiab] OR motor skills[mesh] OR “motor skill*”[tiab] OR “motor performance”[tiab] OR “psychomotor performance”[tiab] OR “motor function”[tiab] OR dexterity[tiab] OR agility[tiab] OR hand strength[mesh] OR strength[tiab] OR “hand eye coordination”[tiab] OR “eye hand coordination”[tiab] OR “eye hand control”[tiab] OR grip*[tiab] OR grasp*[tiab] OR “movement limitation*”[tiab] OR physical functional performance[mesh:noexp] OR "functional performance"[tiab] OR "functional impairment*"[tiab] OR "impaired functioning"[tiab] OR “functional disabilit*”[tiab] OR “functional decline”[tiab] OR “functional status”[tiab] OR “functional abilit*”[tiab] OR “physical abilit*”[tiab] OR “functional limitation*”[tiab] OR “functional restriction*”[tiab] OR “functional capacit*”[tiab] OR “physical function”[tiab] OR “functional independence”[tiab] OR “functional disease”[tiab] OR decision making[mesh] OR “decision making”[tiab] OR attention[mesh] OR attention[tiab] OR concentrat*[tiab] OR motivation[mesh:noexp] OR motivat*[tiab] OR thinking[mesh] OR think*[tiab] OR judgment[tiab] OR efficiency[mesh:noexp] OR efficien*[tiab] OR memory[mesh] OR memor*[tiab] OR cognition[mesh:noexp] OR cognition[tiab] OR cognitive dysfunction[mesh] OR “cognitive dysfunction”[tiab] OR “cognitive function”[tiab] OR “cognitive impairment”[tiab]) AND (aged[mesh] OR aged[tiab] OR elder*[tiab] OR geriatric*[tiab] OR "older people*"[tiab] OR "older person*"[tiab] OR "older adult*"[tiab] OR “older patient*”[tiab] OR senior*[tiab]) AND English[lang] AND 2002:2022[edat]

Ovid Embase:

1 exp medication therapy management/ 13513
2 exp medication compliance/ 40583
3 exp prescription drug/ 12132
4 (medication* or drug* or medicine* or prescription*).ti,ab. 3737293
5 or/1-4 3755108
6 exp drug self administration/ 12540
7 exp self care/ 93966
8 exp self concept/ 218328
9 exp self medication/ 11267
10 ("self administrat*" or "self manag*" or "self efficacy" or "self care" or "self treatment" or "self medicat*").ti,ab. 123841
11 or/6-10 354974
12 exp functional assessment/ 68464
13 exp geriatric assessment/ 19473
14 exp questionnaire/ 837162
15 exp psychometry/ 103495
16 (tool* or instrument* or framework* or assess* or survey* or questionnaire* or scale* or screen* or measur* or psychometric*).ti,ab. 11477933
17 or/12-16 11611896
18 exp mental capacity/ 89132
19 exp skill/ 99353
20 exp aptitude/ 4943
21 exp hearing impairment/ 108867
22 exp hearing acuity/ 3770
23 exp visual disorder/ 262981
24 exp visual acuity/ 142260
25 exp visual impairment/ 108437
26 exp blindness/ 47002
27 exp hemianopia/ 5182
28 exp color blindness/ 1806
29 exp diplopia/ 26242
30 exp photophobia/ 12210
31 exp scotoma/ 19538
32 exp low vision/ 4093
33 exp amblyopia/ 10810
34 exp cataract/ 64068
35 exp contrast sensitivity/ 11946
36 exp sensory dysfunction/ 643699

37 exp motor performance/ 84251
38 exp agility/ 2204
39 exp hand strength/ 34600
40 exp eye hand coordination/ 2045
41 exp grip strength/ 28648
42 exp physical performance/ 109239
43 exp functional disease/ 25652
44 *physical capacity/ 1946
45 exp decision making/ 427244
46 exp attention/ 299076
47 *motivation/ 30773
48 exp thinking/ 652873
49 exp memory/ 333611
50 *cognition/ 81989
51 exp cognitive defect/ 559028
52 (competenc* or capacity or skill* or aptitude or abilit* or "hearing loss" or "hearing impairment" or "impaired hearing" or "loss of hearing" or "hearing difficult*" or hypoacusis or hypacusia or hypacusis or hypoacousia or "transitory deafness" or "transitory hearing loss" or "auditory acuity" or "hearing sensitivity" or "auditory perception" or deaf* or "vision disorder*" or "visual disorder*" or "visual acuity" or "vision impairment" or "vision disturbance" or "visual disturbance" or "visual impairment" or "visually impaired" or blind* or hemianopsia or hemianopia or "vision defect*" or "colour blind*" or colourblind* or "color blind*" or colorblind* or diplopia or "double vision" or "seeing double" or photophobia or scotoma or "low vision" or "vision loss" or "poor vision" or "subnormal vision" or amblyopia or "lazy eye" or cataract* or "contrast detection" or "contrast sensitivity" or "sensory impairment" or "sensory loss" or "sensory dysfunction" or "motor skill*" or "motor performance" or "psychomotor performance" or "motor function" or dexterity or agility or strength or "hand eye coordination" or "eye hand coordination" or "eye hand control" or grip* or grasp* or "movement limitation*" or "functional performance" or "functional impairment*" or "impaired functioning" or "functional disabilit*" or "functional decline" or "functional status" or "functional abilit*" or "physical abilit*" or "functional limitation*" or "functional restriction*" or "functional capacit*" or "physical function" or "functional independence" or "functional disease" or "decision making" or attention or concentrat* or motivat* or think* or judgment or efficien* or memor* or cognition or "cognitive dysfunction" or "cognitive function" or "cognitive impairment").ti,ab. 8066842
53 or/18-52 9385101
54 exp aged/ 3382815
55 (aged or elder* or geriatric* or "older people" or "older person*" or "older adult*" or "older patient*" or senior*).ti,ab. 1471321
56 or/54-55 4213862
57 5 and 11 and 17 and 53 and 56 3537
58 limit 57 to (english language and yr="2002 -Current") 3164

Ovid International Pharmaceutical Abstracts

1 (medication* or drug* or medicine* or prescription*).ti,ab. 271958

2 ("self administrat*" or "self manag*" or "self efficacy" or "self care" or "self treatment" or "self medicat*").ti,ab. 2694

3 (tool* or instrument* or framework* or assess* or survey* or questionnaire* or scale* or screen* or measur* or psychometric*).ti,ab. 177686

4 (competenc* or capacity or skill* or aptitude or abilit* or "hearing loss" or "hearing impairment" or "impaired hearing" or "loss of hearing" or "hearing difficult*" or hypoacusis or hypacusia or hypacusis or hypoacousia or "transitory deafness" or "transitory hearing loss" or "auditory acuity" or "hearing sensitivity" or "auditory perception" or deaf* or "vision disorder*" or "visual disorder*" or "visual acuity" or "vision impairment" or "vision disturbance" or "visual disturbance" or "visual impairment" or "visually impaired" or blind* or hemianopsia or hemianopia or "vision defect*" or "colour blind*" or colourblind* or "color blind*" or colorblind* or diplopia or "double vision" or "seeing double" or photophobia or scotoma or "low vision" or "vision loss" or "poor vision" or "subnormal vision" or amblyopia or "lazy eye" or cataract* or "contrast detection" or "contrast sensitivity" or "sensory impairment" or "sensory loss" or "sensory dysfunction" or "motor skill*" or "motor performance" or "psychomotor performance" or "motor function" or dexterity or agility or strength or "hand eye coordination" or "eye hand coordination" or "eye hand control" or grip* or grasp* or "movement limitation*" or "functional performance" or "functional impairment*" or "impaired functioning" or "functional disabilit*" or "functional decline" or "functional status" or "functional abilit*" or "physical abilit*" or "functional limitation*" or "functional restriction*" or "functional capacit*" or "physical function" or "functional independence" or "functional disease" or "decision making" or attention or concentrat* or motivat* or think* or judgment or efficien* or memor* or cognition or "cognitive dysfunction" or "cognitive function" or "cognitive impairment").ti,ab. 167526

5 (aged or elder* or geriatric* or "older people" or "older person*" or "older adult*" or "older patient*" or senior*).ti,ab. 32061

6 1 and 2 and 3 and 4 and 5 46

7 limit 6 to (english language and yr="2002 -Current") 28

EBSCOhost CINAHL

#	Query	Limiters/Expanders
S55	S5 AND S12 AND S22 AND S49 AND S52	Limiters - Published Date: 20020101-20221231

		Expanders - Apply equivalent subjects Narrow by Language: - english Search modes - Boolean/Phrase
S54	S5 AND S12 AND S22 AND S49 AND S52	Limiters - Published Date: 20020101-20221231
S53	S5 AND S12 AND S22 AND S49 AND S52	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S52	S50 OR S51	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S51	TI ((aged OR elder* OR geriatric* OR "older people" OR "older person*" OR "older adult*" OR "older patient*" OR senior*)) OR AB ((aged OR elder* OR geriatric* OR "older people" OR "older person*" OR "older adult*" OR "older patient*" OR senior*))	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S50	(MH "Aged+")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S49	S23 OR S24 OR S25 OR S26 OR S27 OR S28 OR S29 OR S30 OR S31 OR S32 OR S33 OR S34 OR S35 OR S36 OR S37 OR S38 OR S39 OR S40 OR S41 OR S42 OR S43 OR S44 OR S45 OR S46 OR S47 OR S48	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S48	TI ((competenc* or capacity or skill* or aptitude or abilit* or "hearing loss" or "hearing impairment" or "impaired hearing" or "loss of hearing" or "hearing difficult*" or hypoacusis or hypacusia or hypacusis or hypoacousia or "transitory deafness" or "transitory hearing loss" or "auditory acuity" or "hearing sensitivity" or "auditory perception" or deaf* or "vision disorder*" or "visual disorder*" or "visual acuity" or "vision impairment" or "vision disturbance" or "visual disturbance" or "visual impairment" or "visually impaired" or blind* or hemianopsia or hemianopia or "vision defect*" or "colour blind*" or colourblind* or "color blind*" or colorblind* or diplopia or "double vision" or "seeing double" or photophobia or scotoma or "low vision" or "vision loss" or "poor vision" or "subnormal vision" or amblyopia or "lazy eye" or cataract* or "contrast detection" or "contrast	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase

	sensitivity" or "sensory impairment" or "sensory loss" or "sensory dysfunction" or "motor skill*" or "motor performance" or "psychomotor performance" or "motor function" or dexterity or agility or strength or "hand eye coordination" or "eye hand coordination" or "eye hand control" or grip* or grasp* or "movement limitation*" or "functional performance" or "functional impairment*" or "impaired functioning" or "functional disabilit*" or "functional decline" or "functional status" or "functional abilit*" or "physical abilit*" or "functional limitation*" or "functional restriction*" or "functional capacit*" or "physical function" or "functional independence" or "functional disease" or "decision making" or attention or concentrat* or motivat* or think* or judgment or efficien* or memor* or cognition or "cognitive dysfunction" or "cognitive function" or "cognitive impairment")) OR AB ((competenc* or capacity or skill* or aptitude or abilit* or "hearing loss" or "hearing impairment" or "impaired hearing" or "loss of hearing" or "hearing difficult*" or hypoacusis or hypacusia or hypacusis or hypoacousia or "transitory deafness" or "transitory hearing loss" or "auditory acuity" or "hearing sensitivity" or "auditory perception" or deaf* or "vision disorder*" or "visual disorder*" or "visual acuity" or "vision impairment" or "vision disturbance" or "visual disturbance" or "visual impairment" or "visually impaired" or blind* or hemianopsia or hemianopia or "vision defect*" or "colour blind*" or colourblind* or "color blind*" or colorblind* or diplopia or "double vision" or "seeing double" or photophobia or scotoma or "low vision" or "vision loss" or "poor vision" or "subnormal vision" or amblyopia or "lazy eye" or cataract* or "contrast detection" or "contrast sensitivity" or "sensory impairment" or "sensory loss" or "sensory dysfunction" or "motor skill*" or "motor performance" or "psychomotor performance" or "motor function" or dexterity or agility or strength or "hand eye coordination" or "eye hand coordination" or "eye hand control" or grip* or grasp* or "movement limitation*" or "functional performance" or "functional impairment*" or "impaired functioning" or "functional disabilit*" or "functional decline" or "functional status" or "functional abilit*" or "physical abilit*" or "functional limitation*" or "functional restriction*" or "functional capacit*" or "physical function" or "functional independence" or "functional disease" or "decision making" or attention or concentrat* or motivat* or think* or judgment or efficien*	

	or memor* or cognition or "cognitive dysfunction" or "cognitive function" or "cognitive impairment"))	
S47	(MH "Cognition")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S46	(MH "Memory+")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S45	(MH "Judgment")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S44	(MH "Thinking+")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S43	(MH "Motivation")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S42	(MH "Attention+")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S41	(MH "Decision Making+")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S40	(MH "Functional Status")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S39	(MH "Grip Strength")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S38	(MH "Agility")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S37	(MH "Psychomotor Performance+")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase

S36	(MH "Motor Skills+")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S35	(MH "Cataract")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S34	(MH "Amblyopia")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S33	(MH "Vision, Subnormal")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S32	(MH "Photophobia")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S31	(MH "Diplopia")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S30	(MH "Color Vision Defects")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S29	(MH "Blindness+")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S28	(MH "Visual Acuity")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S27	(MH "Vision Disorders+")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S26	(MH "Deafness+")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S25	(MH "Auditory Perception+")	Expanders - Apply equivalent subjects

		Search modes - Boolean/Phrase
S24	(MH "Hearing Disorders+")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S23	(MH "Aptitude")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S22	S13 OR S14 OR S15 OR S16 OR S17 OR S18 OR S19 OR S20 OR S21	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S21	TI ((tool* OR instrument* OR framework* OR assess* OR survey* OR questionnaire* OR scale* OR screen* OR measur* OR psychometric*)) OR AB ((tool* OR instrument* OR framework* OR assess* OR survey* OR questionnaire* OR scale* OR screen* OR measur* OR psychometric*))	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S20	(MH "Psychometrics")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S19	(MH "Scales")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S18	(MH "Questionnaires+")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S17	(MH "Surveys+")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S16	(MH "Functional Assessment+")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S15	(MH "Geriatric Functional Assessment")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S14	(MH "Research Instruments+")	Expanders - Apply equivalent subjects

		Search modes - Boolean/Phrase
S13	(MH "Clinical Assessment Tools+")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S12	S6 OR S7 OR S8 OR S9 OR S10 OR S11	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S11	TI (("self administrat*" OR "self manag*" OR "self efficacy" OR "self care" OR “self treatment” OR "self medicat*")) OR AB (("self administrat*" OR "self manag*" OR "self efficacy" OR "self care" OR “self treatment” OR "self medicat*"))	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S10	(MH "Self Medication")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S9	(MH "Self Care+")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S8	(MH "Self-Efficacy")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S7	(MH "Self-Management")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S6	(MH "Self Administration+")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S5	S1 OR S2 OR S3 OR S4	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S4	TI ((prescription* OR medication* OR drug* OR medicine*)) OR AB ((prescription* OR medication* OR drug* OR medicine*))	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S3	(MH "Drugs, Prescription+")	Expanders - Apply equivalent subjects Search modes -

		Boolean/Phrase
S2	(MH "Medication Compliance")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase
S1	(MH “Medication Management”)	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase

APA PsycINFO

((((((title: (medication*))) OR ((title: (drug*))) OR ((title: (medicine*))) OR ((title: (prescription*))))) OR ((((abstract: (medication*))) OR ((abstract: (drug*))) OR ((abstract: (medicine*))) OR ((abstract: (prescription*)))))) AND (((((title: ("self administrat*"))) OR ((title: ("self manag*"))) OR ((title: ("self efficacy"))) OR ((title: ("self care"))) OR ((title: ("self treatment"))) OR ((title: ("self medicat*"))))) OR ((((abstract: ("self administrat*"))) OR ((abstract: ("self manag*"))) OR ((abstract: ("self efficacy"))) OR ((abstract: ("self care"))) OR ((abstract: ("self treatment"))) OR ((abstract: ("self medicat*")))))) AND (((((title: (tool*))) OR ((title: (instrument*))) OR ((title: (framework*))) OR ((title: (assess*))) OR ((title: (survey*))) OR ((title: (questionnaire*))) OR ((title: (scale*))) OR ((title: (screen*))) OR ((title: (measur*))) OR ((title: (psychometric*))))) OR ((((abstract: (tool*))) OR ((abstract: (instrument*))) OR ((abstract: (framework*))) OR ((abstract: (assess*))) OR ((abstract: (survey*))) OR ((abstract: (questionnaire*))) OR ((abstract: (scale*))) OR ((abstract: (screen*))) OR ((abstract: (measur*))) OR ((abstract: (psychometric*)))))) AND (((((title: (competenc*))) OR ((title: (capacity))) OR ((title: (skill*))) OR ((title: (aptitude))) OR ((title: (abilit*))) OR ((title: ("hearing loss"))) OR ((title: ("hearing impairment"))) OR ((title: ("impaired hearing"))) OR ((title: ("loss of hearing"))) OR ((title: ("hearing difficult*"))) OR ((title: (hypoacusis))) OR ((title: (hypacusia))) OR ((title: (hypacusis))) OR ((title: (hypoacousia))) OR ((title: ("transitory deafness"))) OR ((title: ("transitory hearing loss"))) OR ((title: ("auditory acuity"))) OR ((title: ("hearing sensitivity"))) OR ((title: ("auditory perception"))) OR ((title: (deaf*))) OR ((title: ("vision disorder*"))) OR ((title: ("visual disorder*"))) OR ((title: ("visual acuity"))) OR ((title: ("vision impairment"))) OR ((title: ("vision disturbance"))) OR ((title: ("visual disturbance"))) OR ((title: ("visual impairment"))) OR ((title: ("visually impaired"))) OR ((title: (blind*))) OR ((title: (hemianopsia))) OR ((title: (hemianopia))) OR ((title: ("vision defect*"))) OR ((title: ("colour blind*"))) OR ((title: (colourblind*))) OR ((title: ("color blind*"))) OR ((title: (colorblind*))) OR ((title: (diplopia))) OR ((title: ("double vision"))) OR ((title: ("seeing double"))) OR ((title: (photophobia))) OR ((title: (scotoma))) OR ((title: ("low vision"))) OR ((title: ("vision loss"))) OR ((title: ("poor vision"))) OR ((title: ("subnormal vision"))) OR ((title: (amblyopia))) OR ((title: ("lazy eye"))) OR ((title: (cataract*))) OR ((title: ("contrast detection"))) OR ((title: ("contrast sensitivity"))) OR ((title: ("sensory impairment"))) OR ((title: ("sensory loss"))) OR ((title: ("sensory dysfunction"))) OR ((title: ("motor skill*"))) OR ((title: ("motor performance"))) OR ((title: ("psychomotor performance"))) OR ((title: ("motor function"))) OR ((title: (dexterity))) OR ((title: (agility))) OR ((title: (strength))) OR ((title: ("hand eye coordination"))) OR ((title: ("eye hand coordination"))) OR ((title: ("eye hand control"))) OR ((title: (grip*))) OR ((title: (grasp*))) OR ((title: ("movement limitation*"))) OR ((title: ("functional performance"))) OR ((title: ("functional impairment*"))) OR ((title: ("impaired functioning"))) OR ((title: ("functional disabilit*"))) OR ((title: ("functional decline"))) OR ((title: ("functional status"))) OR ((title: ("functional abilit*"))) OR ((title: ("physical abilit*"))) OR ((title: ("functional limitation*"))) OR ((title: ("functional restriction*"))) OR ((title: ("functional capacit*"))) OR ((title: ("physical function"))) OR ((title: ("functional independence"))) OR ((title: ("functional disease"))) OR ((title: ("decision making"))) OR ((title: (attention))) OR ((title: (concentrat*))) OR ((title: (motivat*))) OR ((title: (think*))) OR ((title: (judgment))) OR 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("vision impairment"))) OR ((abstract: ("vision disturbance"))) OR ((abstract: ("visual disturbance"))) OR ((abstract: ("visual impairment"))) OR ((abstract: ("visually impaired"))) OR ((abstract: (blind*))) OR ((abstract: (hemianopsia))) OR ((abstract: (hemianopia))) OR ((abstract: ("vision defect*"))) OR ((abstract: ("colour blind*"))) OR ((abstract: (colourblind*))) OR ((abstract: ("color blind*"))) OR ((abstract: (colorblind*))) OR ((abstract: (diplopia))) OR ((abstract: ("double vision"))) OR ((abstract: ("seeing double"))) OR ((abstract: (photophobia))) OR ((abstract: (scotoma))) OR ((abstract: ("low vision"))) OR ((abstract: ("vision loss"))) OR ((abstract: ("poor vision"))) OR ((abstract: ("subnormal vision"))) OR ((abstract: (amblyopia))) OR ((abstract: ("lazy eye"))) OR ((abstract: (cataract*))) OR ((abstract: ("contrast detection"))) OR ((abstract: ("contrast sensitivity"))) OR ((abstract: ("sensory impairment"))) OR ((abstract: ("sensory loss"))) OR ((abstract: ("sensory dysfunction"))) OR ((abstract: ("motor skill*"))) OR ((abstract: ("motor performance"))) OR ((abstract: ("psychomotor performance"))) OR ((abstract: ("motor function"))) OR ((abstract: (dexterity))) OR ((abstract: (agility))) OR ((abstract: (strength))) OR ((abstract: ("hand eye coordination"))) OR ((abstract: ("eye hand coordination"))) OR ((abstract: ("eye hand control"))) OR ((abstract: (grip*))) OR ((abstract: (grasp*))) OR ((abstract: ("movement limitation*"))) OR ((abstract: ("functional performance"))) OR ((abstract: ("functional impairment*"))) OR ((abstract: ("impaired functioning"))) OR ((abstract: ("functional disabilit*"))) OR ((abstract: ("functional decline"))) OR ((abstract: ("functional status"))) OR ((abstract: ("functional abilit*"))) OR ((abstract: ("physical abilit*"))) OR ((abstract: ("functional limitation*"))) OR ((abstract: ("functional restriction*"))) OR ((abstract: ("functional capacit*"))) OR ((abstract: ("physical function"))) OR ((abstract: ("functional independence"))) OR ((abstract: ("functional disease"))) OR ((abstract: ("decision making"))) OR ((abstract: (attention))) OR ((abstract: (concentrat*))) OR ((abstract: (motivat*))) OR ((abstract: (think*))) OR ((abstract: (judgment))) OR ((abstract: (efficien*))) OR ((abstract: (memor*))) OR ((abstract: (cognition))) OR ((abstract: ("cognitive dysfunction"))) OR ((abstract: ("cognitive function"))) OR ((abstract: ("cognitive impairment")))))) AND (((((title: (aged))) OR ((title:

(elder*))) OR ((title: (geriatric*))) OR ((title: ("older people"))) OR ((title: ("older person*"))) OR ((title: ("older adult*"))) OR ((title: ("older patient*"))) OR ((title: (senior*))))) OR ((((abstract: (aged))) OR ((abstract: (elder*))) OR ((abstract: (geriatric*))) OR ((abstract: ("older people"))) OR ((abstract: ("older person*"))) OR ((abstract: ("older adult*"))) OR ((abstract: ("older patient*"))) OR ((abstract: (senior*))))))) AND ((Language: (english))) AND Year: 2002 To 2022

Scopus

(TITLE-ABS ((medication* OR drug* OR medicine* OR prescription*)) AND TITLE-ABS (("self administrat*" OR "self manag*" OR "self efficacy" OR "self care" OR "self treatment" OR "self medicat*")) AND TITLE-ABS ((tool* OR instrument* OR framework* OR assess* OR survey* OR questionnaire* OR sc ale* OR screen* OR measur* OR psychometric*)) AND TITLE-ABS ((competenc* OR capacity OR skill* OR aptitude OR abilit* OR "hearing loss" OR "hearing impairment" OR "impaired hearing" OR "loss of hearing" OR "hearing difficult*" OR hypoacusis OR hypacusia OR hypacusis OR hypoacousia OR "transitory deafness" OR "transitory hearing loss" OR "auditory acuity" OR "hearing sensitivity" OR "auditory perception" OR deaf* OR "vision disorder*" OR "visual disorder*" OR "visual acuity" OR "vision impairment" OR "vision disturbance" OR "visual disturbance" OR "visual impairment" OR "visually impaired" OR blind* OR hemianopsia OR hemianopia OR "vision defect*" OR "colour blind*" OR colourblind* OR "color blind*" OR colorblind* OR diplopia OR "double vision" OR "seeing double" OR photophobia OR scotoma OR "low vision" OR "vision loss" OR "poor vision" OR "subnormal vision" OR amblyopia OR "lazy eye" OR cataract* OR "contrast detection" OR "contrast sensitivity" OR "sensory impairment" OR "sensory loss" OR "sensory dysfunction" OR "motor skill*" OR "motor performance" OR "psychomotor performance" OR "motor function" OR dexterity OR agility OR strength OR "hand eye coordination" OR "eye hand coordination" OR "eye hand control" OR grip* OR grasp* OR "movement limitation*" OR "functional performance" OR "functional impairment*" OR "impaired functioning" OR "functional disabilit*" OR "functional decline" OR "functional status" OR "functional abilit*" OR "physical abilit*" OR "functional limitation*" OR "functional restriction*" OR "functional capacit*" OR "physical function" OR "functional independence" OR "functional disease" OR "decision making" OR attention OR concentrat* OR motivat* OR think* OR judgment OR efficien * OR memor* OR cognition OR "cognitive dysfunction" OR "cognitive function" OR "cognitive impairment")) AND TITLE-ABS ((aged OR elder* OR geriatric* OR "older people" OR "older person*" OR "older adult*" OR "older patient*" OR senior*)) AND LANGUAGE (english)) AND PUBYEAR > 2001

10.1.2 Appendix A-2: Tool Properties

Tools	Purpose	Number of Items	Scoring scale	Administration time	Type of instrument	Type of medication regimen used	Medication management skill assessed	Psychometric properties - study reference	Validity		Reliability		
									Content	Construct	Inter-rater	Test-retest	Internal consistency
Physical + Cognition + Sensory+ Motivation													
ManageMed Screening (MMS)[138]	To quickly determine if someone can handle a moderately difficult medication routine	33 item	0-39	15-20 minutes	Performance-based	Simulated medication regimen	Read Rx label, recall information, open/close vials, perform calculations, organize pillbox	[138]	+	Neurocognitive function (Cognistat) (Pearson Correlation Coefficient of .696)	(0.86-0.96)		0.89
Self-Medication Risk Assessment Tool (RAT)[114]	To assess elderly patients' needs for additional support in managing their medicines	13 item	0-26	5-20 minutes	Performance-based	Simulated and patient's medication regimens	Read Rx labels, open different medication packaging, manipulate with 5 ml spoon and eye or ear drop bottles	[27]	+	Patient's comprehension and dexterity of handling the medications			(≥0.79)
Cognitive Screen for Medication Self-Management (CSMS)[110]	To assess the sensory and cognitive constructs associated with medication adherence	8 item	15	NR	Performance-based	Simulated medication regimen	Bottle opening, label reading, clock reading, dose calculations, arrangement time, study time, immediate recall, delayed, recall, cued recall, prospective memory and dose planning	[110]	+	Cognitive status and age			-0.08-0.84

Physical + Cognition + Sensory+ Environmental													
Medication Management Ability Assessment (MMAA)[127,135]	To assess geriatric mental health patients' ability to independently manage medications	4 item	0-25	45-60 minutes	Performance-based	Simulated medication regimen	Recall information, describe full regimen, open/close, remove the dose from vials, differentiate tablet by color	[147]	+	Cognitive function (neuropsychological battery test), Adherence		0.96	
Self-Medication Assessment Tool (SMAT)[45,109,148]	To screen for medication self-management deficits in older adults and to facilitate targeted interventions	44 item	Multiple scale	45-60 minutes	Performance-based	Patient's own medication regimen Simulated medication regimen	Read Rx labels, recall information, interpret medication instructions, open vials, remove tablets form packaging, differentiate tablets by color, organize pillbox	[148]	+	Cognitive function (MMSE, CDT, CCT), Medication regimen complexity, Self-reported adherence	+(≥0.79)	+(≥0.83)	+(≥0.81)
Physical + Cognition + Motivation + Environmental													
HOME-Rx revised[41]	To assess ability to manage medication routines in context, identify risk factors for medication management problems, and identify the environmental barriers influencing medication management ability	4 subscales	Multiple scale	25 to 35 minutes	Performance-based	Patient's own medication regimen	Knowledge of medications, Recall information, maniple of medication bottles and/or syringe, and calculate medication doses, storing and retrieving pills;	[41]	+	PASS (positively correlated with the HOME–Rx Performance subscale ($r = .57$, $p < .001$) and Safety subscale ($r = .49$, $p < .001$)), MedMaIDE (negatively correlated with			.87 to 1.00

							reading labels; verbalizing the dosage instructions, special instructions, and purpose; following dosing directions correctly and recognizing when one has missed doses; opening containers; setting up medications; taking out medications; and physically administering medications.			the HOME–Rx Performance subscale (r = −.69, p < .001) and positively correlated with the HOME–Rx Barriers subscale (r = .70, p < .001))			
Medication Management Instrument for Deficiencies in the Elderly (MedMaIDE) [41,115]	To identify the deficiencies in older adults' ability to take their medication at home.	20 item	0-13	30 minutes	Performance-based	Patient's own medication regimen	Medication knowledge (name all drugs and describe full regimen including indication, rout of administration, dose and time), Medication taking ability (filling a glass of water, sip enough water, open bottles/vials,	[149]	+	Cognitive function (MMSE), Functional status (ADL), Medication adherence (pill count)	0.74	0.93	0.71

							remove dose from package, and demonstrate admiration method for oral and non-oral dosage form),Knowledge about ongoing supplies (identify existing refills, name of pharmacy or physician office, and available resources)						
Physical + Cognition+ Motivation													
Show Back[145]	To assess older adult medication self-management proficiency	5 item	0-100	22 minutes	Performance-based	Simulated medication regimen	Identify medications, explaining the indication, organizing pillbox, describing the administration process for injectables and inhaled medications, describing the timing of doses	145	+	Medication Discrepancy Tool (MDT)	0.83-1		
MedTake test[132]	To quantify seniors' ability to take oral drugs safely, standardize the brown bag review	4 item	0-100	30-45 minutes	Performance-based	Patient's own medicatio	Identify meds & recall med names, open bottles/vials &	132	+	Cognitive function (MMSE), Educational level			

						n regimen	remove dose from package, state indication, food/water congestion, and timing						
HOME-Rx[127]	To assess an older adult's ability to manage medication routines in the home and to identify at-risk behaviors by home health occupational therapists	16 item	1-16	30-45 minutes	Performance-based	Patient's own medication regimen	Knowledge of medications, recall information, maniple of medication bottles and/or syringe, and calculate medication doses	[127]	+	Cognitive function (MoCA), MMC (MangeMed)			.87 to 1.00
*Hopkins Medication Schedule (*HMS) [137,138]	To test older adults' ability to understand and implement a routine prescription medication	2 item	0-11	15-30 minutes	Performance-based	Simulated medication regimen	Read Rx labels, comprehend medication regimen, plan a schedule for meds regimen, open & close vails, remove dose from vials, organize pillbox.	[150]	+	Cognitive function (MMSE), Functional status (IADL)		0.38	
Cognition + Sensory+ Motivation													
Performance Assessment of Self-care Skills (PASS-IADL) [127]	To measure occupational performance of daily life tasks	26 (four domains)	NR	1.5-3 hour	Performance-based	NA	NA	[151]	+		0.29-0.43	0.82-0.97	0.94-0.96
Physical + Cognition													

Drug Regimen Unassisted Grading Scale (DRUGS) [33,109,129,137]	To assess Medication self-management ability	4 item	0-100	5-15 minutes	Performance-based	Patient's own medication regimen	Identification: showing the appropriate medications, access: opening the appropriate containers, dosage: dispensing the correct number per dose, and timing: demonstrating the appropriate timing of doses	152	+	Cognitive function (MMSE), Functional status (ADL & IADL), Self-reported MMC, Health literacy		0.83	0.81
Cognition + Motivational													
Short Test of Functional Health Literacy in Adults (S-TOFHLA)[120]	To measure patients' ability to read and understand the things they commonly encounter in the health care setting using actual materials like pill bottles and appointment slips	4 Numeracy items and 2 prose passages	0-100	12 minutes	Performance-based	Patient's own medication regimen	NR	153	+	REALM			0.68-0.97
Test of Functional Health Literacy in Adults (TOFHLA-R)[124,124,144]	To measure the functional health literacy of patients.	50-item reading comprehension and 17-item numerical ability test	0-50	22 minutes	Performance-based	Patient's own medication regimen	Reading comprehension and numeracy	154	+	REALM, WRAT-R		0.92	0.98
Comprehensive Health Activities Scale (CHAS) [124,124]	To measure health literacy skills	45 item	0-100	60 minutes	Performance-based	Simulated medication regimen	Organizing and dosing medication	155	+	TOFHLA and the NVS, REALM and the MMSE		> 0.80	
Functional, communicative and critical health literacy scales	Three newly developed scales for measuring functional, communicative, and critical HL	14 item	4-point Likert scale	NR	Self-reported	Patient's own medicatio	NR	156	+			0.67-0.72	0.87

(FCCHL)[141]	among patients with type 2 diabetes in order to propose a measure of HL					n regimen							
Motivation + Environmental													
Long-Term Medication Behavior Self-Efficacy Scale (LTMBSES)[7]	To measures self-efficacy in relation to medication compliance	22 item	Multiple scales	NR	Self reported	NA	NA	[157]	+	Various levels of adherence			0.88
Self-efficacy for appropriate medication use scale (SEAMS)[33,137,121,123,133]	To assess self-efficacy for appropriate medication use	21 item	21-63	5-10 minutes	Self-reported	Patient's own medicatio n regimen	NR	[15,38,42,44,54]	+	REALM Various disease Various literacy levels		0.62	0.90
Cognition													
Mini-Mental State Examination (MMSE) [111,116,118,126,128,130,132,143]	To check for cognitive impairment (problems with thinking, communication, understanding and memory)	11 item	0-30	10 minutes	Performanc e-based	NA	Cognitive ability to manage medications	[158]	+	Mattis Dementia Rating Scale, Wechsler Adult Intelligence Test, Functional Independence Measure, Montgomery Asberg Depression Rating Scale, Zung Depression Scale.	0.69	0.96	0.96
Wisconsin Card Sorting Test (WCST) [111]	To assess abstract reasoning ability and the ability to shift cognitive strategies in response to changing environ-mental contingencies and also considered a measure of the executive functions.	14 item		12–20 minutes	Performanc e-based	NA	Cognitive ability to manage medications	[159]	+				0.93
Digit Span Backward (DSB) [111]	To assess working memory	8 item	0-16	Less than 5 minutes	Performanc e-based	NA	Cognitive ability to manage medications	[160]	+	Wechsler Adult Intelligence Scale		0.76-0.95	

California Verbal Learning Test (CVLT)[111]	To assesses encoding, recall and recognition	16 item		30 minutes	Performance-based	NA	NA	[161]	+			0.80–0.84	
Mini-Cog[113,119]	To evaluate cognition in older adults	4 item	0-5	3 minutes	Performance-based	Pillbox	Read Rx labels, interpret medication instructions, organize pillbox	[162]	+	Abbreviated mental test score (AMTS), the Geriatric Depression Scale	0.76	0.86	0.83
Medi-Cog[113,119]	To assess patients' ability to fill their own prescribed medications into a pillbox	3 item	0-10	7-8 minutes	Performance-based	Pillbox	Read Rx labels, interpret medication instructions, organize pillbox	[163]	+	Cognitive function Correctly filled pills			
Medication-transfer screen (MTS) [113,119]	To assess patients' ability to fill their own prescribed medications into a pillbox	4 item	5	5 minutes	Performance-based	Pillbox	Read Rx labels, interpret medication instructions, organize pillbox	[163]	+	Cognitive function Correctly filled pills			
Montreal Cognitive Assessment (MoCA)[29,144]	It assesses different cognitive domains: attention and concentration, executive functions, memory, language, visual constructional skills, conceptual thinking, calculations, and orientation	30 item	0-30	10 minutes	Performance-based	NA	NA	[164]		Age, educational levels, economic status, and sex, MMSE		0.92	0.82
Short Blessed Test (SBT) [29]	This test addresses cognitive concerns in the areas of orientation, memory, and concentration.	6 item	0 – 28	5-10 minutes	Performance-based	NA	NA	[165]		MMSE			0.52-0.58
Trail-Making Test (TMT)[29,105,130]	To assess executive function	25 item	Part A- 1-39 sec Part B-1-91 sec	5-10 minutes	Performance-based	NA	NA	[166]		Category Test (CAT), Wisconsin Card Sort Test (WCST), Paced Auditory Serial Addition Task		Part A-0.78 Part B- 0.67	

										(PASAT), Visual Search and Attention Test (VSAT).			
Measure of Drug Self Management (MeDS)[132]	An assessment of medication self-management skills	NR	0-12	NR	Self-reported	Patient's own medication regimen	NR	[52]	+	Morisky Medication Adherence Scale and relevant clinical measures (HbA1c, blood pressure, and low-density lipoprotein cholesterol)			0.72
Fuld Object-Memory Evaluation (FOME) [95]	To assess memory	10 item	0-10	15 minutes	Performance-based	NA	NA	[167]	+			0.71	0.84
Sensory													
National Eye Institute Visual Function Questionnaire -25 (NEI VFQ–25)[122,129]	To measures the dimensions of self-reported vision-targeted health status that are most important for persons who have chronic eye diseases.	25+1 item	0-100(Multiple scale)	10 minutes	Self-reported	NA	NA	[168]	+	Various eye disease 51-item NEI VFQ			0.71-0.85
Daily Living Tasks associated with Vision (DLTV) [41]	To assess functional impairment among patients with age-related macular degeneration (AMD)	24 item	0-100	6-10 minutes	Self-reported	NA	NA	[169]	+				0.97
Pelli-Robson letter sensitivity chart (PR test)[137]	To measures a patient's contrast sensitivity (CS) by finding the lowest contrast letters he/she can read correctly	NR	NR	NR	Self-reported	NA	NA	[170]					
Randot Circles[137]	To test the patient depth perception along with normal stereo vision.	NR	NR	NR	Self-reported	NA	NA						

Early Treatment Diabetic Retinopathy Study eye chart (ETDRS)[58]	To measure visual acuity	5 letters of equal difficulty on each row, with standardized logarithmic spacing between letters and rows: a total of 14 lines (70 letters)	NR	NR	Performance-based	NA	NA	[91]		Accuracy- 0.12±0.14		Test - retest variability- 0.23±0.17	
Whisper test[53]	To assess hearing	6 steps	Threshold for hearing impairment <50% correct	5 minutes	Self-reported	NA	NA	[92]		Sensitivity (%; 95% CI) 100 (96-100) ,), Specificity (%; 95% CI) 87 (80-92)			
Motivation													
The Newest Vital Sign (NVS)[46,54,61]	To Identifies patients at risk for low health literacy	6 item	0-6	3 minutes	Performance-based	Patient's own medication regimen	Read Rx labels, interpret medication instructions	[93]	+	TOFHLA			0.76
Rapid Estimate of Adult Literacy in Medicine (REALM)[32,35,38,45,46,55,60]	To assess an adult patient's ability to read common medical words and lay terms for body parts and illnesses	7 item	0-66	2-3 minutes	Performance-based	NA	NA	[94]	+	Peabody Individual Achievement Test-Revised (PIAT-R), Wide Range Achievement Test-Revised (WRAT-R), Slosson Oral Reading Test-Revised (SORT-R)		0.99	0.97

Medication Administration Self-Efficacy Scale (MASES)[65]	To identified levels of self-efficacy, self-care, trust, levels of support from the community and organizations, and satisfaction levels related to self-administration of medications	26 item	0-3	NR	Self-reported	Patient's own medication regimen	NA	[65]	+				0.95
Martin and Park Environmental Demands Questionnaire (MPED)[14]	To measures two dimensions of environmental demand: (1) busyness and (2) routine	13item	Likert scale 1 through 5.	5-10 minutes	Self-reported	NA	NA	[95]	+	Age, Household size, Medication-taking errors.			0.88 for the busyness scale and 0.74 for the routine scale
Environmental													
Medication-Specific Social Support Questionnaire (MSSS)[44]	To identify how often participants received help for their medication taking over a three-month period	8 items	0-4	NR	Self-reported	NA	NA	[96]	+	Various diseases, drugs			0.92
Multidimensional Scale of Perceived Social Support (MSPSS)[57]	To assess an individual's perception of the social support he or she receives from family, friends and significant others	12 item	7-point Likert type scale	5-10 minutes	Self-reported	NA	NA	[97]	+			0.91	0.95
Perceived Social Support from Friends (PSS-Fr) and the Perceived Social Support from Family (PSS-Fa)[14]	To measure the extent to which an individual perceives that his/her needs are fulfilled by friends and family	20 item	0-20	NR	Self-reported	NA	NA	[98]	+	Various symptoms of distress and psychopathology, mood states			0.88 for PSS-FR and 0.90 for PSS-FA

10.2 Appendix B : Classification System for Medication Adherence Technologies

10.2.1 Appendix B-1: Final Classification System of Medication Adherence technologies – Description of Dimensions, Subdimensions and characteristics

Dimension	Subdimensions	Definition	Characteristics
Physical Features	Shape	The shape is defined as a physical form of the product.	• Circular • Rectangular • Box-shaped • Cylindrical

	Non-slip features	Non-slip refers to the ability to hold the device with ease and is graspable.	• Present
			  • Contoured grip
			  • Textured grip
			• Absent

	Portability	Portability refers to a device that can be easily carried by the user.	• Portable
			  • Whole product
			  • A part of the product
			• Non-portable

	Size	The size refers to the volume of the product.	• Small (<300 cm^3) • Medium (300 – 1000 cm^3) • Large (1000 – 5000 cm^3) • Extra-large (>5000 cm^3)

	Button	A button is defined as a small, marked area on a device that can be physically pressed to activate a function.	• Buttons absent
			• Buttons present
			  • Shape
			    ○ Round
			    ○ Rectangular
			    ○ Square
			    ○ Triangular
			    ○ Combination
			  • Size
			    ○ Small (<9.5mm)
			    ○ Medium (9.5- 17.5mm)
			    ○ Large (between 17.5mm-23mm)
			    ○ Extra-large (greater than 23mm)
			    ○ Combination
			  • Colour
			    ○ Single colour
			    ○ Bicolour

		o Multicoloured • Space between buttons o Clustered (space < 6mm) o Spaced (>6mm) o Combination • Placement of buttons o Top o Center o Bottom o Combination • Labelling o Text labels o Icon labels o Combination labels • Type/design o Capacitive o Flat buttons o Raised buttons o Combination • Function of the button o Alarm o Turn on/off o Talk o Light o Dose adjustment o Time adjustment o Dispense
	Power Source	The power source refers to how the device is being powered to enable the device to work.	• None • Internal • Batteries • Rechargeable cells • External • Power banks • Electric plug-in • Combination
	Compartment	A compartment is a location within the device that is used for medication storage. • Compartment capacity - reference point 1 Aspirin sized pill	• Number of compartments • Single compartment • Multiple compartment

		• Compartment opening: the opening through which medication can be loaded and retrieved from the compartment.	• Compartment capacity
			  • 1 Aspirin sized pill
			  • 2-18 Aspirin sized pills
			  • > 18 Aspirin sized pills
			• Compartment opening
			  • Narrow: < 2.5 cm
			  • Wide: ≥ 2.5 cm

	Locking Feature	A locking feature refers to the ability to limit access to medications.	• Lock and key • Personal identification number (PIN) • Thumb print • Facial recognition • Absent

Display	Non-electronic	Display refers to the surface of the medication dispensing device that presents information about device, compartments, or other features. Non-electronic displays can be categorized into 2 different types: product display and setting display.
		
		• Product display refers to the surface of the medication dispensing device that displays information about compartment labels or other types of labeling.
			• Text Contrast Ratio
			  • High contrast ratio = 4.5:1
			  • Low contrast ≤ 4.5:1
			  • Combination
			• Font size
			  • Size 8-12 (small)
			  • Size 12-14 (medium)
			  • Geater than 14 (large)
			  • Combination
			• Labels
			  • Labeled compartments
			  • Unlabeled
			  • Customizable
			  • Multilingual
			  • Picture
			  • Braille
			  • Colour-coded

		• Settings display refers to the display on the device that allows the user to adjust the settings or programming of the device, such as setting the medication schedule or adjusting the volume of alerts and reminders.	• Date setting
			  • Present
			  • Absent
			• Time setting
			  • Present
			  • Absent
			• Text contrast ratio
			  • High contrast ratio = 4.5:1

			◦ Low contrast ≤ 4.5:1 ◦ Combination • Font size ◦ Size 8-12 (small) ◦ Size 12-14 (medium) ◦ Greater than 14 (large)[19] ◦ Adjustable ◦ Combination • Labelling ◦ Labeled ◦ Unlabelled ◦ Customizable ◦ Multilingual ◦ Picture ◦ Braille ◦ Colour-coded
	Electronic	Electronic display refers to a digital display on the device that provides information about the medication schedule, such as the time of day that each dose should be taken.	• Text Contrast ratio ◦ High contrast ratio = 4.5:1 ◦ Low contrast ≤ 4.5:1 ◦ Combination • Font size ◦ Size 8-12 (small) ◦ Size 12-14 (medium) ◦ Greater than 14 (large)[19] ◦ Combination ◦ Adjustable • Zoom functionality ◦ Present ◦ Absent • Date ◦ Present ◦ Absent • Time ◦ Present ◦ Absent • Screen size ◦ Small: < 2 inches

			• Medium: 2 – 5 inches
			• Large: > 5 inches
			• No screen
			• Types of Display
			  • Transmissive
			    ○ LCD (Liquid Crystal Display)
			  • Emissive
			    ○ LED (Light-Emitting Diode)
			    ○ OLED (Organic Light-Emitting Diode)
			  • Reflective
			    ○ E Ink Display

System Alert	Internal Alert	System notification refers to the ability of the device to draw attention to a particular event or situation by producing sounds or tones, either directly by the device or communicated to another device.
		• Internal alert refers to the ability of the device to draw attention to a particular event or situation through an internal source.
			• Absent
			• Audio
			  • Present
			    ○ Voice commands
			    ○ Beeping sound
			  • Absent
			  • Customization
			    ○ Volume
			    ○ Duration
			    ○ Tone
			    ○ Frequency
			• Visual
			  • Present
			  • Absent
			  • Customization
			    ○ Colour
			    ○ Duration
			    ○ Frequency
			• Haptics
			  • Present
			  • Absent

	External Alert	External alert refers to the ability of the device to draw attention to a particular event or situation through an external source.	• Absent
			• Present
			  • Smartphone
			    ○ Email
			    ○ Text message
			    ○ Phone call

			○ Applications • Wearables ○ Haptics ○ Audible ○ Visual • Home Assistants ○ Haptics ○ Audible ○ Visual
Operations	Instructions	Instructions refer to the information provided by the manufacturer to set and operate the device.	• Absent • External •Absent •Present • Paper ○ Step by step ○ Multilingual ○ Picture • Online resources • Internal • Absent • Present • Video ○ Repeated instructions ○ Step by step ○ Multilingual • Audio ○ Repeated instructions ○ Step by step ○ Multilingual • Text based ○ Repeated instructions ○ Step by step ○ Multilingual • Combination
	Dispensing	Dispensing refers to actions required to operate the device to dispense medication.	• One-handed operation • Two-handed operation • Remote control • No-handed operation

			• Voice activated
	Steps	The number of steps refers to the number actions needed to operate the device as intended.	• < 5 steps • 5 to 10 steps • > 10 steps
	Medication Access	Access refers to the actions required to access a dose of medication where medications are dispensed in packaging from the device.	• Pull tab • Puncture blister • Twist cap • Slide door • Flip top cap • Flip device • Lift lid • Lift tab • Tear away
Connectivity	Standalone	Standalone refers to the ability of the device to perform its functions independently without external connections.	

	Connected	A connected device is one that is connected to other devices to enable an exchange of data and information.	• Short Range
			  • Bluetooth
			  • Near Field Communication (NFC)
			  • Wi-fi
			  • Radio-Frequency Identification (RFID) Technology
			• Long Range
			  • Cellular

Data Collection and Management	Method	Method refers to the ability of the device to collect data and organize it into information related to medication adherence.	• Absent
			• Present
			  • Manual
			  • Automatic
			  • Interactive

	Monitoring	Monitoring is the ability of device to record data based on patient medication usage.	• Absent
			• Present
			  • Dose
			  • Refill
			  • Side effects
			  • Missed dose
			  • Medication schedule
			  • Adherence
			    ○ Overall
			    ○ Medication specific

	Reporting	Reporting is the ability to generate reports based on the data collected by the device regarding the medication adherence of the user.	• Absent
			• Present
			  • Type of report generated
			    ○ Summary reports
			    ○ Detailed reports
			    ○ Trend reports
			  • Frequency of report generation
			    ○ Daily
			    ○ Weekly
			    ○ Monthly

	Data accessibility	Data accessibility refers to ability of the device to share and retrieve collected user medication adherence data.	• Absent
			• Present
			  • Platform
			    ○ Mobile app
			    ○ Webpage
			    ○ E-mail
			  • Personnel
			    ○ Patient
			    ○ Caregiver
			    ○ Healthcare provider
			  • Privacy features
			    ○ Non-Connected Devices
			    ○ Local Data Storage Devices
			    ○ Cloud-Based Storage Devices
			    ○ Data Encryption and Anonymization
			    ○ User Consent and Control

Integration	Device	Device integration is the ability of the device to connect and communicate with other devices and features.	• Applications
			  • First party
			  • Third party
			• GPS (location)
			• Electronic Health Record (EHR)
			• Other Health Devices
			• Wearable Devices
			• Accessibility Devices

	Support	Support refers to the ability of a device to connect and communicate with various support systems.	• Absent
			• Present
			  • IT Support
			  • Healthcare Provider (HCP)

			• Pharmacy • Caregiver

10.2.2 Appendix B-2: Classification of Sample Medication Adherence Devices based on the developed taxonomy

Dimensions	Subdimensions	Characteristics					GMS Med-e-lert Automatic Pill Dispenser	LiveFine Automatic Pill Dispenser and Reminder	MedReady 1700 Automated Medication Dispenser	MedSmart Med-Reminder and Dispensing System	e-pill MedTime Station Automatic Pill Dispenser with Timer	e-pill Accutab Weekly Pill Dispenser	VitaCarry Advanced Pill Case	Nishiki Round Pill Box with Alarm	MedGlider System 1 with Talking Reminder	Patterson Medical TabTime Super 8	100-Hour Pill Reminder	Med-Q Smart Pillbox	e-pill MedGlider Home Medication Management System	MedCentre System	Pillbox with Digital Timer Instructions	TimerCap Travel Size	eNNOVEA Weekly Planner with Advanced Auto Reminder	Jones medication adherence system	Spencer Medication Dispenser	EllieGrid Smart Pill Box
Physical Features	Shape	Circular					X	X	X	X	X			X							X	X				
		Rectangular																		X				X	X	
		Box-shaped										X	X		X	X	X	X	X							X
		Cylindrical																					X			
	Non-slip features	Absent					X	X			X	X		X		X	X	X	X	X	X			X	X	X
		Present	Contoured grip							X			X													X
			Textured grip						X						X							X	X			
	Portability	Portable	Whole product				X	X		X		X	X	X	X	X	X	X			X	X		X		X
			A part of the product								X								X	X			X			
		Non-portable							X																X	
	Size	Small (<300 cm^3)												X	X	X	X				X	X				
		Medium (300 – 1000 cm^3)											X					X								X

		Large (1000 – 5000 cm^3)					X	X		X		X							X					X		
		Extra-large (>5000 cm^3)							X		X									X			X		X	
	Button	Absent										X										X		X		X
		Present	Shape	Round			X	X	X	X	X			X		X	X				X				X	
				Rectangular															X							
				Square																						
				Triangular																						
				Combination									X		X			X		X			X			
			Size	Small (<9.5mm)			X	X	X		X			X		X	X				X					
				Medium (9.5-17.5mm)														X	X				X			
				Large (between 17.5mm-23mm)																					X	
				Extra-large (greater than 23mm)[6-10]																						
				Combination						X			X		X					X						
			Colour	Single colour			X	X	X		X			X	X	X					X				X	
				Bicolour						X			X				X	X	X							
				Multicoloured																X			X			
			Space between buttons	Clustered (space < 6mm)											X		X		X		X				X	
				Spaced (>6mm)			X	X	X	X	X			X		X										
				Combination[9-11]									X					X		X			X			
			Placement of buttons	Top											X			X			X		X			
				Center			X	X	X	X	X			X		X	X									
				Bottom																					X	
				Combination									X						X	X						
			Labelling	Text labels			X	X	X			X		X	X	X	X		X		X					

				Icon labels																						
				Combination labels						X			X					X		X			X			
			Type/design	Capacitive														X							X	
				Flat buttons					X																	
				Raised buttons			X	X		X	X		X	X	X	X	X		X	X	X					
				Combination																			X			
			Functionality	Alarm			X	X	X	X	X		X	X	X	X	X	X	X	X	X		X			
				Turn on/off																						
				Talk																X						
				Light																X			X			
				Dose adjustment						X																
				Time adjustment			X	X	X	X	X		X		X	X	X	X	X	X	X		X			
				Dispense																						
	Power source	None										X														
		Internal	Batteries				X	X					X	X	X	X	X	X	X	X	X	X	X			
			Rechargeable cells																							
		External	Power banks																							
			Electric plug-in																							
		Combination							X	X	X													X	X	X
	Compartment	Number of compartments	Single compartment																		X				
			Multiple compartment				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X
		Compartment capacity	1 Aspirin sized pill																						
			2-18 Aspirin sized pills											X	X	X	X	X	X	X	X		X	X		
			> 18 Aspirin sized pills				X	X	X	X	X	X	X									X			X	X
		Compartment opening	Narrow: < 2.5 cm				X	X		X	X	X				X		X		X			X			
			Wide: ≥ 2.5 cm						X				X	X	X		X		X		X	X		X		X

	Locking Feature	Absent										X	X	X	X	X	X	X	X	X	X	X	X	X		X
		Present	Lock and key				X	X	X	X	X															
			Personal identification number (PIN)																						X	
			Thumb print																							
			Facial recognition																							
Display	Non-electronic	Product display	Absent										X													
			Present	Text Contrast Ratio[18]	High contrast ratio = 4.5:1		X	X	X	X	X	X		X				X	X	X		X	X	X	X	X
					Low contrast ≤ 4.5:1										X	X	X				X					
					Combination																					
				Font size	Small (Size 8-12)		X	X		X				X			X									
					Medium (Size 12-14)						X											X				
					Large (Geater than 14)							X	X		X	X		X	X		X		X	X		
					Combination				X											X						
				Labelling	Labeled		X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X		
					Unlabelled																					
					Customizable		X	X		X	X															
					Multilingual																					
					Picture														X				X			
					Braille													X								
					Colour-coded		X	X	X	X	X							X								
					Combination																					
		Setting display	Absent									X										X		X	X	X
			Present	Date setting	Present					X								X	X	X						
					Absent		X	X	X		X		X	X	X	X	X				X		X			
				Time setting	Present		X	X	X	X	X		X	X	X	X	X	X	X	X	X		X			
					Absent																					
				Text Contrast Ratio[18]	High contrast ratio = 4.5:1						X			X	X	X		X	X	X	X		X			

					Low contrast ≤ 4.5:1		X	X	X	X						X										
					Combination								X													
				Font size	Small (Size 8-12)									X	X	X	X			X	X					
					Medium (Size 12-14)		X	X	X	X	X		X						X				X			
					Large (Geater than 14)													X								
					Adjustable																					
					Combination								X													
				Labelling	Labeled		X	X	X	X	X		X	X	X	X	X	X	X	X	X		X			
					Unlabelled																					
					Customizable																					
					Multilingual																					
					Picture																		X			
					Braille																					
					Colour-coded												X			X						
	Electronic	Absent										X														X
		Present	Text Contrast Ratio[18]	High contrast ratio = 4.5:1			X	X	X		X		X	X	X	X	X	X	X	X	X	X	X	X	X	
				Low contrast ≤ 4.5:1						X																
				Combination																						
			Font size	Small (Size 8-12)													X									
				Medium (Size 12-14)										X							X	X		X		
				Large (Geater than 14)					X						X	X									X	
				Adjustable																						
				Combination			X	X		X	X		X					X	X	X			X			
			Zoom functionality	Absent			X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X
				Present																						
			Date	Present						X									X	X	X			X	X	
				Absent			X	X	X		X	X	X	X	X	X	X	X				X	X			

			Time	Present			X	X	X	X	X		X	X	X	X	X	X	X	X	X		X	X	X	
				Absent								X										X				
			Screen size	Screen absent								X									X					
				Screen present	Small: < 2 inches		X	X			X			X	X		X		X		X	X				
					Medium: 2 – 5 inches				X	X			X			X		X					X	X		
					Large: > 5 inches															X					X	
			Types of Display	Transmissive	LCD (Liquid Crystal Display)		X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X		X	
				Emissive	LED (Light-Emitting Diode)																					
					OLED (Organic Light-Emitting Diode)																					
				Reflective	E Ink Display																			X		
System alert	Absent											X										X		X		
	Present	Internal Alert	Absent																							
			Present	Audio	Absent																					
					Present	Voice commands									X					X						
						Beeping sound	X	X	X	X	X		X	X	X	X	X	X	X	X	X		X		X	X
					Customization	Volume										X		X		X					X	X
						Duration			X																	X
						Tone	X	X		X	X						X									X
						Frequency	X	X	X	X	X		X	X	X	X		X	X	X	X		X		X	
				Visual	Absent									X			X			X		X	X	X		
					Present		X	X	X	X	X		X		X	X		X	X		X				X	X
					Customization	Colour																				X
						Duration																				

						Frequency																				
				Haptics	Absent		X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X
					Present								X													
		External Alert	Absent				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			
			Present	Smartphone	Email																			X		
					Text message																			X		
					Phone call																				X	
					Applications																					X
				Wearables	Haptics																					
					Audible																					
					Visual																					
				Home Assistants	Haptics																					
					Audible																					
					Visual																					
Operations	Instructions	Absent																								
		Present	External	Absent																		X				
				Present	Paper	Step by step	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	
						Multilingual															X					
						Picture	X	X	X	X	X		X				X	X	X	X	X		X	X	X	
					Online resources		X	X	X	X	X		X	X	X	X	X	X	X	X	X		X	X	X	X
			Internal	Absent			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X
				Present	Video	Repeated instructions																			X	
						Step by step																			X	
						Multilingual																				
					Audio	Repeated instructions														X						
						Step by step																				
						Multilingual																				
					Text based	Repeated instructions																				
						Step by step																				
						Multilingual																				
					Combination																					

	Dispensing	One-handed operation					X	X	X	X	X	X			X	X	X	X			X					
		Two-handed operation											X	X					X	X		X	X	X	X	X
		Remote control																								
		No-handed operation	Voice activated																							
	Steps	< 5 steps							X		X	X	X					X								
		5 to 10 steps					X	X		X				X	X	X	X	X	X		X	X	X	X	X	X
		> 10 steps																		X						
	Medication Access	Pull tab																								
		Puncture blister																						X		
		Twist cap																				X	X			
		Slide door							X			X			X											X
		Flip top cap																	X	X						
		Flip device					X	X		X	X															
		Lift lid											X	X			X	X								
		Lift tab														X					X					
		Tear away																							X	
Connectivity	Standalone						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			
	Connected	Short Range	Bluetooth																							X
			Near Field Communication (NFC)																							
			Wi-fi																						X	
			Radio-Frequency Identification (RFID) Technology																							
		Long Range	Cellular																					X	X	
Data Collectio	Method	Absent					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			
		Present	Manual																							
			Automatic																					X		X

			Interactive																						X	
	Monitoring	Absent					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X			
		Present	Dose																					X	X	X
			Refill																						X	
			Side effects																						X	
			Missed dose																					X	X	X
			Medication schedule																					X	X	X
			Adherence	Overall																				X	X	X
				Medication specific																						
	Reporting	Absent					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			
		Present	Type of report generated	Summary reports																						
				Detailed reports																				X		X
				Trend reports																					X	
			Frequency of report generation	Daily																				X	X	X
				Weekly																				X	X	X
				Monthly																				X	X	X
	Data accessibility	Absent					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			
		Present	Platform	Mobile app																						X
				Webpage																				X	X	
				E-mail																				X		X
			Personnel	Patient																				X	X	X
				Caregiver																				X	X	X
				Healthcare provider																				X	X	X
			Privacy features	Non-Connected Devices			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			
				Local Data Storage Devices																				X	X	X

				Cloud-Based Storage Devices																						
				Data Encryption and Anonymization																						
				User Consent and Control																						
Integration	Absent						X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			
	Present	Device	Absent																							
			Present	Applications	First party																					X
					Third party																					
				GPS (location)																						
				Electronic Health Record (EHR)																						
				Wearable Devices																						
				Accessibility Devices				X																		
				Other Health Devices																					X	
		Support	Absent																							
			Present	IT Support																				X	X	X
				Healthcare Provider (HCP)																					X	
				Pharmacy																					X	
				Caregiver																					X	X

10.3 Appendix C: Study Methods

10.3.1 Appendix C-1: Screening Questions and Patient Information Letter

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Eligibility Checklist	
1. Age ≥ 60 years	☐ Yes ☐ No
2. Able to speak and read English ?	☐ Yes ☐ No
3. Please indicate yes or no for the following symptoms:	
• Memory problems	Yes ☐ No ☐
• Hand tremor	Yes ☐ No ☐
• Limited hand movements	Yes ☐ No ☐
• Low hand grip strength	Yes ☐ No ☐
• Low vision	Yes ☐ No ☐
• Difficulty in differentiating colours	Yes ☐ No ☐
• Blurred Vision	Yes ☐ No ☐
• Low hearing	Yes ☐ No ☐
• Hand paralysis	Yes ☐ No ☐
• Lack of sensation on hands	Yes ☐ No ☐
4. How often have you skipped your medication due to a lack of motivation?	☐Never ☐Rarely ☐Sometimes ☐Often ☐Very often
5. How often are you so busy that you missed your regular medications?	☐Never ☐Rarely ☐Sometimes ☐Often ☐Very often

Is the participant eligible to participate? Yes ☐ No ☐

Investigator Name: Date of Decision:

UNIVERSITY OF WATERLOO
FACULTY OF SCIENCE
School of Pharmacy

Consent Form Product User

Title of Project: User Experience with Medication Adherence Technology: Determining Usability by Capabilities

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INFORMATION LETTER FOR PARTICIPANTS

Investigator: This project is led by Dr. Tejal Patel a faculty member at University of Waterloo, School of Pharmacy.

Summary of the Project:
The purpose of this study is to identify the types of medication adherence products which are most appropriate for older adults with diverse physical, cognitive, sensory, motivation and environmental barriers to medication taking. In order to achieve this goal, the study will recruit older adults with a variety of limitations in order to assess the usefulness of three smart and ten electronic medication adherence products and to provide feedback and experiences regarding these products.

Procedure:
As an older adult, you have been invited to participate in our study, which involves several steps. First, you will be screened to ensure that you are eligible to participate. If you are eligible, we will measure your medication management capacity using a combination of tests.During these tests, you will be asked to complete a few questionnaires and perform medication management tasks such as organizing a pillbox. We will be also administering the Mini-Cog test to screen for cognitive capacity. Please note that individual results will not be provided. This test is only intended for screening purposes and cannot be used to diagnose any medical conditions. You will then be provided with four medication adherence products to use, which will be randomly assigned by the investigator. Medication adherence products are devices that help people take their medications on time and as prescribed by their healthcare provider. These products can include things like pill organizers, which help people keep track of their pills and remember to take them, or smart pill bottles that can send reminders to a person's phone when it's time to take their medication. The following are some examples of medication adherence products that you may be asked to use:

- Spencer
- Jones Healthcare Group Smart Blister Pack
- Pharmatrac Countertop Device
- MedReady 1700 Automated Medication Dispenser
- e-pill Accutab Weekly Pill Dispenser
- TimerCap Travel Size

A mock medication regimen that reflects the medications commonly taken by older adults will be provided to you. You will then be asked to use the medication adherence products provided to manage this regimen. For instance, you may be asked to use a pill organizer to sort and organize the mock medications according to a specific schedule, or to use a smart pill bottle that sends reminders to your phone when it's time to take a dose. An instruction sheet will be provided to you, detailing how to put the mock medications into the medication adherence product and how to remove them from it. You will be asked to follow the instructions on the sheet carefully. The contents of the mock medication regime are simply tic-tacs, candy, and lactose, and you will not be asked to ingest these contents under any circumstances. If you have any skin allergies related to any of these products, it is important to inform our research team so that we can refrain from using them. An audio recorder will be used to record your interactions with each product. You will also be asked to complete three questionnaires after testing each product. After you have tested all four products, we will conduct a one-to-one interview to discuss your experience. Please note that your statements during the interview will be audio-recorded to ensure that they are accurately recorded. Your participation in this study is entirely voluntary, and you may withdraw at any time without penalty.

As a participant in this study, you will meet with researchers for a session that will last approximately two hours. You can take breaks during the study if you want and can also ask to split the session into two and participate on separate days. If you have a caregiver, you are welcome to invite them to these meetings as well. The meeting will take place at the University of Waterloo School of Pharmacy building, or at a location designated by our supporting organizations.

Voluntary participation in the study:

Participation in this study is voluntary and you are under no obligation to participate. You may decline to answer any of the questions or perform any tasks you do not wish to do. Furthermore, participants may decide to withdraw from this study at any time, without any negative consequences, simply by letting us know your decision.

Possible risks or discomfort:

Participating in the study might cause some anxiety, or discomfort due to use of an unfamiliar product and audio recording while using various medication adherence products. You may also be anxious about recording your voice during one-on-one interview. However, in all instances, we will try to make it as comfortable for you as possible.

Possible benefits:

There is no direct benefit to participants from participating in this study. However, the results from participation will help the research team to identify most appropriate medication adherence product for participants with diverse limitations.

Eligibility requirements for participation:

For this study, we are looking for individuals who are aged 60 years or over. Participants must reside in Canada and must be able to speak and understand English in order to participate in this study.

Confidentiality:

We would like to assure participants that their identity and its association with the research data obtained in the study will be kept confidential. For your protection, we will assign each participant a code number that will be used to label all information and responses. However, with your permission, anonymous quotations may be used. The results of the study may be published for scientific purposes, but we will not include identifying information such as names or other identifying information. All collected data will be securely stored on a password-protected computer and in a locked office at the University of Waterloo, School of Pharmacy for a minimum of 15 years. You can withdraw your consent to participate and request that your data be removed from the study by contacting the researchers within this time period. Please note that data cannot be withdrawn once study results are submitted for publication.

Remuneration:

Participants have to travel to University of Waterloo School of Pharmacy and can subject to travel expenses. To thank participants for their time, all participants will receive $50. Additional remuneration will not be provided to those who accompany a participant. Please be advised that the amount received is taxable. It is the participant's responsibility to report this amount for income tax purposes.

Ethics review and clearance: We would like to assure you that this study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Board (REB #45203). If you have questions for the Board, contact the Office of Research Ethics, toll-free at 1-833-643-2379 (Canada and USA), 1-519-888-4440, or reb@uwaterloo.ca.

Questions and Contacts: Should you have any questions about the study or would like additional information to assist you in reaching a decision about participation, please contact Bincy Baby by email at b3baby@uwaterloo.ca or Tejal Patel by phone at 519-888-4567 ext. 21337 or by email at t5patel@uwaterloo.ca. Thank you for your assistance in this project.

CONSENT FORM

By signing this consent form, you are not waiving your legal rights or releasing the investigator(s) or involved institution(s) from their legal and professional responsibilities.

Project: User Experience with Medication Adherence Technology: Determining Usability by Capabilities

I have read the information presented in the information letter about a study being conducted by Dr. Tejal Patel, a faculty member at the University of Waterloo, School of Pharmacy. All the procedures and any risks and benefits relating to my participation have been explained. I have had the opportunity to ask any questions related to this study (if any), to receive satisfactory answers to my questions, and any additional details I wanted.

I am aware that I may withdraw my consent for any of the above statements or withdraw my study participation at any time without penalty by advising the researcher.

I am aware that audio-recording may be taken as I test the usability of the products and during one-on-one interviews.

I am aware that, with my permission, anonymous quotations, may be used for publications and educational purposes.

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Board (REB #45203). If you have questions for the Board, contact the Office of Research Ethics, toll-free at 1-833-643-2379 (Canada and USA), 1-519-888-4440, or reb@uwaterloo.ca.

With full knowledge of all foregoing, I agree, of my own free will, to the following:

I agree to participate in this study.

□ Agree □ Disagree

I agree to use:

□ Smart medication adherence products □ Electronic medication adherence products

I agree to the use of anonymous quotations in any presentation or report that comes of this study.

□ Agree □ Disagree

I agree to store the data collected during this study for a minimum of 15 years.

□ Agree □ Disagree

Participant Name (Please print)	Witness Name (Please print)
Participant Signature	Witness Signature
Date	Date

10.3.2 Appendix C-2: Scales Used to Measure Barriers to Medication Management Capacity

Self-Medication Assessment Tool (SMAT)

Section 1: Demographics

Patient ID :	Date of Test Assessment :
Age:	Gender: Male ☐ Female ☐ other ☐
Education:	Occupation:
Current medications : Yes ☐ No ☐	If yes, How Many :
Medical History :	
Place of residence: Home ☐ Retirement home ☐ Other ☐	

Section 2 : Functional & Cognitive Assessment

- **(Bottle 1: 10pt font; child-resistant [align arrows]; 7-dram vial)**

	Ease	Difficulty	Unable
F1. Please read the medication name and instructions from the label on this bottle out loud.			
Reading the medication name:			
Reading the instructions:			
F2. **Please open the bottle**			
C1. If this was your medication, how would you take it?			
Dosage correct:			
Time correct:			

- **(Bottle 2: 12pt font; non-child-resistant [pop top]; 12-dram vial)**

	Ease	Difficulty	Unable
F3. Please read the medication name and instructions from the label on this bottle out loud.			
Reading the medication name:			
Reading the instructions:			
F4. **Please open the bottle**			
C2. If this was your medication, how would you take it?			
Dosage correct:			
Time correct:			

- **(Bottle 3: 14pt font; child-resistant [push & turn]; 40-dram vial)**

	Ease	Difficulty	Unable
F5. Please read the medication name and instructions from			

the label on this bottle out loud.			
Reading the medication name:			
Reading the instructions:			
F6. **Please open the bottle**			
C3. If this was your medication, how would you take it?			
Dosage correct:			
Time correct:			

- **(<u>Bottle 3</u>: 14pt font; child-resistant [push & turn]; 40-dram vial)**

	Ease	Difficulty	Unable
F7. Please take 2 pills out of the bottle.			

- **(<u>Bottle 3, 4, & 5</u> : 14pt font; child-resistant [push & turn]; 40-dram vial)**

	Ease	Difficulty	Unable
C4. **If you were prescribed all three of these medications, describe when you would take the tablets and how many you would take at each time for a typical day.**			
Bottle 3 (labelled: Take 1 tablet 3 times a day)			
Dosage correct:			
Time correct:			
Bottle 4 (labelled: Take 1 tablet daily)			
Dosage correct:			
Time correct:			
Bottle 5 (labelled: Take 1 tablet daily)			
Dosage correct:			
Time correct:			

- **<u>(7 x 4 slot dosette</u>)**

This is a dosette. The names of the days are printed across the top, and the times of day are printed along the side. Here is Sunday, Monday, Tuesday, and here is Morning, Noon-time meal, evening meal, and before bed.

		Ease	Difficulty	Unable
C5. Please point to the slot for Tuesday at noon.				
F8/C6. Please take out the pills for Friday morning	F score			
	C score			

- **(Bottles 3, 4 & 5 with 7x4 slot dosette)**

C7. **Please place the pills from the 3 bottles into the dosette in the correct way for a full week**. **<u>Note to assessor:</u>** Allow maximum of 10 minutes to complete this task.

Time started: **Time Finished:**			
<u>Bottle 3</u>: (labelled: Take 1 tablet 3 times a day)	<u>Ease</u>	<u>Difficulty</u>	<u>Unable</u>
Dosage correct			
Time correct			
<u>Bottle 4</u>: (labelled: Take 1 tablet once a day)			
Dosage correct			
Time correct			
Bottle 5: (labelled: Take 1 tablet once a day)			
Dosage correct			
Time correct			

- **(<u>Blister Pack</u>)**

This is blister packaging for medication. The names of the days are printed along the side, and the times of the day are printed across the top. Here is Sunday, Monday, Tuesday, and here is Morning, Noon-time meal, evening meal, and before bed.

		Ease	Difficulty	Unable
C8. Please point to the bubble for Monday evening.				
F9/C9. Please take out the tablets for ………. (Select a day and time).	F score			
	C score			

F10 & F11. **What colour is each of these pills?**

Colour	Ease	Unable	Colour	Ease	Unable
White			White		
(Light) Yellow			(Dark) Yellow		
(Light) Green			(Dark) Green		
(Light) Orange			(Dark) Orange		
(Light) Pink			(Dark) Pink		

	Ease	Difficulty	Unable
Do you have any difficulty swallowing tablets?			
Pharmacist's estimate of hearing difficulty			
Pharmacist's estimate of visual difficulty			

<u>Section 3: Medication Aid Use</u>

Do you use anything to help you remember to take your medication? (please indicate all that apply)

Daily routine	
Pill box (dosette)	
Blister pack	
Medication calendar	

Alarm/beeper	
Someone else reminds me (who?) If yes, how do they help?	
Other	

If you use any medication aids, why did you start to use this aid or device? Please explain

Scoring

Functional	
Physical	
Vision	
Hearing	
Cognitive	
Medication aid use	

Comments:

Whisper Test

1. With the patient sitting on an exam table or chair, stand an arm's length away (approximately 2 ft.) behind the patient.
2. Tell the patient: "During the hearing test, I will ask you to cover the ear that is not being tested as I say the letters and numbers out loud. You will cover your ear by putting your finger over your tragus."
3. Have the patient cover the ear that's NOT being tested with one finger over the tragus. Have the patient slowly move the finger in a circular motion.
4. Take a deep breath and exhale fully before whispering the number-letter combination.
5. Give a number-letter-number combination (LISTED BELOW). Ensure that the number-letter-number combination is different for each ear
6. Have the patient repeat what they hear.
7. If the patient successfully repeats, move on to testing the other ear.
8. If the patient is unsuccessful, reattempt testing with a different number-letter number combination. If a patient gets 3 total letters and/or numbers correct after a second attempt, it is considered a pass.

8-M-3	2-J-7
K-5-R	S-4-G

PASS	R-	L-
FAIL	R-	L-

Self-Efficacy for Appropriate Medication Use Scale

Patient ID : ________________________Date of Test Assessment : ______

How confident are you that you can take your medicines correctly:	**Not At All Confident**	**Somewhat Confident**	**Very Confident**
1. If you take several different medicines each day	☐	☐	☐
2. If you take medicines more than once a day	☐	☐	☐
3. If you are away from home	☐	☐	☐
4. If you have a busy day planned	☐	☐	☐
5. If they cause some side effects	☐	☐	☐
6. If no one reminds you to take the medicine	☐	☐	☐
7. If the schedule to take the medicine is not convenient	☐	☐	☐
8. If your normal routine gets messed up	☐	☐	☐
9. If you are not sure how to take the medicine	☐	☐	☐
10. If you are not sure what time of the day to take your medicine	☐	☐	☐
11. If you are feeling sick (you know, like having a cold or the flu)	☐	☐	☐
12. If you get a refill of your old medicines and some of the pills look different than usual	☐	☐	☐
13. If a doctor changes your medicines	☐	☐	☐
14. If you are not sure how it works or what it does for you	☐	☐	☐
15. How confident are you that you will be able to afford your medicines?	☐	☐	☐
16. How confident are you that you will be able to get to the pharmacy to get your medicines?	☐	☐	☐

Martin & Park Environmental Demands(MPED) Questionnaire

Patient ID : ________________Date of Test Assessment : ____________

	Busyness Items	Not busy at all	Rarely busy	Somewhat busy	Very busy	Extremely busy
1	How busy are you during an average day?					
		Never	Rarely	Sometimes	Often	Very often
2	How often do you have too many things to do each day to actually get them all done?					
3	How often do you find yourself rushing from place to place trying to get to appointments or to get things done?					
4	How often are you so busy that you miss scheduled breaks or rest periods?					
5	How often are you so busy that you miss your regular mealtimes?					
6	How often do you rush out of the house in the mornings to get to where you need to be?					
7	How often do you have so many things to do that you go to bed later than your regular bedtime?					
	Routine Items					
8	How often do your days follow a basic routine?					
9	How often do you get out of bed in the morning and go to bed at night at about the same time?					
19	How often do you eat all of your meals at the same time each day and night?					
11	How often do you engage in activities at home at a specific time(i.e., read the paper after work, watch a particular television show, children, hobbies, etc.)?					
Instruction: Possible answers to the first question were: 1 = Not busy at all, 2 = Rarely busy, 3 = Somewhat busy, 4 = Very busy, and 5 = Extremely busy. Possible answers to all other questions were: 1 = Never, 2 = Rarely, 3 = Sometimes,4 = Often, and 5 = Very often						

10.3.3 Appendix C-3: Performance-based Usability Metric- Cognitive Walkthrough Patient Information Sheet and Evaluation Sheet

Cognitive walkthrough - Introduction

• Now we can Move to our usability study
• You will be given the opportunity to test four different products.
• You will be testing them one at a time.
• I will give you a product and any instruction manuals that came with it.
• You will be asked to complete certain tasks with each product (filling tray with medication, setting the alarm, etc.).
• There will be a sheet of paper available for you to look at, so you know which tasks you need to complete.
• Please perform the task in the best possible way.
• When you begin using the product, I would ask that you think aloud. This means that you verbalize your thoughts as much as possible by saying everything that goes through your mind while doing the task. (Show participant how to do it. Could fold a sheet of paper in half.)
• There is a reminder included on this sheet of paper (sheet with tasks listed- to think aloud & not to ingest mock medication regimen)
• I will be recording information such as the number of attempts made, how long it takes you to complete the task, etc.
• While you are testing the product, I will be unable to answer any questions.
• When you have finished each task, I will ask you two questions and once you are done using each product, I will give you three questionnaires to complete
• You may decline to answer any questions if you so wish.
• Also, we have 5 mock medications here, you can use then to fill the device based on the instructions given on the label. They are just tic tacs and lactose tablets and just for demonstration purpose. So, you do not have to ingest any of them at stages of the test
• Please do your best to accomplish each task.
• You are free to take breaks in between testing as you like
• If it becomes to frustrating or overwhelming for you, please let me know we can stop the usability test at any time
• If you choose to participate in the optional interview, you will complete that after you have tested the four products.
• Do you have any questions for me? (Answer any questions.)
• Alright.
• Here is your first product you will be testing.
• Please complete these tasks (sheet of paper) in the best possible way. Remember, try to say everything that goes explains your mind and explain what you are doing.

Reference List on How to Fill Out Form:

Please ensure when reading the script that you do NOT say "tell me what you think" as the participant may think you want their opinion on the device rather than what is going through their mind as they do the tasks.

As the participant completes the cognitive walk-through, please fill out "Cognitive Walk-Through Checklist" for the corresponding product. Explanations on how to fill out the form are below:

- **Task Success** :
  - o Assisted :able to complete task without assistance
  - o Unassisted: able to complete task with assistance from the evaluator
- **Task Failure** : Not able to complete task even with assistance from the evaluator. Evaluator

can complete the task and then ask the participant to move to next task

- **Task Error** :
    - o Present: (more than one) attempts needed to successfully complete the step. For example: If a person tries to do a step three times, then they would be making two additional attempts.
    - o Absent: For example: If a person is able to complete the task on the first try.
- Remember to take notes during the session
- Remember to audio record the session
- Remember to monitor task time – start the stopwatch when participant starts with task 1 and stop once the 1st task is complete.

Please complete the following tasks:

Task 1: Put the batteries in

Task 2: Set up the time and date for today

Task 3: Fill Medication Tray

Task 4: Set the Alarm 2-3 Minutes After the Current Time

Task 5: Take Medication Out of Device for today morning when Alarm Sounds

Please remember to keep talking out loud

Please note that the mock regimen provided is for demonstration purposes only and should not be ingested

PBA 001

Please complete the following tasks:

Task 1: Put the batteries in

Task 2: Set up the time for current time

Task 3: Fill Medication Tray

Task 4: Set the Alarm 2-3 Minutes After the Current Time

Task 5: Take Medication Out of Device for today morning when Alarm Sounds

Please remember to keep talking out loud

Please note that the mock regimen provided is for demonstration purposes only and should not be ingested

PBA 002/PBA 003

Please complete the following tasks:

Task 1: Set up the time for 10.27 AM

Task 2: Fill Medication Tray

Task 3: Set the Alarm at 10.30 AM

Task 4: Take Medication Out of Device for today morning when Alarm Sounds

Please remember to keep talking out loud

Please note that the mock regimen provided is for demonstration purposes only and should not be ingested

PBA 004

Please complete the following tasks:

Task 1: Fill Medication Tray

Task 2: Set the Alarm 2-3 Minutes After the Current Time

Task 3: Take Medication Out of Device for today morning when Alarm Sounds

Please remember to keep talking out loud

Please note that the mock regimen provided is for demonstration purposes only and should not be ingested

PBA 005

Please complete the following tasks:

Task 1: Put the batteries in

Task 2: Set up the time for current time

Task 3: Set the alarm 10 minutes after the current time

Task 4: Fill pill organizers with medication for 2 days – Sunday, Monday

Task 5: Take Medication Out of Device for Monday Morning when Alarm Sounds

Task 6: Turn the Carousel three days from today's day

Please remember to keep talking out loud

Please note that the mock regimen provided is for demonstration purposes only and should not be ingest

Product ID: PBA 006

Please complete the following tasks:

Task 1: Set up the time for current time

Task 2: Fill Medication Tray

Task 3: Set the Alarm 2-3 Minutes After the Current Time

Task 4: Take Medication Out of Device for today Morning when Alarm Sounds

Please remember to keep talking out loud Please note that the mock regimen provided is for demonstration purposes only and should not be ingest

Product ID: PBA 007

Please complete the following tasks:

Task 1: Put the batteries in

Task 2: Set up the time and date for today

Task 3: Fill Medication organizer for 3 days from today's date

Task 4: Set the Alarm 2 to 3 Minutes After the Current Time

Task 5: Take Medication Out of Device for today morning when Alarm Sounds

Please remember to keep talking out loud

Please note that the mock regimen provided is for demonstration purposes only and should not be ingest

Product ID: PBA 008

Please complete the following tasks:

- **Task 1:** Open the **"EllieGrid"** app and click on the "Add to pillbox" option
- **Task 2: Press "Add new pill" and add first pill to the app**
- **Task 3:** Empty the medications to the first compartment
- **Task 4: Press "Add new pill" and add second pill to the app**
- **Task 5:** Empty the medications to the second compartment
- **Task 6:** Turn off the smart alarm option and set alarm time for medication in the first compartment (time to take the medication) 3 minutes after the current time
- **Task 7:** Take pills when alarm sounds
- **Task 8:** Respond to the questions in the app

Product ID : PBA 009

Please complete the following tasks:

Task 1: Put the batteries in

Task 2: Unlock and Open the device using the key

Task 3: Set up the time for current time

Task 4: Fill medication tray for 2 days on the right of the “start” compartment

Task 5: Set the alarm 4 to 5 minutes after the current time

Task 6: Lock the device

Task 7: Take medication out of device for today morning when alarm sounds

Please remember to keep talking out loud

Please note that the mock regimen provided is for demonstration purposes only and should not be ingest

Product ID : APD 001

Please complete the following tasks:

Task 1: Put the batteries in

Task 2: Unlock and Open the device using the key

Task 3: Set up the time for current time

Task 4: Fill medication tray for 3 days from todays date

Task 5: Set the alarm 4 to 5 minutes after the current time

Task 6: Lock the device

Task 7: Take medication out of device when alarm sounds

Please remember to keep talking out loud
Please note that the mock regimen provided is for demonstration purposes only and should not be ingest

Product ID : APD 00

Please complete the following tasks:

Task 1: Load a new medication cartridge into the device

Task 2: Adjust the alert volume for medication reminders (Navigate to the “**settings**” option on the home screen (typically represented by a gear icon or labeled "Settings") then **“volume”** option

Task 3: Wait for a medication reminder and dispense the scheduled dose

Task 4: Open the medication pack to retrieve the medication.

Task 5: Shut down the device Navigate to the settings option on the home screen (typically represented by a gear icon or labeled "Settings") then “help” option and then shutdown

Please remember to keep talking out loud Please note that the mock regimen provided is for demonstration purposes only and should not be ingested

Product ID : SM 001

Please complete the following tasks:
Task 1: Connect the blister pack to the device
Task 2: Make sure the blister pack is connected correctly to the device by checking the display
Task 3: On the basis of the notification received on the iPad, remove the medication from the blister pack cavity number ……
Task 4: Remove the blister pack from the device

Please remember to keep talking out loud

Please note that the mock regimen provided is for demonstration purposes only and should not be ingested

Product ID : SM 002

PBA 001 (MedQ Smart PillBox)

Task	Task Success	Task Error	Notes
Task 1: Put the Batteries in **Start Time:** **End Time:**			
• Locate battery compartment	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Put the batteries correctly	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Put the battery door in	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 2: Set up the time and date for today **Start Time:** **End Time:**			
• Hold down the "SET BUTTON" and press the right arrow key three times and release both. (The hour will start flashing)	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Using right arrow button ,scroll to the current hour and then release	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Press the "SET BUTTON'(The minute will be flashing "on and off".	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Using the right button, scroll to the minute you want to set	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Press the "SET BUTTON'(The AM/PM will start flashing.	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Using the right arrow key scroll to A for AM or P form PM and release	Success ☐ • Unassisted ☐ • Assisted ☐	Present ☐ Absent ☐	

	Failure ☐		
• Press the "SET BUTTON'(Across the top of the LCD (clock) days of the week will appear)	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Using the right arow key scroll from Sunday to the correct day of the week	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 3: Fill Tray (*participant may remove compartment if desired*) **Start Time:**	**End Time:**		
• Open compartments for 1 week	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Fill compartments with medication	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Close lid of compartment	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 4: Set Alarm **Start Time:**	**End Time:**		
• Hold down the "set" button and press the right arrow once, release both	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Set hour using the right arrow button	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Press "set" button	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Set minute using the right arrow button	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Press "set" button	Success ☐	Present ☐	

	• Unassisted ☐ • Assisted ☐ Failure ☐	Absent ☐	
• Use the right arrow key to select A for AM or P for PM	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 5: Remove Medication After alarm sounds: **Start Time:**	**End Time:**		
• Stop alarm by pressing "next alert"	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Open compartment lid (can remove compartment if needed)	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Remove medication	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	

Total Completion Time: __________

Comments :

PBA 002 (MedGlider System 1 with Talking Reminder)

Task	Task Success	Task Error	Notes
Task 1: Put the Batteries in **Start Time:**	**End Time:**		
• Locate battery compartment	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Slide battery door off	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Put the batteries correctly	Success ☐ • Unassisted ☐ • Assisted ☐	Present ☐ Absent ☐	

	Failure ☐		
• Slide the battery door in	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 2: Set up the time for the current time **Start Time:** **End Time:**			
• Open the protective cover to access the set buttons	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Slide the function selector to CLOCK. The LCD display will flash	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Press HR to advance the hour	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Press MIN to advance to proper time	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 3: Fill Tray **Start Time:** **End Time:**			
• Slide tray out from underneath the alarm	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Insert medication into compartments	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Slide pillbox back to original location	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 4: Set Alarm **Start Time:** **End Time:**			
• Lift the blue/green clear cover	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	

• Slide the gray function selector to A1	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Use the hour and minute buttons to change time for the alarm	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Slide function selector to the lock setting	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Close cover	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 5: Remove Medication After alarm sounds: **Start Time:**	**End Time:**		
• Hit alarm stop button	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Slide pillbox out to appropriate side	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Remove medication	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	

Total Completion Time: ___________
Comments :

PBA 003 (VitaCarry Advanced Pill Case)

Task	**Task Success**	**Task Error**	**Notes**
Task 1: Put the Batteries in **Start Time:**	**End Time:**		
• Slide "lock" tab to the right and lift to open lid	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	

• Locate battery compartment	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Put the batteries correctly	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Check whether the device is on	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 2: Set up the time for the current time **Start Time:** **End Time:**			
• Press SET button on the left-hand side until SET TIME appears on the display	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Press Hrs & Min buttons	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Press SET button on the left-hand side again to confirm	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 3: Fill Tray for 1 week Start Time: **End Time:**			
• Place medication into compartments	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 4: Set Alarm **Start Time:** **End Time:**			
• Press alarm set button	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Press number for which alarm you want to sound (1-7)	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	

• Use hour and minute buttons to set time	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Press set alarm to confirm alarm	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Close lid until it clicks	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 5: Remove Medication After alarm sounds: **Start Time:** **End Time:**			
• Open container (slide lock, open lid)	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Press the corresponding alarm button	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Remove medication	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	

Total Completion Time: ___________
Comments :
PBA 004 (e-pill Multi-Alarm Pocket XL)

Task	**Task Success**	**Task Error**	**Notes**
Task 1:Set up the time for the current time **Start Time:** **End Time**			
• Press the SET key for three seconds to enter time setting mode (hour blinking)	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Tap ADJ jet to set HOUR	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	

• Press the SET key (minute blinking)	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Tap the ADJ key to set MINUTES	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Press SET to finish time setting	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 2: Fill Tray **Start Time:**	**End Time**		
• Slide "lock" tab down on the left side to unlock the pillbox underneath	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Slide pillbox out to the left	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Insert medication into compartments	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Slide pillbox to the right until it snaps and won't go further	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Slide "lock" tab up	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 3: Set Alarm **Start Time:**	**End Time**		
• Lift protective cover	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Slide alarm button up	Success ☐ • Unassisted ☐	Present ☐	

	• Assisted ☐ Failure ☐	Absent ☐	
• Close protective cover	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 4: Remove Medication when the alarm sounds **Start Time:** **End Time**			
• Hit stop button	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Unlock pillbox as before	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Slide pillbox out	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Remove medication for today's date	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	

Total Completion Time: __________
Comments :
PBA 005 (100-Hour Pill Reminder)

Task	**Task Success**	**Task Error**	**Notes**
Task 1: Fill Tray **Start Time:** **End Time**			
• open pillbox	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Insert pills	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Close lid and be sure that it snaps shut	Success ☐ • Unassisted ☐	Present ☐	

	• Assisted ☐ Failure ☐	Absent ☐	
Task 2: Set Alarm **Start Time:** **End Time**			
• Open timer lid	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Press the button corresponding with minutes to adjust the minutes for the countdown timer	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Press the red key to start the timer	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Close lid of timer	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 3: Remove Medication when the alarm sounds **Start Time:** **End Time**			
• Press red button (can open lid if needed)	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Open left compartment	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Remove medication	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	

Total Completion Time: __________

Comments :

PBA-006 (eNNOVEA Weekly Planner with Advanced Auto Reminder)

Task	Task	Task Error	Notes

	Success		
Task 1: Put the batteries in **Start Time:** **End Time:**			
• Locate battery compartment	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Put the batteries correctly	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Check whether the device is on	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 2: Set up the time for current time **Start Time:** **End Time:**			
• Press set time	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Press set hours and set the correct hour	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Press set minutes and set correct minute	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Again, press set time	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 3: Set Alarm **Start Time:** **End Time:**			
• Press alarm set button	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Press number for which alarm you want to sound (1-4)	Success ☐ • Unassisted ☐ • Assisted ☐	Present ☐ Absent ☐	

	Failure ☐		
• Use hour and minute buttons to set time	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Press alarm set button	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 4: Fill pill organizers **Start Time:**	**End Time:**		
• Pick correct pill organizers	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Open lid	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Insert 3 dividers to make 4 compartments	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Put stickers	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Insert pills into compartment	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Close lid	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Return daily pill organizer to upper carousel tray	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 5: Remove Medication **Start Time:**	**End Time**		
• Press corresponding alarm button	Success ☐	Present ☐	

	• Unassisted ☐ • Assisted ☐ Failure ☐	Absent ☐	
• Remove daily pill organizer, open lid	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Remove pills from compartment 1	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Put lid back on, return daily pill organizer	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 6: Turning Carousel **Start Time:** **End Time**			
• Rotate the carousel three days from today's date	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	

Total Completion Time: __________
Comments :

PBA 007 (Pillbox with digital timer instructions)

Task	**Task Success**	**Task Error**	**Notes**
Task 1: Set up the time for the current time **Start Time:** **End Time:**			
• Press the S button five times until the time and clock symbol is blinking	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Press the H button until the correct hour is selected	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Press the M button until the correct minute is selected	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	

• Press the S button once to confirm	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 2: Fill Tray for 1 week **Start Time:** **End Time:**			
• Open the compartments	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Insert correct medications	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Close the compartments	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 3: Set Alarm **Start Time:** **End Time:**			
• Press the S button once	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Press the H button until the correct hour is selected	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Press the M button until the correct minute is selected	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Press the S button once to confirm	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 4: Remove Medication After alarm sounds: **Start Time:** **End Time:**			
• Open the correct compartment	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	

• Take out the medication	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	

Total Completion Time: __________

Comments :

PBA -008 ((MedCentre System))

Task	**Task Success**	**Task Error**	**Notes**
Task 1:Put the Batteries in **Start Time:**	**End Time:**		
• Locate battery compartment	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Put the batteries correctly	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Check whether the device is on	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 2: Set up the time and date for today **Start Time:**	**End Time:**		
• Slide mode section switch to 'TIME SET'	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• PRESS SET/ADVANCE button once to enter hour set mode	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Use '-' and '+' button on the back to select the current hour	Success ☐ • Unassisted ☐	Present ☐	

	• Assisted ☐ Failure ☐	Absent ☐	
• Press SET/ADVANCE Once to enter Minute set mode, use "-‘’ and "+" to select the current minute	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Press SET/ADVANCE Once to enter Month set mode, use "-‘’ and "+" to select the correct month	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Press SET/ADVANCE Once to enter Date set mode, use "-‘’ and "+" to select the correct date	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Press SET/ADVANCE Once to enter Year set mode, use "-‘’ and "+" to select the correct year	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Press the green TALK button on the top of the clock once t confirms the time settings and exit TIME SET MODE	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Slide MOSE SELECTION switch back to "LOCK/RUN’	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 3: Filling Medication Tray **Start Time:**	**End Time:**		
• Pick correct pillbox	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Open compartments	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Fill compartments with medication	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Put pillbox on "Today’s Pills"	Success ☐ • Unassisted ☐	Present ☐	

	• Assisted ☐ Failure ☐	Absent ☐	
Task 4: Set Alarm **Start Time:** **End Time:**			
• Slide "alarm selection" to the appropriate alarm (based on task 1 instructions)	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Switch "lock/run" mode to "alarm set"	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Press set advance button	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Set hour by pressing +/-	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Press set/advance	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Set minute by pressing +/-	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Press blue alarm check to confirm information	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Change mode back to "lock/run"	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 5: Remove Medication After alarm sounds: **Start Time:** **End Time:**			
• Press red "alarm acknowledge" button	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	

• Select correct pillbox	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Open specified compartment	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Remove medication	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	

Total Completion Time: __________

Comments :

PBA 009 (EllieGrid)

Task	Task Success	Task Error	Notes
Task 1: Open the "EllieGrid" app and click on the "Add to pillbox" option **Start Time: End Time:**			
• Open the EllieGrid App	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Click **"Add to pillbox" option**	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 2: Press "Add new pill" and add first pill to the app. **Start Time: End Time:**			
• Press "Add new pill"	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Enter pill name	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Enter treatment frequency	Success ☐ • Unassisted ☐ • Assisted ☐	Present ☐ Absent ☐	

	Failure ☐		
• Enter dose per day	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Press “Add”	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 3: Empty the medications to the first compartment **Start Time:**	**End Time:**		
• **Hold the device with both hand**	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• **Slide the lid upwards**	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• **Empty the medication in the correct compartment**	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• **Close the lid**	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• **Press “Done” in the app**	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 4: Press “Add new pill” and add second pill to the app. **Start Time:**	**End Time:**		
• Press “Add new pill"	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Enter pill name	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Enter treatment frequency	Success ☐	Present ☐	

	• Unassisted ☐ • Assisted ☐ Failure ☐	Absent ☐	
• Enter dose per day	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Press “add”	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 5: Empty the medications to the second compartment **Start Time:** **End Time:**			
• **Hold the device with both hand**	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• **Slide the lid upwards**	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☒ Absent ☐	
• **Empty the medication in the correct compartment**	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• **Close the lid**	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• **Press “Done” in the app**	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 6: Turn off the smart alarm option and set alarm time for medication in the first compartment(time to take the medication) 3 minutes after the current **Start Time:** **End Time:**			
• Turn off the smart alarm option	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Set time to take the medication 3 minutes after the current time	Success ☐ • Unassisted ☐	Present ☐	

	• Assisted ☐ Failure ☐	Absent ☐	
• Press Done.	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Press update	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 7: Take pills when alarm sounds **Start Time:**	**End Time:**		
• Open the pillbox.	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Take out the correct number of pills for that time.	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Close the pillbox securely after taking the pills.	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 8: Respond to the questions in the app **Start Time:**	**End Time:**		
• Press Taken	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☒	
• Press ok	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	

APD-001 (MedReady 1700 Automated Medication Dispenser)

Task	**Task Success**	**Task Error**	**Notes**
Task 1:Put the Batteries in (electric plug in) **Start Time:**	**End Time:**		
• Locate battery compartment	Success ☐ • Unassisted ☐ • Assisted ☐	Present ☐ Absent ☐	

	Failure ☐		
• Put the batteries correctly	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Check whether the device is on	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 2: Unlock and Open the device using the key **Start Time:**		**End Time:**	
• Insert the key into the lock and rotate it clockwise	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Put the key into the lock Place hands at 3 and 9 o'clock, depress slightly and rotate clockwise	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Lift lid, leaving key in lid	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 3: Set up the time for the current time Start Time:	**End Time:**		
• With one finger, Press and hold TIME SET button	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• With another finger press the HOUR button until it advances to the correct hour	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Continue to hold the TIME SET button down while advancing the minutes by pressing the MIN button	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Continue to hold the TIME SET button down and press the AM-PM button down to select	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	

Task 4: Fill Tray for 1 week Start Time: End Time:			
• Fill tray with medication on the right of the “start” compartment	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 5: Set Alarm **Start Time:** **End Time:**			
• Press and hold button 1 while pressing the hour button to change the hour	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Press and hold button 1 while pressing the minute button to change the minute	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Press and hold button 1 while pressing the AM/PM button to achieve the appropriate time	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Press and hold button 1 to confirm alarm	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 6: Lock Device **Start Time:** **End Time:**			
• Ensure the T-bar is pushed up toward the arrow and that lock key is in lid	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Close medication door on the blue lid	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Place blue lid on device slightly rotated clockwise about an inch	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Place hands at 3 and 9 o’clock, depress slightly and rotate counterclockwise until taps lock	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	

• Rotate key counterclockwise	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Test to make sure lid is locked	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 7: Remove Medication After alarm sounds: **Start Time:**	**End Time:**		
• Push door up to open	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Use fingers to take out medication OR flip device to remove medication	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	

Total Completion Time: ___________
Comments :

APD 002 (GMS Med-e-lert Automatic Pill Dispenser)

Task	**Task Success**	**Task Error**	**Notes**
Task 1:Put the Batteries in **Start Time:**	**End Time:**		
• Locate battery compartment	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Put the batteries correctly	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Check whether the device is on	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 2: Unlock and Open the device using the key **Start Time:**	**End Time:**		
• Flip device over	Success ☐	Present ☐	

	• Unassisted ☐ • Assisted ☐ Failure ☐	Absent ☐	
• Put the key into the lock	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Rotate key clockwise to unlock	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Press the front tab and open the lid (requires some force)	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 3: Set up the time for the current time **Start Time:**	**End Time:**		
• Press and hold button 1 for a few second	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Set the correct time by pressing button 2 (hours) and button 3 (minutes)	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Store clock time by pressing button 1	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 4: Fill Tray for 1 week **Start Time:**	**End Time:**		
• Put pills into correct compartment	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 5: Set Alarm **Start Time:**	**End Time:**		
• Quickly press button 1 (alarm will blink)	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Set hour by pressing button 2	Success ☐ • Unassisted ☐	Present ☐	

	• Assisted ☐ Failure ☐	Absent ☐	
• Set minute by pressing button 3	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Press button 1 to confirm	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Wait for device to time out	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 6: Lock Device **Start Time:** **End Time:**			
• Close lid	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Put key in lock	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Turn counterclockwise	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Test to make sure lid is locked	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 7: Remove Medication After alarm sounds: **Start Time:** **End Time:**			
• Grab device with one hand	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Place hand over open slot	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	

• Flip device over, ensuring pills end up in hand	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Flip device back over and take medication	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	

Total Completion Time: ___________
Comments :

SM 001 (Spencer)

Task	**Task Success**	**Task Error**	**Notes**
Task 1: Load a new medication cartridge into the device **Start Time:** **End Time:**			
• Follow the instructions in the video	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Locate the medication cartridge slot on the device	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Align the medication cartridge correctly	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Securely insert it into the designated slot	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 2: Adjust the alert volume for medication reminders **Start Time:** **End Time:**			
• Navigate to the settings option on the home screen	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Locate the "Volume" option	Success ☐ • Unassisted ☐ • Assisted ☐	Present ☐ Absent ☐	

	Failure ☐		
• Select "Volume"	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Increase or decrease the volume using the provided controls	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Verify that the volume changes accordingly by listening to a sample alert	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 3: Wait for a medication reminder and dispense the scheduled dose **Start Time:**	**End Time:**		
• Wait for a medication reminder	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Press the dispense button	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Respond to any additional reminders or messages displayed (e.g., acknowledge or dismiss)	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 4: Open the medication pack to retrieve the medication **Start Time:**	**End Time:**		
• Take out the medication package	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Tear the package	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Retrieve the medications from the opened pack, intact and undamaged	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 5: Shut down the device			

Start Time: **End Time:**			
• Navigate to the settings option on the home screen	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Locate the "Help" option	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Locate the "Shutdown" option	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Select the "Shutdown" option and confirm the action if prompted.	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	

Total Completion Time: __________

Comments :

SM 002 (Jones Healthcare Blister Pack)

Task	**Task Success**	**Task Error**	**Notes**
Task 1: Connect the blister pack to the device **Start Time:** **End Time:**			
• Rotate retaining clips at each end of the device in an open position	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Align connectors to one another and gently push card into the device	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Ensure indicator light flashes for 3 seconds	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Rotate retaining clips back into the closed position	Success ☐ • Unassisted ☐ • Assisted ☐	Present ☐ Absent ☐	

	Failure ☐		
• Ensure the device is properly connected by looking for the symbols in the display	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 2: Make sure the blister pack is connected correctly to the device by checking the display **Start Time:** **End Time:**			
• Examine the display	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Identify symbols related to the connection status of the blister pack.	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Understand the meaning of the identified symbols.	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 3: On the basis of the notification received on the iPad, remove the medication from the blister pack **Start Time:** **End Time:**			
• Identify dosage cavity to take	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Pierce cavity barrier	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Pinch number printed on card and pull out	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Remove medication	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
Task 4: Remove the blister pack from the device **Start Time:** **End Time:**			
• Use both hands and hold device	Success ☐ • Unassisted ☐	Present ☐	

	• Assisted ☐ Failure ☐	Absent ☐	
• Open the retaining clips	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	
• Pull the blister pack away from the connector	Success ☐ • Unassisted ☐ • Assisted ☐ Failure ☐	Present ☐ Absent ☐	

Total Completion Time: __________

Comments :

10.3.4 Appendix C-4: Perception Based Usability Metrics – Standardized Usability and Workload Questionnaires

Single Ease Question (SEQ)

Overall, this task was

Very difficult Very easy

▪ **1**	▪ **2**	▪ **3**	▪ **4**	▪ **5**	▪ **6**	▪ **7**

SMEQ (Subjective Mental Effort Questionnaire)

Draw a line through the scale to indicate the perceived mental effort of completing this task.

150

140

130

120

Tremendously hard to do

110

Ver, very hard to do

100

90

Ver hard to do

80

Pretty hard to do

70

60

Rather hard to do

50

40

Fairly hard to do

30

A bit hard to do

20

Not very had to do

10

0

Not at all hard to do

System Usability Scale

Instruction: For each of the following statements, mark **one box** that best describes your reactions to the product.

	Strongly Disagree				Strongly Agree
1. I think that I would like to use this product frequently.	1	2	3	4	5
2. I found this product unnecessarily complex.	1	2	3	4	5
3. I thought this product was easy to use.	1	2	3	4	5
4. I think that I would need assistance to be able to use this product.	1	2	3	4	5
5. I found the various functions in this product were well integrated.	1	2	3	4	5
6. I thought there was too much inconsistency in this product.	1	2	3	4	5
7. I would imagine that most people would learn to use this product very quickly.	1	2	3	4	5
8. I found this product very cumbersome/awkward to use.	1	2	3	4	5
9. I felt very confident using this product.	1	2	3	4	5
10. I needed to learn a lot of things before I could get going with this product	1	2	3	4	5

NASA Task Load Index

Rating procedure
Rate each of the below-mentioned variables on a 20-point scale (scored from 0 to 100)

Mental Demand How mentally demanding was the task?

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

Very Low Very
High

Physical Demand How physically demanding was the task?

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

Very Low Very
High

Temporal Demand How hurried or rushed was the pace of the task?

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

Very Low Very
High

Performance How successful were you in accomplishing what you were asked to do?

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

Perfect
Failure

Effort How hard did you have to work to accomplish your level of performance?

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

Very Low Very
High

Frustration How insecure, discouraged, irritated, stressed, and annoyed were you?

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

Very Low Very
High

10.3.5 Appendix C-5: Interview Guide

Screening questions
Please tell me about yourself -for example ,your age, your place of residence, highest level of education?
Do you take any medications?
Can you describe your typical day of taking medications?
Does anyone help you take medications?
Is there any device that you use or have used to help you take your medications?
If yes, did you encounter any challenges while using this device?

In-test questions
Question 1
Among the various products you tested,

- Which of the features of products you find most useful? Why did you find these features most useful?

- Which of the features of products you find least useful? Why did you find these features least useful?

Question 2
Among the various products you tested,

- Which of the features of products you find most easy to use? Why did you find these features most easy to use?
- Which of the features of products you find most difficult to use? Why did you find these features most difficult to use?

Question 3
In your opinion,

- Which products is the easiest to learn to use? What made this product the easiest for you to learn to use?
- Which products is the most difficult to learn to use? What made this product the difficult for you to learn to use?

Question 4

- Are you satisfied with the features of various technologies you tested? Why or why not?
- Do you think that any other additional product features could make these products most appropriate you? What kind of features? How can these features make the product most appropriate for you?

Question 5
Are there any of the products you tested that you would use for your own medication regimen or consider using if you need to take any medication in the future?

- If not, why not?
- If yes, which products? Why this products? Would you recommend this product to your family or friends?

10.3.6 Appendix C-6: Ethics Clearance

File #: 45203

Title: User experience with medication adherence technology: determining usability by capabilities.

The Clinical Research Ethics Board is pleased to inform you this study has been reviewed and given ethics clearance.

Initial Approval Date: 05/03/23 (m/d/y)

University of Waterloo Research Ethics Boards are composed in accordance with, and carry out their functions and operate in a manner consistent with, the institution's guidelines for research with human participants, the Tri-Council Policy Statement for the Ethical Conduct for Research Involving Humans (TCPS, 2nd edition), International Conference on Harmonization: Good Clinical Practice (ICH-GCP), the Ontario Personal Health Information Protection Act (PHIPA), the applicable laws and regulations of the province of Ontario. Both Boards are registered with the U.S. Department of Health and Human Services under the Federal Wide Assurance, FWA00021410, and IRB registration number IRB00002419 (HREB) and IRB00007409 (CREB).

This study is to be conducted in accordance with the submitted application and the most recently approved versions of all supporting materials.

Expiry Date: 05/04/24 (m/d/y)

Multi-year research must be renewed at least once every 12 months unless a more frequent review has otherwise been specified. Studies will only be renewed if the renewal report is received and approved before the expiry date. Failure to submit renewal reports will result in the investigators being notified ethics clearance has been suspended and Research Finance being notified the ethics clearance is no longer valid.

Level of review: Delegated Review

Signed on behalf of the Clinical Research Ethics Board

Heather Dekker, Ethics Advisor, hdekker@uwaterloo.ca, 519-888-4567, ext. 41506

10.4 Appendix D: Performance-based Metrics-Analysis Results

10.4.1 Appendix D-1: Task Success Rate Unassisted

Descriptive Statistics and Kruskal-Wallis Test for Task Success Rate Unassisted (%) by Device – Overall

Task Success Rate Unassisted -Overall								
Product tested	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
APD-001	20	71.30	20.94	26.09	100.00	54.35	73.91	91.30
APD-002	24	77.26	16.80	25.00	95.83	72.92	83.33	87.50
PBA-001	19	66.82	19.51	30.43	95.65	56.52	65.22	86.96
PBA-002	21	86.97	10.99	52.63	94.74	84.21	89.47	94.74
PBA-003	21	71.73	17.07	37.50	93.75	56.25	68.75	87.50
PBA-004	20	74.93	22.42	5.88	100.00	71.57	82.35	88.24
PBA-005	20	75.00	20.65	30.00	100.00	60.00	80.00	90.00
PBA-006	19	77.17	18.82	34.78	100.00	69.57	82.61	91.30
PBA-007	21	80.95	19.70	38.46	100.00	69.23	84.62	100.00
PBA-008	26	79.40	17.18	35.71	96.43	64.29	87.50	89.29
PBA-009	23	73.49	11.47	54.84	96.77	64.52	70.97	80.65
SM-001	38	86.84	20.02	0.00	100.00	84.21	94.74	100.00
SM-002	16	83.33	16.51	46.67	100.00	70.00	86.67	100.00

Kruskal-Wallis Test		
Chi-Square	**DF**	**Pr > ChiSq**
41.7529	12	<.0001

Descriptive Statistics and Kruskal-Wallis Test for Task Success Rate Unassisted (%) by Device - Cognitive Impairment Present

Task Success Rate Unassisted – Cognitive Impairment Present								
Product tested	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
APD-001	3	59.42	13.28	47.83	73.91	47.83	56.52	73.91
APD-002	6	65.97	22.58	25.00	83.33	54.17	77.08	79.17
PBA-001	4	57.61	19.24	39.13	78.26	41.30	56.52	73.91
PBA-002	4	84.21	21.05	52.63	94.74	73.68	94.74	94.74
PBA-003	4	60.94	9.38	50.00	68.75	53.13	62.50	68.75
PBA-004	4	68.30	21.19	47.06	94.12	51.31	66.01	85.29
PBA-005	3	70.00	30.00	40.00	100.00	40.00	70.00	100.00
PBA-006	4	78.26	13.75	60.87	91.30	67.39	80.43	89.13
PBA-007	3	87.18	11.75	76.92	100.00	76.92	84.62	100.00
PBA-008	2	78.57	20.20	64.29	92.86	64.29	78.57	92.86
PBA-009	3	66.67	9.86	58.06	77.42	58.06	64.52	77.42
SM-001	8	65.13	33.63	0.00	94.74	44.74	76.32	92.11
SM-002	3	73.33	11.55	66.67	86.67	66.67	66.67	86.67

Kruskal-Wallis Test		
Chi-Square	**DF**	**Pr > ChiSq**
10.20	12	0.598

Descriptive Statistics and Kruskal-Wallis Test for Task Success Rate Unassisted (%) by Device - Physical Impairment Present

Task Success Rate Unassisted – Physical Impairment Present								
Product tested	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
APD-001	12	64.13	21.47	26.09	95.65	47.83	65.22	80.43
APD-002	7	66.07	20.61	25.00	83.33	54.17	75.00	79.17
PBA-001	7	55.90	17.47	30.43	78.26	43.48	56.52	69.57
PBA-002	8	86.84	10.90	63.16	94.74	84.21	89.47	94.74
PBA-003	3	50.00	12.50	37.50	62.50	37.50	50.00	62.50
PBA-004	6	70.37	17.44	47.06	94.12	55.56	71.57	82.35
PBA-005	8	71.25	21.00	40.00	100.00	60.00	65.00	90.00
PBA-006	5	61.96	22.20	34.78	91.30	47.83	60.87	75.00

PBA-007	3	61.54	13.32	53.85	76.92	53.85	53.85	76.92
PBA-008	7	68.88	24.98	35.71	89.29	39.29	85.71	89.29
PBA-009	9	68.46	9.51	54.84	80.65	58.06	70.97	77.42
SM-001	15	80.00	26.41	0.00	100.00	68.42	94.74	94.74
SM-002	7	78.10	20.63	46.67	100.00	60.00	86.67	100.00

Kruskal-Wallis Test		
Chi-Square	DF	Pr > ChiSq
22.60	12	0.031

Descriptive Statistics and Kruskal-Wallis Test for Task Success Rate Unassisted (%) by Device - Vision Impairment Present

Task Success Rate Unassisted – Vision Impairment Present								
Product tested	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
APD-001	2	73.91	24.60	56.52	91.30	56.52	73.91	91.30
PBA-001	2	69.57	12.30	60.87	78.26	60.87	69.57	78.26
PBA-003	3	60.42	9.55	50.00	68.75	50.00	62.50	68.75
PBA-004	2	30.72	35.12	5.88	55.56	5.88	30.72	55.56
PBA-005	2	60.00	42.43	30.00	90.00	30.00	60.00	90.00
PBA-006	2	39.13	6.15	34.78	43.48	34.78	39.13	43.48
PBA-007	4	80.77	18.31	53.85	92.31	69.23	88.46	92.31
PBA-008	3	80.95	14.43	64.29	89.29	64.29	89.29	89.29
PBA-009	2	83.87	9.12	77.42	90.32	77.42	83.87	90.32
SM-001	4	46.05	35.53	0.00	78.95	18.42	52.63	73.68
SM-002	2	86.67	0.00	86.67	86.67	86.67	86.67	86.67

Kruskal-Wallis Test		
Chi-Square	DF	Pr > ChiSq
12.69	10	0.242

Descriptive Statistics and Kruskal-Wallis Test for Task Success Rate Unassisted (%) by Device - Hearing Impairment Present

Task Success Rate Unassisted – Hearing Impairment Present								
Product tested	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
APD-001	8	66.30	17.20	47.83	91.30	50.00	65.22	80.43
APD-002	15	72.22	18.61	25.00	91.67	66.67	79.17	83.33
PBA-001	11	63.24	23.36	30.43	95.65	43.48	60.87	91.30
PBA-002	10	83.68	14.77	52.63	94.74	78.95	89.47	94.74
PBA-003	12	67.71	18.04	37.50	93.75	53.13	65.63	81.25
PBA-004	12	77.94	26.32	5.88	100.00	79.41	88.24	91.18
PBA-005	15	76.00	21.65	30.00	100.00	60.00	90.00	90.00
PBA-006	11	70.45	21.04	34.78	100.00	47.83	75.00	86.96
PBA-007	14	77.47	21.43	38.46	100.00	53.85	84.62	92.31
PBA-008	17	80.46	19.20	35.71	96.43	75.00	89.29	92.86
PBA-009	12	75.00	14.30	54.84	96.77	61.29	74.19	88.71
SM-001	26	84.01	22.10	0.00	100.00	78.95	92.11	94.74
SM-002	9	76.30	17.36	46.67	100.00	66.67	80.00	86.67

Kruskal-Wallis Test		
Chi-Square	DF	Pr > ChiSq
22.76	12	0.030

Descriptive Statistics and Kruskal-Wallis Test for Task Success Rate Unassisted (%) by Device - Motivational Impairment Present

Task Success Rate Unassisted – Motivational Impairment Present								
Product tested	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
APD-001	9	71.01	19.92	43.48	95.65	56.52	73.91	91.30
APD-002	5	70.83	26.52	25.00	87.50	70.83	83.33	87.50
PBA-001	4	77.17	17.53	56.52	95.65	63.04	78.26	91.30

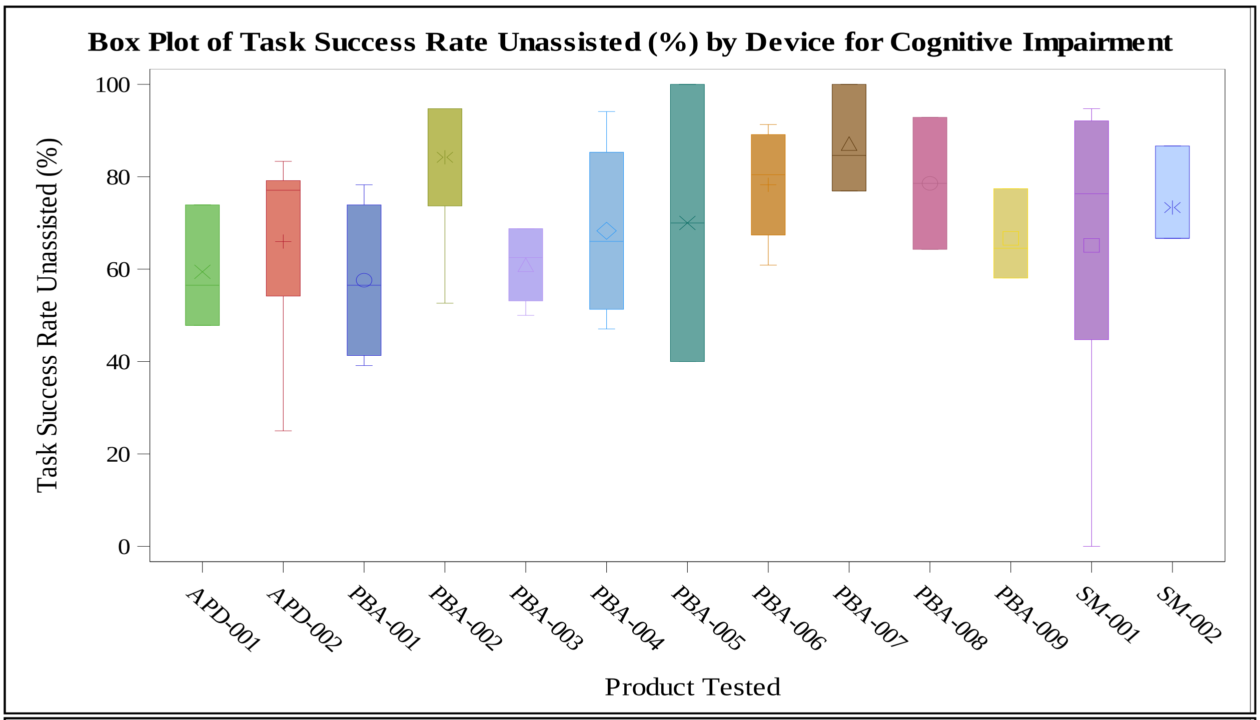
PBA-002	3	91.23	3.04	89.47	94.74	89.47	89.47	94.74
PBA-003	7	64.29	12.35	50.00	87.50	56.25	62.50	68.75
PBA-004	6	61.76	31.95	5.88	88.24	41.18	76.47	82.35
PBA-005	9	63.33	21.21	30.00	90.00	50.00	60.00	80.00
PBA-006	6	83.33	21.90	43.48	100.00	73.91	91.30	100.00
PBA-007	7	79.12	18.69	38.46	92.31	76.92	84.62	92.31
PBA-008	9	74.60	19.84	39.29	96.43	64.29	85.71	89.29
PBA-009	7	74.19	10.20	61.29	90.32	64.52	77.42	80.65
SM-001	9	73.10	36.60	0.00	100.00	52.63	100.00	100.00
SM-002	6	88.89	12.41	66.67	100.00	86.67	90.00	100.00

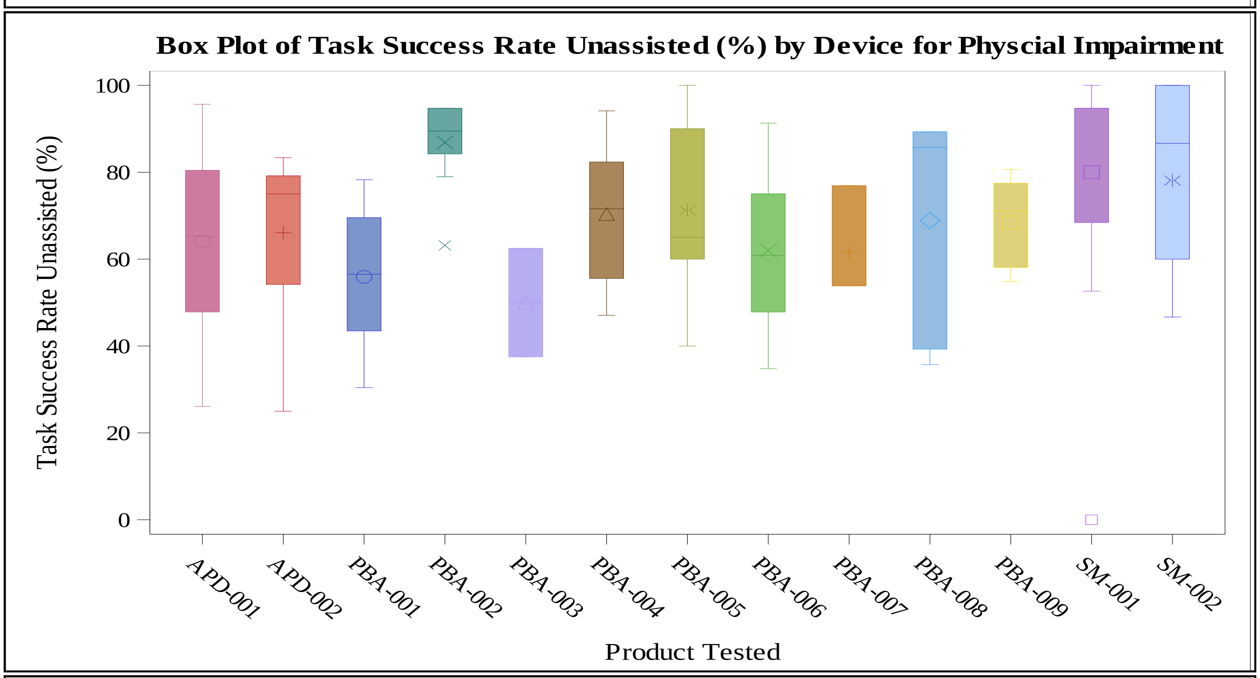
Kruskal-Wallis Test		
Chi-Square	**DF**	**Pr > ChiSq**
15.24	12	0.229

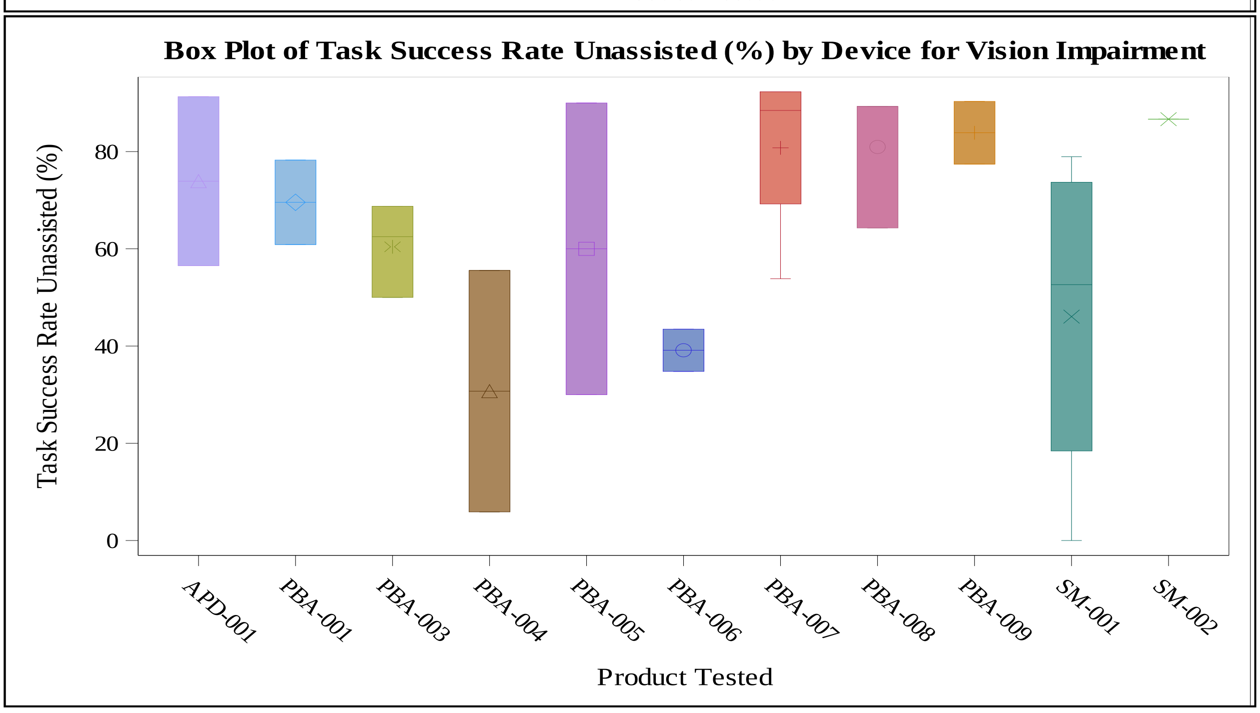
Descriptive Statistics and Kruskal-Wallis Test for Task Success Rate Unassisted (%) by Device - Environmental Impairment Present

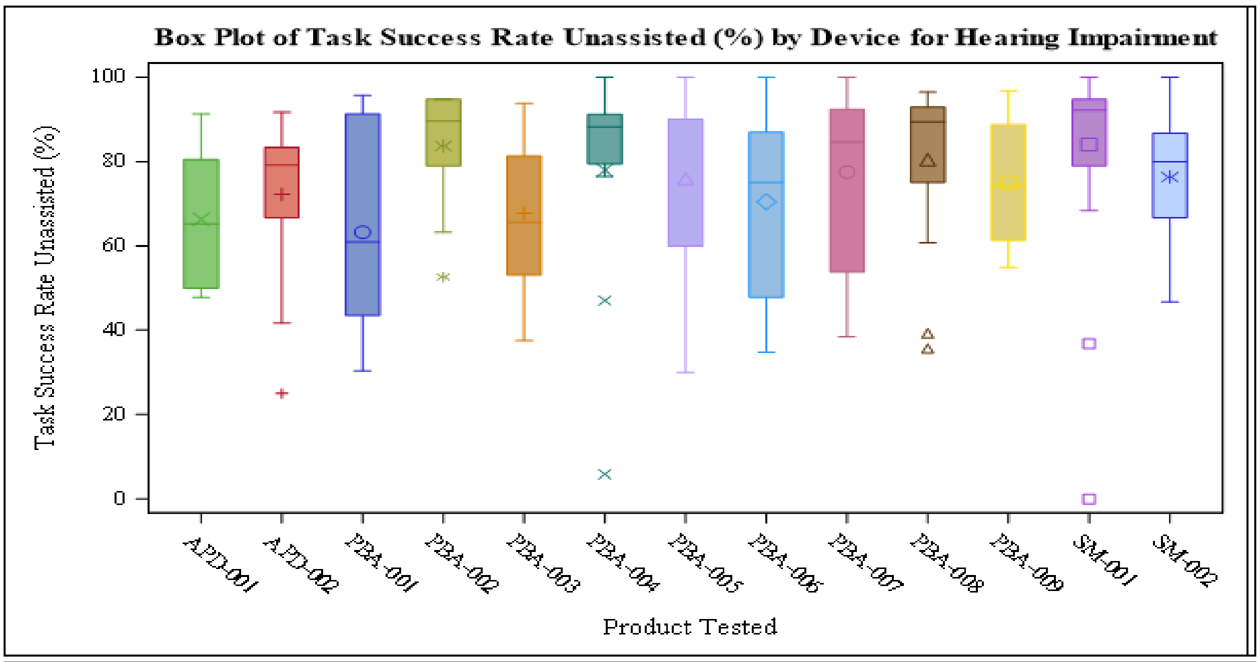
Task Success Rate Unassisted - Environmental Impairment Present								
Product tested	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
APD-001	4	61.96	27.81	26.09	91.30	41.30	65.22	82.61
APD-002	10	79.17	19.93	25.00	91.67	83.33	85.42	87.50
PBA-001	5	73.04	18.80	56.52	95.65	60.87	60.87	91.30
PBA-002	6	92.98	2.72	89.47	94.74	89.47	94.74	94.74
PBA-003	7	75.89	16.31	56.25	93.75	56.25	75.00	93.75
PBA-004	8	86.76	6.85	76.47	94.12	82.35	88.24	91.18
PBA-005	7	81.43	20.35	40.00	100.00	70.00	90.00	90.00
PBA-006	8	77.72	21.10	34.78	100.00	67.39	84.78	91.30
PBA-007	11	83.92	18.35	46.15	100.00	76.92	92.31	100.00
PBA-008	10	86.07	11.84	64.29	96.43	89.29	89.29	92.86
PBA-009	5	83.23	8.66	70.97	90.32	77.42	87.10	90.32
SM-001	13	88.66	15.32	52.63	100.00	89.47	94.74	100.00
SM-002	5	88.00	9.89	73.33	100.00	86.67	86.67	93.33

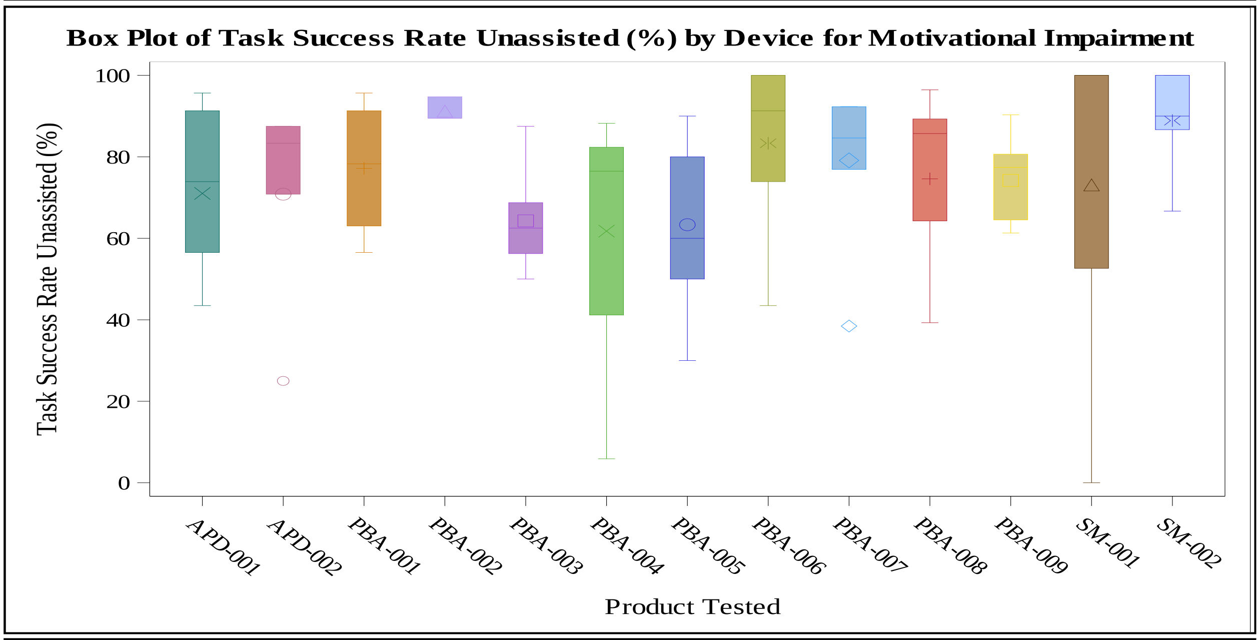
Kruskal-Wallis Test		
Chi-Square	**DF**	**Pr > ChiSq**
17.63	12	0.127

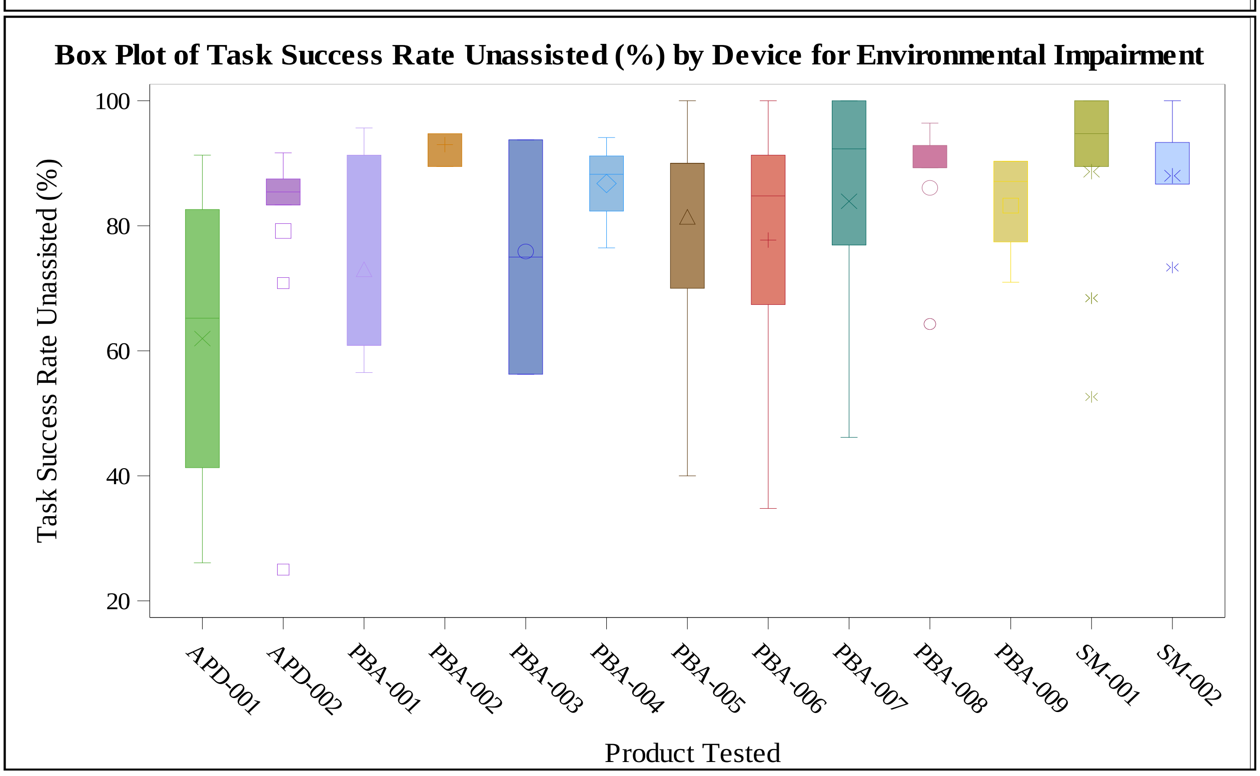

Box Plot of Task Success Rate Unassisted (%) by Device for Cognitive Impairment
Task Success Rate Unassisted (%)
0
20
40
60
80
100
APD-001
APD-002
PBA-001
PBA-002
PBA-003
PBA-004
PBA-005
PBA-006
PBA-007
PBA-008
PBA-009
SM-001
SM-002
Product Tested


Box Plot of Task Success Rate Unassisted (%) by Device for Physcial Impairment
Task Success Rate Unassisted (%)
0
20
40
60
80
100
APD-001
APD-002
PBA-001
PBA-002
PBA-003
PBA-004
PBA-005
PBA-006
PBA-007
PBA-008
PBA-009
SM-001
SM-002
Product Tested


Box Plot of Task Success Rate Unassisted (%) by Device for Vision Impairment
Task Success Rate Unassisted (%)
0
20
40
60
80
APD-001
PBA-001
PBA-003
PBA-004
PBA-005
PBA-006
PBA-007
PBA-008
PBA-009
SM-001
SM-002
Product Tested


Box Plot of Task Success Rate Unassisted (%) by Device for Hearing Impairment
Task Success Rate Unassisted (%)
100
80
60
40
20
0
APD-001
APD-002
PBA-001
PBA-002
PBA-003
PBA-004
PBA-005
PBA-006
PBA-007
PBA-008
PBA-009
SM-001
SM-002
Product Tested


Box Plot of Task Success Rate Unassisted (%) by Device for Motivational Impairment
Task Success Rate Unassisted (%)
100
80
60
40
20
0
APD-001
APD-002
PBA-001
PBA-002
PBA-003
PBA-004
PBA-005
PBA-006
PBA-007
PBA-008
PBA-009
SM-001
SM-002
Product Tested


Box Plot of Task Success Rate Unassisted (%) by Device for Environmental Impairment
Task Success Rate Unassisted (%)
100
80
60
40
20
APD-001
APD-002
PBA-001
PBA-002
PBA-003
PBA-004
PBA-005
PBA-006
PBA-007
PBA-008
PBA-009
SM-001
SM-002
Product Tested

10.4.2 Appendix D-2: Total Task Completion Time (Minutes)

Descriptive Statistics and Kruskal-Wallis Test for Total Task Completion Time by Device – Overall

Total Task Completion Time - Overall								
Product tested	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
APD-001	20	15.38	5.72	7.08	27.42	11.30	15.38	18.59
APD-002	24	14.95	4.39	7.02	26.03	12.63	14.63	16.28
PBA-001	19	14.54	5.47	8.55	28.40	11.60	13.07	14.00
PBA-002	21	11.68	3.05	7.35	20.02	9.62	11.17	13.15
PBA-003	21	15.58	6.30	7.57	31.77	10.30	15.37	19.33
PBA-004	20	10.27	3.75	4.70	19.00	8.05	9.62	12.52
PBA-005	20	5.76	2.59	2.75	11.85	3.79	5.01	7.67
PBA-006	19	12.53	3.74	6.68	18.52	9.00	13.13	15.65
PBA-007	21	11.17	4.17	6.43	21.92	8.30	9.33	13.25
PBA-008	26	13.29	3.33	8.03	22.17	10.95	12.84	15.20
PBA-009	23	11.22	3.24	6.68	20.25	8.58	10.63	12.43
SM-001	38	4.53	1.78	2.15	9.00	3.27	4.08	5.50
SM-002	16	6.54	2.94	2.32	14.63	4.68	5.79	8.32

Kruskal-Wallis Test		
Chi-Square	**DF**	**Pr > ChiSq**
160.44	12	<.0001

Descriptive Statistics and Kruskal-Wallis Test for Total Task Completion Time by Device - Cognitive Impairment Present

Total Task Completion Time – Cognitive Impairment Present								
Product tested	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
APD-001	3	16.57	4.30	12.35	20.95	12.35	16.40	20.95
APD-002	6	16.71	5.43	10.60	25.68	12.40	16.05	19.50
PBA-001	4	18.99	7.70	11.60	28.40	12.78	17.98	25.21
PBA-002	4	12.08	3.17	9.62	16.73	10.20	10.98	13.95
PBA-003	4	19.04	9.12	11.37	31.77	12.53	16.52	25.55
PBA-004	4	10.31	2.75	8.22	14.18	8.36	9.43	12.27
PBA-005	3	7.31	3.00	4.02	9.90	4.02	8.00	9.90
PBA-006	4	13.37	4.47	6.68	16.00	10.91	15.39	15.83
PBA-007	3	10.31	3.95	7.22	14.75	7.22	8.95	14.75
PBA-008	2	17.27	6.93	12.37	22.17	12.37	17.27	22.17
PBA-009	3	10.39	1.92	8.58	12.40	8.58	10.20	12.40
SM-001	8	4.88	1.85	2.22	8.20	3.46	5.08	5.76
SM-002	3	5.07	0.88	4.50	6.08	4.50	4.63	6.08

Kruskal-Wallis Test		
Chi-Square	**DF**	**Pr > ChiSq**
35.62	12	0.0004

Descriptive Statistics and Kruskal-Wallis Test for Total Task Completion Time by Device - Physical Impairment Present

Total Task Completion Time – Physical Impairment Present								
Product tested	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
APD-001	12	16.17	6.54	7.08	27.42	11.58	15.38	20.39
APD-002	7	16.75	4.77	10.60	25.68	14.50	15.00	19.50
PBA-001	7	15.16	3.77	11.60	22.02	12.75	13.95	18.72
PBA-002	8	12.66	3.94	8.62	20.02	9.13	12.23	14.97
PBA-003	3	20.06	5.70	16.55	26.63	16.55	17.00	26.63
PBA-004	6	12.03	4.11	8.22	19.00	8.50	11.02	14.45
PBA-005	8	6.91	3.04	3.43	11.85	3.98	7.05	8.95
PBA-006	5	15.40	3.08	11.45	18.52	13.20	15.65	18.17
PBA-007	3	17.59	3.81	14.75	21.92	14.75	16.10	21.92
PBA-008	7	13.95	2.52	10.83	17.90	11.95	13.17	16.43
PBA-009	9	11.21	4.29	6.68	20.25	8.58	10.20	12.23
SM-001	15	4.65	1.89	2.18	8.20	3.08	4.37	5.50
SM-002	7	8.17	3.52	4.50	14.63	4.63	8.30	9.97

Kruskal-Wallis Test		
Chi-Square	**DF**	**Pr > ChiSq**
61.13	12	<.0001

Descriptive Statistics and Kruskal-Wallis Test for Total Task Completion Time by Device - Vision Impairment Present

Total Task Completion Time – Vision Impairment Present								
Product tested	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
APD-001	2	13.76	3.74	11.12	16.40	11.12	13.76	16.40
PBA-001	2	18.99	10.45	11.60	26.38	11.60	18.99	26.38
PBA-003	3	21.77	9.19	13.70	31.77	13.70	19.85	31.77
PBA-004	2	7.53	4.00	4.70	10.35	4.70	7.53	10.35
PBA-005	2	3.40	0.59	2.98	3.82	2.98	3.40	3.82
PBA-006	2	12.83	8.04	7.15	18.52	7.15	12.83	18.52
PBA-007	4	11.56	7.01	6.43	21.92	7.68	8.94	15.43
PBA-008	3	9.68	2.35	8.03	12.37	8.03	8.63	12.37
PBA-009	2	7.86	1.03	7.13	8.58	7.13	7.86	8.58
SM-001	4	6.48	1.16	5.08	7.68	5.55	6.57	7.40
SM-002	2	3.41	1.54	2.32	4.50	2.32	3.41	4.50

Kruskal-Wallis Test		
Chi-Square	**DF**	**Pr > ChiSq**
20.34	10	0.0262

Descriptive Statistics and Kruskal-Wallis Test for Total Task Completion Time by Device - Hearing Impairment Present

Total Task Completion Time – Hearing Impairment Present								
Product tested	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
APD-001	8	17.79	7.35	7.08	27.42	11.73	17.77	24.40

APD-002	15	15.89	5.05	7.02	26.03	12.85	15.08	18.32
PBA-001	11	16.35	6.66	8.55	28.40	12.27	13.95	22.02
PBA-002	10	11.79	2.52	8.65	16.73	10.23	11.03	13.57
PBA-003	12	17.43	6.89	9.43	31.77	12.10	16.04	21.56
PBA-004	12	9.72	3.75	4.70	17.15	7.33	8.80	12.52
PBA-005	15	5.29	2.44	2.75	11.85	3.77	4.45	7.02
PBA-006	11	13.92	3.57	7.15	18.52	11.45	14.65	16.95
PBA-007	14	11.52	4.74	6.43	21.92	7.95	9.98	13.25
PBA-008	17	13.61	3.98	8.03	22.17	10.17	13.23	16.43
PBA-009	12	11.08	4.01	6.68	20.25	7.64	10.31	13.38
SM-001	26	4.31	1.37	2.22	7.68	3.40	3.98	5.08
SM-002	9	5.56	1.70	2.32	8.70	4.72	5.75	6.08

Kruskal-Wallis Test		
Chi-Square	DF	Pr > ChiSq
112.09	12	<.0001

Descriptive Statistics and Kruskal-Wallis Test for Total Task Completion Time by Device - Motivational Impairment Present

Total Task Completion Time – Motivational Impairment Present								
Product tested	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
APD-001	9	16.71	6.18	10.50	27.42	11.68	15.55	16.40
APD-002	5	13.95	4.47	7.02	19.50	14.12	14.13	14.98
PBA-001	4	13.60	3.91	9.20	18.72	11.19	13.24	16.01
PBA-002	3	11.76	2.99	9.05	14.97	9.05	11.25	14.97
PBA-003	7	17.44	8.94	9.17	31.77	9.43	13.70	26.63
PBA-004	6	9.79	5.03	4.70	17.15	5.20	8.62	14.45
PBA-005	9	6.65	2.42	2.98	9.90	4.45	7.65	8.00
PBA-006	6	11.18	3.84	7.15	16.95	8.47	9.93	14.65
PBA-007	7	9.90	2.76	6.43	14.75	8.30	8.95	11.87
PBA-008	9	12.76	3.02	8.03	16.43	10.83	13.95	14.68
PBA-009	7	11.03	2.34	7.13	14.35	9.27	11.22	12.40
SM-001	9	4.86	2.10	2.15	8.20	3.05	5.08	6.02
SM-002	6	7.81	4.23	2.32	14.63	5.58	7.19	9.97

Kruskal-Wallis Test		
Chi-Square	DF	Pr > ChiSq
45.21	12	<.0001

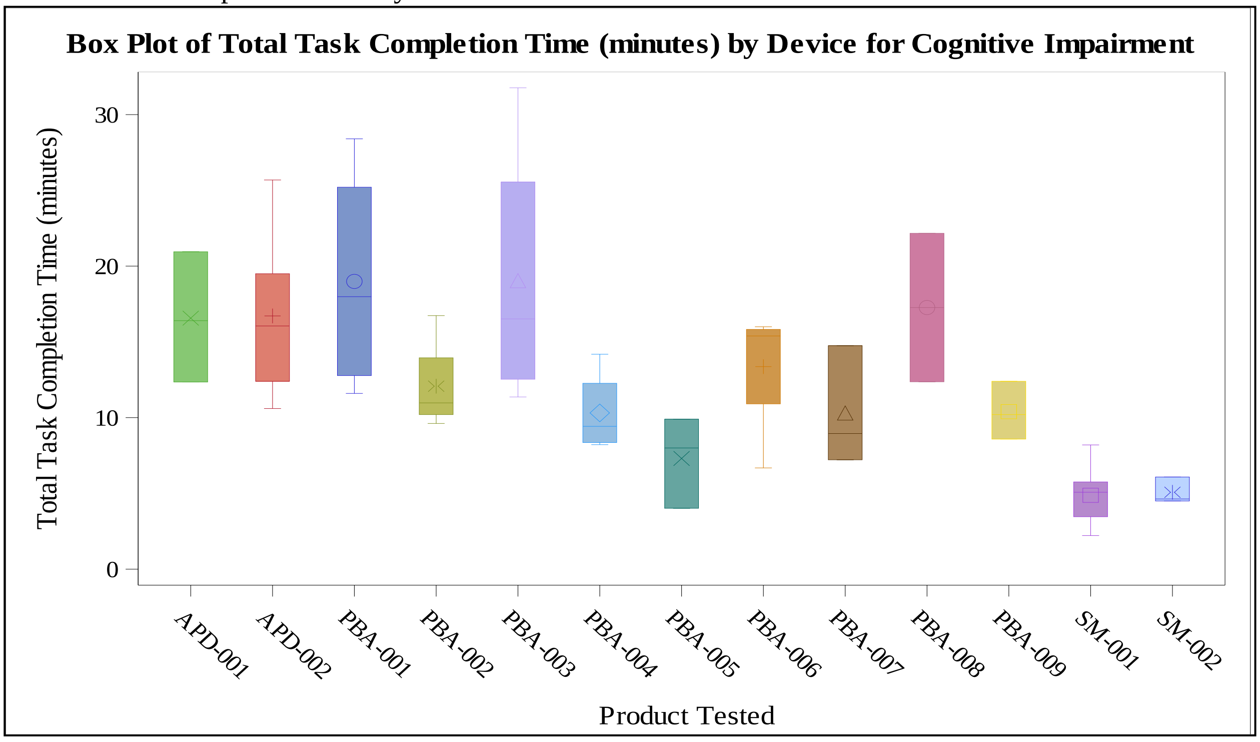
Descriptive Statistics and Kruskal-Wallis Test for Total Task Completion Time by Device - Environmental Impairment Present

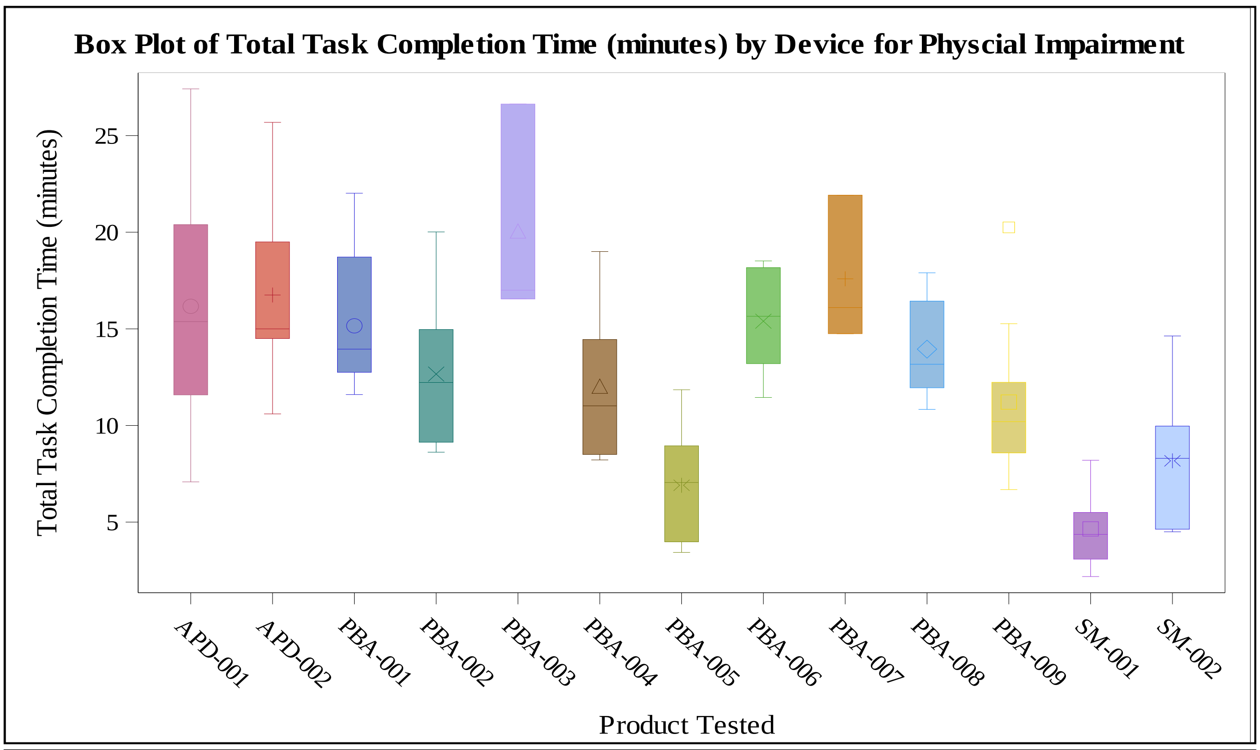
Total Task Completion Time - Environmental Impairment Present								
Product tested	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
APD-001	4	14.34	5.42	8.88	20.95	10.00	13.76	18.68
APD-002	10	14.58	3.37	7.02	19.50	14.12	14.88	15.55
PBA-001	5	10.80	2.07	8.55	13.30	9.20	10.40	12.57

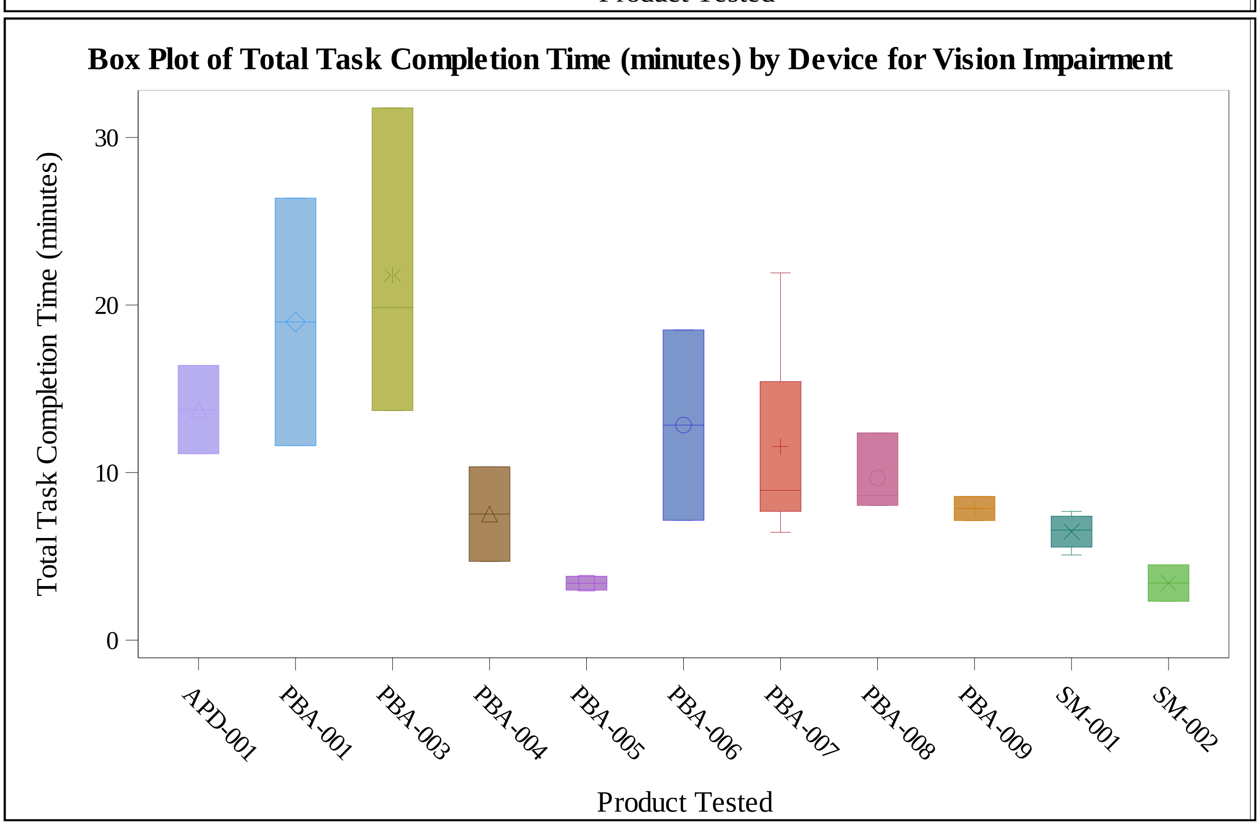
PBA-002	6	11.19	1.60	9.05	13.15	9.62	11.39	12.52
PBA-003	7	14.20	5.96	7.57	23.27	8.88	13.70	19.33
PBA-004	8	9.00	2.49	5.20	13.35	7.34	9.21	10.17
PBA-005	7	5.41	2.58	2.82	9.90	3.77	4.45	8.00
PBA-006	8	12.73	4.66	6.68	18.52	8.05	13.78	16.48
PBA-007	11	11.20	5.25	6.43	21.92	7.72	8.93	14.75
PBA-008	10	12.38	3.20	8.03	17.08	8.63	12.20	15.20
PBA-009	5	9.49	2.86	7.13	14.35	8.08	8.27	9.60
SM-001	13	4.88	2.11	2.15	8.20	3.72	4.20	6.50
SM-002	5	4.98	1.50	2.32	5.83	5.40	5.58	5.75

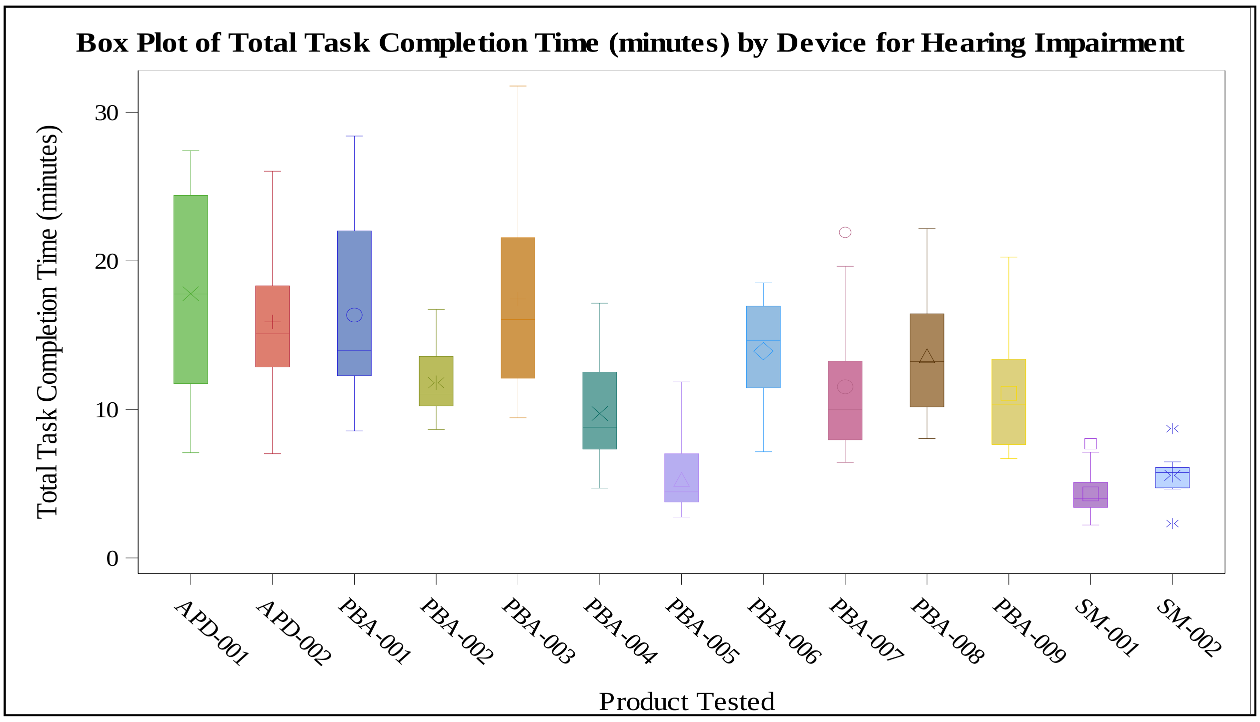
Kruskal-Wallis Test		
Chi-Square	**DF**	**Pr > ChiSq**
55.52	12	<.0001

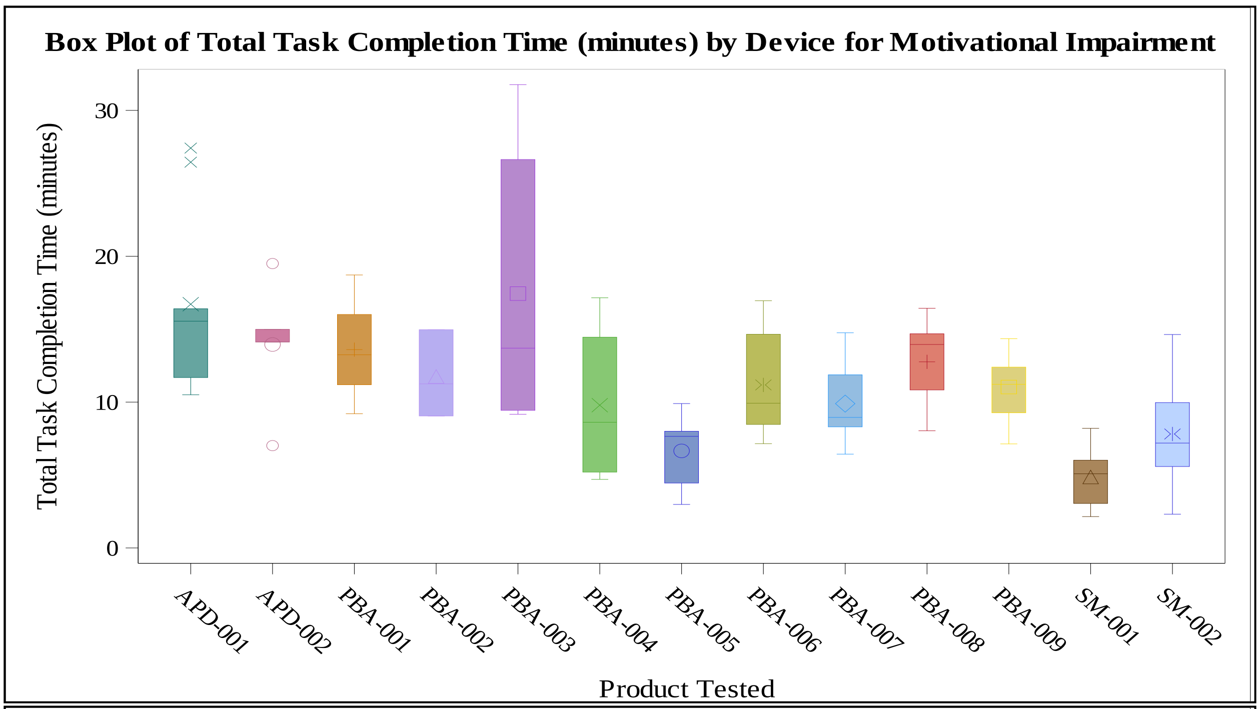
Box plot of Total Task Completion Time by Device for Various Barriers

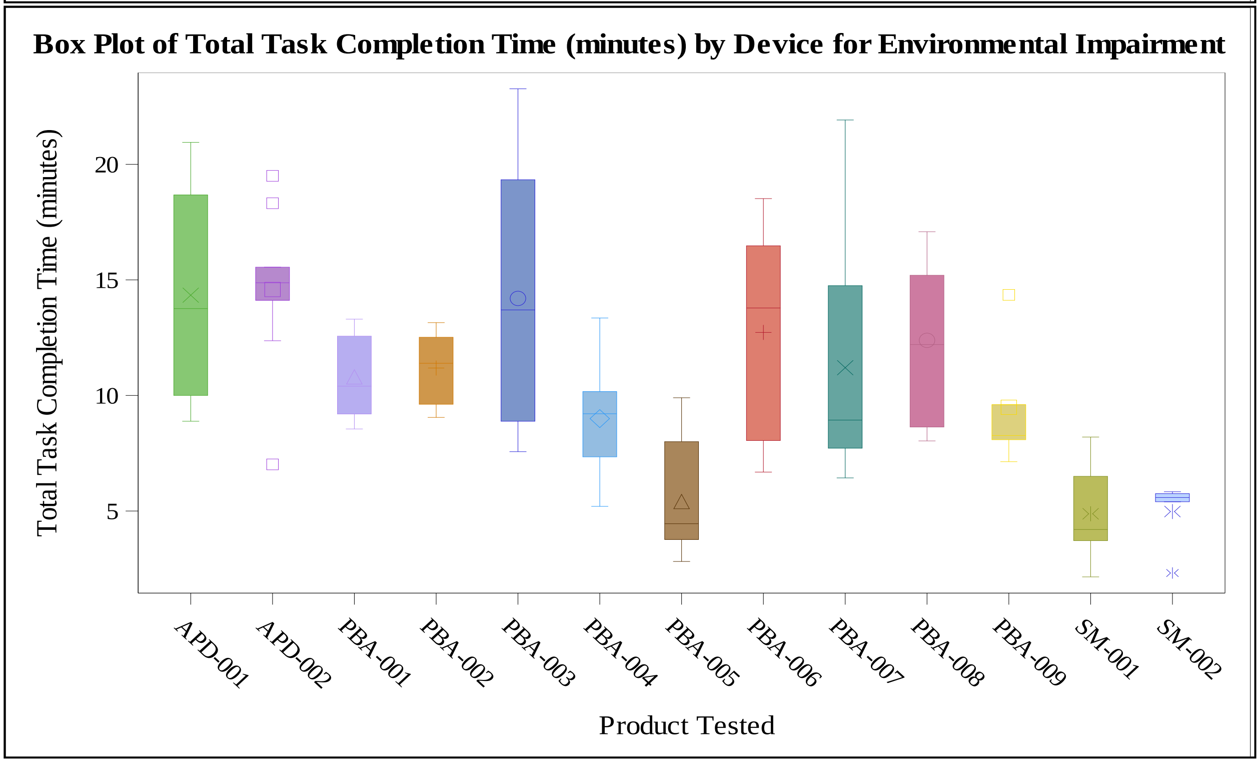







Box Plot of Total Task Completion Time (minutes) by Device for Hearing Impairment
Total Task Completion Time (minutes)
0
10
20
30
APD-001
APD-002
PBA-001
PBA-002
PBA-003
PBA-004
PBA-005
PBA-006
PBA-007
PBA-008
PBA-009
SM-001
SM-002
Product Tested


Box Plot of Total Task Completion Time (minutes) by Device for Motivational Impairment
Total Task Completion Time (minutes)
0
10
20
30
APD-001
APD-002
PBA-001
PBA-002
PBA-003
PBA-004
PBA-005
PBA-006
PBA-007
PBA-008
PBA-009
SM-001
SM-002
Product Tested


Box Plot of Total Task Completion Time (minutes) by Device for Environmental Impairment
Total Task Completion Time (minutes)
5
10
15
20
APD-001
APD-002
PBA-001
PBA-002
PBA-003
PBA-004
PBA-005
PBA-006
PBA-007
PBA-008
PBA-009
SM-001
SM-002
Product Tested

10.4.3 Appendix D-3: Efficiency for Unassisted Task Completion

Descriptive Statistics and Kruskal-Wallis Test for Efficiency for Unassisted Task Completion by Device – Overall

Efficiency for Unassisted Task Completion- Overall								
Product tested	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
APD-001	20	5.40	2.94	2.01	11.66	3.19	4.55	7.27
APD-002	24	5.86	2.43	1.28	12.42	4.67	5.77	7.09
PBA-001	19	5.27	2.64	1.38	10.68	3.12	4.84	6.75
PBA-002	21	7.97	2.30	3.15	12.17	6.21	8.27	9.85
PBA-003	21	5.57	3.03	1.57	12.39	3.02	5.09	6.82
PBA-004	20	7.96	3.79	1.25	16.97	5.33	7.19	10.75
PBA-005	20	16.18	9.13	5.00	35.50	7.83	14.01	23.74
PBA-006	19	6.82	2.72	1.88	11.11	5.30	6.08	8.82
PBA-007	21	8.47	3.89	2.35	14.35	5.22	9.45	11.05
PBA-008	26	6.34	2.24	2.68	11.32	4.95	5.98	7.47
PBA-009	23	7.17	2.56	2.87	12.66	5.29	6.75	9.07
SM-001	38	22.87	11.30	0.00	46.51	14.08	22.69	27.86
SM-002	16	15.28	8.12	5.36	37.41	10.12	13.98	17.18

Kruskal-Wallis Test		
Chi-Square	**DF**	**Pr > ChiSq**
124.47	12	<.0001

Descriptive Statistics and Kruskal-Wallis Test for Efficiency for Unassisted Task Completion by Device - Cognitive Impairment Present

Efficiency for Unassisted Task Completion– Cognitive Impairment Present								
Product tested	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
APD-001	3	3.64	0.21	3.45	3.87	3.45	3.61	3.87
APD-002	6	4.56	2.45	1.28	7.47	2.11	5.06	6.38
PBA-001	4	3.60	2.26	1.38	6.75	2.25	3.14	4.95
PBA-002	4	7.57	3.01	3.15	9.85	5.81	8.63	9.32
PBA-003	4	3.89	2.02	1.57	6.05	2.24	3.96	5.53
PBA-004	4	6.94	3.01	5.37	11.45	5.38	5.46	8.50
PBA-005	3	12.32	10.94	5.00	24.90	5.00	7.07	24.90
PBA-006	4	6.60	3.10	3.89	11.06	4.80	5.73	8.40
PBA-007	3	9.51	4.32	5.22	13.86	5.22	9.45	13.86
PBA-008	2	4.69	0.71	4.19	5.20	4.19	4.69	5.20
PBA-009	3	6.64	2.08	5.20	9.02	5.20	5.69	9.02
SM-001	8	17.22	14.11	0.00	42.74	6.27	14.53	26.73
SM-002	3	14.87	4.17	10.96	19.26	10.96	14.39	19.26

Kruskal-Wallis Test		
Chi-Square	**DF**	**Pr > ChiSq**

22.16	12	0.0357

Descriptive Statistics and Kruskal-Wallis Test for Efficiency for Unassisted Task Completion by Device - Physical Impairment Present

Efficiency for Unassisted Task Completion– Physical Impairment Present								
Product tested	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
APD-001	12	4.56	2.74	2.01	11.66	2.52	4.00	6.04
APD-002	7	4.41	2.11	1.28	7.47	2.11	4.66	5.73
PBA-001	7	3.80	1.45	2.33	6.75	3.11	3.16	4.43
PBA-002	8	7.49	2.59	3.94	10.95	5.78	6.59	10.12
PBA-003	3	2.52	0.44	2.21	3.02	2.21	2.35	3.02
PBA-004	6	6.37	2.73	3.51	11.45	5.29	5.45	7.05
PBA-005	8	13.33	9.22	5.00	29.13	6.07	10.14	20.04
PBA-006	5	4.37	2.27	1.88	6.92	2.63	3.89	6.55
PBA-007	3	3.67	1.41	2.46	5.22	2.46	3.34	5.22
PBA-008	7	4.98	1.77	2.68	7.47	2.82	4.99	6.51
PBA-009	9	6.98	2.76	2.87	10.62	5.54	6.90	9.02
SM-001	15	21.40	13.11	0.00	43.39	12.44	21.50	25.60
SM-002	7	10.84	4.80	5.36	19.26	6.83	9.28	14.39

Kruskal-Wallis Test		
Chi-Square	**DF**	**Pr > ChiSq**
49.87	12	<.0001

Descriptive Statistics and Kruskal-Wallis Test for Efficiency for Unassisted Task Completion by Device - Vision Impairment Present

Efficiency for Unassisted Task Completion– Vision Impairment Presen								
Product tested	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
APD-001	2	5.83	3.37	3.45	8.21	3.45	5.83	8.21
PBA-001	2	4.53	3.14	2.31	6.75	2.31	4.53	6.75
PBA-003	3	3.25	1.72	1.57	5.02	1.57	3.15	5.02
PBA-004	2	3.31	2.91	1.25	5.37	1.25	3.31	5.37
PBA-005	2	16.82	9.56	10.06	23.58	10.06	16.82	23.58
PBA-006	2	3.98	2.97	1.88	6.08	1.88	3.98	6.08
PBA-007	4	9.15	4.94	2.46	14.35	5.96	9.89	12.34
PBA-008	3	8.88	3.22	5.20	11.11	5.20	10.34	11.11
PBA-009	2	10.84	2.58	9.02	12.66	9.02	10.84	12.66
SM-001	4	6.53	4.81	0.00	11.09	3.06	7.51	10.00
SM-002	2	28.33	12.83	19.26	37.41	19.26	28.33	37.41

Kruskal-Wallis Test		
Chi-Square	**DF**	**Pr > ChiSq**
16.04	10	0.0984

Descriptive Statistics and Kruskal-Wallis Test for Efficiency for Unassisted Task Completion by Device - Hearing Impairment Present

Efficiency for Unassisted Task Completion– Hearing Impairment Present								
Product tested	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
APD-001	8	4.84	3.43	2.01	11.66	2.12	4.00	6.39
APD-002	15	5.20	2.29	1.28	10.10	4.38	5.41	6.38
PBA-001	11	4.75	3.30	1.38	10.68	2.33	3.16	7.80
PBA-002	10	7.49	2.29	3.15	10.95	5.98	7.99	8.79
PBA-003	12	4.59	2.42	1.57	9.80	2.68	4.03	6.07
PBA-004	12	8.68	4.41	1.25	16.97	5.46	7.97	11.84
PBA-005	15	17.02	8.10	5.00	29.13	10.06	17.59	23.89
PBA-006	11	5.42	1.99	1.88	8.55	3.89	5.75	6.55
PBA-007	14	8.12	4.20	2.35	14.35	3.62	8.40	10.71
PBA-008	17	6.46	2.70	2.68	11.32	4.61	5.64	7.72
PBA-009	12	7.71	3.17	2.87	12.66	5.30	8.08	10.24
SM-001	26	22.21	10.31	0.00	43.17	15.66	22.69	26.43
SM-002	9	15.93	9.01	5.36	37.41	10.96	14.86	16.96

Kruskal-Wallis Test		
Chi-Square	**DF**	**Pr > ChiSq**
84.58	12	<.0001

Descriptive Statistics and Kruskal-Wallis Test for Efficiency for Unassisted Task Completion by Device - Motivational Impairment Present

Efficiency for Unassisted Task Completion– Motivational Impairment Present								
Product tested	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
APD-001	9	4.76	2.41	2.01	9.33	2.89	4.62	6.15
APD-002	5	5.86	3.12	1.28	10.10	5.73	5.99	6.19
PBA-001	4	6.24	3.04	3.72	10.40	3.98	5.42	8.50
PBA-002	3	8.10	1.97	5.98	9.89	5.98	8.42	9.89
PBA-003	7	4.76	2.76	1.57	9.55	2.35	5.02	6.05
PBA-004	6	6.95	5.38	1.25	16.97	4.80	5.25	8.21
PBA-005	9	11.10	6.67	5.00	23.89	7.07	7.84	12.47
PBA-006	6	7.87	2.54	5.05	11.11	5.90	7.45	10.27
PBA-007	7	8.72	3.67	3.62	14.35	5.22	9.45	11.12
PBA-008	9	6.35	2.95	2.68	11.32	4.95	5.43	6.14
PBA-009	7	7.17	2.72	5.20	12.66	5.40	5.76	8.70
SM-001	9	20.38	16.61	0.00	46.51	6.42	13.95	32.79
SM-002	6	15.44	11.27	6.83	37.41	8.70	11.50	16.72

Kruskal-Wallis Test		
Chi-Square	**DF**	**Pr > ChiSq**
26.41	12	0.0094

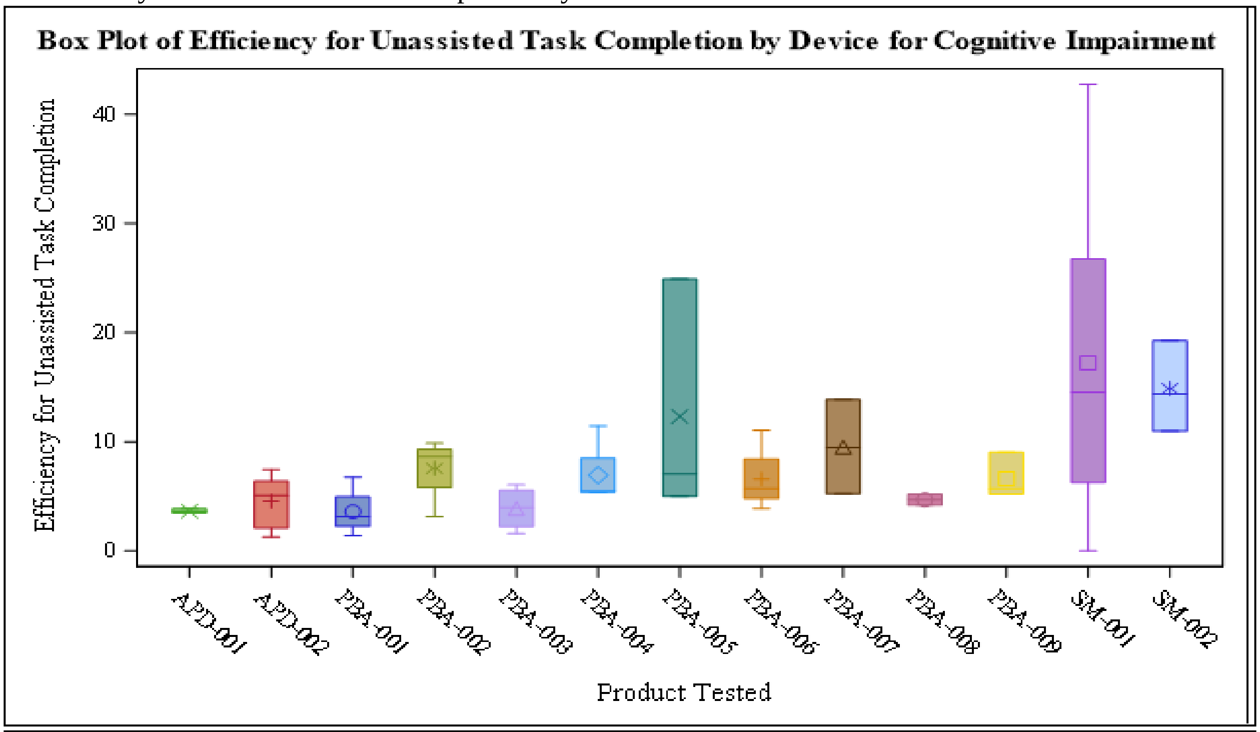
Descriptive Statistics and Kruskal-Wallis Test for Efficiency for Unassisted Task Completion by Device - Environmental Impairment Present

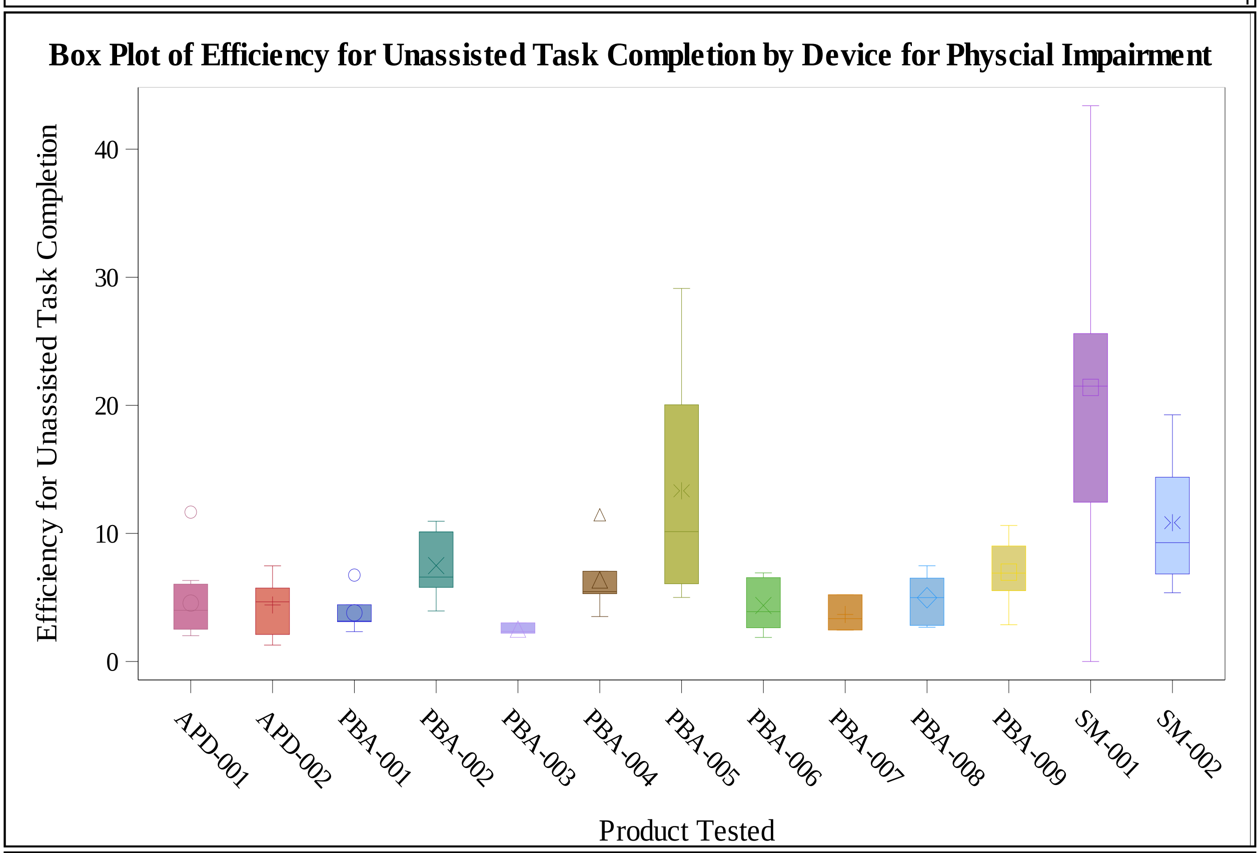
Efficiency for Unassisted Task Completion- Environmental Impairment Present

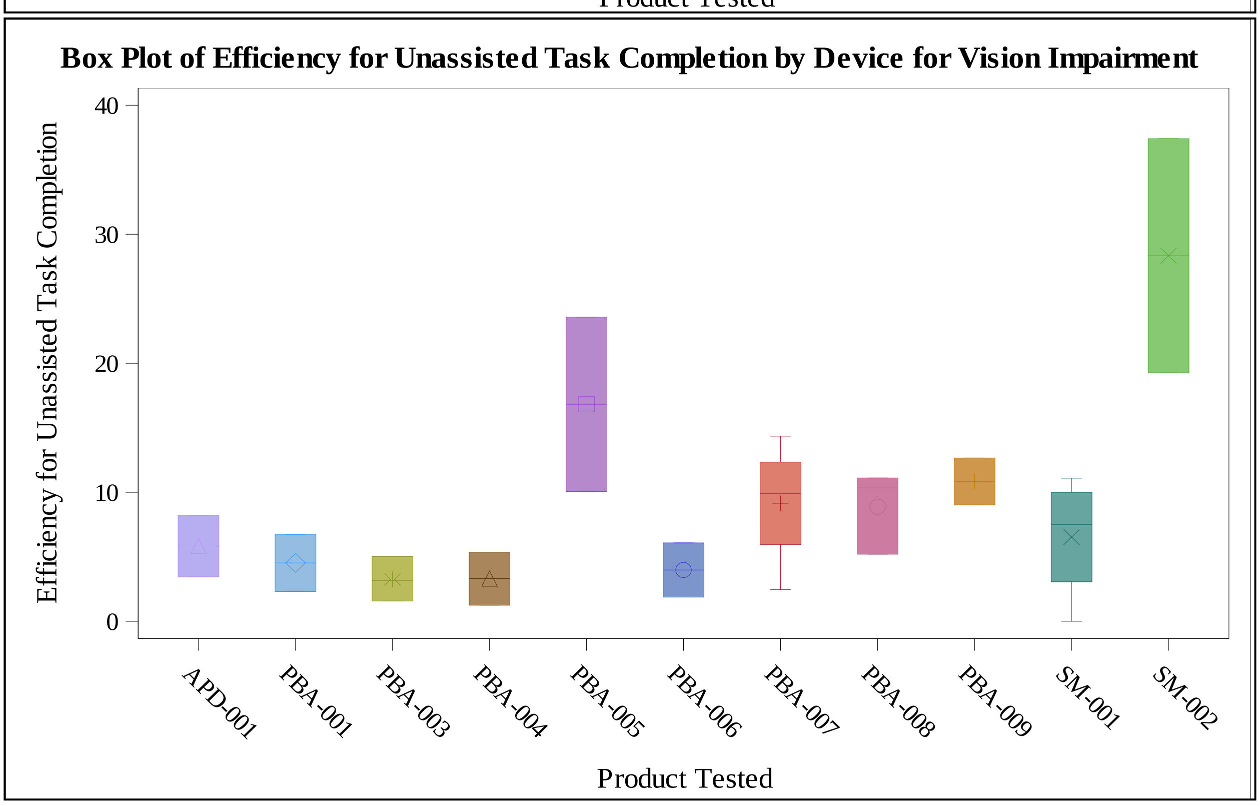
Product tested	N	Mean	Std Dev	Minimum	Maximum	25th Pctl	Median	75th Pctl
APD-001	4	4.55	2.46	2.94	8.21	3.19	3.53	5.91
APD-002	10	5.95	2.23	1.28	10.10	5.65	5.89	6.21
PBA-001	5	7.20	3.10	4.25	10.68	4.84	5.85	10.40
PBA-002	6	8.45	1.21	7.15	9.89	7.20	8.32	9.85
PBA-003	7	6.45	3.63	2.91	12.39	3.22	5.09	10.55
PBA-004	8	10.43	3.50	6.61	16.97	7.77	9.62	12.55
PBA-005	7	18.98	10.48	5.00	35.50	7.07	20.22	23.89
PBA-006	8	7.15	3.40	1.88	11.06	4.80	6.78	10.55
PBA-007	11	9.21	4.20	2.35	14.35	5.22	10.13	12.96
PBA-008	10	7.50	2.59	4.19	11.32	5.64	6.78	10.34
PBA-009	5	9.38	2.77	5.40	12.66	8.58	9.07	11.17
SM-001	13	23.22	13.44	6.42	46.51	13.77	23.68	25.49
SM-002	5	19.99	9.85	13.58	37.41	14.86	16.72	17.39

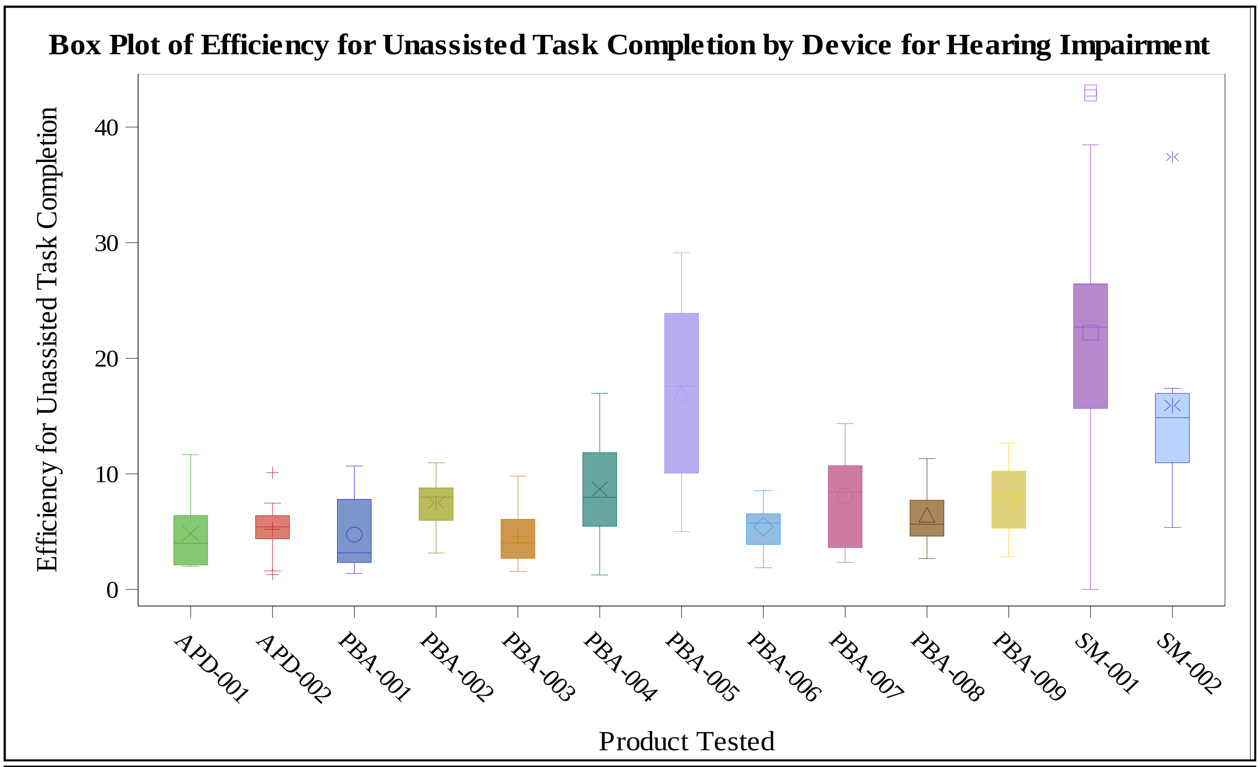
Kruskal-Wallis Test		
Chi-Square	DF	Pr > ChiSq
46.86	12	<.0001

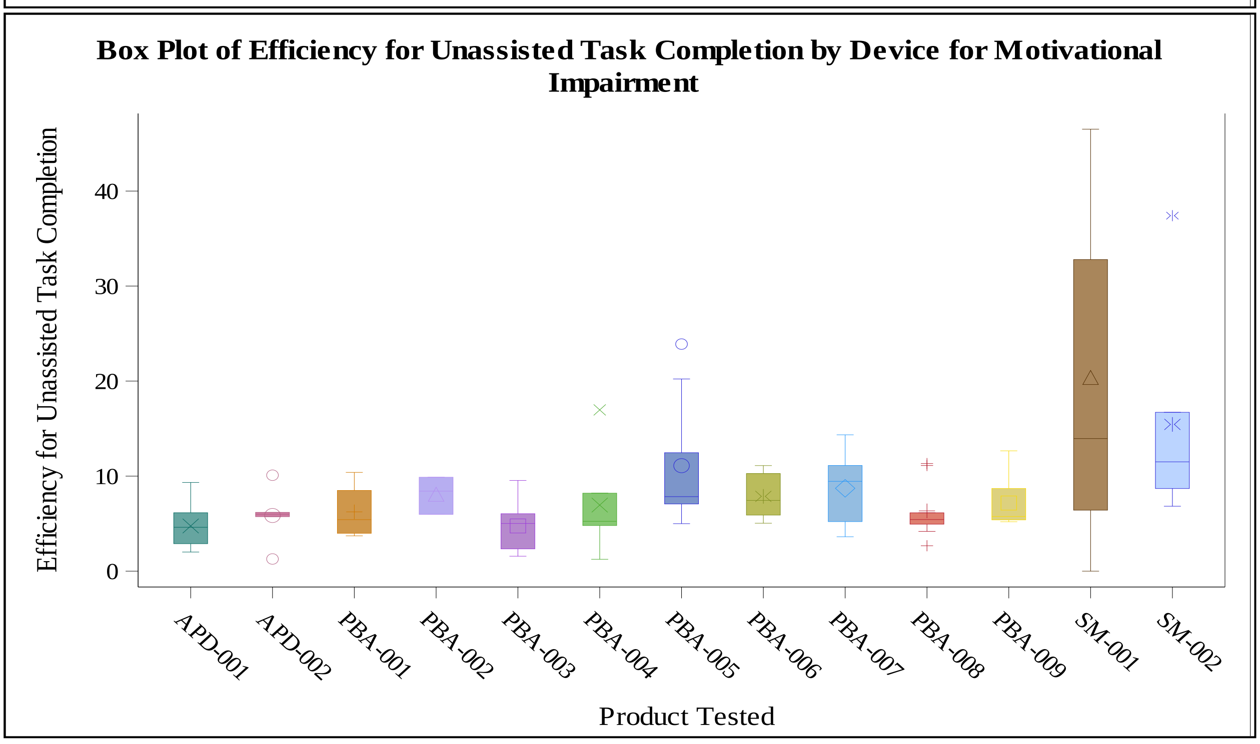
Box plot of Efficiency for Unassisted Task Completion by Device for Various Barriers

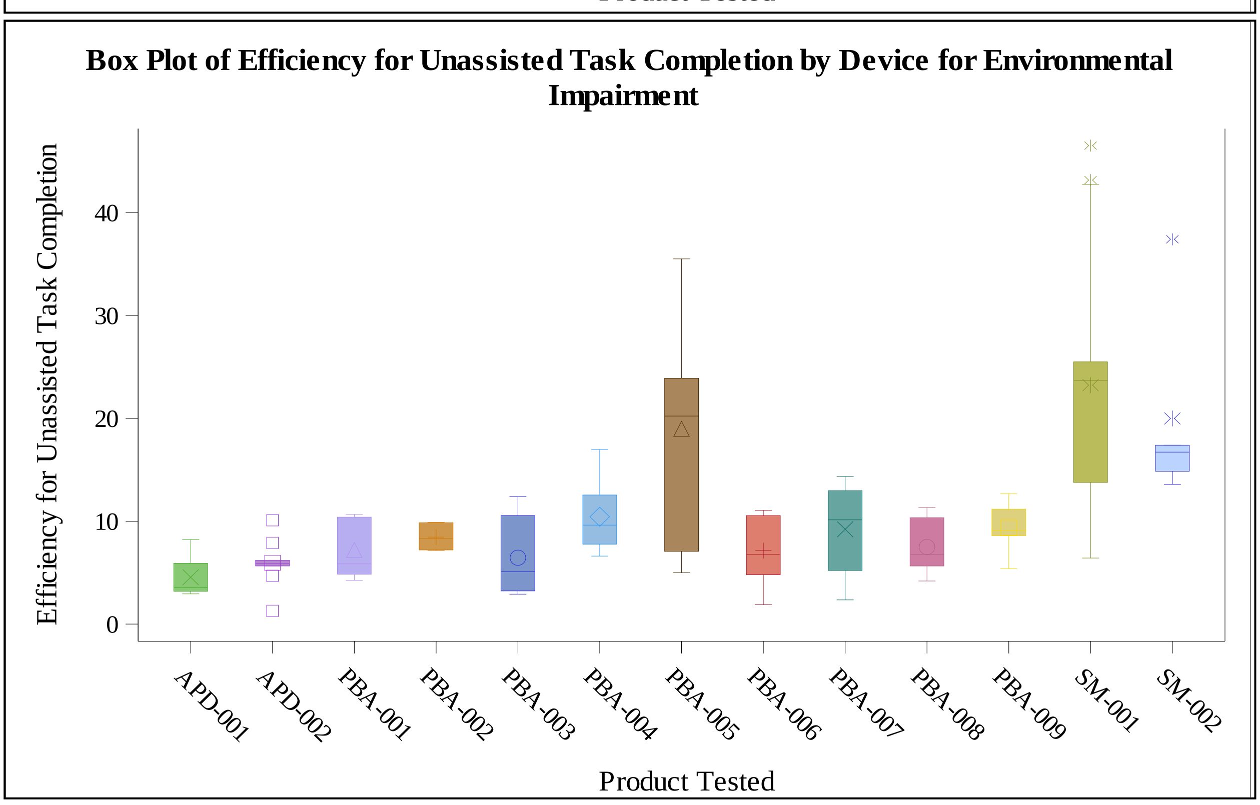







Box Plot of Efficiency for Unassisted Task Completion by Device for Hearing Impairment
Efficiency for Unassisted Task Completion
0
10
20
30
40
APD-001
APD-002
PBA-001
PBA-002
PBA-003
PBA-004
PBA-005
PBA-006
PBA-007
PBA-008
PBA-009
SM-001
SM-002
Product Tested


Box Plot of Efficiency for Unassisted Task Completion by Device for Motivational Impairment
Efficiency for Unassisted Task Completion
0
10
20
30
40
APD-001
APD-002
PBA-001
PBA-002
PBA-003
PBA-004
PBA-005
PBA-006
PBA-007
PBA-008
PBA-009
SM-001
SM-002
Product Tested


Box Plot of Efficiency for Unassisted Task Completion by Device for Environmental Impairment
Efficiency for Unassisted Task Completion
0
10
20
30
40
APD-001
APD-002
PBA-001
PBA-002
PBA-003
PBA-004
PBA-005
PBA-006
PBA-007
PBA-008
PBA-009
SM-001
SM-002
Product Tested

10.4.4 Appendix D-4: Total Error Rate (%)

Descriptive Statistics and Kruskal-Wallis Test for Total Error Rate (%) by Device – Overall

Total Error Rate (%)- Overall									
Product tested	**N Obs**	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
APD-001	20	20	17.39	16.75	0.00	65.22	4.35	8.70	26.09
APD-002	24	24	15.97	12.93	0.00	50.00	8.33	12.50	18.75
PBA-001	19	19	20.14	17.88	4.35	73.91	8.70	13.04	34.78
PBA-002	21	21	14.79	11.36	5.26	47.37	5.26	10.53	15.79
PBA-003	21	21	26.19	14.34	0.00	62.50	18.75	25.00	37.50
PBA-004	20	20	18.43	20.34	0.00	94.12	7.87	11.76	20.59
PBA-005	20	20	20.00	21.52	0.00	70.00	5.00	10.00	30.00
PBA-006	19	19	17.34	10.23	0.00	39.13	8.70	17.39	26.09
PBA-007	21	21	21.98	16.90	0.00	53.85	7.69	23.08	30.77
PBA-008	26	26	12.09	13.33	0.00	60.71	3.57	8.93	14.29
PBA-009	23	23	10.52	7.48	0.00	29.03	6.45	9.68	12.90
SM-001	38	38	12.47	17.88	0.00	100.00	0.00	10.53	10.53
SM-002	16	16	17.08	19.47	0.00	86.67	6.67	13.33	20.00

Kruskal-Wallis Test		
Chi-Square	**DF**	**Pr > ChiSq**
29.86	12	0.0029

Descriptive Statistics and Kruskal-Wallis Test for Total Error Rate (%) by Device - Cognitive Impairment Present

Total Error Rate (%)– Cognitive Impairment Present									
Product tested	**N Obs**	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
APD-001	3	3	28.99	9.05	21.74	39.13	21.74	26.09	39.13
APD-002	6	6	22.92	13.88	12.50	50.00	16.67	16.67	25.00
PBA-001	4	4	34.78	29.06	4.35	73.91	15.22	30.43	54.35
PBA-002	4	4	18.42	19.93	5.26	47.37	5.26	10.53	31.58
PBA-003	4	4	39.06	20.65	18.75	62.50	21.88	37.50	56.25
PBA-004	4	4	13.62	6.92	7.41	23.53	9.59	11.76	17.65
PBA-005	3	3	16.67	11.55	10.00	30.00	10.00	10.00	30.00
PBA-006	4	4	17.39	10.65	4.35	30.43	10.87	17.39	23.91
PBA-007	3	3	15.38	15.38	0.00	30.77	0.00	15.38	30.77
PBA-008	2	2	14.29	10.10	7.14	21.43	7.14	14.29	21.43
PBA-009	3	3	7.53	8.12	0.00	16.13	0.00	6.45	16.13
SM-001	8	8	25.66	32.25	0.00	100.00	7.89	13.16	31.58
SM-002	3	3	13.33	6.67	6.67	20.00	6.67	13.33	20.00

Kruskal-Wallis Test		
Chi-Square	**DF**	**Pr > ChiSq**
12.50	12	0.4061

Descriptive Statistics and Kruskal-Wallis Test for Total Error Rate (%) by Device - Physical Impairment Present

Total Error Rate (%)– Physical Impairment Present									
Product tested	**N Obs**	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
APD-001	12	12	16.30	17.70	0.00	65.22	4.35	8.70	21.74
APD-002	7	7	19.64	14.58	8.33	50.00	8.33	16.67	25.00
PBA-001	7	7	19.25	12.76	4.35	34.78	8.70	17.39	34.78
PBA-002	8	8	15.13	11.41	5.26	42.11	10.53	10.53	15.79
PBA-003	3	3	8.33	9.55	0.00	18.75	0.00	6.25	18.75
PBA-004	6	6	11.45	6.37	5.88	23.53	7.41	10.05	11.76
PBA-005	8	8	20.00	16.04	0.00	50.00	10.00	15.00	30.00
PBA-006	5	5	17.21	11.42	0.00	30.43	13.04	20.83	21.74
PBA-007	3	3	35.90	8.88	30.77	46.15	30.77	30.77	46.15
PBA-008	7	7	13.78	21.27	0.00	60.71	3.57	3.57	14.29
PBA-009	9	9	13.26	9.74	0.00	29.03	6.45	9.68	22.58
SM-001	15	15	17.19	26.05	0.00	100.00	0.00	10.53	26.32
SM-002	7	7	20.95	29.67	0.00	86.67	6.67	13.33	20.00

Kruskal-Wallis Test		
Chi-Square	**DF**	**Pr > ChiSq**
12.16	12	0.4327

Descriptive Statistics and Kruskal-Wallis Test for Total Error Rate (%) by Device - Vision Impairment Present

Total Error Rate (%)– Vision Impairment Present									
Product tested	**N Obs**	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
APD-001	2	2	15.22	15.37	4.35	26.09	4.35	15.22	26.09
PBA-001	2	2	19.57	9.22	13.04	26.09	13.04	19.57	26.09
PBA-003	3	3	35.42	23.66	18.75	62.50	18.75	25.00	62.50
PBA-004	2	2	50.76	61.31	7.41	94.12	7.41	50.76	94.12
PBA-005	2	2	40.00	42.43	10.00	70.00	10.00	40.00	70.00
PBA-006	2	2	26.09	6.15	21.74	30.43	21.74	26.09	30.43
PBA-007	4	4	25.00	17.06	7.69	46.15	11.54	23.08	38.46
PBA-008	3	3	8.33	11.48	0.00	21.43	0.00	3.57	21.43
PBA-009	2	2	4.84	6.84	0.00	9.68	0.00	4.84	9.68
SM-001	4	4	40.79	41.08	10.53	100.00	13.16	26.32	68.42
SM-002	2	2	6.67	0.00	6.67	6.67	6.67	6.67	6.67

Kruskal-Wallis Test		
Chi-Square	**DF**	**Pr > ChiSq**
11.49	10	0.321

Descriptive Statistics and Kruskal-Wallis Test for Total Error Rate (%) by Device - Hearing Impairment Present

Total Error Rate (%)– Hearing Impairment Present									
Product tested	**N Obs**	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
APD-001	8	8	13.59	10.25	0.00	26.09	4.35	15.22	21.74
APD-002	15	15	19.17	15.41	0.00	50.00	8.33	16.67	25.00

PBA-001	11	11	17.00	20.80	4.35	73.91	4.35	8.70	17.39
PBA-002	10	10	18.42	14.94	5.26	47.37	5.26	15.79	21.05
PBA-003	12	12	23.96	16.39	0.00	62.50	15.63	21.88	31.25
PBA-004	12	12	22.06	24.07	0.00	94.12	11.76	17.65	23.53
PBA-005	15	15	16.67	18.39	0.00	70.00	0.00	10.00	30.00
PBA-006	11	11	20.08	7.83	8.70	30.43	13.04	20.83	26.09
PBA-007	14	14	20.88	16.91	0.00	46.15	7.69	23.08	30.77
PBA-008	17	17	8.61	9.70	0.00	39.29	3.57	7.14	10.71
PBA-009	12	12	10.75	6.92	0.00	22.58	6.45	9.68	14.52
SM-001	26	26	13.77	20.20	0.00	100.00	5.26	10.53	10.53
SM-002	9	9	13.33	6.67	0.00	20.00	13.33	13.33	20.00

Kruskal-Wallis Test		
Chi-Square	**DF**	**Pr > ChiSq**
21.39	12	0.045

Descriptive Statistics and Kruskal-Wallis Test for Total Error Rate (%) by Device - Motivational Impairment Present

Total Error Rate (%)– Motivational Impairment Present									
Product tested	**N Obs**	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
APD-001	9	9	19.81	20.06	4.35	65.22	4.35	8.70	26.09
APD-002	5	5	8.33	7.80	0.00	16.67	0.00	12.50	12.50
PBA-001	4	4	8.70	6.15	4.35	17.39	4.35	6.52	13.04
PBA-002	3	3	12.28	8.04	5.26	21.05	5.26	10.53	21.05
PBA-003	7	7	25.00	19.43	6.25	62.50	12.50	18.75	37.50
PBA-004	6	6	32.35	33.22	5.88	94.12	5.88	23.53	41.18
PBA-005	9	9	27.78	28.19	0.00	70.00	10.00	20.00	50.00
PBA-006	6	6	15.94	10.53	4.35	30.43	8.70	13.04	26.09
PBA-007	7	7	18.68	9.79	7.69	30.77	7.69	15.38	30.77
PBA-008	9	9	13.10	19.32	0.00	60.71	0.00	7.14	14.29
PBA-009	7	7	12.90	8.53	6.45	29.03	6.45	9.68	19.35
SM-001	9	9	18.13	32.99	0.00	100.00	0.00	5.26	15.79
SM-002	6	6	25.56	30.53	6.67	86.67	6.67	16.67	20.00

Kruskal-Wallis Test		
Chi-Square	**DF**	**Pr > ChiSq**
12.31	12	0.4209

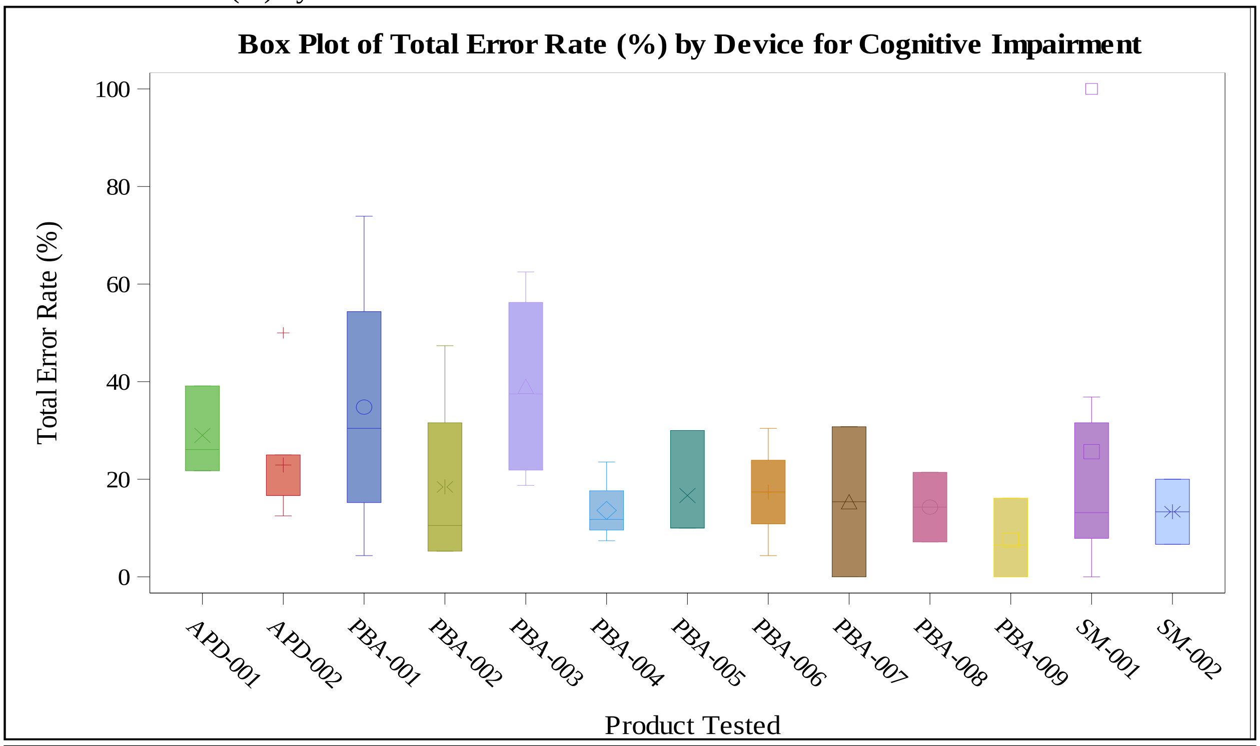
Descriptive Statistics and Kruskal-Wallis Test for Total Error Rate (%) by Device - Environmental Impairment Present

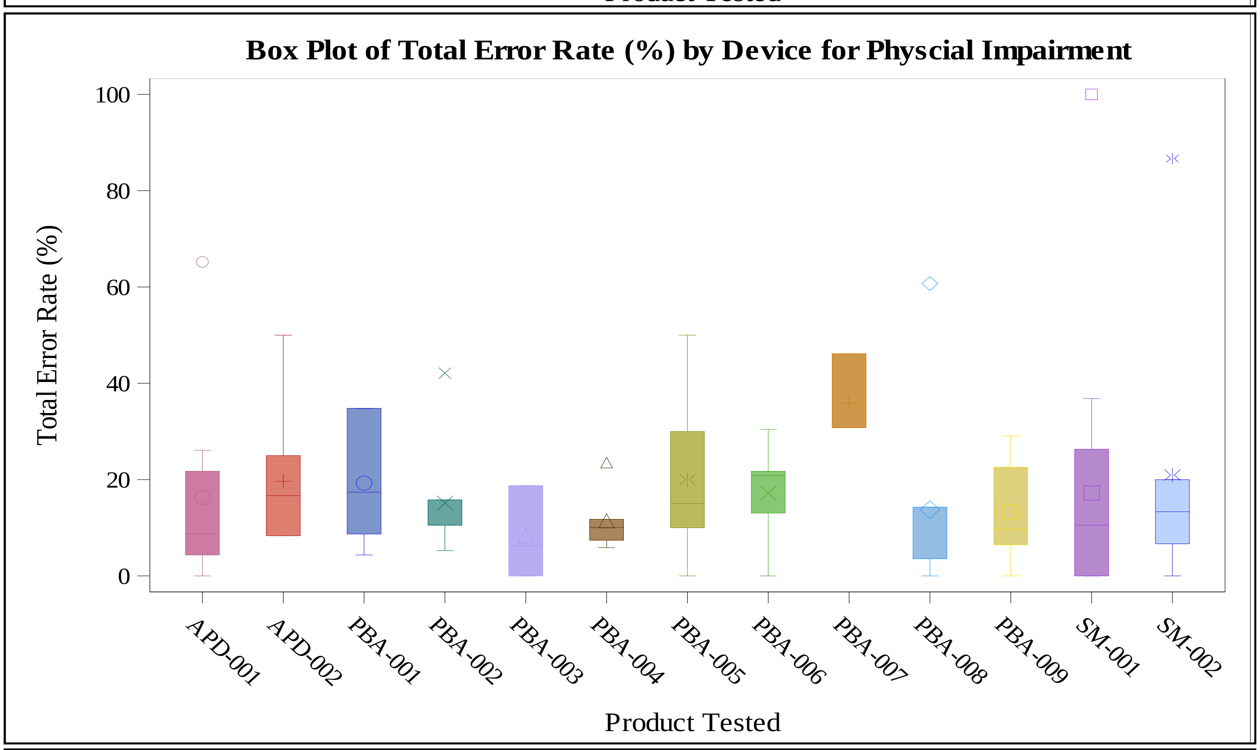
Total Error Rate (%)- Environmental Impairment Present									
Product tested	**N Obs**	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
APD-001	4	4	18.48	17.16	4.35	39.13	4.35	15.22	32.61
APD-002	10	10	9.17	6.75	0.00	20.83	4.17	8.33	12.50
PBA-001	5	5	14.78	16.44	4.35	43.48	4.35	8.70	13.04
PBA-002	6	6	11.40	6.15	5.26	21.05	5.26	10.53	15.79

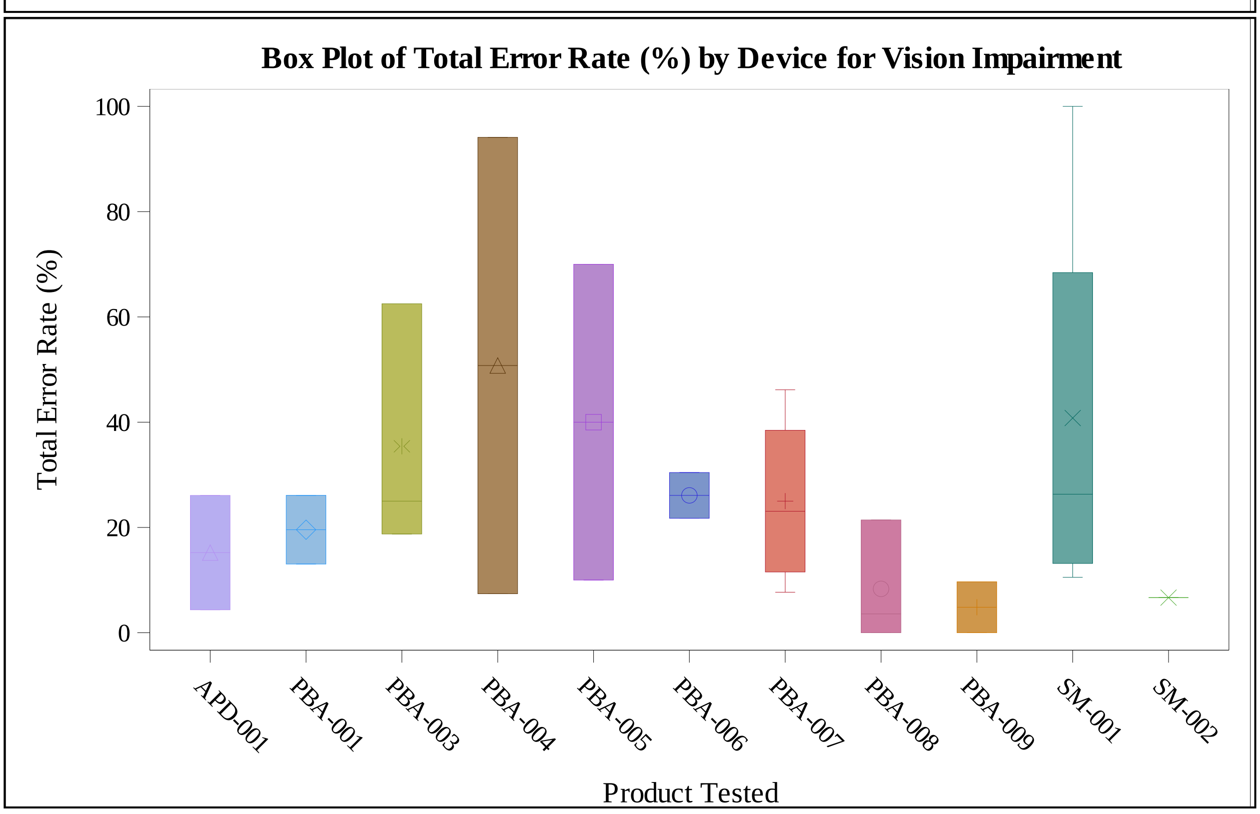
PBA-003	7	7	27.68	12.43	12.50	50.00	18.75	25.00	37.50
PBA-004	8	8	13.97	4.38	5.88	17.65	11.76	14.71	17.65
PBA-005	7	7	7.14	7.56	0.00	20.00	0.00	10.00	10.00
PBA-006	8	8	17.39	12.30	4.35	39.13	8.70	13.04	26.09
PBA-007	11	11	24.48	18.79	0.00	53.85	7.69	23.08	46.15
PBA-008	10	10	8.21	7.91	0.00	21.43	3.57	5.36	10.71
PBA-009	5	5	8.39	3.68	3.23	12.90	6.45	9.68	9.68
SM-001	13	13	11.34	13.39	0.00	36.84	0.00	5.26	10.53
SM-002	5	5	14.67	5.58	6.67	20.00	13.33	13.33	20.00

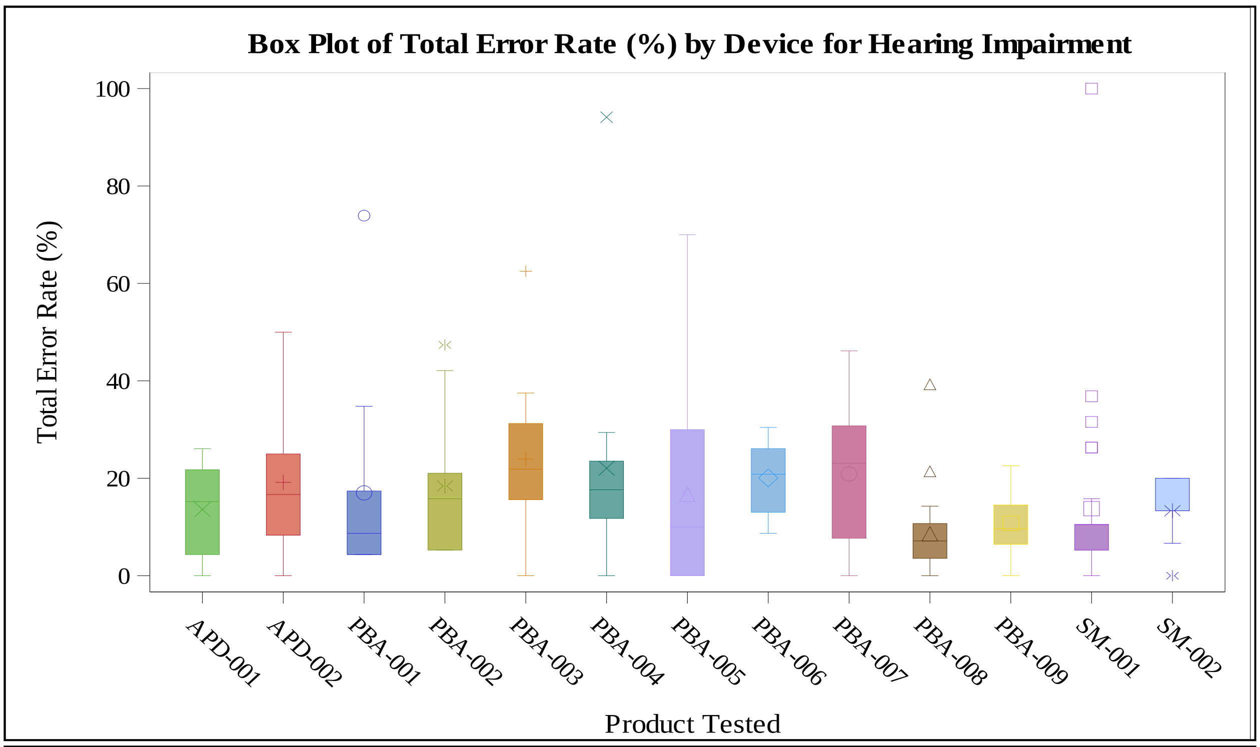
Kruskal-Wallis Test		
Chi-Square	**DF**	**Pr > ChiSq**
23.06	12	0.0272

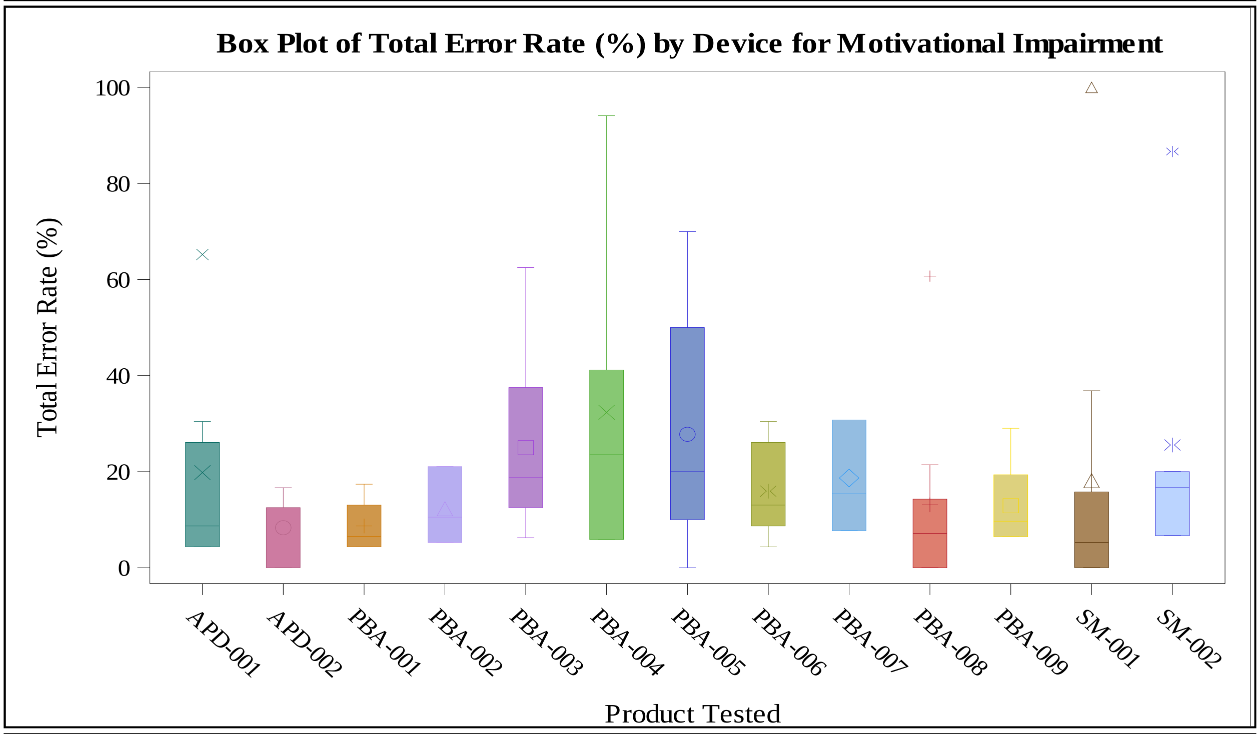
Box plot of Total Error Rate (%) by Device for Various Barriers

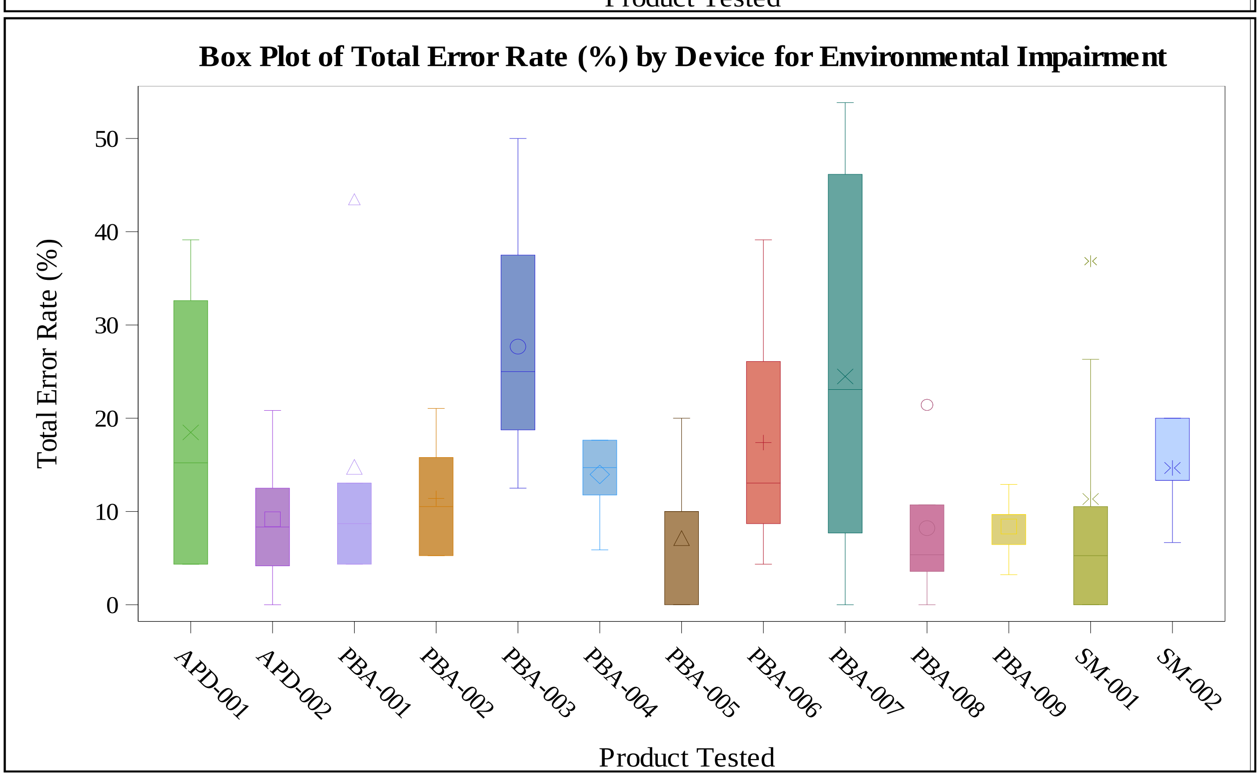







Box Plot of Total Error Rate (%) by Device for Hearing Impairment
Total Error Rate (%)
0
20
40
60
80
100
APD-001
APD-002
PBA-001
PBA-002
PBA-003
PBA-004
PBA-005
PBA-006
PBA-007
PBA-008
PBA-009
SM-001
SM-002
Product Tested


Box Plot of Total Error Rate (%) by Device for Motivational Impairment
Total Error Rate (%)
0
20
40
60
80
100
APD-001
APD-002
PBA-001
PBA-002
PBA-003
PBA-004
PBA-005
PBA-006
PBA-007
PBA-008
PBA-009
SM-001
SM-002
Product Tested


Box Plot of Total Error Rate (%) by Device for Environmental Impairment
Total Error Rate (%)
0
10
20
30
40
50
APD-001
APD-002
PBA-001
PBA-002
PBA-003
PBA-004
PBA-005
PBA-006
PBA-007
PBA-008
PBA-009
SM-001
SM-002
Product Tested

10.4.5 Appendix D-5: Time on Task (Seconds)

Descriptive Statistics and Kruskal-Wallis Test for Time on Task (Seconds) by Device – Overall

Variable	N	Mean	Std Dev	Minimum	Maximum	25th Pctl	Median	50th Pctl	75th Pctl
Time A	150	104.03	74.65	19	493	51	81	81	137
Time B	44	100.80	76.35	12	340	37	74	74	154
Time C	191	194.27	121.80	47	733	106	168	168	240
Time D	234	246.53	118.05	47	768	164	224.5	224.5	299
Time E	211	147.82	97.22	0	600	85	123	123	184
Time F	44	84.68	87.10	0	345	23.5	42.5	42.5	132.5
Time G	233	58.80	67.83	0	776	25	43	43	71
Time H	18	19.56	15.80	4	60	10	13.5	13.5	24
Time I	23	30.35	21.33	6	87	15	27	27	36
Time J	23	31.78	11.81	18	58	23	28	28	38
Time K	23	40.74	29.72	10	92	14	22	22	70
Time L	23	22.74	15.26	4	62	10	20	20	32
Time M	38	33.84	22.64	9	85	16	24.5	24.5	50
Time N	38	65.00	45.29	2	191	34	54.5	54.5	78
Time O	38	37.26	35.44	1	180	15	24.5	24.5	44
Time P	38	42.37	25.39	4	91	17	41	41	60
Time Q	38	38.89	20.12	2	80	24	35	35	60
Time R	16	23.94	14.29	10	66	14	19.5	19.5	31.5
Time S	16	65.44	20.73	18	90	51.5	69	69	83
Time T	16	29.25	22.68	10	77	12	19	19	37.5
Time U	16	22.38	20.43	5	80	10	15	15	27.5

Descriptive Statistics and Kruskal-Wallis Test for Time on Task (Seconds) by Device - Cognitive Impairment Present

Variable	N	Mean	Std Dev	Minimum	Maximum	25th Pctl	Median	50th Pctl	75th Pctl
Time A	27	115.30	82.12	31	414	60	85	85	165
Time B	9	146.22	75.68	31	240	80	159	159	212
Time C	34	223.32	152.48	58	589	104	175	175	275
Time D	40	271.50	120.60	75	535	189	248.5	248.5	332.5
Time E	37	166.43	107.21	37	560	102	130	130	192
Time F	9	63.22	66.33	5	213	25	40	40	62
Time G	40	76.60	72.85	14	325	30	52	52	92.5
Time H	4	9.75	6.24	4	18	5	8.5	8.5	14.5
Time I	3	48.00	28.93	15	69	15	60	60	69
Time J	3	23.67	7.37	18	32	18	21	21	32
Time K	3	78.33	11.93	70	92	70	73	73	92
Time L	3	20.00	17.32	10	40	10	10	10	40
Time M	8	29.00	21.68	12	76	14	20	20	38
Time N	8	50.25	38.29	2	129	27.5	44	44	64

Time O	8	25.00	18.65	1	60	13	21.5	21.5	35
Time P	8	47.25	24.95	12	83	26.5	49	49	66
Time Q	8	25.25	16.10	2	52	14.5	24	24	35.5
Time R	3	15.00	2.00	13	17	13	15	15	17
Time S	3	81.00	7.81	76	90	76	77	77	90
Time T	3	21.00	12.77	10	35	10	18	18	35
Time U	3	18.33	18.93	5	40	5	10	10	40

Descriptive Statistics and Kruskal-Wallis Test for Time on Task (Seconds) by Device - Physical Impairment Present

Variable	N	Mean	Std Dev	Minimum	Maximum	25th Pctl	Median	50th Pctl	75th Pctl
Time A	49	130.78	82.59	28	493	70	125	125	166
Time B	19	88.68	77.38	12	240	33	45	45	166
Time C	58	201.78	116.41	60	600	123	180.5	180.5	239
Time D	75	266.07	134.10	47	768	180	240	240	327
Time E	66	160.86	99.19	0	540	87	147	147	194
Time F	19	122.05	105.79	0	345	30	86	86	208
Time G	74	71.11	96.99	0	776	29	51	51	86
Time H	4	20.25	15.20	6	40	8.5	17.5	17.5	32
Time I	9	31.89	18.34	6	69	22	30	30	36
Time J	9	32.00	15.84	18	58	20	24	24	38
Time K	9	54.44	30.15	11	92	22	68	68	73
Time L	9	25.00	19.42	10	62	10	18	18	33
Time M	15	33.47	22.85	12	76	15	24	24	50
Time N	15	54.33	34.46	2	125	34	42	42	68
Time O	15	38.33	43.53	1	180	15	26	26	42
Time P	15	47.40	25.82	4	83	18	48	48	72
Time Q	15	38.93	23.62	2	80	16	36	36	60
Time R	7	25.29	9.21	15	38	17	23	23	36
Time S	7	58.71	21.65	18	79	49	57	57	77
Time T	7	30.71	22.32	12	77	13	29	29	35
Time U	7	26.43	29.21	5	80	6	14	14	55

Descriptive Statistics and Kruskal-Wallis Test for Time on Task (Seconds) by Device - Vision Impairment Present

Variable	N	Mean	Std Dev	Minimum	Maximum	25th Pctl	Median	50th Pctl	75th Pctl
Time A	12	131.58	109.09	23	414	67.5	96	96	168.5
Time B	2	47.50	45.96	15	80	15	47.5	47.5	80
Time C	18	210.94	159.72	49	733	100	193.5	193.5	251
Time D	22	277.82	170.09	76	768	150	237.5	237.5	330
Time E	20	130.10	96.25	30	329	54.5	94.5	94.5	201
Time F	2	38.00	33.94	14	62	14	38	38	62
Time G	21	60.00	66.34	7	325	30	45	45	68
Time H	1	10.00	.	10	10	10	10	10	10

Time I	2	11.00	5.66	7	15	7	11	11	15
Time J	2	22.00	5.66	18	26	18	22	22	26
Time K	2	69.00	1.41	68	70	68	69	69	70
Time L	2	10.00	0.00	10	10	10	10	10	10
Time M	4	32.50	27.09	17	73	17.5	20	20	47.5
Time N	4	80.00	59.91	2	129	33	94.5	94.5	127
Time O	4	37.25	53.61	1	117	8	15.5	15.5	66.5
Time P	4	25.50	14.25	12	44	14.5	23	23	36.5
Time Q	4	33.50	30.82	2	70	8.5	31	31	58.5
Time R	2	41.50	34.65	17	66	17	41.5	41.5	66
Time S	2	65.00	16.97	53	77	53	65	65	77
Time T	2	16.50	2.12	15	18	15	16.5	16.5	18
Time U	2	5.00	0.00	5	5	5	5	5	5

Descriptive Statistics and Kruskal-Wallis Test for Time on Task (Seconds) by Device - Hearing Impairment Present

Variable	N	Mean	Std Dev	Minimum	Maximum	25th Pctl	Median	50th Pctl	75th Pctl
Time A	84	106.19	85.02	23	493	48	78.5	78.5	148.5
Time B	23	116.22	84.59	15	340	37	120	120	164
Time C	110	209.85	131.28	49	733	116	182	182	259
Time D	137	259.29	133.29	47	768	156	236	236	316
Time E	125	151.61	102.79	10	600	87	124	124	186
Time F	23	85.35	99.25	4	345	22	35	35	137
Time G	136	64.14	79.32	5	776	25.5	45	45	79.5
Time H	10	20.50	14.57	6	43	10	13	13	40
Time I	12	33.75	20.96	6	69	19.5	30	30	53
Time J	12	33.17	14.62	20	58	20.5	29	29	44.5
Time K	12	48.33	32.95	11	92	11.5	67	67	73.5
Time L	12	25.00	16.79	4	62	10	21	21	36
Time M	26	33.62	20.78	9	80	17	30	30	42
Time N	26	63.42	47.20	2	191	31	47	47	78
Time O	26	31.69	26.62	1	117	14	25	25	42
Time P	26	44.42	25.31	4	83	17	45	45	64
Time Q	26	38.85	20.30	2	80	24	36	36	52
Time R	9	22.78	17.12	11	66	13	17	17	22
Time S	9	61.89	24.94	18	90	50	55	55	87
Time T	9	25.33	18.81	10	65	11	15	15	35
Time U	9	17.67	10.40	5	40	12	15	15	20

Descriptive Statistics and Kruskal-Wallis Test for Time on Task (Seconds) by Device - Motivational Impairment Present

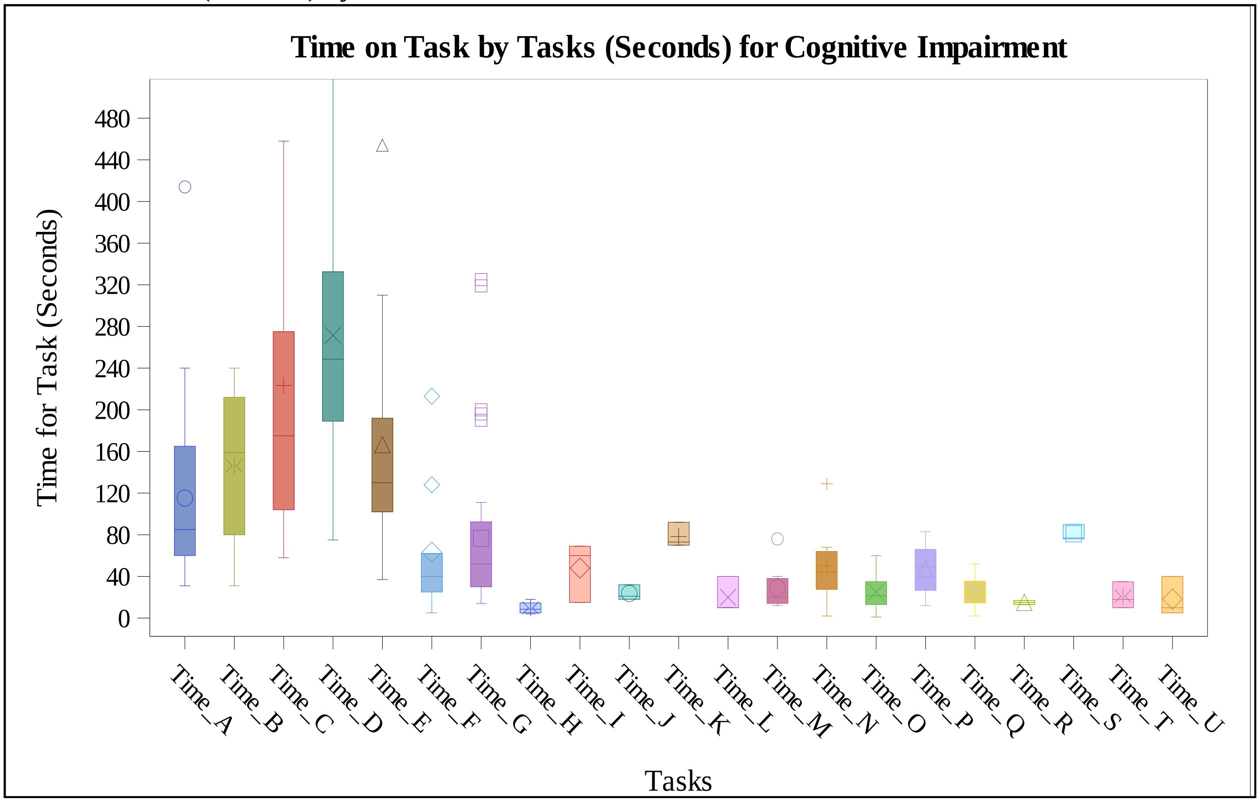
Variable	N	Mean	Std Dev	Minimum	Maximum	25th Pctl	Median	50th Pctl	75th Pctl
Time A	43	121.42	98.62	22	493	50	105	105	160
Time B	14	91.14	78.25	12	240	37	61.5	61.5	131

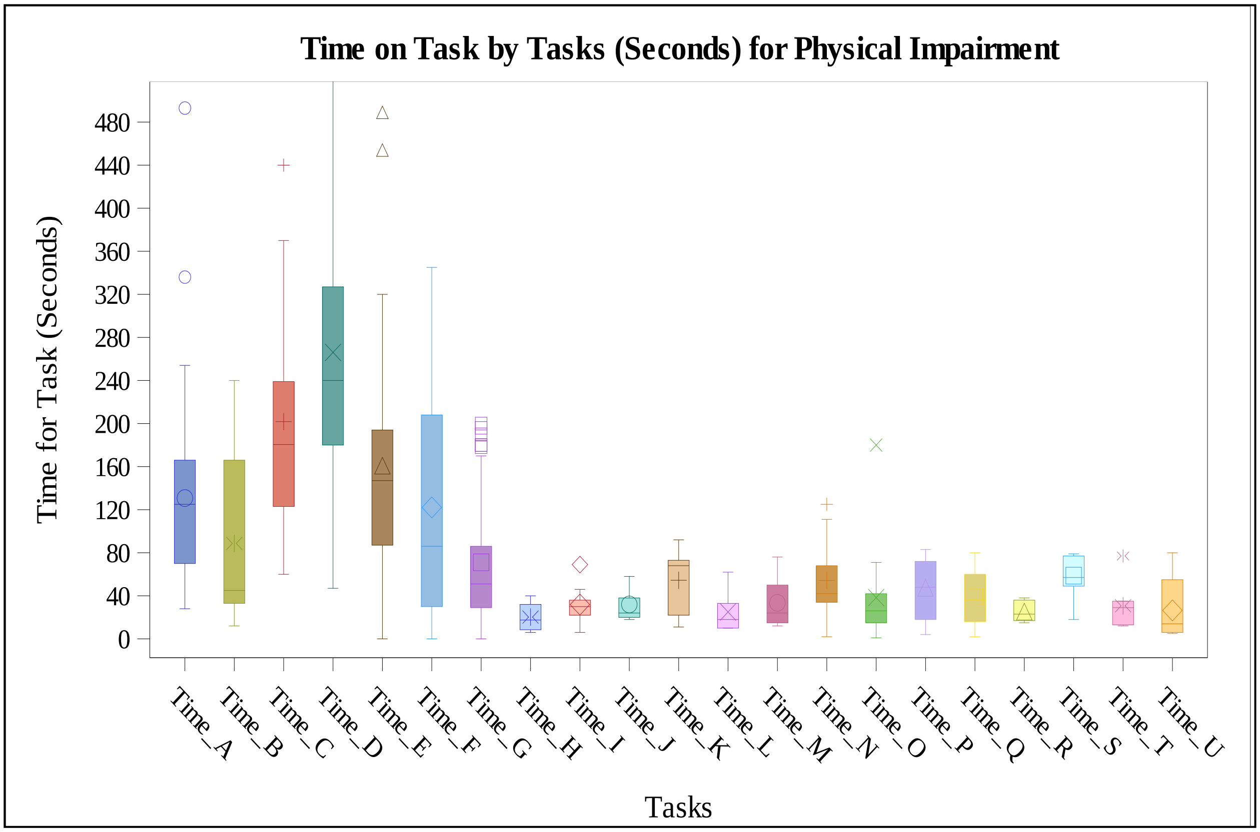
Time C	56	185.91	110.22	49	600	106.5	165	165	238.5
Time D	72	238.28	125.39	47	600	151.5	214	214	289.5
Time E	65	143.43	84.47	27	454	81	120	120	182
Time F	14	104.43	80.78	10	240	30	89.5	89.5	182
Time G	72	61.76	98.14	4	776	22	38	38	72.5
Time H	6	23.50	22.62	4	60	9	12.5	12.5	43
Time I	7	32.86	21.28	7	60	10	30	30	60
Time J	7	33.57	8.94	24	51	26	32	32	38
Time K	7	56.71	26.56	15	80	22	68	68	73
Time L	7	25.43	16.20	10	50	10	26	26	40
Time M	9	31.67	22.76	12	76	18	22	22	30
Time N	9	48.33	37.60	2	129	23	39	39	64
Time O	9	43.44	34.44	1	99	20	24	24	71
Time P	9	35.00	18.83	10	60	18	35	35	47
Time Q	9	18.33	9.77	2	33	14	15	15	27
Time R	6	33.00	18.68	13	66	22	29.5	29.5	38
Time S	6	61.33	19.13	40	90	49	55	55	79
Time T	6	30.83	25.51	10	77	12	23	23	40
Time U	6	35.50	29.17	5	80	6	33.5	33.5	55

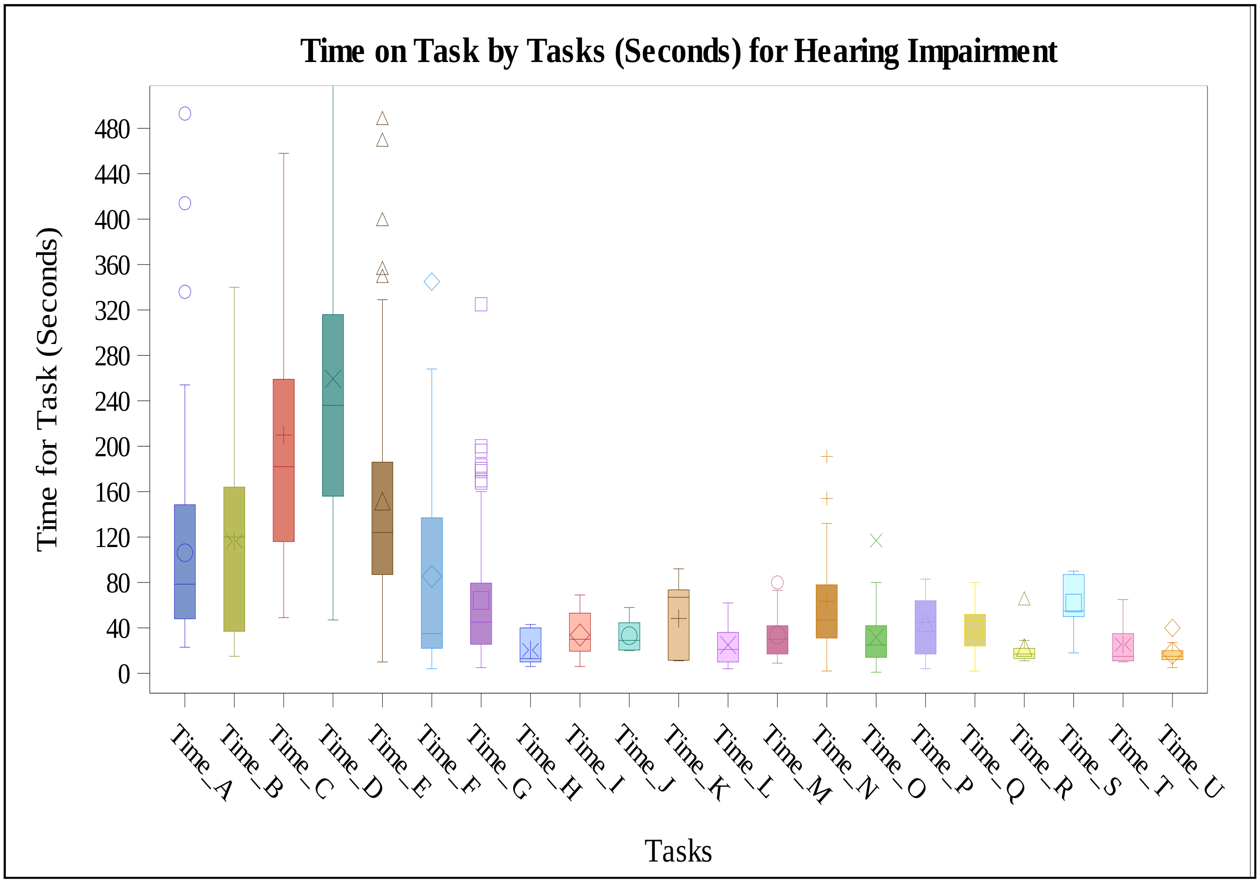
Descriptive Statistics and Kruskal-Wallis Test for Time on Task (Seconds) by Device - Environmental Impairment Present

Variable	N	Mean	Std Dev	Minimum	Maximum	25th Pctl	Median	50th Pctl	75th Pctl
Time A	50	88.16	60.77	20	240	35	72.5	72.5	136
Time B	14	136.07	93.59	15	340	66	137	137	212
Time C	69	178.39	106.15	47	577	100	177	177	208
Time D	81	242.74	120.53	65	768	170	228	228	292
Time E	76	142.97	107.94	0	600	81.5	114	114	176.5
Time F	14	46.79	58.84	0	213	14	27	27	50
Time G	80	47.58	45.71	0	319	22.5	33	33	58.5
Time H	7	18.14	16.74	4	43	4	12	12	40
Time I	5	30.20	19.14	7	60	24	30	30	30
Time J	5	29.60	12.34	20	51	23	26	26	28
Time K	5	51.60	28.44	12	80	32	66	66	68
Time L	5	19.40	14.99	6	39	10	10	10	32
Time M	13	41.54	29.35	12	85	16	25	25	73
Time N	13	67.00	46.11	19	191	37	60	60	68
Time O	13	35.38	25.86	13	99	20	25	25	40
Time P	13	37.23	24.64	10	91	17	34	34	58
Time Q	13	33.46	19.37	14	75	21	30	30	34
Time R	5	27.60	21.73	13	66	17	20	20	22
Time S	5	71.60	23.39	40	90	53	87	87	88
Time T	5	30.20	22.42	11	65	15	20	20	40
Time U	5	15.60	8.56	5	27	10	16	16	20

Box plot of Time on Task (Seconds) by Device for Various Barriers






Time on Task by Tasks (Seconds) for Hearing Impairment
Time for Task (Seconds)
0
40
80
120
160
200
240
280
320
360
400
440
480
Time_A
Time_B
Time_C
Time_D
Time_E
Time_F
Time_G
Time_H
Time_I
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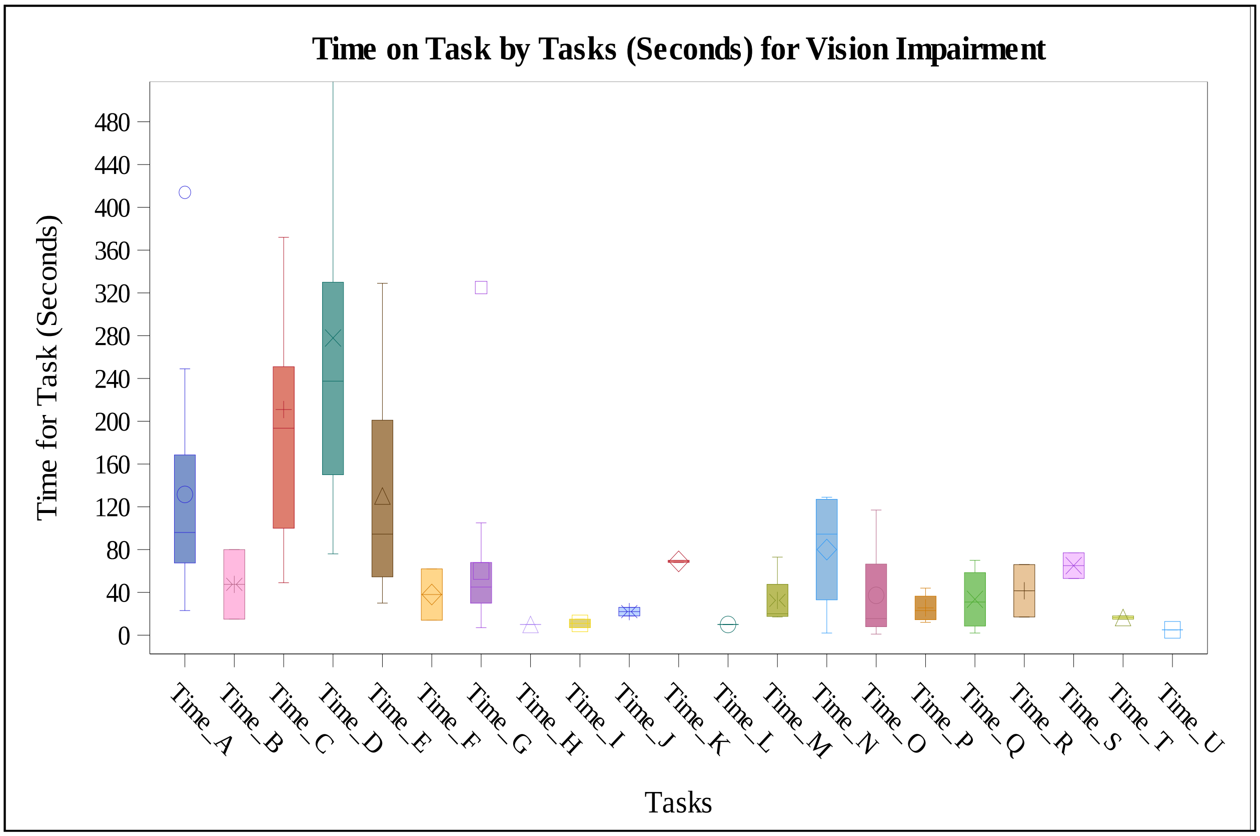
Time_T
Time_U
Tasks


Time on Task by Tasks (Seconds) for Vision Impairment
Time for Task (Seconds)
0
40
80
120
160
200
240
280
320
360
400
440
480
Time_A
Time_B
Time_C
Time_D
Time_E
Time_F
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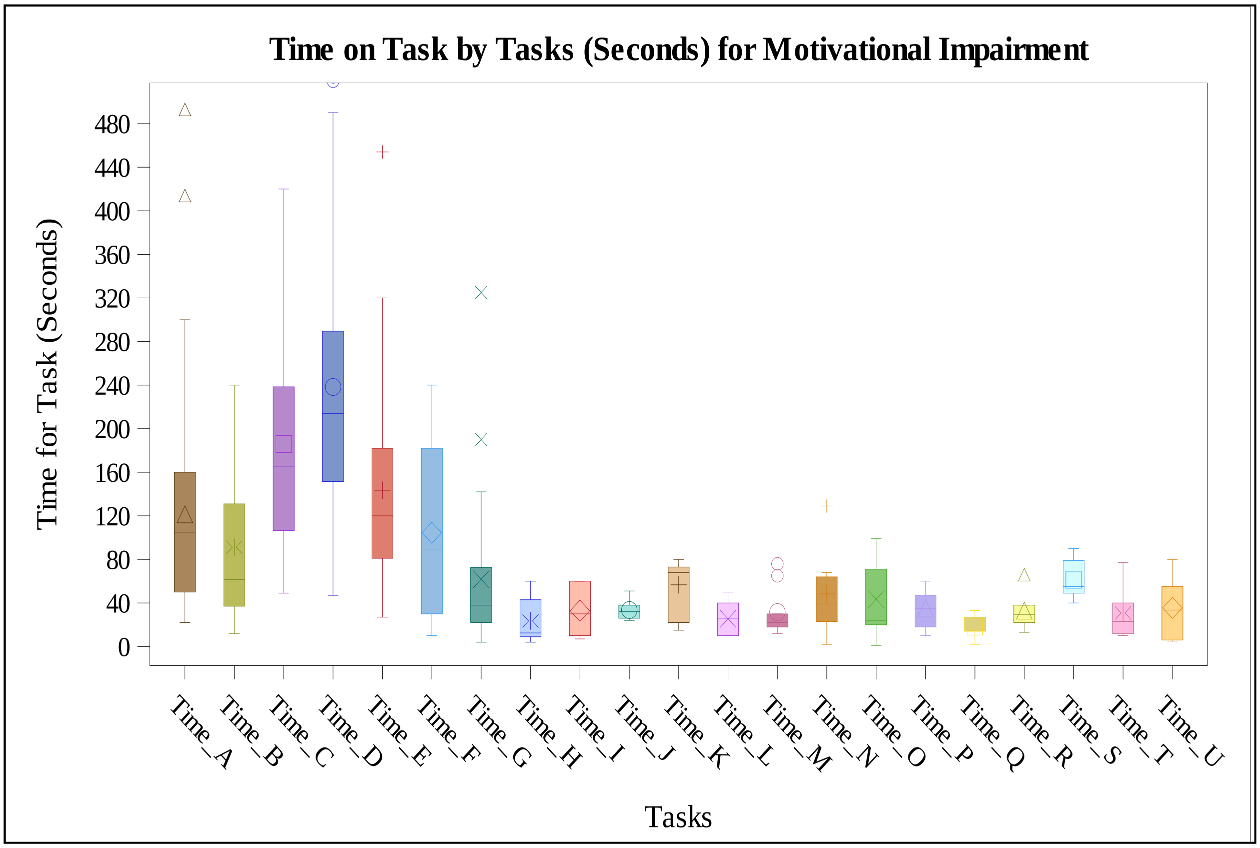
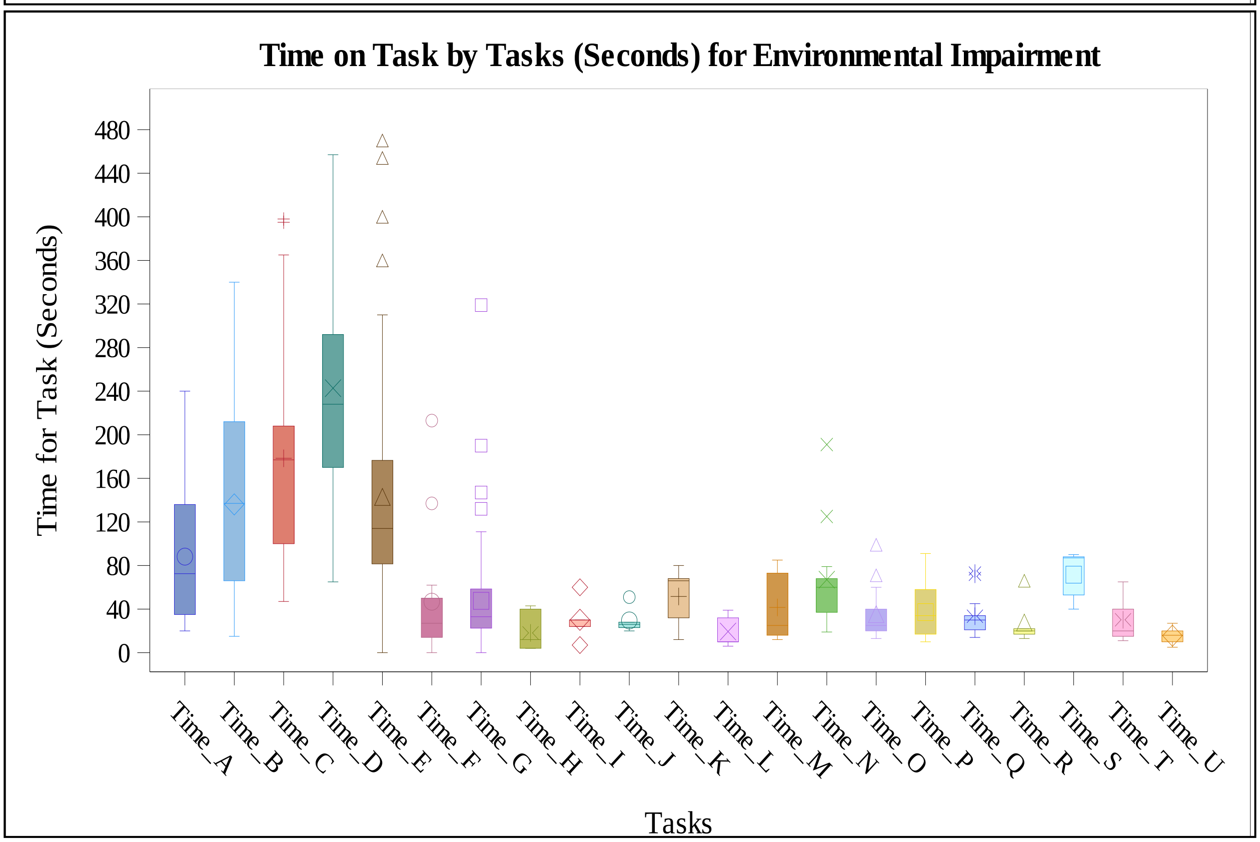
Time_T
Time_U
Tasks





10.4.6 Appendix D-6: Proportion of Subtask Success

Descriptive Statistics and Kruskal-Wallis Test for Proportion of Subtask Success by Subtask – Overall

Proportion of Subtask Success - Overall

Subtasks	N	Mean	Std Dev	Minimum	Maximum	25th Pctl	Median	75th Pctl
A1	80	0.94	0.18	0	1	1	1	1
A2	78	0.92	0.2	0	1	1	1	1
A4	37	0.94	0.23	0	1	1	1	1
A5	65	0.81	0.25	0	1	0.66667	0.875	1
A6	80	0.91	0.19	0	1	1	1	1
B1	44	0.77	0.34	0	1	0.66667	1	1
B2	44	0.85	0.19	0.5	1	0.75	1	1
B3	20	0.78	0.29	0.33333	1	0.5	1	1
B4	77	0.92	0.14	0.5	1	0.83333	1	1
C1	54	0.89	0.22	0	1	0.85714	1	1
C2	79	0.82	0.21	0.22222	1	0.71429	0.9	1
D2	53	0.88	0.25	0	1	0.85714	1	1
D3	50	0.86	0.19	0.33333	1	0.66667	1	1
D4	79	0.89	0.18	0.25	1	0.75	1	1
D5	79	0.88	0.22	0	1	0.75	1	1
D6	19	0.26	0.45	0	1	0	0	1
G1	80	0.95	0.15	0	1	1	1	1
G2	45	0.97	0.16	0	1	1	1	1
G3	24	0.92	0.28	0	1	1	1	1
H1	19	0.89	0.32	0	1	1	1	1
I1	60	0.96	0.14	0	1	1	1	1
I3	60	0.98	0.14	0	1	1	1	1
M1	38	0.96	0.18	0	1	1	1	1
P1	38	0.76	0.43	0	1	1	1	1
R1	16	0.96	0.11	0.66667	1	1	1	1
R2	16	0.88	0.34	0	1	1	1	1
T1	16	0.94	0.25	0	1	1	1	1
T2	16	0.94	0.25	0	1	1	1	1

Kruskal-Wallis Test		
Chi-Square	DF	Pr > ChiSq
207.769	27	<.0001

Descriptive Statistics and Kruskal-Wallis Test for Proportion of Subtask Success by Subtask - Cognitive Impairment Present

Proportion of Subtask Success – Cognitive Impairment Present								
Subtasks	N	Mean	Std Dev	Minimum	Maximum	25th Pctl	Median	75th Pctl
A1	16	0.88	0.29	0	1	1	1	1
A2	15	0.97	0.13	0.5	1	1	1	1
A4	6	0.94	0.14	0.66667	1	1	1	1
A5	10	0.66	0.35	0	1	0.5	0.74242	1
A6	16	0.85	0.3	0	1	0.83333	1	1

B1	9	0.59	0.4	0	1	0.33333	0.66667	1
B2	9	0.83	0.18	0.5	1	0.75	0.75	1
B3	3	0.89	0.19	0.66667	1	0.66667	1	1
B4	13	0.89	0.14	0.66667	1	0.75	1	1
C1	10	0.87	0.2	0.42857	1	0.71429	1	1
C2	15	0.73	0.23	0.28571	1	0.5	0.8	0.90909
D2	8	0.92	0.12	0.66667	1	0.86607	1	1
D3	7	0.88	0.21	0.5	1	0.66667	1	1
D4	15	0.93	0.13	0.66667	1	0.75	1	1
D5	15	0.89	0.17	0.5	1	0.75	1	1
D6	4	0.25	0.5	0	1	0	0	0.5
G1	16	0.83	0.28	0	1	0.66667	1	1
G2	9	1	0	1	1	1	1	1
G3	6	0.83	0.41	0	1	1	1	1
H1	4	1	0	1	1	1	1	1
I1	11	0.88	0.3	0	1	0.91667	1	1
I3	11	0.91	0.3	0	1	1	1	1
M1	8	0.81	0.37	0	1	0.75	1	1
P1	8	0.63	0.52	0	1	0	1	1
R1	3	0.89	0.19	0.66667	1	0.66667	1	1
R2	3	1	0	1	1	1	1	1
T1	3	1	0	1	1	1	1	1
T2	3	1	0	1	1	1	1	1

Kruskal-Wallis Test		
Chi-Square	**DF**	**Pr > ChiSq**
53.7212	27	0.0016

Descriptive Statistics and Kruskal-Wallis Test for Proportion of Subtask Success by Subtask - Physical Impairment Present

Proportion of Subtask Success – Physical Impairment Present								
Subtasks	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
A1	27	0.9	0.25	0	1	1	1	1
A2	26	0.81	0.28	0	1	0.5	1	1
A4	12	0.89	0.3	0	1	1	1	1
A5	19	0.78	0.23	0.2	1	0.66667	0.8	1
A6	27	0.82	0.27	0	1	0.66667	1	1
B1	19	0.82	0.34	0	1	0.66667	1	1
B2	19	0.83	0.22	0.5	1	0.5	1	1
B3	12	0.72	0.31	0.33333	1	0.33333	0.83333	1
B4	26	0.94	0.11	0.66667	1	1	1	1
C1	22	0.83	0.24	0.28571	1	0.71429	1	1
C2	26	0.76	0.24	0.28571	1	0.66667	0.83676	0.96667

D2	18	0.86	0.25	0	1	0.85714	1	1
D3	13	0.73	0.25	0.33333	1	0.66667	0.66667	1
D4	26	0.88	0.15	0.66667	1	0.66667	1	1
D5	26	0.87	0.24	0	1	0.8	1	1
D6	5	0	0	0	0	0	0	0
G1	27	0.92	0.21	0	1	1	1	1
G2	16	0.92	0.26	0	1	1	1	1
G3	7	0.71	0.49	0	1	0	1	1
H1	5	0.6	0.55	0	1	0	1	1
I1	23	0.92	0.22	0	1	0.91667	1	1
I3	23	0.94	0.22	0	1	1	1	1
M1	15	0.93	0.26	0	1	1	1	1
P1	15	0.67	0.49	0	1	0	1	1
R1	7	0.9	0.16	0.66667	1	0.66667	1	1
R2	7	0.71	0.49	0	1	0	1	1
T1	7	1	0	1	1	1	1	1
T2	7	1	0	1	1	1	1	1

Kruskal-Wallis Test		
Chi-Square	**DF**	**Pr > ChiSq**
75.3244	27	<.0001

Descriptive Statistics and Kruskal-Wallis Test for Proportion of Subtask Success by Subtask - Vision Impairment Present

Proportion of Subtask Success – Vision Impairment Present								
Subtasks	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
A1	9	0.8	0.35	0	1	0.66667	1	1
A2	8	1	0	1	1	1	1	1
A4	2	0.5	0.71	0	1	0	0.5	1
A5	7	0.72	0.37	0	1	0.5	0.88889	1
A6	9	0.87	0.33	0	1	1	1	1
B1	2	0.5	0.71	0	1	0	0.5	1
B2	2	1	0	1	1	1	1	1
B3	2	0.83	0.24	0.66667	1	0.66667	0.83333	1
B4	7	0.93	0.19	0.5	1	1	1	1
C1	4	0.96	0.07	0.85714	1	0.92857	1	1
C2	8	0.71	0.24	0.22222	0.92	0.60294	0.74937	0.90238
D2	5	0.77	0.44	0	1	0.85714	1	1
D3	5	0.7	0.21	0.5	1	0.5	0.75	0.75
D4	8	0.83	0.27	0.25	1	0.70833	1	1
D5	8	0.8	0.29	0.33333	1	0.53333	1	1
D6	2	0	0	0	0	0	0	0
G1	9	0.79	0.33	0	1	0.66667	1	1

G2	2	1	0	1	1	1	1	1
H1	2	0.5	0.71	0	1	0	0.5	1
I1	6	0.81	0.4	0	1	0.91667	0.95833	1
I3	6	0.83	0.41	0	1	1	1	1
M1	4	0.63	0.48	0	1	0.25	0.75	1
P1	4	0.75	0.5	0	1	0.5	1	1
R1	2	1	0	1	1	1	1	1
R2	2	1	0	1	1	1	1	1
T1	2	1	0	1	1	1	1	1
T2	2	1	0	1	1	1	1	1

Kruskal-Wallis Test		
Chi-Square	**DF**	**Pr > ChiSq**
33.8577	26	0.1386

Descriptive Statistics and Kruskal-Wallis Test for Proportion of Subtask Success by Subtask - Hearing Impairment Present

Proportion of Subtask Success – Hearing Impairment Present								
Subtasks	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
A1	48	0.94	0.19	0	1	1	1	1
A2	46	0.91	0.22	0	1	1	1	1
A4	19	0.88	0.32	0	1	1	1	1
A5	38	0.79	0.29	0	1	0.66667	0.9375	1
A6	48	0.89	0.21	0	1	0.81667	1	1
B1	23	0.84	0.2	0.33333	1	0.66667	1	1
B2	23	0.82	0.17	0.5	1	0.75	0.75	1
B3	8	0.71	0.33	0.33333	1	0.33333	0.83333	1
B4	45	0.92	0.15	0.5	1	0.83333	1	1
C1	27	0.87	0.25	0	1	0.85714	1	1
C2	47	0.77	0.23	0.22222	1	0.66667	0.88	0.95652
D2	29	0.91	0.21	0	1	1	1	1
D3	31	0.88	0.18	0.33333	1	0.75	1	1
D4	47	0.9	0.19	0.25	1	0.75	1	1
D5	47	0.86	0.23	0	1	0.66667	1	1
D6	11	0.09	0.3	0	1	0	0	0
G1	48	0.95	0.17	0	1	1	1	1
G2	26	0.99	0.07	0.66667	1	1	1	1
G3	15	0.87	0.35	0	1	1	1	1
H1	11	0.82	0.4	0	1	1	1	1
I1	37	0.95	0.17	0	1	1	1	1
I3	37	0.96	0.17	0	1	1	1	1
M1	26	0.94	0.22	0	1	1	1	1

P1	26	0.73	0.45	0	1	0	1	1
R1	9	0.93	0.15	0.66667	1	1	1	1
R2	9	0.78	0.44	0	1	1	1	1
T1	9	0.89	0.33	0	1	1	1	1
T2	9	0.89	0.33	0	1	1	1	1

Kruskal-Wallis Test		
Chi-Square	**DF**	**Pr > ChiSq**
146.867	27	<.0001

Descriptive Statistics and Kruskal-Wallis Test for Proportion of Subtask Success by Subtask - Motivational Impairment Present

Proportion of Subtask Success – Motivational Impairment Present								
Subtasks	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
A1	25	0.9	0.25	0	1	1	1	1
A2	24	0.94	0.15	0.5	1	1	1	1
A4	8	0.88	0.35	0	1	1	1	1
A5	19	0.82	0.26	0	1	0.71429	1	1
A6	25	0.9	0.22	0	1	0.85714	1	1
B1	14	0.67	0.41	0	1	0.33333	0.83333	1
B2	14	0.84	0.21	0.5	1	0.75	1	1
B3	9	0.78	0.29	0.33333	1	0.66667	1	1
B4	22	0.89	0.17	0.5	1	0.75	1	1
C1	17	0.9	0.18	0.42857	1	0.85714	1	1
C2	24	0.8	0.24	0.22222	1	0.61905	0.89444	1
D2	17	0.8	0.39	0	1	0.875	1	1
D3	17	0.82	0.25	0.33333	1	0.66667	1	1
D4	24	0.88	0.2	0.25	1	0.75	1	1
D5	24	0.84	0.26	0	1	0.66667	1	1
D6	6	0.5	0.55	0	1	0	0.5	1
G1	25	0.92	0.22	0	1	1	1	1
G2	12	0.92	0.29	0	1	1	1	1
G3	5	1	0	1	1	1	1	1
H1	6	1	0	1	1	1	1	1
I1	16	0.89	0.25	0	1	0.91667	1	1
I3	16	0.94	0.25	0	1	1	1	1
M1	9	0.83	0.35	0	1	1	1	1
P1	9	0.78	0.44	0	1	1	1	1
R1	6	1	0	1	1	1	1	1
R2	6	1	0	1	1	1	1	1
T1	6	1	0	1	1	1	1	1
T2	6	1	0	1	1	1	1	1

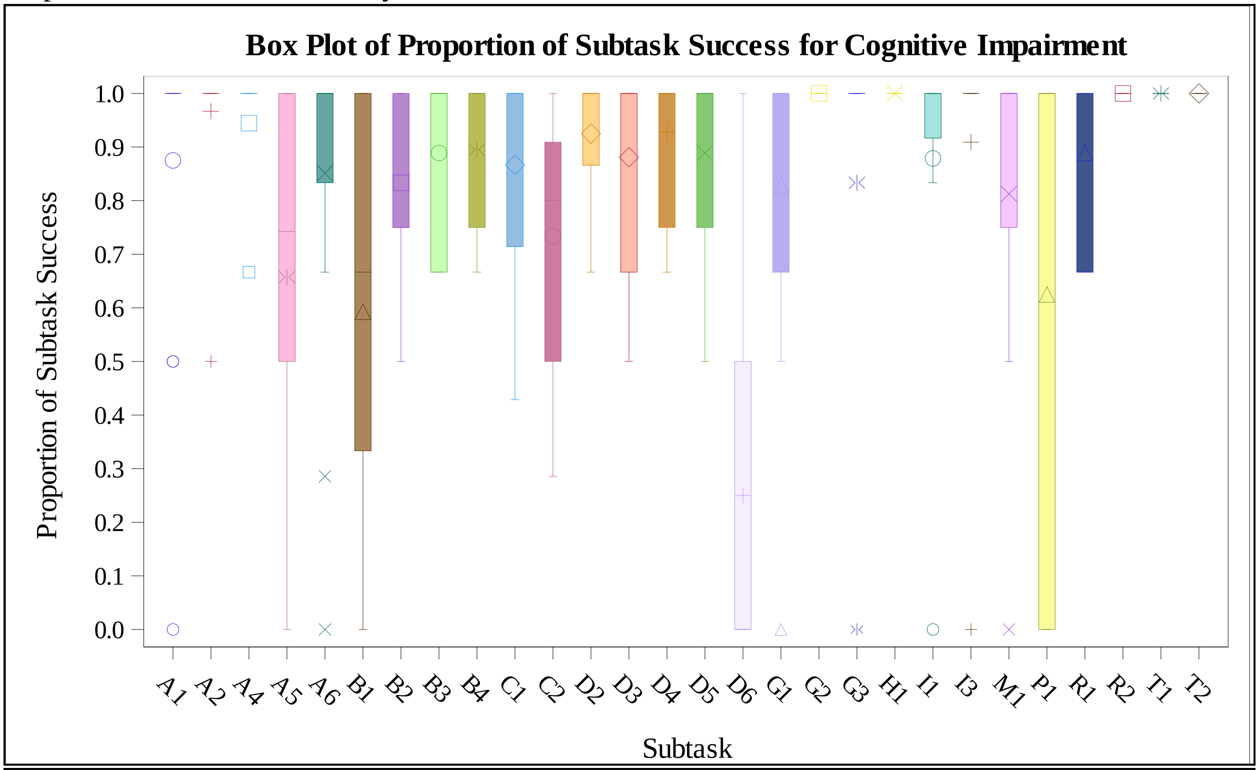
Kruskal-Wallis Test		
Chi-Square	DF	Pr > ChiSq
52.5032	27	0.0023

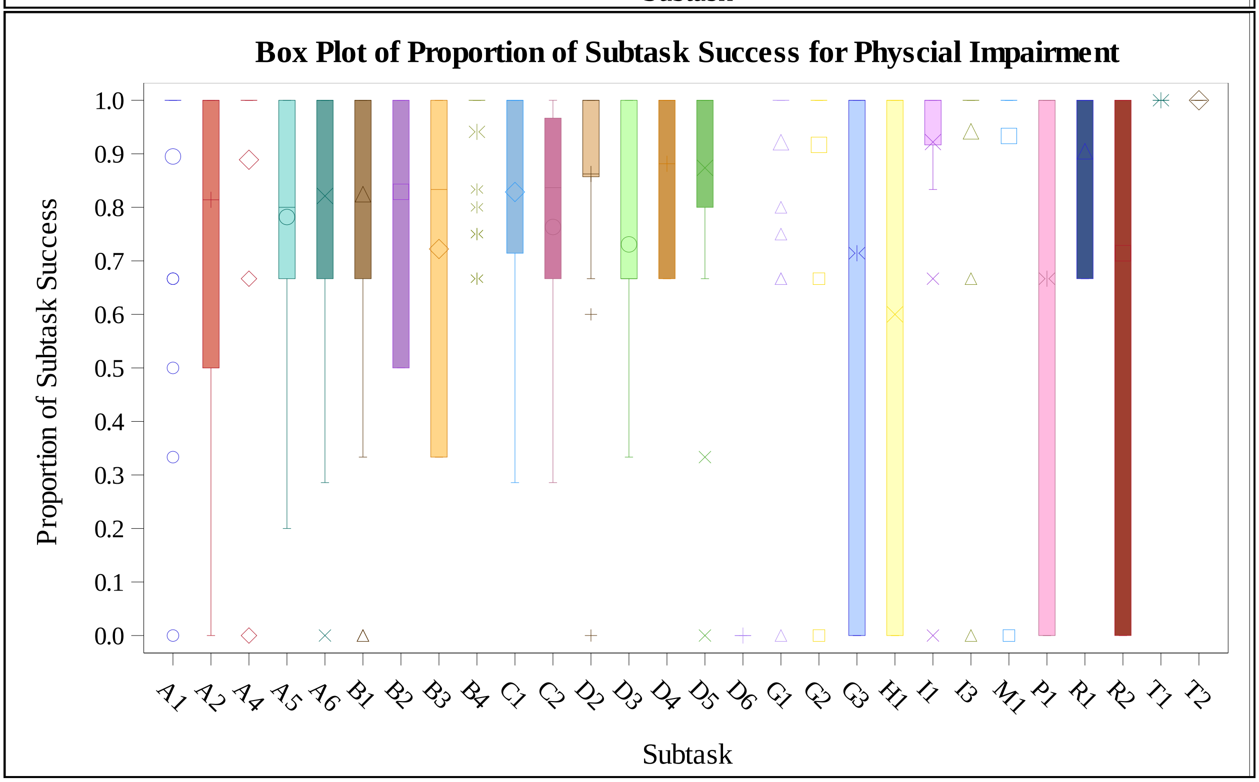
Descriptive Statistics and Kruskal-Wallis Test for Proportion of Subtask Success by Subtask - Environmental Impairment Present

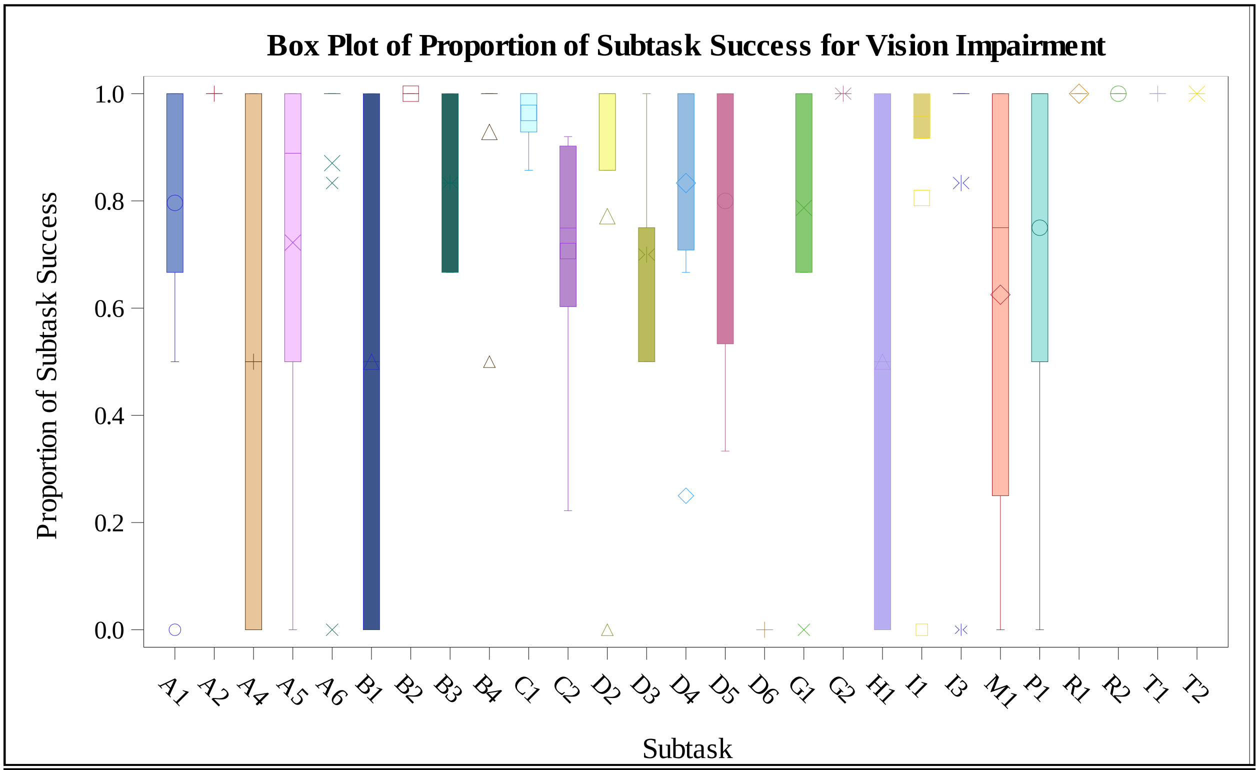
Proportion of Subtask Success - Environmental Impairment Present								
Subtasks	N	Mean	Std Dev	Minimum	Maximum	25th Pctl	Median	75th Pctl
A1	27	1	0	1	1	1	1	1
A2	26	0.99	0.07	0.66667	1	1	1	1
A4	13	0.97	0.09	0.66667	1	1	1	1
A5	21	0.9	0.16	0.5	1	0.85714	1	1
A6	27	0.94	0.15	0.33333	1	1	1	1
B1	14	0.62	0.39	0	1	0.33333	0.66667	1
B2	14	0.79	0.19	0.5	1	0.75	0.75	1
B3	4	0.75	0.32	0.33333	1	0.5	0.83333	1
B4	27	0.93	0.11	0.66667	1	0.83333	1	1
C1	17	0.9	0.21	0.28571	1	1	1	1
C2	27	0.88	0.13	0.57143	1	0.8	0.92	1
D2	18	0.92	0.14	0.66667	1	0.85714	1	1
D3	21	0.87	0.18	0.5	1	0.75	1	1
D4	27	0.9	0.17	0.5	1	0.75	1	1
D5	27	0.92	0.19	0.33333	1	1	1	1
D6	8	0.38	0.52	0	1	0	0	1
G1	27	0.95	0.12	0.5	1	1	1	1
G2	14	1	0	1	1	1	1	1
G3	10	1	0	1	1	1	1	1
H1	8	0.88	0.35	0	1	1	1	1
I1	18	0.99	0.04	0.83333	1	1	1	1
I3	18	1	0	1	1	1	1	1
M1	13	1	0	1	1	1	1	1
P1	13	0.69	0.48	0	1	0	1	1
R1	5	1	0	1	1	1	1	1
R2	5	1	0	1	1	1	1	1
T1	5	0.8	0.45	0	1	1	1	1
T2	5	0.8	0.45	0	1	1	1	1

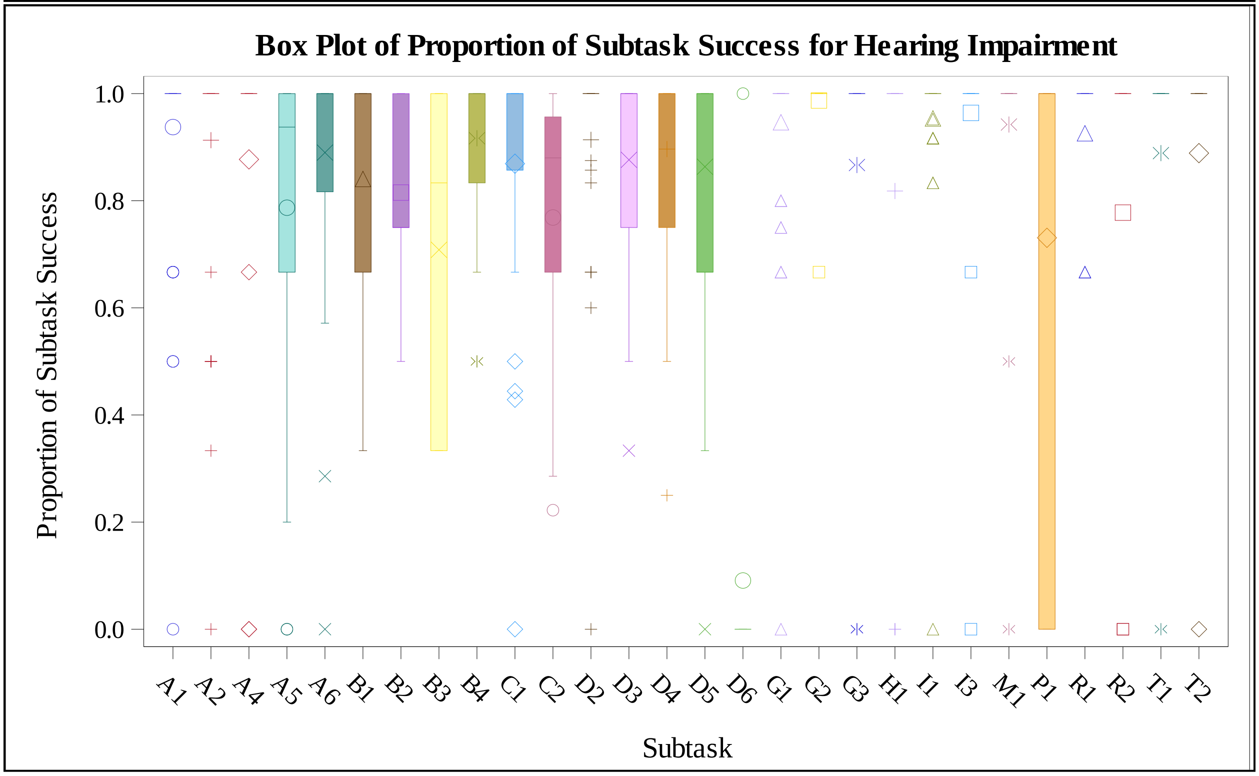
Kruskal-Wallis Test		
Chi-Square	DF	Pr > ChiSq
102.27	27	<.0001

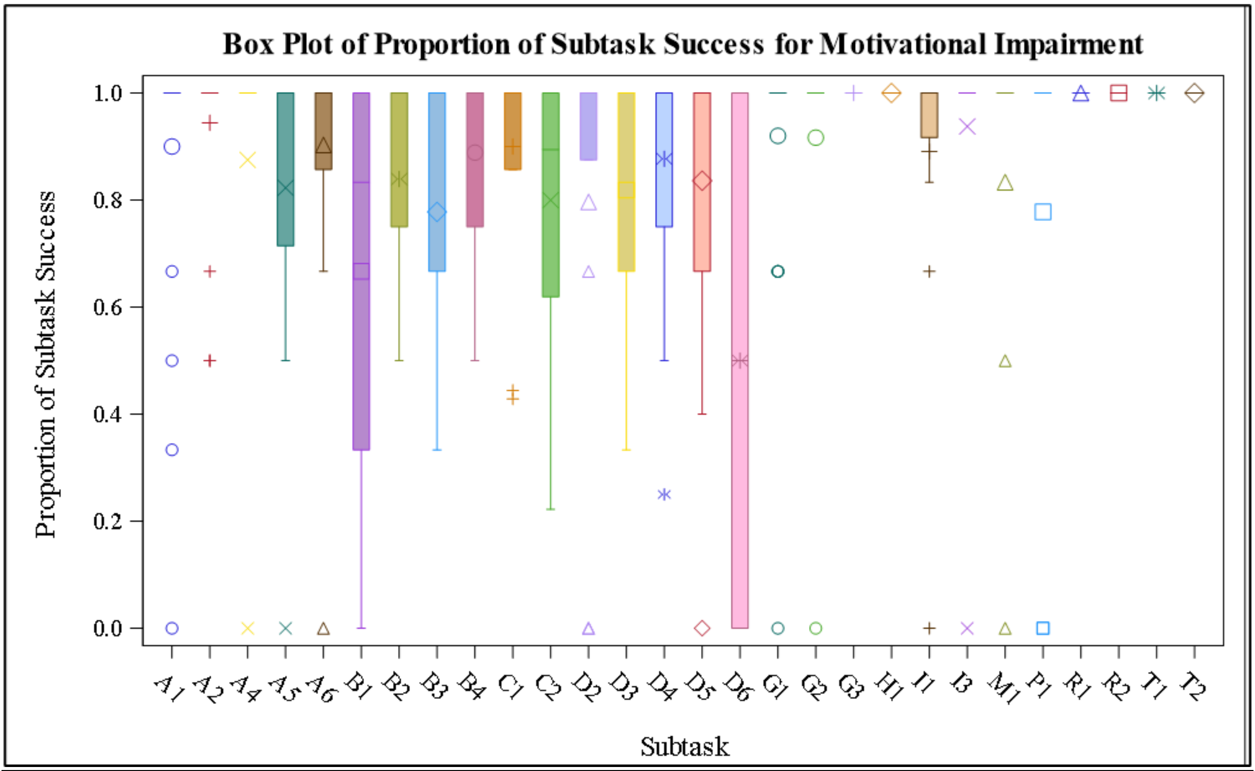
Box plot of Proportion of Subtask Success by Subtask for Various Barriers

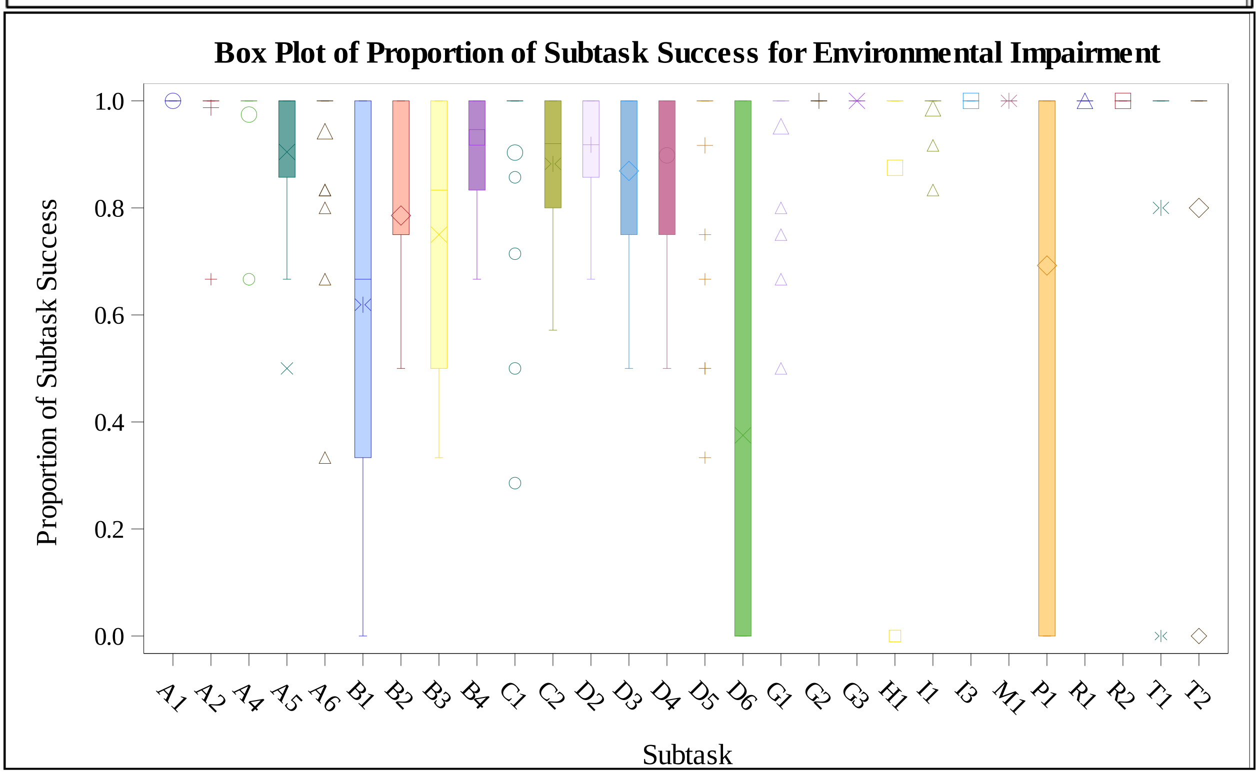





Box Plot of Proportion of Subtask Success for Vision Impairment
Proportion of Subtask Success
1.0
0.8
0.6
0.4
0.2
0.0
A1 A2 A4 A5 A6 B1 B2 B3 B4 C1 C2 D2 D3 D4 D5 D6 G1 G2 H1 I1 I3 M1 P1 R1 R2 T1 T2
Subtask


Box Plot of Proportion of Subtask Success for Hearing Impairment
Proportion of Subtask Success
1.0
0.8
0.6
0.4
0.2
0.0
A1 A2 A4 A5 A6 B1 B2 B3 B4 C1 C2 D2 D3 D4 D5 D6 G1 G2 G3 H1 I1 I3 M1 P1 R1 R2 T1 T2
Subtask


Box Plot of Proportion of Subtask Success for Motivational Impairment
Proportion of Subtask Success
1.0
0.8
0.6
0.4
0.2
0.0
A1 A2 A4 A5 A6 B1 B2 B3 B4 C1 C2 D2 D3 D4 D5 D6 G1 G2 G3 H1 I1 I3 M1 P1 R1 R2 T1 T2
Subtask


Box Plot of Proportion of Subtask Success for Environmental Impairment
Proportion of Subtask Success
1.0
0.8
0.6
0.4
0.2
0.0
A1 A2 A4 A5 A6 B1 B2 B3 B4 C1 C2 D2 D3 D4 D5 D6 G1 G2 G3 H1 I1 I3 M1 P1 R1 R2 T1 T2
Subtask

10.5 Appendix E- Perception-based Usability Metrics

10.5.1 Appendix E-1 – System Usability Scale (SUS) Scores

Descriptive Statistics and Kruskal-Wallis Test for SUS Score by Device – Overall

SUS Score - Overall								
Product tested	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
APD-001	19	35.13	18.59	0	82.5	25	32.5	45
APD-002	24	32.5	19.17	0	70	21.25	31.25	46.25
PBA-001	19	40.66	17.12	2.5	62.5	25	45	52.5
PBA-002	21	46.07	25.75	0	90	30	45	60
PBA-003	21	39.52	20.96	0	75	27.5	42.5	50
PBA-004	20	45.38	22.74	7.5	92.5	28.75	42.5	60
PBA-005	20	44	20.67	2.5	100	31.25	41.25	55
PBA-006	18	44.72	22.85	7.5	80	30	41.25	70
PBA-007	20	47.88	24.09	0	100	30	48.75	63.75
PBA-008	26	50.29	25.32	5	100	32.5	47.5	70
PBA-009	23	56.09	22.43	10	100	45	60	67.5
SM-001	36	64.38	22.2	20	100	48.75	62.5	78.75
SM-002	16	55.47	18.82	22.5	87.5	40	55	71.25

Kruskal-Wallis Test		
Chi-Square	**DF**	**Pr > ChiSq**
43.2872	12	<.0001

Descriptive Statistics and Kruskal-Wallis Test for SUS Score by Device - Cognitive Impairment Present

SUS Score - Cognitive Impairment Present								
Product tested	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
APD-001	3	33.33	12.58	20	45	20	35	45
APD-002	6	40.42	16.54	25	62.5	25	36.25	57.5
PBA-001	4	26.88	23.31	2.5	52.5	7.5	26.25	46.25
PBA-002	4	43.13	32.87	10	87.5	20	37.5	66.25
PBA-003	4	31.25	22.03	12.5	55	12.5	28.75	50
PBA-004	4	54.38	21.64	30	75	36.25	56.25	72.5
PBA-005	3	59.17	37.11	27.5	100	27.5	50	100
PBA-006	4	35.63	12.14	17.5	42.5	28.75	41.25	42.5
PBA-007	2	66.25	47.73	32.5	100	32.5	66.25	100
PBA-008	2	48.75	26.52	30	67.5	30	48.75	67.5
PBA-009	3	61.67	27.54	35	90	35	60	90

SM-001	8	57.5	25.39	20	100	42.5	51.25	76.25
SM-002	3	70.83	20.82	47.5	87.5	47.5	77.5	87.5

Kruskal-Wallis Test		
Chi-Square	**DF**	**Pr > ChiSq**
12.5011	12	0.4063

Descriptive Statistics and Kruskal-Wallis Test for SUS Score by Device - Physical Impairment Present

SUS Score - Physical Impairment Present								
Product tested	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
APD-001	11	31.82	14.79	0	57.5	30	32.5	40
APD-002	7	34.29	8.26	25	45	25	32.5	42.5
PBA-001	7	36.79	18.91	2.5	52.5	20	40	52.5
PBA-002	8	53.44	32.59	10	90	20	65	78.75
PBA-003	3	35	13.23	25	50	25	30	50
PBA-004	6	40.42	21.06	7.5	70	30	41.25	52.5
PBA-005	8	53.44	23.3	27.5	100	35	52.5	62.5
PBA-006	4	37.5	25.41	17.5	72.5	18.75	30	56.25
PBA-007	3	42.5	51.66	0	100	0	27.5	100
PBA-008	7	50	33.82	10	100	25	45	90
PBA-009	9	58.89	25.16	10	90	57.5	60	72.5
SM-001	14	60	21.79	20	100	47.5	55	75
SM-002	7	49.64	24.72	22.5	87.5	30	40	77.5

Kruskal-Wallis Test		
Chi-Square	**DF**	**Pr > ChiSq**
17.7122	12	0.1247

Descriptive Statistics and Kruskal-Wallis Test for SUS Score by Device - Vision Impairment Present

SUS Score - Vision Impairment Present								
Product tested	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
APD-001	2	51.25	44.19	20	82.5	20	51.25	82.5
PBA-001	2	28.75	37.12	2.5	55	2.5	28.75	55
PBA-003	3	33.33	18.09	12.5	45	12.5	42.5	45
PBA-004	2	48.75	30.05	27.5	70	27.5	48.75	70
PBA-005	2	18.75	22.98	2.5	35	2.5	18.75	35
PBA-006	1	7.5	.	7.5	7.5	7.5	7.5	7.5
PBA-007	4	40.63	12.81	27.5	55	30	40	51.25

PBA-008	3	60	25.98	30	75	30	75	75
PBA-009	2	50	56.57	10	90	10	50	90
SM-001	4	46.25	18.98	27.5	72.5	33.75	42.5	58.75
SM-002	2	63.75	33.59	40	87.5	40	63.75	87.5

Kruskal-Wallis Test		
Chi-Square	**DF**	**Pr > ChiSq**
6.6117	10	0.7615

Descriptive Statistics and Kruskal-Wallis Test for SUS Score by Device - Hearing Impairment Present

SUS Score - Hearing Impairment Present								
Product tested	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
APD-001	8	39.69	17.7	30	82.5	30	33.75	38.75
APD-002	15	37.33	20.6	0	70	25	40	52.5
PBA-001	11	44.32	14.32	12.5	57.5	40	50	55
PBA-002	10	45.5	29.76	10	90	22.5	41.25	75
PBA-003	12	33.96	16.36	0	55	26.25	36.25	46.25
PBA-004	12	47.5	24.73	17.5	92.5	28.75	42.5	63.75
PBA-005	15	36.67	14.47	2.5	57.5	27.5	35	50
PBA-006	10	32.75	20.5	7.5	72.5	17.5	31.25	42.5
PBA-007	14	45.71	22.56	0	87.5	27.5	48.75	60
PBA-008	17	51.47	27.1	5	90	32.5	52.5	75
PBA-009	12	50.21	25.42	10	100	33.75	55	60
SM-001	25	60.9	21.21	20	100	45	60	75
SM-002	9	53.89	17.81	30	77.5	40	52.5	70

Kruskal-Wallis Test		
Chi-Square	**DF**	**Pr > ChiSq**
25.7512	12	0.0116

Descriptive Statistics and Kruskal-Wallis Test for SUS Score by Device - Motivational Impairment Present

SUS Score - Motivation Impairment Present								
Product tested	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
APD-001	9	25.83	17.37	0	57.5	15	25	32.5
APD-002	5	26	17.01	0	47.5	25	27.5	30
PBA-001	4	54.38	7.47	45	62.5	48.75	55	60
PBA-002	3	55.83	16.65	45	75	45	47.5	75
PBA-003	7	42.14	17.53	12.5	67.5	30	42.5	55

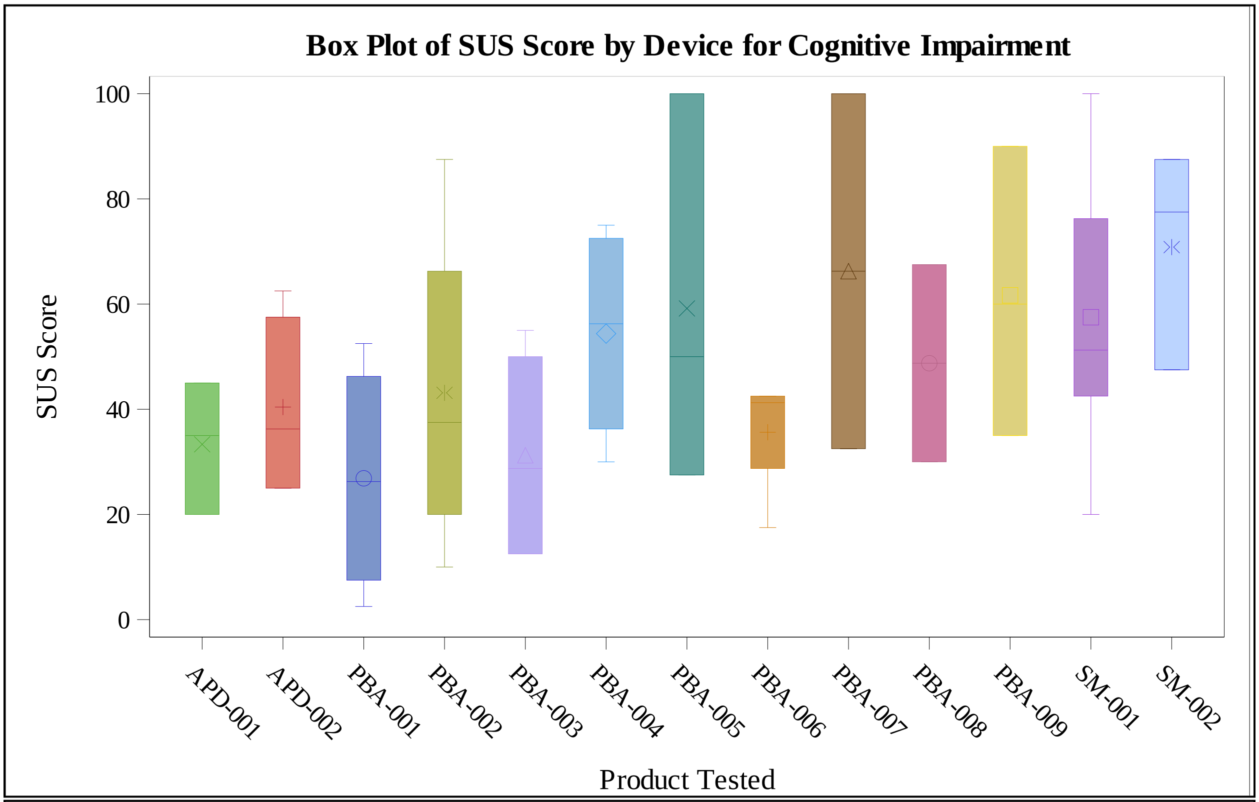
PBA-004	6	41.67	29.01	7.5	85	25	32.5	67.5
PBA-005	9	43.89	27.98	2.5	100	27.5	40	55
PBA-006	6	44.17	23.17	7.5	70	30	47.5	62.5
PBA-007	7	55.71	25.11	25	100	32.5	55	67.5
PBA-008	9	45.83	28.86	10	90	27.5	32.5	75
PBA-009	7	48.21	24.9	10	87.5	32.5	52.5	60
SM-001	9	61.94	20.38	40	100	47.5	55	75
SM-002	6	42.92	11.77	22.5	55	40	43.75	52.5

Kruskal-Wallis Test		
Chi-Square	**DF**	**Pr > ChiSq**
19.218	12	0.0834

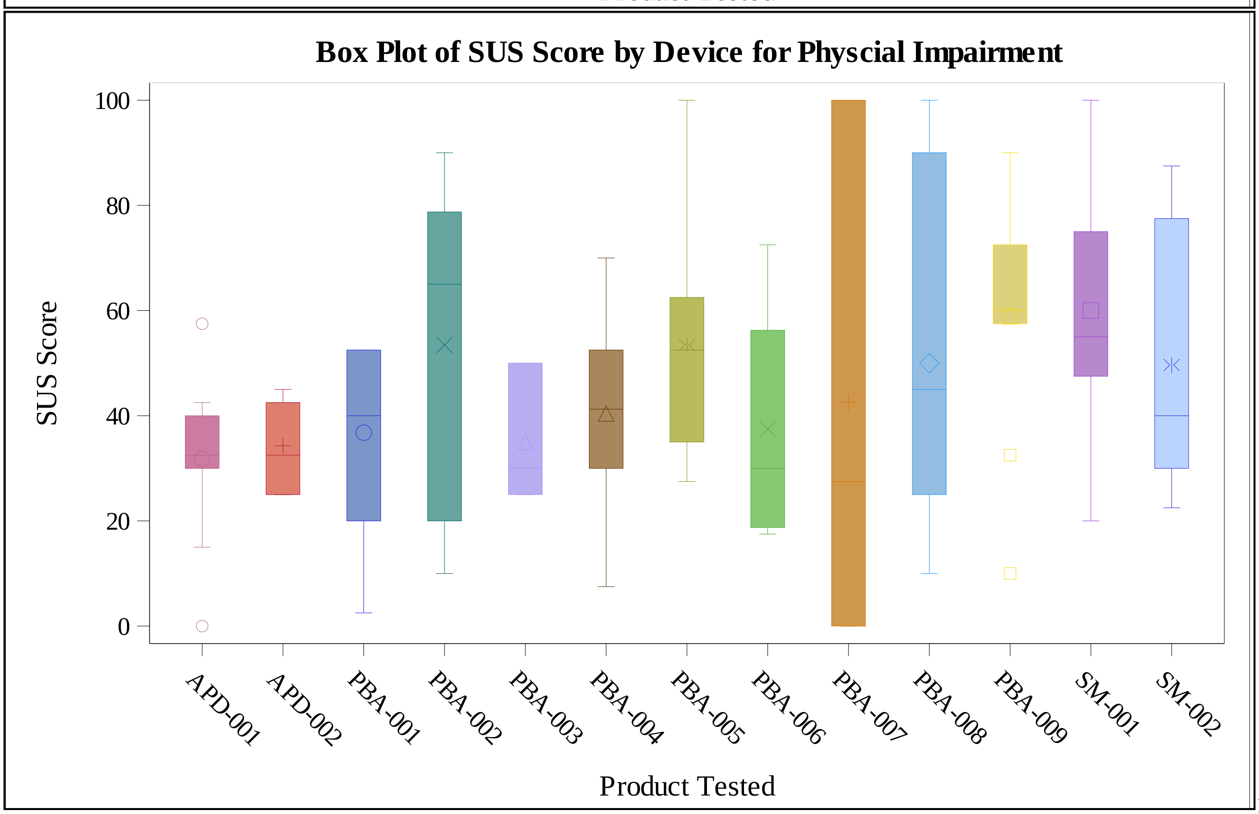
Descriptive Statistics and Kruskal-Wallis Test for SUS Score by Device - Environmental Impairment Present

SUS Score - Environmental Impairment Present								
Product tested	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
APD-001	3	49.17	31.46	20	82.5	20	45	82.5
APD-002	10	23	15.93	0	47.5	10	25	30
PBA-001	5	38	16.34	17.5	57.5	25	45	45
PBA-002	6	32.5	12.94	10	45	30	32.5	45
PBA-003	7	45.71	17.3	12.5	65	42.5	45	62.5
PBA-004	8	40.94	21.63	17.5	85	22.5	42.5	47.5
PBA-005	7	45.71	28.42	22.5	100	25	35	67.5
PBA-006	7	42.14	18.45	17.5	70	30	40	62.5
PBA-007	10	50	27.49	20	100	27.5	46.25	65
PBA-008	10	53.5	23.25	10	82.5	40	55	75
PBA-009	5	57.5	32.21	10	100	52.5	60	65
SM-001	13	63.08	23.59	20	100	47.5	72.5	77.5
SM-002	5	57	13.62	40	77.5	52.5	55	60

Kruskal-Wallis Test		
Chi-Square	**DF**	**Pr > ChiSq**
22.5164	12	0.0321

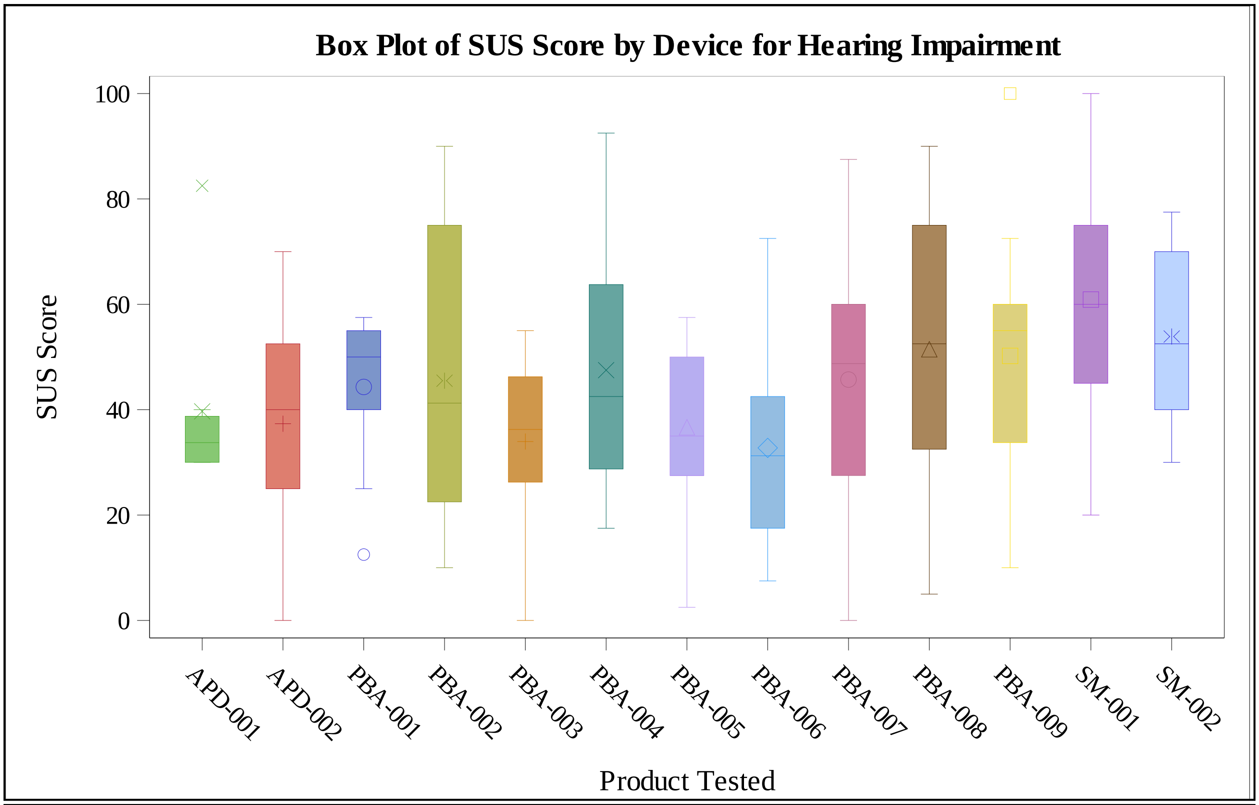


Box Plot of SUS Score by Device for Cognitive Impairment
SUS Score
100
80
60
40
20
0
APD-001
APD-002
PBA-001
PBA-002
PBA-003
PBA-004
PBA-005
PBA-006
PBA-007
PBA-008
PBA-009
SM-001
SM-002
Product Tested

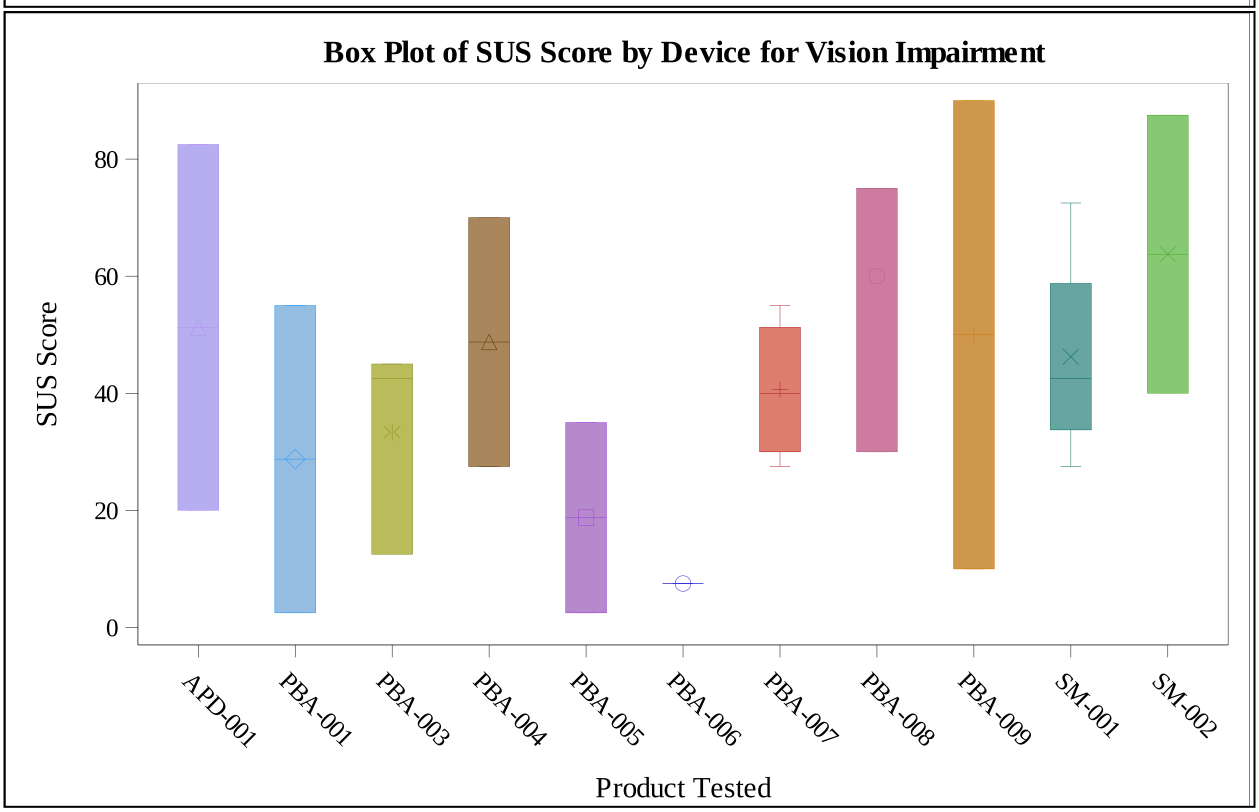


Box Plot of SUS Score by Device for Physcial Impairment
SUS Score
100
80
60
40
20
0
APD-001
APD-002
PBA-001
PBA-002
PBA-003
PBA-004
PBA-005
PBA-006
PBA-007
PBA-008
PBA-009
SM-001
SM-002
Product Tested

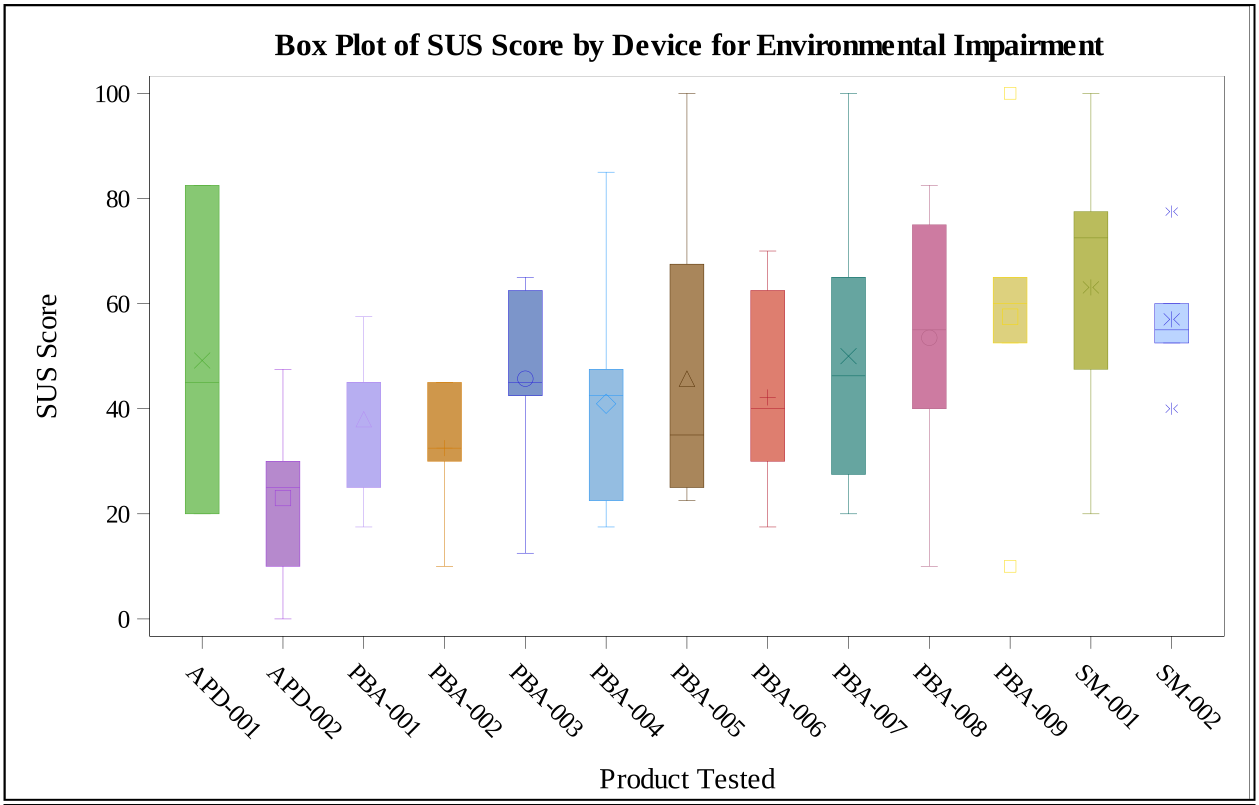
rriers



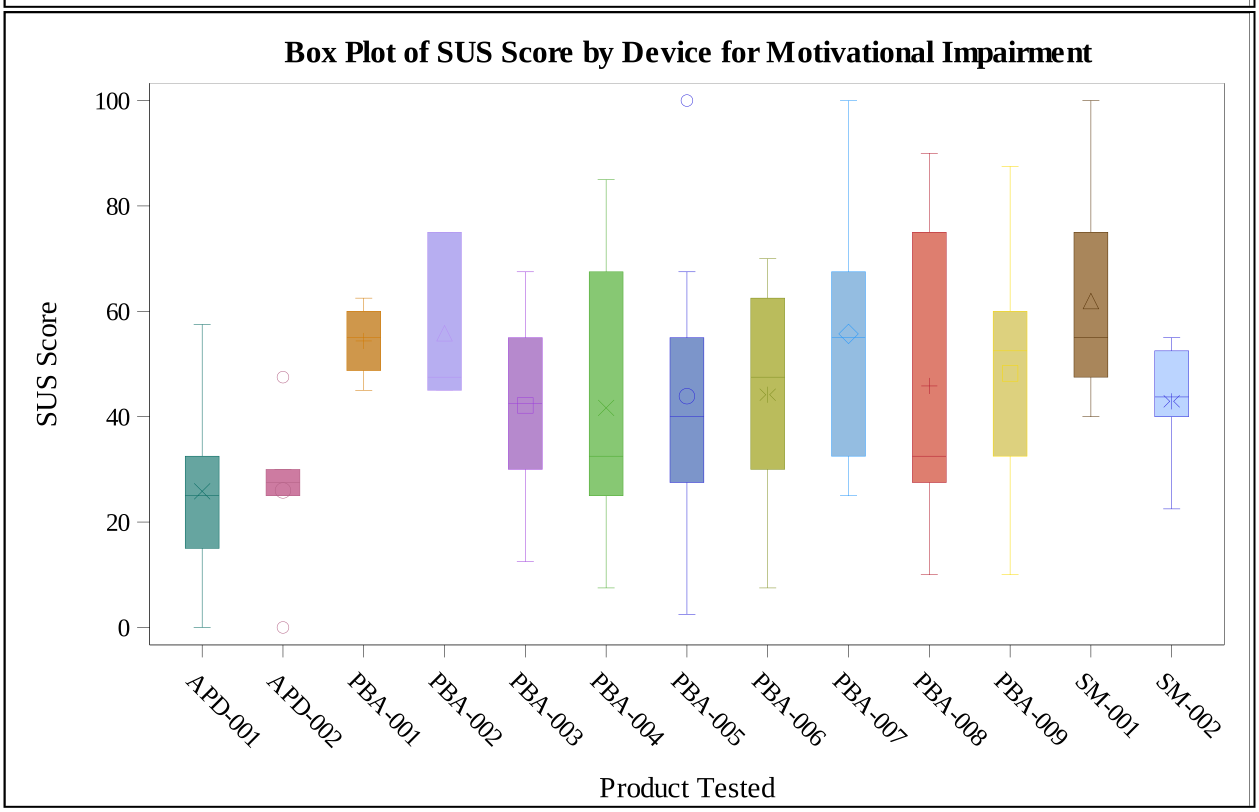
Box Plot of SUS Score by Device for Hearing Impairment
SUS Score
100
80
60
40
20
0
APD-001
APD-002
PBA-001
PBA-002
PBA-003
PBA-004
PBA-005
PBA-006
PBA-007
PBA-008
PBA-009
SM-001
SM-002
Product Tested



Box Plot of SUS Score by Device for Vision Impairment
SUS Score
80
60
40
20
0
APD-001
PBA-001
PBA-003
PBA-004
PBA-005
PBA-006
PBA-007
PBA-008
PBA-009
SM-001
SM-002
Product Tested



Box Plot of SUS Score by Device for Environmental Impairment
SUS Score
100
80
60
40
20
0
APD-001
APD-002
PBA-001
PBA-002
PBA-003
PBA-004
PBA-005
PBA-006
PBA-007
PBA-008
PBA-009
SM-001
SM-002
Product Tested



Box Plot of SUS Score by Device for Motivational Impairment
SUS Score
100
80
60
40
20
0
APD-001
APD-002
PBA-001
PBA-002
PBA-003
PBA-004
PBA-005
PBA-006
PBA-007
PBA-008
PBA-009
SM-001
SM-002
Product Tested

10.5.2 Appendix E-2 – NASA-TLX Workload Scores

Descriptive Statistics and Kruskal-Wallis Test for NASA-TLX Workload Score by Device – Overall

NASA-TLX Workload Score - Overall								
Product tested	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
APD-001	20	77.6	32.68	18	116	49	90.5	101.5
APD-002	24	69.71	23.68	15	104	55.5	74.5	88.5
PBA-001	19	61.16	22.7	23	108	49	59	73
PBA-002	21	49.62	32.34	5	120	24	50	81
PBA-003	21	71.71	25.04	19	108	59	72	91
PBA-004	20	53.2	27.73	6	117	35.5	49.5	74
PBA-005	20	58.8	29.69	7	120	37	61	75
PBA-006	17	59.53	31.91	14	110	34	51	84
PBA-007	20	54.4	35.57	4	120	23.5	53.5	86
PBA-008	24	53.29	33.39	0	103	22	57	82
PBA-009	23	45.26	25.31	9	93	19	45	69
SM-001	37	34	24.34	0	120	14	33	48
SM-002	16	46.88	27.53	8	97	22.5	44	69.5

Kruskal-Wallis Test			
Chi-Square	**DF**	**Pr > ChiSq**	**Exact Pr >= ChiSq**
46.7349	12	<.0001	.

Descriptive Statistics and Kruskal-Wallis Test for NASA-TLX Workload Score by Device - Cognitive Impairment Present

NASA-TLX Workload Score– Cognitive Impairment Present								
Product tested	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
APD-001	3	73.67	48.69	20	115	20	86	115
APD-002	6	66.83	25.9	25	104	60	67	78
PBA-001	4	79.25	26.85	50	108	57	79.5	101.5
PBA-002	4	61.25	51.55	5	120	19.5	60	103
PBA-003	4	79.5	22.49	51	98	61.5	84.5	97.5
PBA-004	4	33.25	34.94	6	82	8	22.5	58.5
PBA-005	3	34.33	23.29	18	61	18	24	61
PBA-006	3	75	30.32	40	93	40	92	93
PBA-007	2	48	50.91	12	84	12	48	84
PBA-008	2	57.5	62.93	13	102	13	57.5	102
PBA-009	3	35	24.52	10	59	10	36	59
SM-001	8	45.88	36.17	6	120	18	45	57.5

SM-002	3	43	29.82	11	70	11	48	70

Kruskal-Wallis Test			
Chi-Square	**DF**	**Pr > ChiSq**	**Exact Pr >= ChiSq**
12.1438	12	0.4342	.

Descriptive Statistics and Kruskal-Wallis Test for NASA-TLX Workload Score by Device - Physical Impairment Present

NASA-TLX Workload Score– Physical Impairment Present								
Product tested	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
APD-001	12	82.25	31.93	20	116	53.5	97.5	103.5
APD-002	7	75.71	28.34	25	104	62	78	101
PBA-001	7	67.71	21.11	48	100	50	59	95
PBA-002	8	43.88	30.06	5	86	22	37.5	70.5
PBA-003	3	98	12.49	84	108	84	102	108
PBA-004	6	52.83	28.46	10	82	35	56	78
PBA-005	8	52.5	37.18	7	120	21	54	71.5
PBA-006	4	74.75	39.53	19	110	48	85	101.5
PBA-007	3	69.33	54.31	12	120	12	76	120
PBA-008	6	70.5	22.84	33	101	64	71	83
PBA-009	9	50.89	31.23	10	93	19	69	70
SM-001	14	41.5	31.27	0	120	19	43.5	55
SM-002	7	61.86	29.51	11	97	44	69	91

Kruskal-Wallis Test			
Chi-Square	**DF**	**Pr > ChiSq**	**Exact Pr >= ChiSq**
21.7538	12	0.0404	.

Descriptive Statistics and Kruskal-Wallis Test for NASA-TLX Workload Score by Device - Vision Impairment Present

NASA-TLX Workload Score– Vision Impairment Present								
Product tested	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
APD-001	2	66.5	68.59	18	115	18	66.5	115
PBA-001	2	84	15.56	73	95	73	84	95
PBA-003	3	86.67	13.05	72	97	72	91	97
PBA-004	2	76	57.98	35	117	35	76	117
PBA-005	2	62	15.56	51	73	51	62	73
PBA-006	1	110	.	110	110	110	110	110
PBA-007	4	56	30.16	18	84	32	61	80

PBA-008	3	45.67	48.79	17	102	17	18	102
PBA-009	2	55	26.87	36	74	36	55	74
SM-001	4	62	42.54	23	120	31	52.5	93
SM-002	2	57	18.38	44	70	44	57	70

Kruskal-Wallis Test			
Chi-Square	**DF**	**Pr > ChiSq**	**Exact Pr >= ChiSq**
5.16	10	0.8802	.

Descriptive Statistics and Kruskal-Wallis Test for NASA-TLX Workload Score by Device - Hearing Impairment Present

NASA-TLX Workload Score– Hearing Impairment Present								
Product tested	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
APD-001	8	77.13	39.64	18	116	39	99	103.5
APD-002	15	68.47	20.22	25	97	54	72	82
PBA-001	11	67.18	21.55	34	108	56	59	78
PBA-002	10	56.6	40.19	5	120	22	65.5	86
PBA-003	12	74.58	24.22	19	108	62.5	77.5	89.5
PBA-004	12	53.33	32.81	6	117	28.5	55	74
PBA-005	15	58.4	31.84	7	120	30	61	73
PBA-006	9	77.56	27.3	27	110	69	81	93
PBA-007	14	57.71	37.16	4	120	20	62	88
PBA-008	17	50.88	34.49	0	103	18	56	81
PBA-009	12	45.83	28.26	10	93	19	51.5	69
SM-001	26	40.27	24.69	6	120	22	39	55
SM-002	9	44.67	27.94	11	97	22	44	51

Kruskal-Wallis Test			
Chi-Square	**DF**	**Pr > ChiSq**	**Exact Pr >= ChiSq**
27.0358	12	0.0076	.

Descriptive Statistics and Kruskal-Wallis Test for NASA-TLX Workload Score by Device - Motivational Impairment Present

NASA-TLX Workload Score– Motivational Impairment Present								
Product tested	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
APD-001	9	86.67	25.83	38	115	86	97	98
APD-002	5	86	15.56	62	104	82	90	92
PBA-001	4	43.5	15.95	26	58	30	45	57
PBA-002	3	52.67	32.08	22	86	22	50	86

PBA-003	7	70.71	18.84	45	97	51	72	84
PBA-004	6	68.17	32.22	21	117	48	72.5	78
PBA-005	9	63.11	20.97	18	84	61	68	77
PBA-006	6	56.67	34.79	14	110	34	49	84
PBA-007	7	52.29	31.03	12	90	18	63	84
PBA-008	8	67.38	37.96	17	103	26	82	101.5
PBA-009	7	61.14	22.2	14	78	58	70	75
SM-001	9	34.89	34.49	7	120	13	26	34
SM-002	6	61.5	19.25	44	91	44	58.5	73

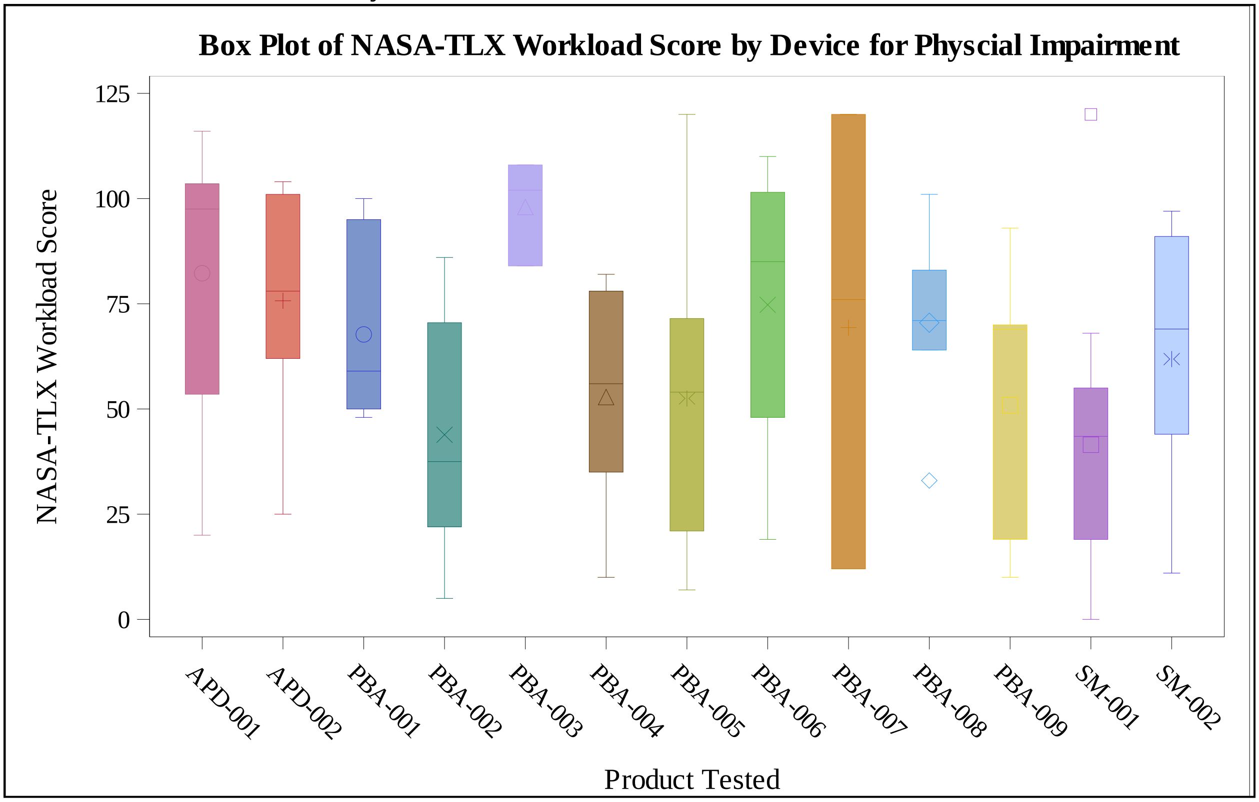
Kruskal-Wallis Test			
Chi-Square	**DF**	**Pr > ChiSq**	**Exact Pr >= ChiSq**
21.9852	12	0.0377	.

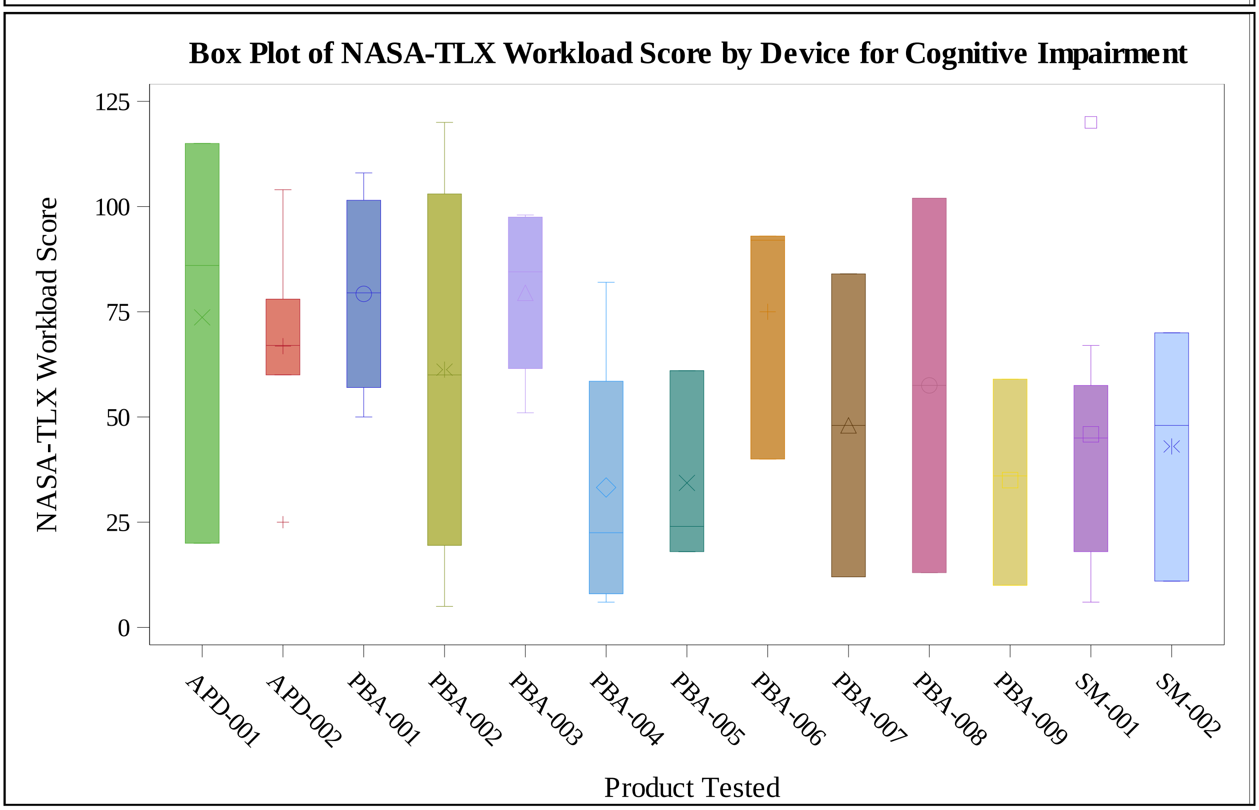
Descriptive Statistics and Kruskal-Wallis Test for NASA-TLX Workload Score by Device - Environmental Impairment Present

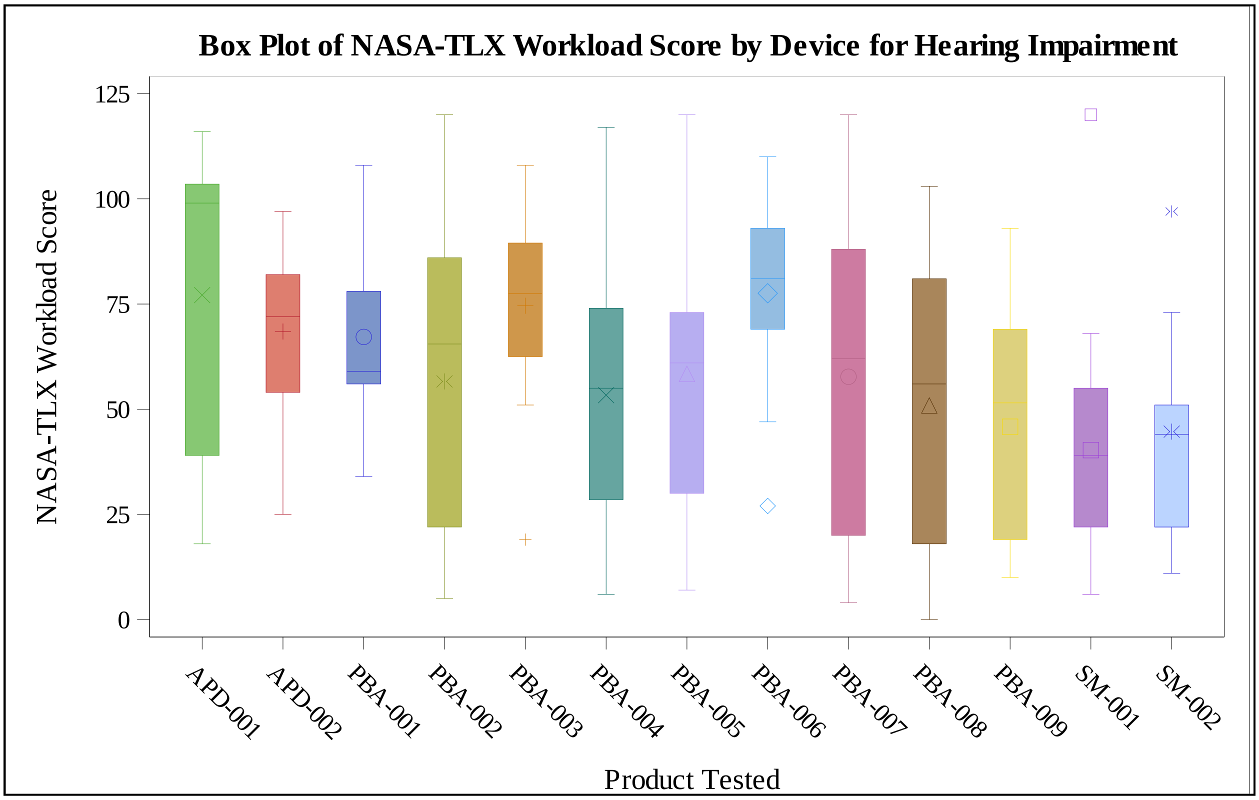
NASA-TLX Workload Score- Environmental Impairment Present								
Product tested	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**25th Pctl**	**Median**	**75th Pctl**
APD-001	4	81.75	44.26	18	115	52	97	111.5
APD-002	10	76.5	18.28	44	104	62	79.5	90
PBA-001	5	55.4	12.52	34	66	56	59	62
PBA-002	6	64	21.84	34	86	50	64.5	85
PBA-003	7	73.86	20.91	39	98	62	72	97
PBA-004	8	61.13	21.05	21	82	47	69.5	76.5
PBA-005	7	54.86	20.46	18	84	44	61	64
PBA-006	7	63.86	26.98	34	93	35	69	92
PBA-007	10	51.9	33.65	4	93	18	53.5	84
PBA-008	9	45.67	38.58	0	103	18	25	64
PBA-009	5	44.2	23.59	13	74	31	45	58
SM-001	13	34.62	16.8	7	67	25	33	42
SM-002	5	43.2	21.22	13	73	43	43	44

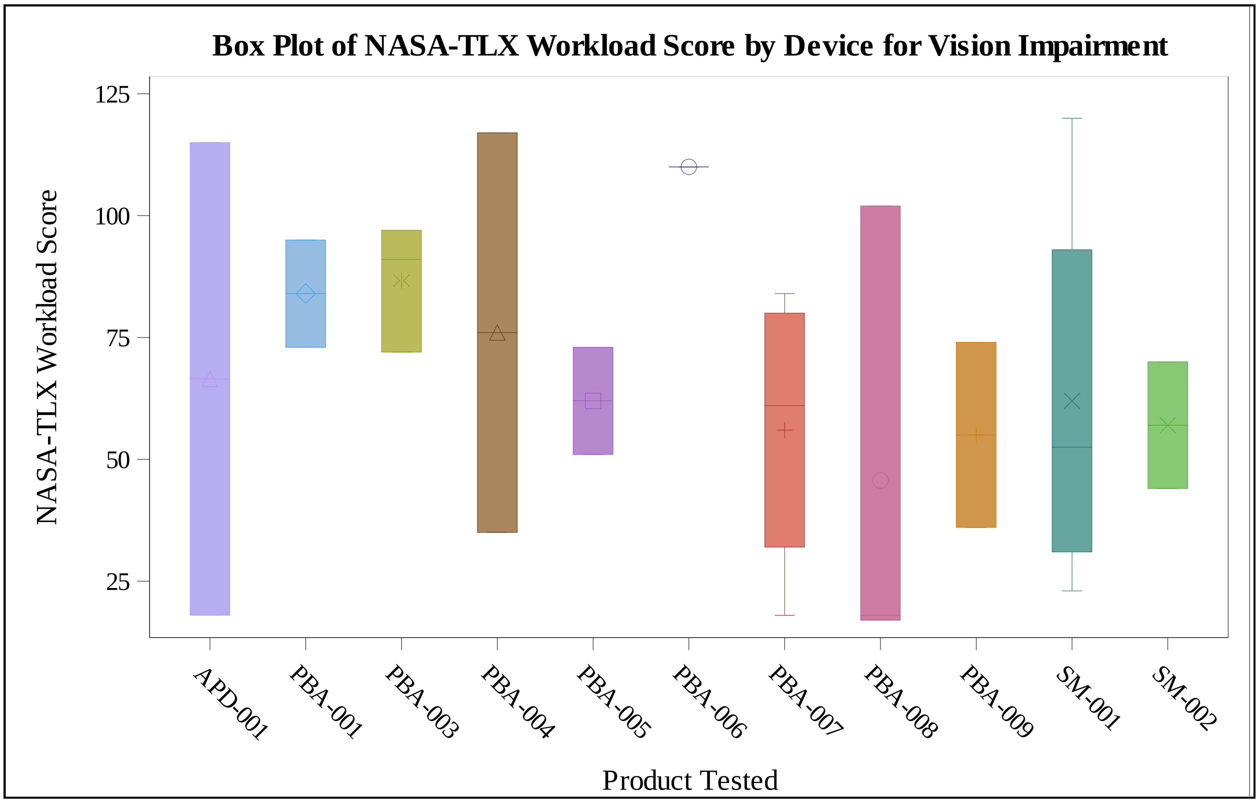
Kruskal-Wallis Test			
Chi-Square	**DF**	**Pr > ChiSq**	**Exact Pr >= ChiSq**
24.6794	12	0.0164	.

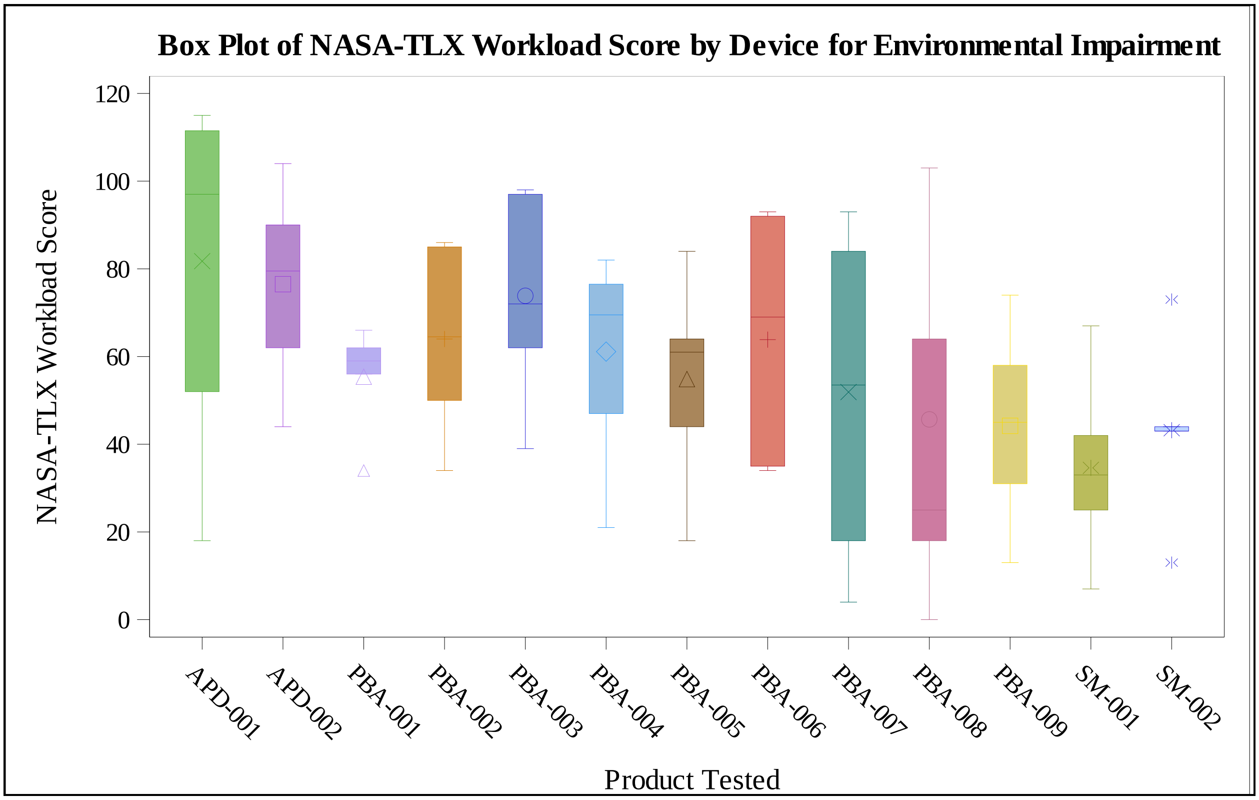
Box plot of NASA-TLX Workload Score by Device for Various Barriers

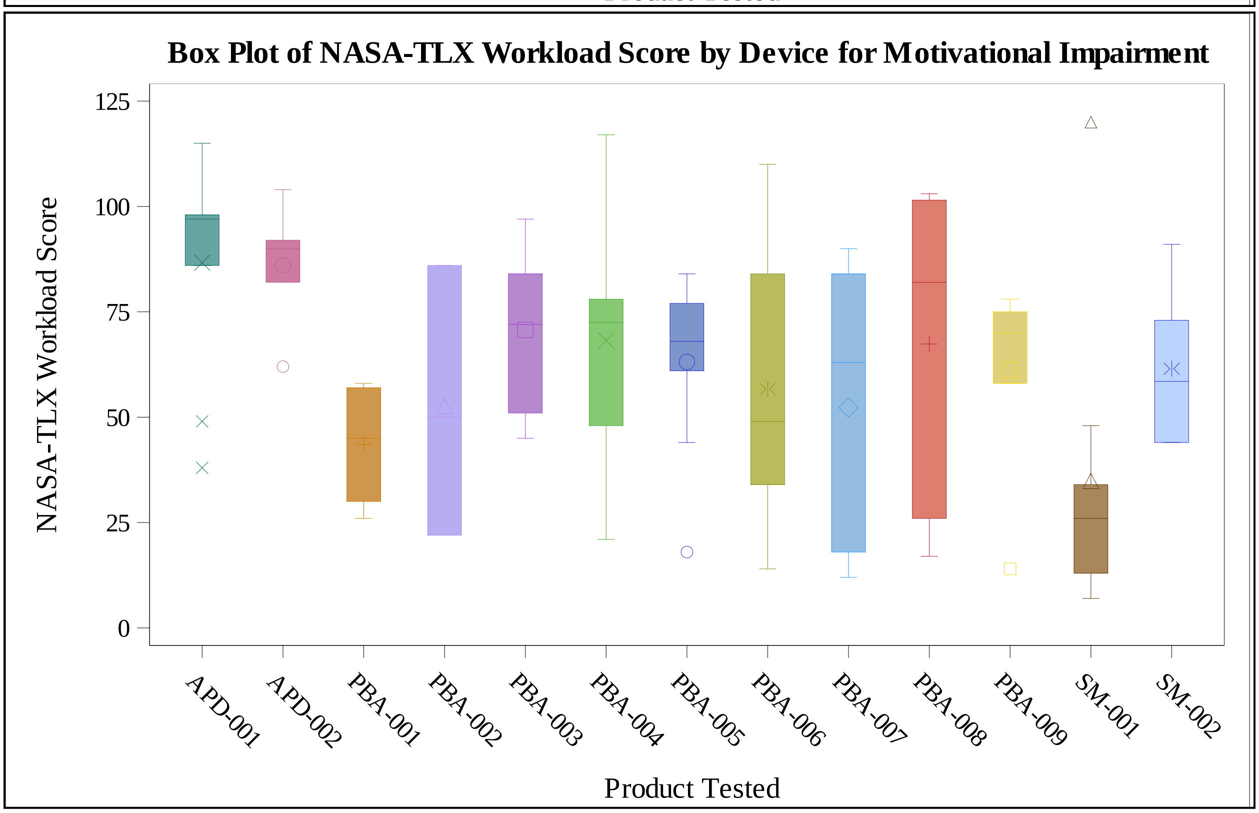





Box Plot of NASA-TLX Workload Score by Device for Hearing Impairment
NASA-TLX Workload Score
125
100
75
50
25
0
APD-001
APD-002
PBA-001
PBA-002
PBA-003
PBA-004
PBA-005
PBA-006
PBA-007
PBA-008
PBA-009
SM-001
SM-002
Product Tested


Box Plot of NASA-TLX Workload Score by Device for Vision Impairment
NASA-TLX Workload Score
125
100
75
50
25
APD-001
PBA-001
PBA-003
PBA-004
PBA-005
PBA-006
PBA-007
PBA-008
PBA-009
SM-001
SM-002
Product Tested


Box Plot of NASA-TLX Workload Score by Device for Environmental Impairment
NASA-TLX Workload Score
120
100
80
60
40
20
0
APD-001
APD-002
PBA-001
PBA-002
PBA-003
PBA-004
PBA-005
PBA-006
PBA-007
PBA-008
PBA-009
SM-001
SM-002
Product Tested


Box Plot of NASA-TLX Workload Score by Device for Motivational Impairment
NASA-TLX Workload Score
125
100
75
50
25
0
APD-001
APD-002
PBA-001
PBA-002
PBA-003
PBA-004
PBA-005
PBA-006
PBA-007
PBA-008
PBA-009
SM-001
SM-002
Product Tested

10.5.3 Appendix E-3: Single Ease-of-Use Question (SEQ) Score

Descriptive Statistics and Kruskal-Wallis Test for SEQ Score by Task – Overall

Variable	N	Mean	Std Dev	Minimum	Maximum	25th Pctl	Median	50th Pctl	75th Pctl
SEQ A	150	4.83	2.22	1	7	3	6	6	7
SEQ B	44	3.23	2.41	1	7	1	2	2	6
SEQ C	191	3.96	2.03	1	7	2	4	4	6
SEQ D	233	5.03	1.83	1	7	4	6	6	6
SEQ E	211	3.65	2.04	1	7	2	3	3	6
SEQ F	44	3.84	2.39	1	7	2	3.5	3.5	6
SEQ G	233	5.06	1.92	1	7	4	6	6	7
SEQ H	18	6.56	1.04	3	7	7	7	7	7
SEQ I	23	6.26	1.18	3	7	5	7	7	7
SEQ J	23	4.65	1.47	1	7	4	5	5	6
SEQ K	23	4.43	1.78	1	7	3	5	5	6
SEQ L	23	5.57	1.59	2	7	5	6	6	7
SEQ M	38	5.87	1.77	1	7	5	7	7	7
SEQ N	38	6.03	1.35	1	7	5	6.5	6.5	7
SEQ O	38	6.37	1.22	1	7	6	7	7	7
SEQ P	38	3.16	1.75	1	7	2	3	3	4
SEQ Q	38	5.21	1.77	1	7	4	6	6	7
SEQ R	16	3.94	1.73	1	7	3	3.5	3.5	5
SEQ S	16	4.75	2.02	1	7	4.5	5	5	6
SEQ T	16	4.38	1.93	1	7	2.5	4.5	4.5	6
SEQ U	16	6.69	0.48	6	7	6	7	7	7

Kruskal-Wallis Test		
Chi-Square	DF	Pr > ChiSq
249.2	20	<.0001

Descriptive Statistics and Kruskal-Wallis Test for SEQ Score by Task - Cognitive Impairment Present

Variable	N	Mean	Std Dev	Minimum	Maximum	25th Pctl	Median	50th Pctl	75th Pctl
SEQ A	27	4.63	2.24	1	7	2	5	5	7
SEQ B	9	2.33	1.73	1	6	1	2	2	3
SEQ C	34	3.85	2.08	1	7	2	4	4	6
SEQ D	40	4.98	1.94	1	7	4	6	6	6.5
SEQ E	37	3.46	1.99	1	7	2	3	3	5
SEQ F	9	4.11	2.37	1	7	2	4	4	7
SEQ G	40	4.78	1.98	1	7	3	5	5	6.5

SEQ H	4	6.75	0.5	6	7	6.5	7	7	7
SEQ I	3	5	2	3	7	3	5	5	7
SEQ J	3	4.67	1.15	4	6	4	4	4	6
SEQ K	3	5.33	0.58	5	6	5	5	5	6
SEQ L	3	5.67	0.58	5	6	5	6	6	6
SEQ M	8	4.88	2.75	1	7	2	6.5	6.5	7
SEQ N	8	5.75	2.05	1	7	5.5	6.5	6.5	7
SEQ O	8	6.13	2.1	1	7	6.5	7	7	7
SEQ P	8	2.38	1.41	1	4	1	2	2	4
SEQ Q	8	5	1.93	1	7	4.5	5	5	6.5
SEQ R	3	2.67	0.58	2	3	2	3	3	3
SEQ S	3	5.33	0.58	5	6	5	5	5	6
SEQ T	3	4.33	2.08	2	6	2	5	5	6
SEQ U	3	6.67	0.58	6	7	6	7	7	7

Kruskal-Wallis Test		
Chi-Square	**DF**	**Pr > ChiSq**
53.34	20	<.0001

Descriptive Statistics and Kruskal-Wallis Test for SEQ Score by Task - Physical Impairment Present

Variable	N	Mean	Std Dev	Minimum	Maximum	25th Pctl	Median	50th Pctl	75th Pctl
SEQ A	49	4.08	2.43	1	7	2	4	4	7
SEQ B	19	4.21	2.57	1	7	1	6	6	6
SEQ C	58	3.45	2.09	1	7	1	3	3	5
SEQ D	74	4.72	2.25	1	7	3	5	5	7
SEQ E	66	3.26	2.12	1	7	1	3	3	5
SEQ F	19	3.21	2.39	1	7	1	2	2	6
SEQ G	74	5.04	2.09	1	7	3	6	6	7
SEQ H	4	6	2	3	7	5	7	7	7
SEQ I	9	5.89	1.54	3	7	5	7	7	7
SEQ J	9	4.11	1.76	1	6	3	4	4	6
SEQ K	9	4.78	1.72	2	7	4	5	5	6
SEQ L	9	5.56	1.81	2	7	6	6	6	7
SEQ M	15	5.8	2.24	1	7	5	7	7	7
SEQ N	15	5.87	1.68	1	7	5	7	7	7
SEQ O	15	6.33	1.59	1	7	6	7	7	7
SEQ P	15	2.8	1.61	1	5	1	3	3	4
SEQ Q	15	4.87	2.1	1	7	4	5	5	7
SEQ R	7	3.43	1.99	1	7	2	3	3	5

SEQ S	7	4.29	2.29	1	6	1	5	5	6
SEQ T	7	5	1.83	2	7	3	6	6	6
SEQ U	7	6.57	0.53	6	7	6	7	7	7

Kruskal-Wallis Test		
Chi-Square	**DF**	**Pr > ChiSq**
89.96	20	<.0001

Descriptive Statistics and Kruskal-Wallis Test for SEQ Score by Task - Vision Impairment Present

Variable	N	Mean	Std Dev	Minimum	Maximum	25th Pctl	Median	50th Pctl	75th Pctl
SEQ A	12	5.42	1.62	2	7	4.5	6	6	6.5
SEQ B	2	5	1.41	4	6	4	5	5	6
SEQ C	18	3.28	1.84	1	7	1	3	3	5
SEQ D	21	4.81	1.81	1	7	4	5	5	6
SEQ E	20	3.7	2	1	6	2	3.5	3.5	6
SEQ F	2	5	2.83	3	7	3	5	5	7
SEQ G	21	4.48	2.11	1	7	3	5	5	6
SEQ H	1	5	.	5	5	5	5	5	5
SEQ I	2	6.5	0.71	6	7	6	6.5	6.5	7
SEQ J	2	5	1.41	4	6	4	5	5	6
SEQ K	2	4.5	2.12	3	6	3	4.5	4.5	6
SEQ L	2	4.5	2.12	3	6	3	4.5	4.5	6
SEQ M	4	4.25	2.75	1	7	2	4.5	4.5	6.5
SEQ N	4	4.5	2.65	1	7	2.5	5	5	6.5
SEQ O	4	4	2.45	1	6	2	4.5	4.5	6
SEQ P	4	3.5	1.73	1	5	2.5	4	4	4.5
SEQ Q	4	3.75	1.89	1	5	2.5	4.5	4.5	5
SEQ R	2	3.5	0.71	3	4	3	3.5	3.5	4
SEQ S	2	3	2.83	1	5	1	3	3	5
SEQ T	2	4	2.83	2	6	2	4	4	6
SEQ U	2	7	0	7	7	7	7	7	7

Kruskal-Wallis Test		
Chi-Square	**DF**	**Pr > ChiSq**
23.9	20	0.247

Descriptive Statistics and Kruskal-Wallis Test for SEQ Score by Task - Hearing Impairment Present

Variable	N	Mean	Std Dev	Minimum	Maximum	25th Pctl	Median	50th Pctl	75th Pctl
SEQ A	84	4.8	2.26	1	7	3	6	6	7

SEQ B	23	3	2.28	1	7	1	2	2	6
SEQ C	110	3.77	2.13	1	7	2	4	4	6
SEQ D	136	4.93	1.89	1	7	4	6	6	6
SEQ E	125	3.43	2	1	7	2	3	3	5
SEQ F	23	4.13	2.32	1	7	2	4	4	7
SEQ G	136	4.86	2	1	7	3	6	6	7
SEQ H	10	6.3	1.34	3	7	6	7	7	7
SEQ I	12	6	1.41	3	7	5	7	7	7
SEQ J	12	4.25	1.6	1	7	3.5	4	4	5.5
SEQ K	12	4.25	1.42	2	7	3	4	4	5
SEQ L	12	5.42	1.78	2	7	4	6	6	7
SEQ M	26	5.5	1.96	1	7	4	6.5	6.5	7
SEQ N	26	5.77	1.48	1	7	5	6	6	7
SEQ O	26	6.19	1.39	1	7	6	7	7	7
SEQ P	26	2.81	1.58	1	7	1	3	3	4
SEQ Q	26	4.85	1.89	1	7	4	5	5	7
SEQ R	9	3.78	1.92	1	7	2	4	4	5
SEQ S	9	4.78	2.28	1	7	5	5	5	6
SEQ T	9	3.33	1.66	1	6	2	4	4	4
SEQ U	9	6.67	0.5	6	7	6	7	7	7

Kruskal-Wallis Test		
Chi-Square	**DF**	**Pr > ChiSq**
118.31	20	<.0001

Descriptive Statistics and Kruskal-Wallis Test for SEQ Score by Task - Motivational Impairment Present

Variable	N	Mean	Std Dev	Minimum	Maximum	25th Pctl	Median	50th Pctl	75th Pctl
SEQ A	43	4.79	2.17	1	7	3	6	6	7
SEQ B	14	4	2.57	1	7	1	4.5	4.5	6
SEQ C	56	4.05	2.03	1	7	2	4	4	6
SEQ D	72	4.78	1.86	1	7	3	5	5	6
SEQ E	65	3.66	1.99	1	7	2	3	3	6
SEQ F	14	3.21	2.36	1	7	1	2.5	2.5	6
SEQ G	72	4.79	1.99	1	7	3	5	5	6.5
SEQ H	6	6.67	0.82	5	7	7	7	7	7
SEQ I	7	6.14	0.9	5	7	5	6	6	7
SEQ J	7	4.43	0.98	3	6	4	4	4	5
SEQ K	7	4.71	2.21	1	7	3	5	5	7
SEQ L	7	5.14	1.57	3	7	3	6	6	6

SEQ M	9	5.44	2.55	1	7	6	7	7	7
SEQ N	9	6	1.94	1	7	6	7	7	7
SEQ O	9	6.11	1.96	1	7	6	7	7	7
SEQ P	9	3	2	1	7	1	3	3	4
SEQ Q	9	5.22	2.05	1	7	5	6	6	7
SEQ R	6	4.33	1.75	2	7	3	4.5	4.5	5
SEQ S	6	4	2.37	1	6	1	5	5	6
SEQ T	6	3.5	2.43	1	7	2	2.5	2.5	6
SEQ U	6	6.67	0.52	6	7	6	7	7	7

Kruskal-Wallis Test		
Chi-Square	**DF**	**Pr > ChiSq**
63.42	20	<.0001

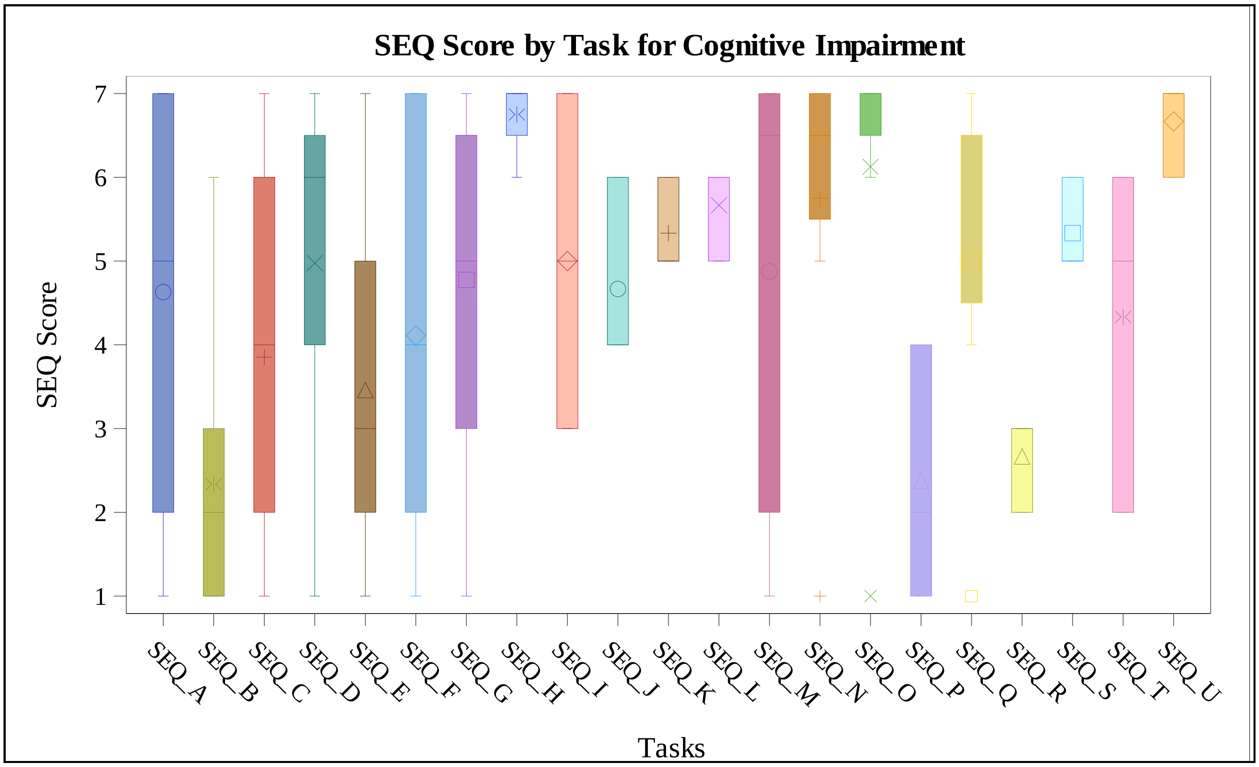
Descriptive Statistics and Kruskal-Wallis Test for SEQ Score by Task - Environmental Impairment Present

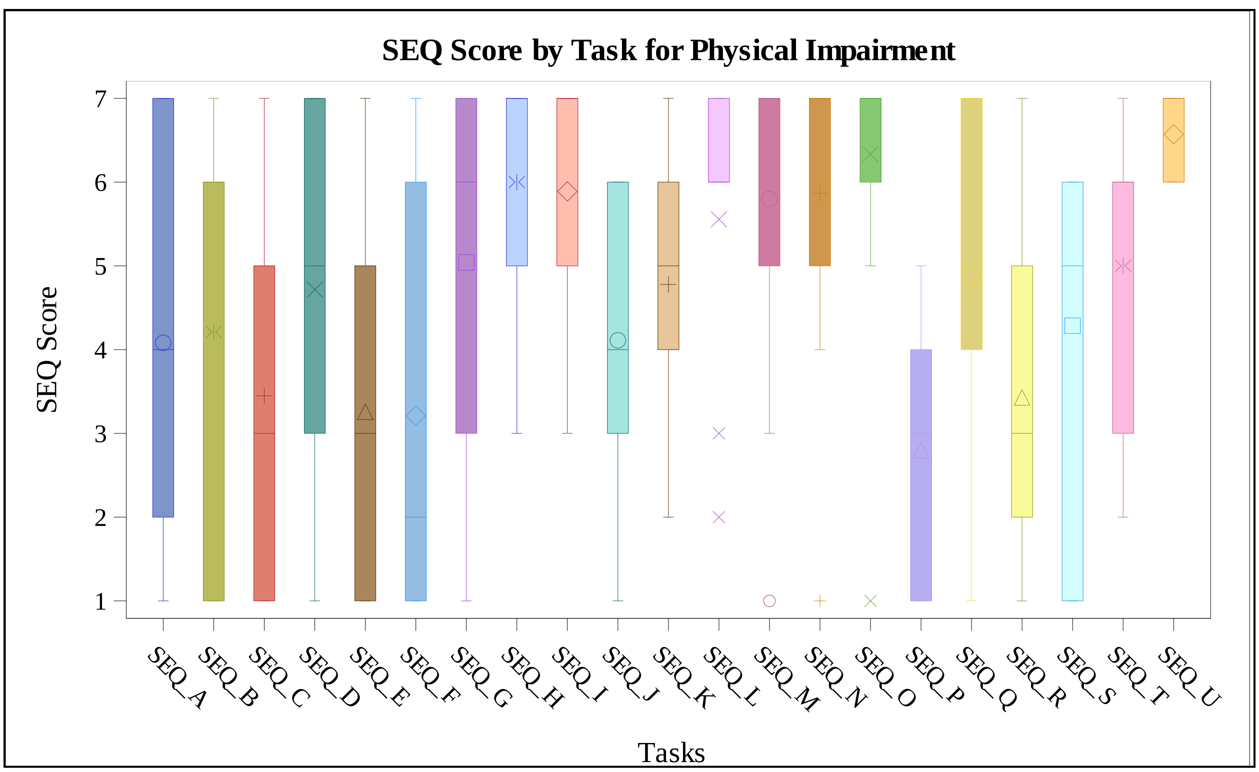
Variable	N	Mean	Std Dev	Minimum	Maximum	25th Pctl	Median	50th Pctl	75th Pctl
SEQ A	50	5.02	2.05	1	7	3	6	6	7
SEQ B	14	2.29	2.09	1	7	1	1	1	4
SEQ C	69	3.99	1.77	1	7	3	4	4	6
SEQ D	80	4.93	1.7	1	7	4	5	5	6
SEQ E	76	3.62	1.74	1	7	2	4	4	5
SEQ F	14	4.43	2.44	1	7	2	5	5	7
SEQ G	80	4.88	1.97	1	7	3	6	6	6.5
SEQ H	7	6.71	0.49	6	7	6	7	7	7
SEQ I	5	6.8	0.45	6	7	7	7	7	7
SEQ J	5	5.6	1.14	4	7	5	6	6	6
SEQ K	5	5.2	1.64	3	7	4	6	6	6
SEQ L	5	5.6	1.52	3	7	6	6	6	6
SEQ M	13	5.77	1.92	1	7	4	7	7	7
SEQ N	13	6.31	1.18	3	7	6	7	7	7
SEQ O	13	6.54	0.66	5	7	6	7	7	7
SEQ P	13	3	1.63	1	7	2	3	3	4
SEQ Q	13	5.46	1.45	3	7	5	6	6	7
SEQ R	5	4.8	1.48	3	7	4	5	5	5
SEQ S	5	4.6	2.3	1	7	4	5	5	6
SEQ T	5	3.6	2.3	1	7	2	4	4	4
SEQ U	5	7	0	7	7	7	7	7	7

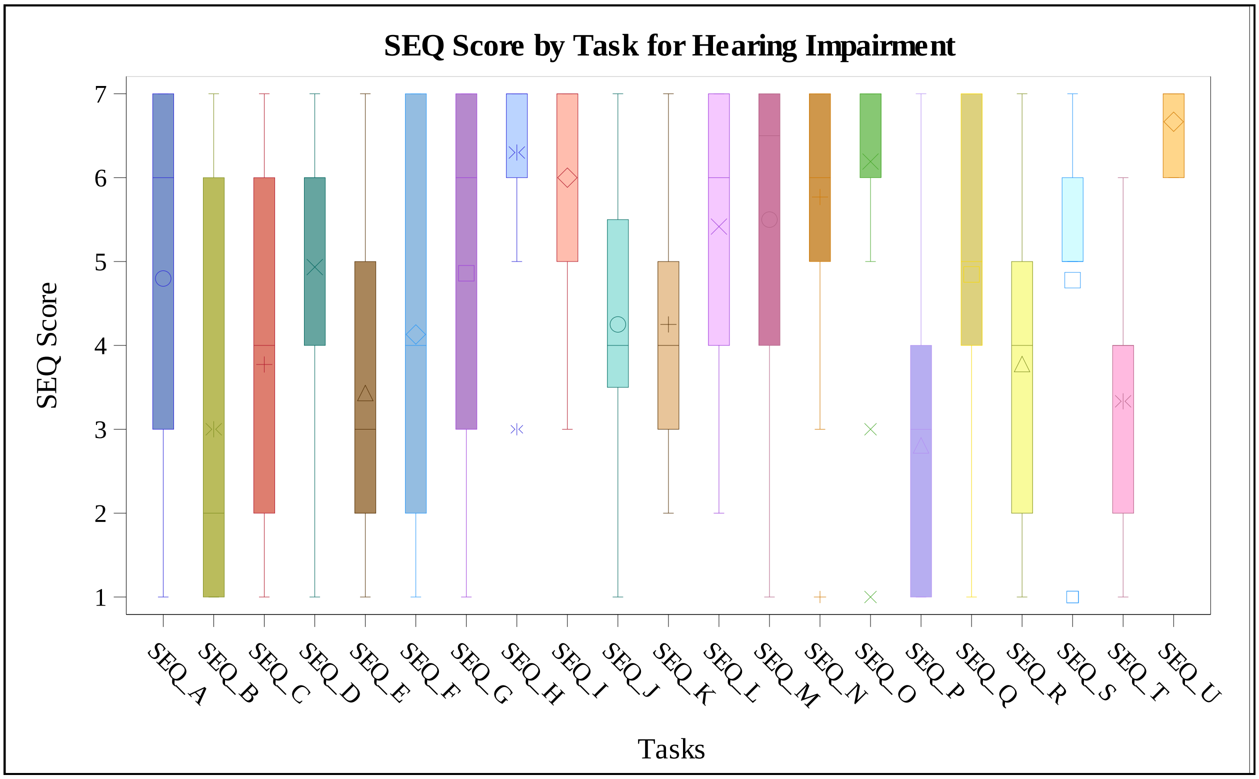
Kruskal-Wallis Test		
Chi-Square	**DF**	**Pr > ChiSq**

117.82	20	<.0001

Box plot of SEQ Score by Task for Various Barriers






SEQ Score by Task for Hearing Impairment
SEQ Score
1
2
3
4
5
6
7
SEQ_A
SEQ_B
SEQ_C
SEQ_D
SEQ_E
SEQ_F
SEQ_G
SEQ_H
SEQ_I
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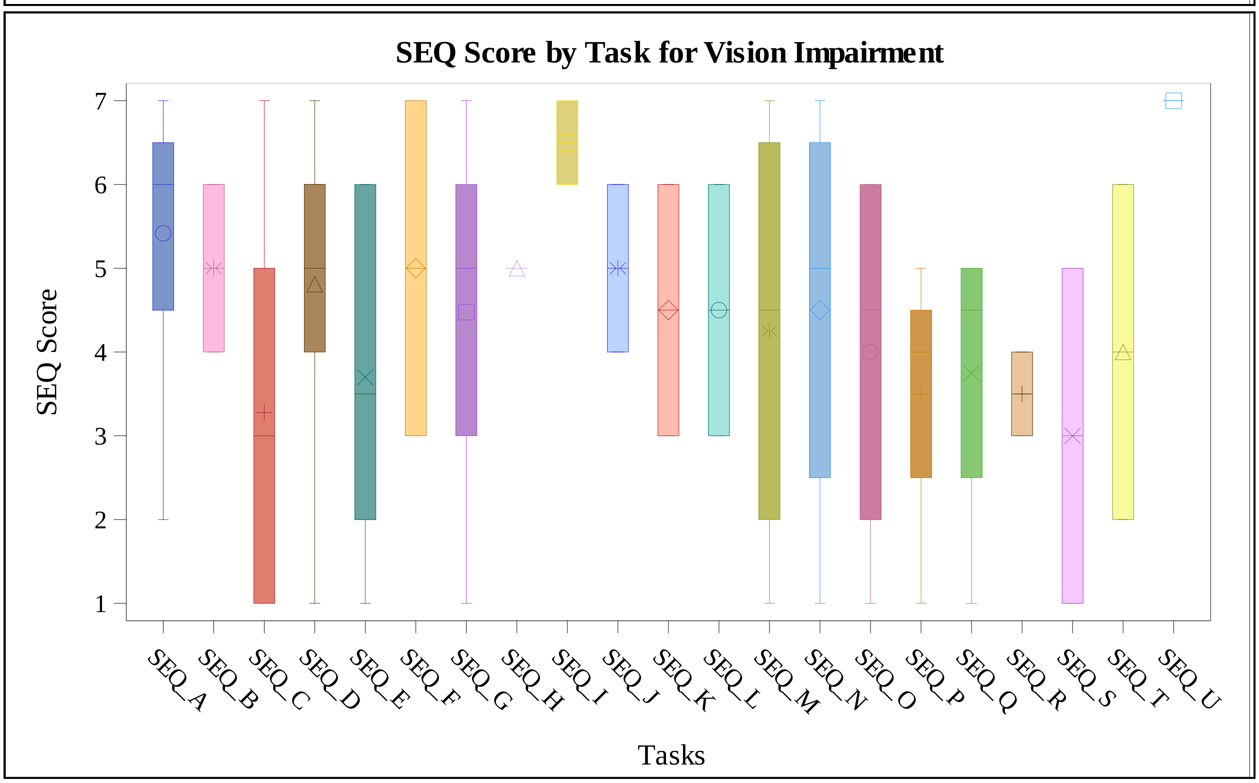
SEQ_R
SEQ_S
SEQ_T
SEQ_U
Tasks


SEQ Score by Task for Vision Impairment
SEQ Score
1
2
3
4
5
6
7
SEQ_A
SEQ_B
SEQ_C
SEQ_D
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SEQ_G
SEQ_H
SEQ_I
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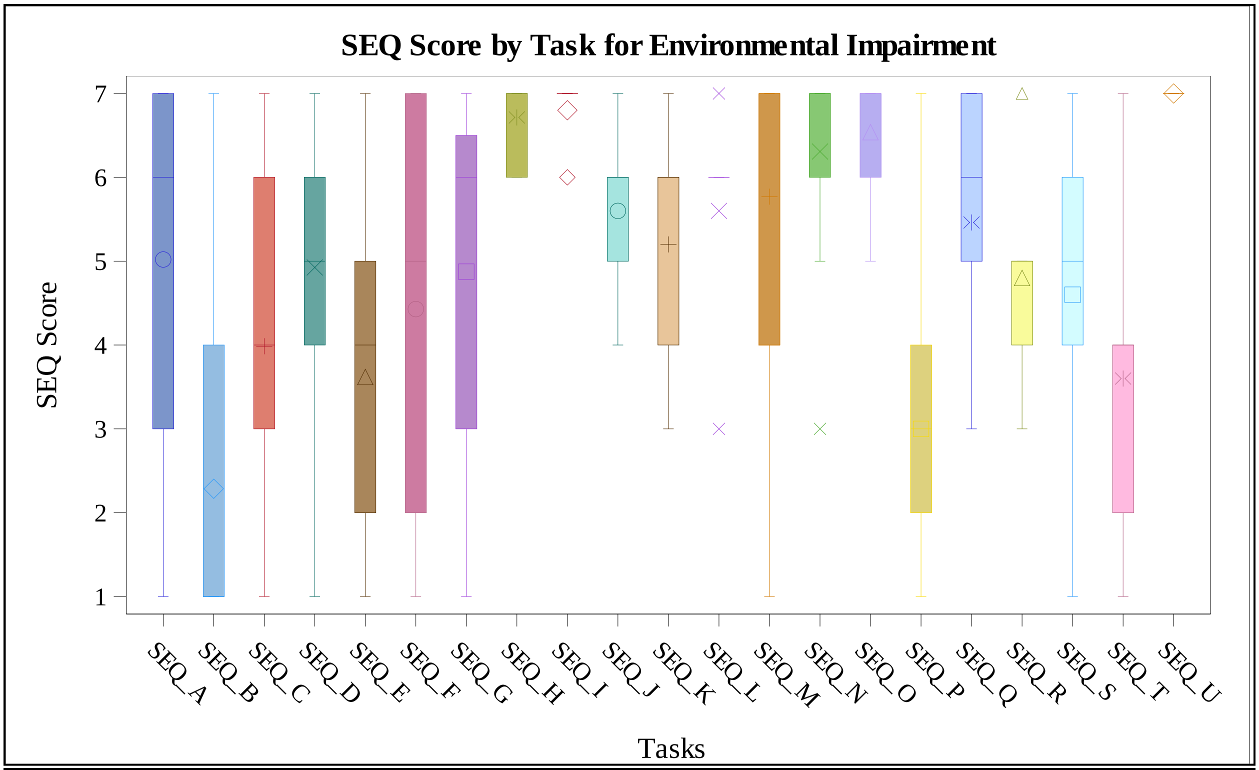
SEQ_S
SEQ_T
SEQ_U
Tasks


SEQ Score by Task for Environmental Impairment
SEQ Score
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2
3
4
5
6
7
SEQ_A
SEQ_B
SEQ_C
SEQ_D
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SEQ_G
SEQ_H
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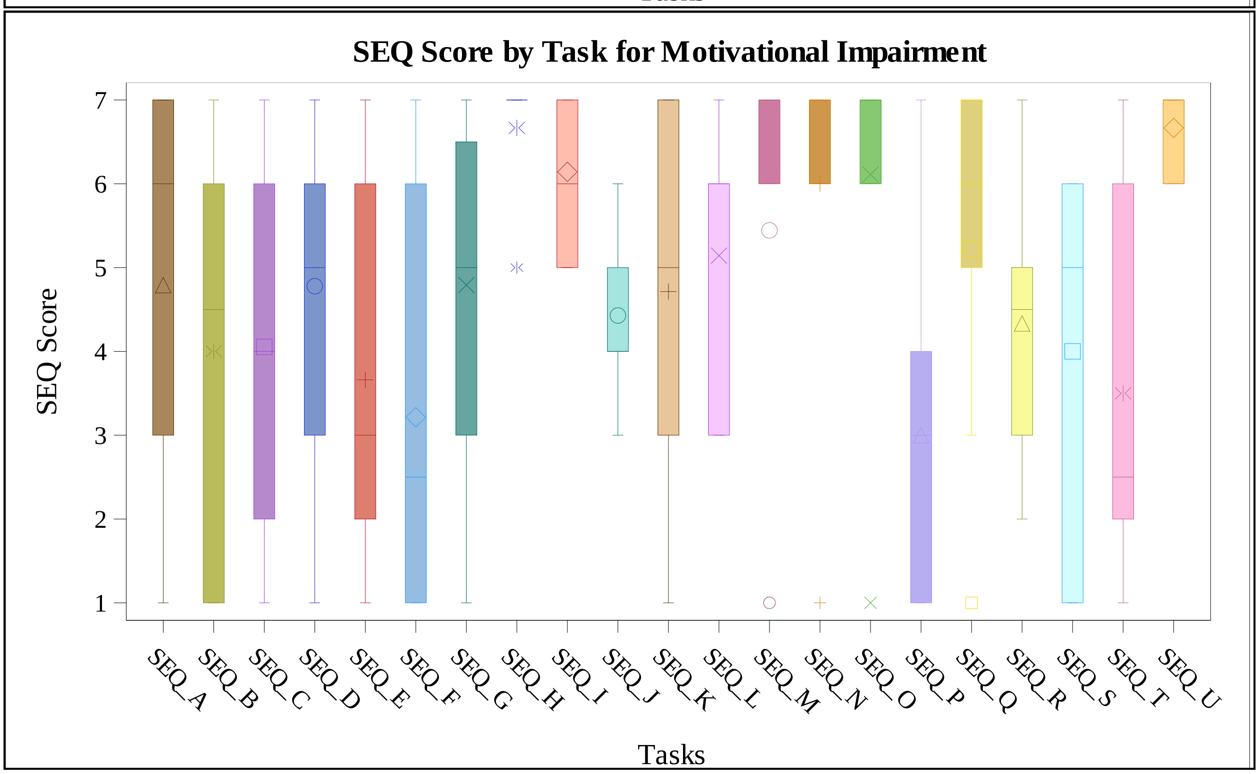
SEQ_T
SEQ_U
Tasks


SEQ Score by Task for Motivational Impairment
SEQ Score
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2
3
4
5
6
7
SEQ_A
SEQ_B
SEQ_C
SEQ_D
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SEQ_F
SEQ_G
SEQ_H
SEQ_I
SEQ_J
SEQ_K
SEQ_L
SEQ_M
SEQ_N
SEQ_O
SEQ_P
SEQ_Q
SEQ_R
SEQ_S
SEQ_T
SEQ_U
Tasks

10.5.4 Appendix E-4: Subjective Mental Effort Questionnaire (SMEQ) Score

Descriptive Statistics and Kruskal-Wallis Test for SMEQ Score by Task – Overall

Variable	N	Mean	Std Dev	Minimum	Maximum	25th Pctl	Median	50th Pctl	75th Pctl
SMEQ A	150	28.07	36.37	0	150	0	20	20	40
SMEQ B	44	59.77	51.38	0	150	10	45	45	110
SMEQ C	191	41.99	38.58	0	150	10	30	30	60
SMEQ D	233	27.34	30.63	0	150	10	20	20	30
SMEQ E	211	46.49	40.18	0	150	20	30	30	70
SMEQ F	44	45.91	45.92	0	150	10	30	30	80
SMEQ G	233	19.34	21.78	0	90	0	11	11	30
SMEQ H	18	6.11	11.95	0	40	0	0	0	10
SMEQ I	23	7.39	8.64	0	30	0	10	10	10
SMEQ J	23	24.22	21.98	0	75	10	20	20	30
SMEQ K	23	21.3	22.01	0	90	10	20	20	20
SMEQ L	23	13.91	17.25	0	80	0	10	10	20
SMEQ M	38	10.13	16.95	0	80	0	0	0	20
SMEQ N	38	10.13	9.9	0	40	0	10	10	20
SMEQ O	38	9.61	16.12	0	90	0	0	0	20
SMEQ P	38	33.45	26.38	0	80	12	30	30	60
SMEQ Q	38	17.5	16.67	0	80	0	20	20	20
SMEQ R	16	29.5	27.59	10	90	10.5	20	20	30
SMEQ S	16	23.81	22.13	0	80	10	15.5	15.5	30
SMEQ T	16	30.63	28.16	0	80	10	20	20	55
SMEQ U	16	2.5	4.47	0	10	0	0	0	5

Kruskal-Wallis Test		
Chi-Square	DF	Pr > ChiSq
235.02	20	<.0001

Descriptive Statistics and Kruskal-Wallis Test for SMEQ Score by Task - Cognitive Impairment Present

Variable	N	Mean	Std Dev	Minimum	Maximum	25th Pctl	Median	50th Pctl	75th Pctl
SMEQ A	27	25.19	31.42	0	110	0	20	20	30
SMEQ B	9	84.44	57.9	0	150	30	90	90	120
SMEQ C	34	48.24	45.69	0	150	20	30	30	60
SMEQ D	40	28.75	33.47	0	150	0	20	20	40
SMEQ E	37	55.14	47.53	0	150	20	40	40	80
SMEQ F	9	41.11	28.04	0	90	20	30	30	60
SMEQ G	40	23.6	23.87	0	90	10	20	20	30

SMEQ H	4	5	10	0	20	0	0	0	10
SMEQ I	3	16.67	15.28	0	30	0	20	20	30
SMEQ J	3	30	13.23	20	45	20	25	25	45
SMEQ K	3	16.67	5.77	10	20	10	20	20	20
SMEQ L	3	6.67	11.55	0	20	0	0	0	20
SMEQ M	8	20.63	31.45	0	80	0	5	5	37.5
SMEQ N	8	11.88	11.32	0	30	0	12.5	12.5	20
SMEQ O	8	20.63	30.05	0	90	0	12.5	12.5	25
SMEQ P	8	31.88	25.9	0	60	10	27.5	27.5	60
SMEQ Q	8	19.38	12.08	0	40	12.5	20	20	25
SMEQ R	3	43.67	41.24	11	90	11	30	30	90
SMEQ S	3	26.67	5.77	20	30	20	30	30	30
SMEQ T	3	40	34.64	20	80	20	20	20	80
SMEQ U	3	0	0	0	0	0	0	0	0

Kruskal-Wallis Test		
Chi-Square	**DF**	**Pr > ChiSq**
49.3	20	0.0003

Descriptive Statistics and Kruskal-Wallis Test for SMEQ Score by Task - Physical Impairment Present

Variable	N	Mean	Std Dev	Minimum	Maximum	25th Pctl	Median	50th Pctl	75th Pctl
SMEQ A	49	40.82	44.01	0	150	0	20	20	70
SMEQ B	19	43.16	48.31	0	150	10	20	20	90
SMEQ C	58	50	40.22	0	140	20	40	40	80
SMEQ D	74	31.76	38.48	0	150	0	20	20	40
SMEQ E	66	53.48	43.45	0	150	20	40	40	90
SMEQ F	19	60.53	48.47	0	150	20	60	60	110
SMEQ G	74	18.26	22.06	0	90	0	12	12	20
SMEQ H	4	7.5	15	0	30	0	0	0	15
SMEQ I	9	10	10	0	30	0	10	10	10
SMEQ J	9	28	27.24	0	75	12	20	20	30
SMEQ K	9	21.11	27.59	0	90	10	10	10	20
SMEQ L	9	15.56	26.51	0	80	0	0	0	20
SMEQ M	15	11	15.83	0	60	0	10	10	20
SMEQ N	15	11.67	11.9	0	40	0	10	10	20
SMEQ O	15	9	10.04	0	30	0	10	10	20
SMEQ P	15	38.6	25.3	10	80	15	30	30	60
SMEQ Q	15	21.67	15.31	0	50	10	20	20	30
SMEQ R	7	38.71	32.73	10	90	11	30	30	80

SMEQ S	7	27.29	21.25	10	70	10	30	30	30
SMEQ T	7	25.71	24.4	10	80	10	20	20	20
SMEQ U	7	4.29	5.35	0	10	0	0	0	10

Kruskal-Wallis Test		
Chi-Square	DF	Pr > ChiSq
91.51	20	<.0001

Descriptive Statistics and Kruskal-Wallis Test for SMEQ Score by Task - Vision Impairment Present

Variable	N	Mean	Std Dev	Minimum	Maximum	25th Pctl	Median	50th Pctl	75th Pctl
SMEQ A	12	19.17	17.82	0	60	0	20	20	30
SMEQ B	2	25	7.07	20	30	20	25	25	30
SMEQ C	18	54.44	43.42	0	150	30	35	35	80
SMEQ D	21	31.9	30.23	0	120	20	20	20	40
SMEQ E	20	59	49.73	10	150	20	40	40	95
SMEQ F	2	45	63.64	0	90	0	45	45	90
SMEQ G	21	26.81	23.43	0	90	10	20	20	40
SMEQ H	1	40	.	40	40	40	40	40	40
SMEQ I	2	5	7.07	0	10	0	5	5	10
SMEQ J	2	47.5	38.89	20	75	20	47.5	47.5	75
SMEQ K	2	20	0	20	20	20	20	20	20
SMEQ L	2	15	21.21	0	30	0	15	15	30
SMEQ M	4	13.75	9.46	0	20	7.5	17.5	17.5	20
SMEQ N	4	13.75	9.46	0	20	7.5	17.5	17.5	20
SMEQ O	4	16.25	4.79	10	20	12.5	17.5	17.5	20
SMEQ P	4	21.25	26.58	0	60	5	12.5	12.5	37.5
SMEQ Q	4	21.25	6.29	15	30	17.5	20	20	25
SMEQ R	2	55	49.5	20	90	20	55	55	90
SMEQ S	2	55	35.36	30	80	30	55	55	80
SMEQ T	2	45	35.36	20	70	20	45	45	70
SMEQ U	2	0	0	0	0	0	0	0	0

Kruskal-Wallis Test		
Chi-Square	DF	Pr > ChiSq
33.36	20	0.0308

Descriptive Statistics and Kruskal-Wallis Test for SMEQ Score by Task - Hearing Impairment Present

Variable	N	Mean	Std Dev	Minimum	Maximum	25th Pctl	Median	50th Pctl	75th Pctl

SMEQ A	84	28.33	37.99	0	150	0	20	20	30
SMEQ B	23	73.04	52.35	0	150	20	90	90	120
SMEQ C	110	47.45	42.28	0	150	10	30	30	80
SMEQ D	136	30.04	34.07	0	150	10	20	20	40
SMEQ E	125	50.88	42.56	0	150	20	40	40	80
SMEQ F	23	40.43	43.43	0	140	0	20	20	70
SMEQ G	136	19.79	21.49	0	90	0	11	11	30
SMEQ H	10	9	14.49	0	40	0	0	0	10
SMEQ I	12	10	9.53	0	30	0	10	10	15
SMEQ J	12	27.67	24.14	0	75	11	22.5	22.5	37.5
SMEQ K	12	22.5	23.4	0	90	10	20	20	25
SMEQ L	12	17.5	22.61	0	80	0	10	10	25
SMEQ M	26	14.04	18.97	0	80	0	10	10	20
SMEQ N	26	11.35	9.96	0	40	0	10	10	20
SMEQ O	26	12.5	18.4	0	90	0	10	10	20
SMEQ P	26	31.96	26.3	0	80	12	30	30	60
SMEQ Q	26	20.19	17.8	0	80	10	20	20	20
SMEQ R	9	23.56	22.22	10	80	11	20	20	20
SMEQ S	9	30	27.39	0	80	10	20	20	30
SMEQ T	9	45.56	29.2	10	80	20	40	40	70
SMEQ U	9	2.22	4.41	0	10	0	0	0	0

Kruskal-Wallis Test		
Chi-Square	**DF**	**Pr > ChiSq**
119.06	20	<.0001

Descriptive Statistics and Kruskal-Wallis Test for SMEQ Score by Task - Motivational Impairment Present

Variable	N	Mean	Std Dev	Minimum	Maximum	25th Pctl	Median	50th Pctl	75th Pctl
SMEQ A	43	27.91	37.77	0	150	0	20	20	40
SMEQ B	14	48.57	46.22	0	120	10	25	25	90
SMEQ C	56	42.5	41.75	0	150	10	30	30	80
SMEQ D	72	30.56	30.12	0	140	10	20	20	40
SMEQ E	65	44.15	37.2	0	150	10	40	40	80
SMEQ F	14	67.14	51.65	0	150	20	65	65	110
SMEQ G	72	21.96	23.57	0	90	0	17.5	17.5	30
SMEQ H	6	6.67	16.33	0	40	0	0	0	0
SMEQ I	7	11.43	6.9	0	20	10	10	10	20
SMEQ J	7	37.86	28.7	0	75	20	30	30	75
SMEQ K	7	22.86	26.28	0	80	10	20	20	20

SMEQ L	7	17.14	9.51	0	30	10	20	20	20
SMEQ M	9	9.44	19.76	0	60	0	0	0	10
SMEQ N	9	11.67	11.73	0	30	0	15	15	20
SMEQ O	9	6.11	7.82	0	20	0	0	0	10
SMEQ P	9	35	26.46	0	80	15	30	30	60
SMEQ Q	9	12.78	10.93	0	30	0	15	15	20
SMEQ R	6	18.5	7.31	10	30	11	20	20	20
SMEQ S	6	23.5	27.96	10	80	10	10.5	10.5	20
SMEQ T	6	45	31.46	10	80	20	45	45	70
SMEQ U	6	5	5.48	0	10	0	5	5	10

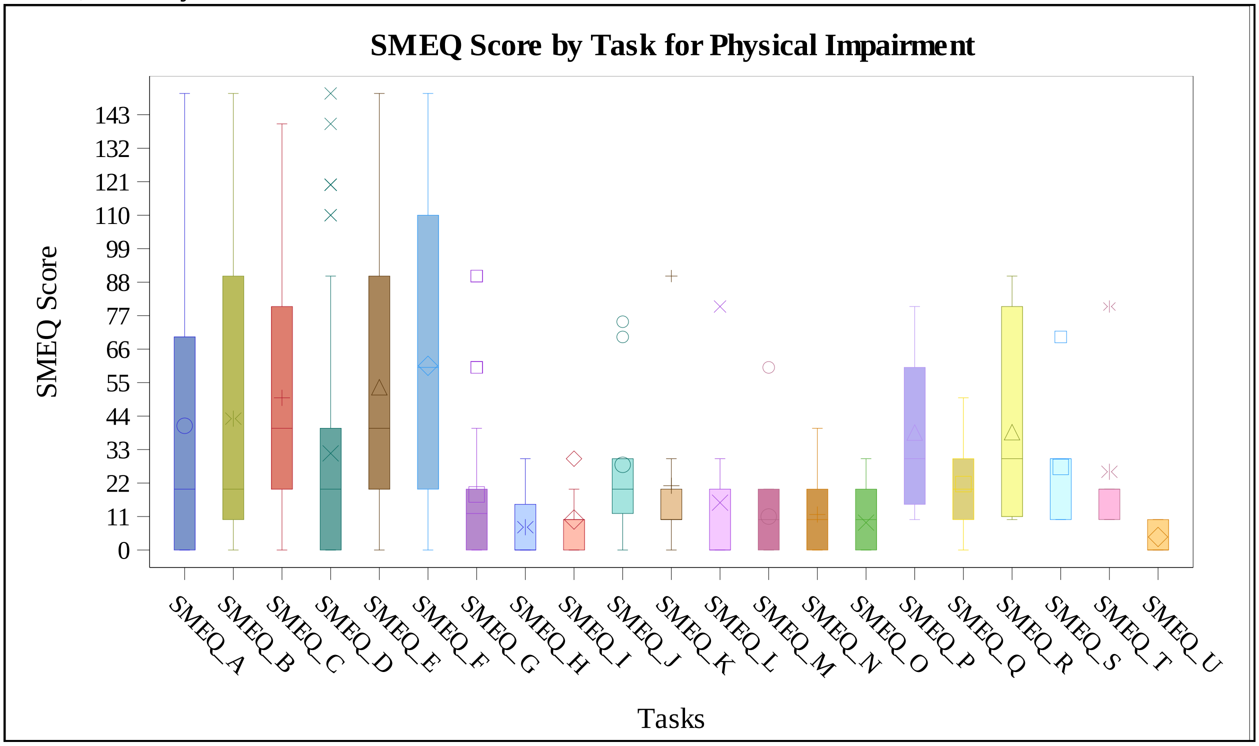
Kruskal-Wallis Test		
Chi-Square	**DF**	**Pr > ChiSq**
68.13	20	<.0001

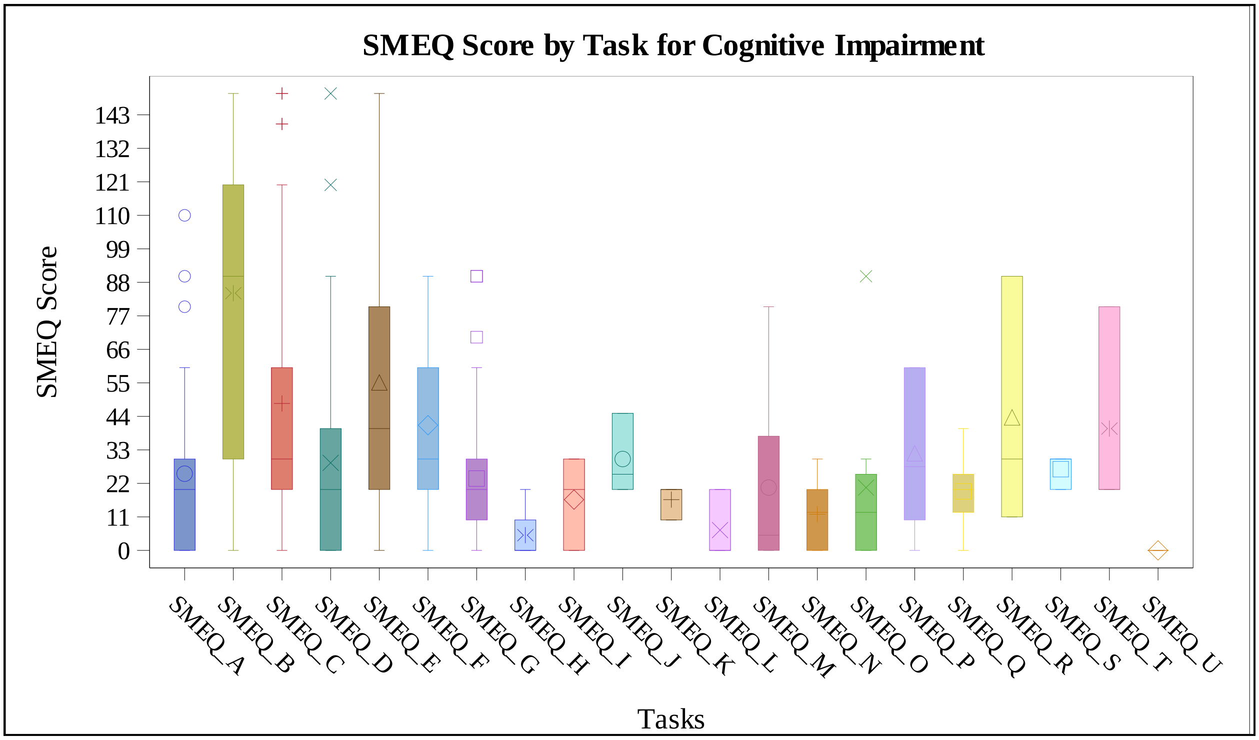
Descriptive Statistics and Kruskal-Wallis Test for SMEQ Score by Task - Environmental Impairment Present

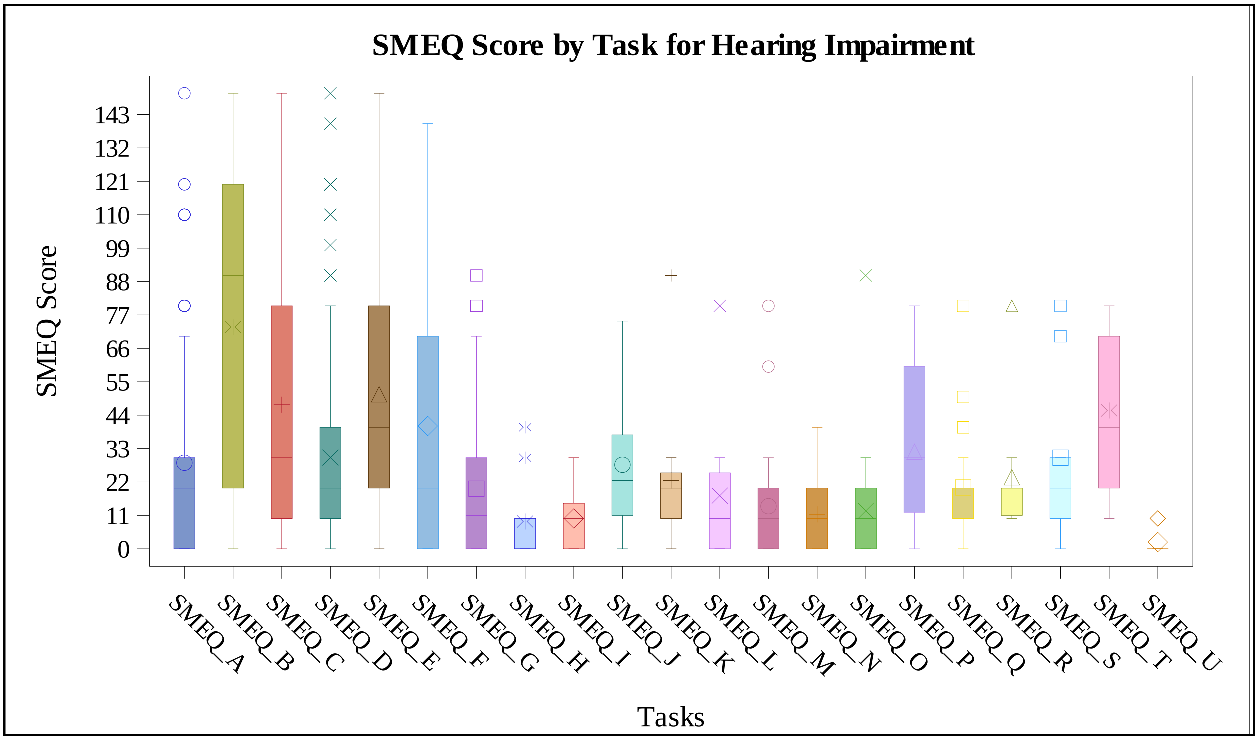
Variable	N	Mean	Std Dev	Minimum	Maximum	25th Pctl	Median	50th Pctl	75th Pctl
SMEQ A	50	23.6	28.77	0	120	0	20	20	30
SMEQ B	14	72.14	45.6	0	120	30	90	90	110
SMEQ C	69	36.81	30.12	0	140	10	30	30	50
SMEQ D	80	27.69	26.61	0	150	10	20	20	30
SMEQ E	76	45.39	36.27	0	150	20	30	30	60
SMEQ F	14	42.86	46.65	0	150	10	25	25	70
SMEQ G	80	21.99	20.76	0	90	5	20	20	30
SMEQ H	7	4.29	7.87	0	20	0	0	0	10
SMEQ I	5	4	5.48	0	10	0	0	0	10
SMEQ J	5	23	29.71	5	75	5	10	10	20
SMEQ K	5	12	8.37	0	20	10	10	10	20
SMEQ L	5	14	11.4	0	30	10	10	10	20
SMEQ M	13	13.08	16.53	0	60	0	10	10	20
SMEQ N	13	13.08	9.47	0	30	10	10	10	20
SMEQ O	13	6.92	10.32	0	30	0	0	0	10
SMEQ P	13	40	23.45	0	80	30	30	30	60
SMEQ Q	13	16.15	10.44	0	30	10	20	20	20
SMEQ R	5	28	29.5	10	80	10	20	20	20
SMEQ S	5	30	29.15	10	80	10	20	20	30
SMEQ T	5	40	30.82	0	70	20	40	40	70
SMEQ U	5	2	4.47	0	10	0	0	0	0

Kruskal-Wallis Test		
Chi-Square	**DF**	**Pr > ChiSq**
102.34	20	<.0001

Box plot of SMEQ Score by Task for Various Barriers






SMEQ Score by Task for Hearing Impairment
SMEQ Score
143
132
121
110
99
88
77
66
55
44
33
22
11
0
SMEQ_A
SMEQ_B
SMEQ_C
SMEQ_D
SMEQ_E
SMEQ_F
SMEQ_G
SMEQ_H
SMEQ_I
SMEQ_J
SMEQ_K
SMEQ_L
SMEQ_M
SMEQ_N
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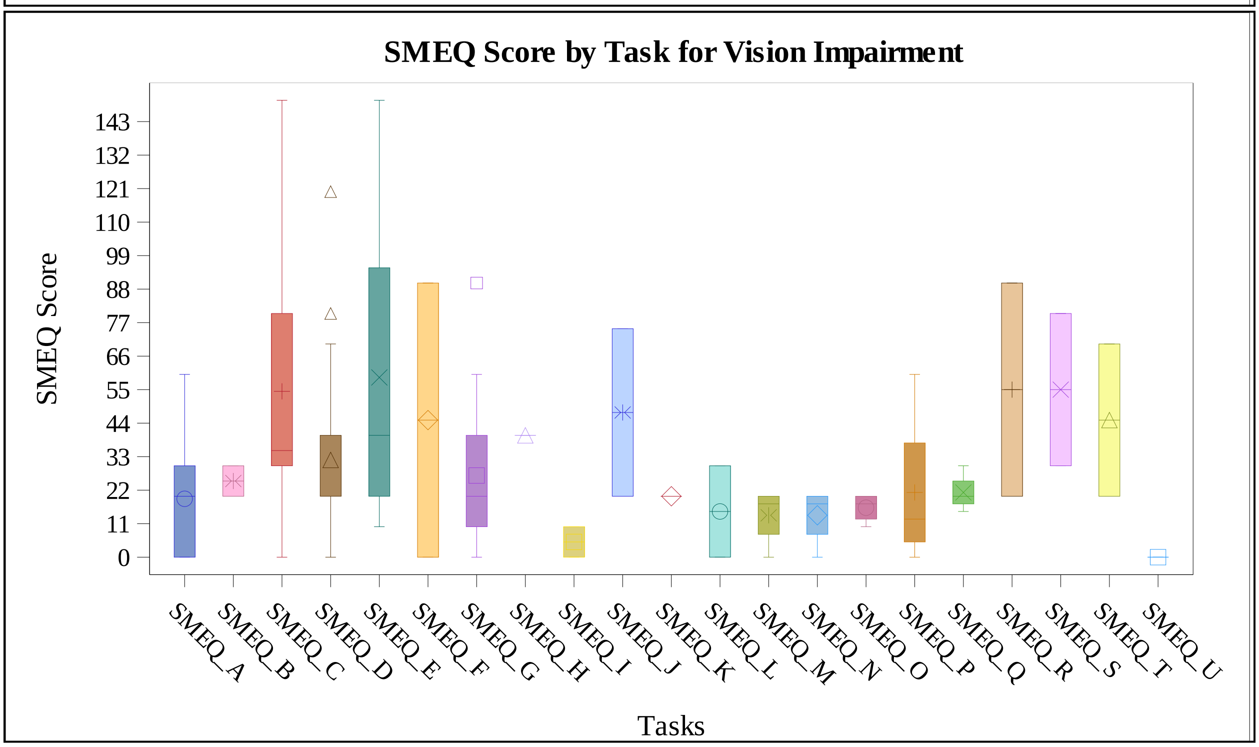
SMEQ_R
SMEQ_S
SMEQ_T
SMEQ_U
Tasks


SMEQ Score by Task for Vision Impairment
SMEQ Score
143
132
121
110
99
88
77
66
55
44
33
22
11
0
SMEQ_A
SMEQ_B
SMEQ_C
SMEQ_D
SMEQ_E
SMEQ_F
SMEQ_G
SMEQ_H
SMEQ_I
SMEQ_J
SMEQ_K
SMEQ_L
SMEQ_M
SMEQ_N
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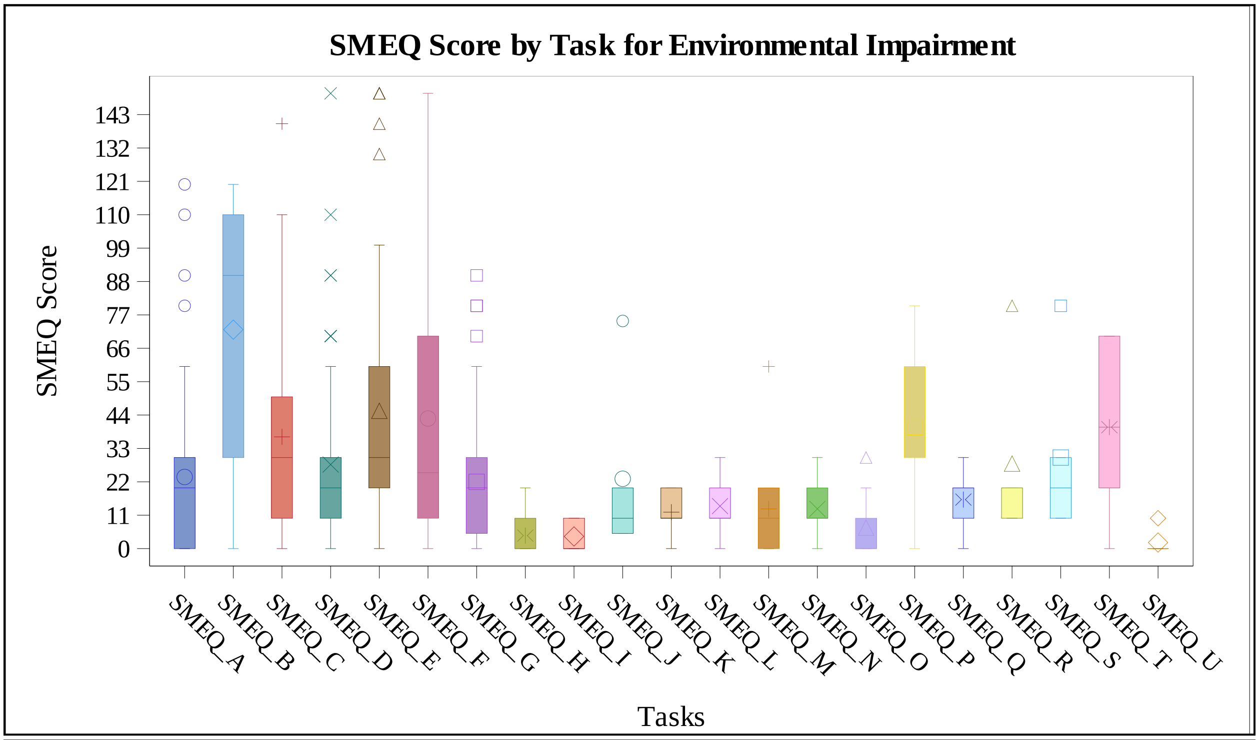
SMEQ_R
SMEQ_S
SMEQ_T
SMEQ_U
Tasks


SMEQ Score by Task for Environmental Impairment
SMEQ Score
0
11
22
33
44
55
66
77
88
99
110
121
132
143
SMEQ_A
SMEQ_B
SMEQ_C
SMEQ_D
SMEQ_E
SMEQ_F
SMEQ_G
SMEQ_H
SMEQ_I
SMEQ_J
SMEQ_K
SMEQ_L
SMEQ_M
SMEQ_N
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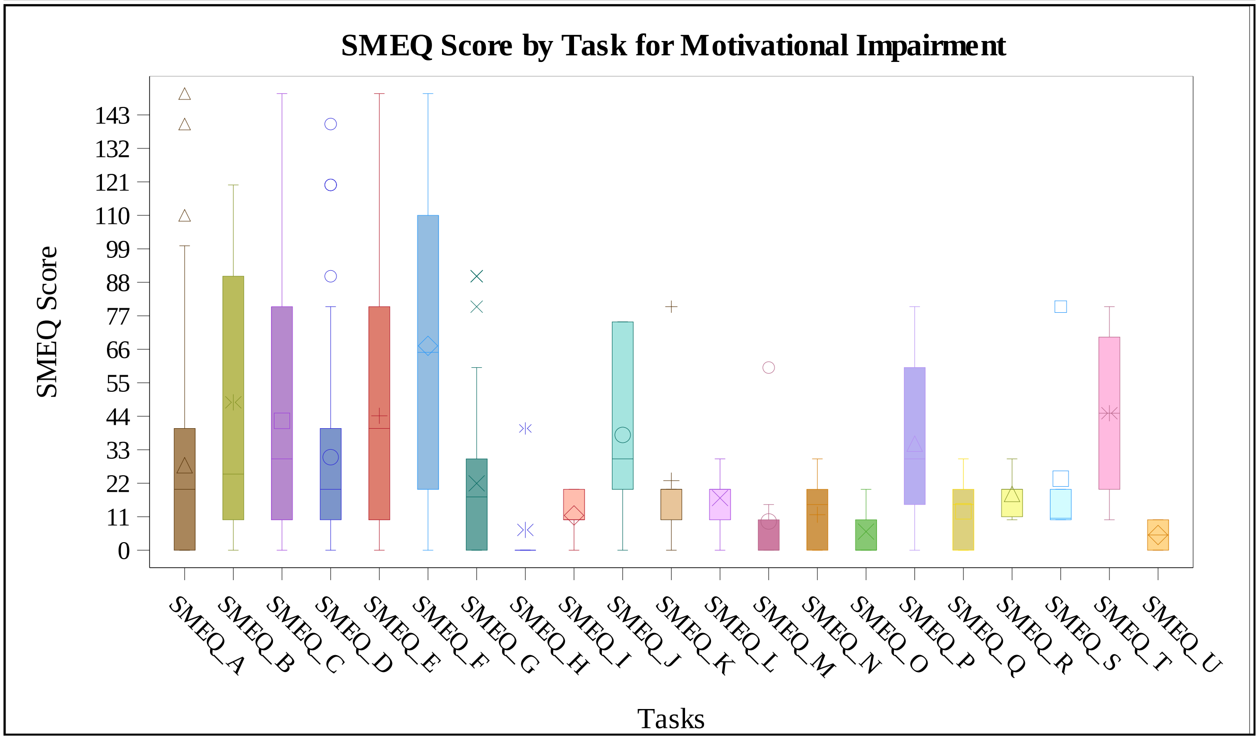
SMEQ_T
SMEQ_U
Tasks


SMEQ Score by Task for Motivational Impairment
SMEQ Score
0
11
22
33
44
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66
77
88
99
110
121
132
143
SMEQ_A
SMEQ_B
SMEQ_C
SMEQ_D
SMEQ_E
SMEQ_F
SMEQ_G
SMEQ_H
SMEQ_I
SMEQ_J
SMEQ_K
SMEQ_L
SMEQ_M
SMEQ_N
SMEQ_O
SMEQ_P
SMEQ_Q
SMEQ_R
SMEQ_S
SMEQ_T
SMEQ_U
Tasks

10.6 Appendix F: Qualitative findings – Codebook

Code	Code Description	Quotes	PT ID
Dislike for Large, Cumbersome size	Dislike for large and bulky medication management devices, citing them as cumbersome, awkward, and space-consuming.	Yeah. That one I did not like at all , because it's cumbersome. It's too big.	10
		Well, it's an awkward thing. Yeah it is big for what it does.	18
		Yeah, but it seems clunky.	17
		The bigger ones are more difficult. I mean, but again, you have to think that your prescription pills are important. Right. This prescription medication is important. Yeah. And to have a big, cumbersome thing on your, like, table in your bathroom.	3
		Probably that big monster. Yeah, it did. I mean, it takes up a whole lot of space.	7
		The first thing I thought was. Oh, no. Like, it's too huge. Yeah. Where would you put it? Where the heck will we put it?	3
		No, it's just too big, too bulky.	20
		The big One. You know , that was awful .	25
		Not really because they're just in the way. And this one especially is - I don't know. I think they're too big, too eyesore?	26
		Too big and cumbersome.	32
		Yeah . But again , that is simply too large , too cumbersome , because it does the whole month .	62
Preference for compact size	Preference for compact-sized devices, highlighting their ease of use and user-friendly design.	If I had to choose one, it would be actually this one (MedGlider), because it's small. It's small.	10
		Oh , no , no , no , no ..No . I prefer the small flat ones . Mm hmm .	24
		I just think it's a good size. Yeah, I think It was as user-friendly as any of them was. I think it'd be easier to figure it out. The size of it's good. Some of the other stuff seemed a bit small or whatever. So I think that if I had to	1

		pick one, I would pick that for sure.	
Preference for portable devices	Users value portability in medication management devices, emphasizing the need for devices that are convenient to carry during travel or daily outings.	I just think it's a good size. Yeah, I think It was as user-friendly as any of them was. I think it'd be easier to figure it out. The size of it's good. Some of the other stuff seemed a bit small or whatever. So I think that if I had to pick one, I would pick that for sure.	1
		Is that so if you have like a Spencer at home, right. Well, if you go away, you can't. Not going to take this big, heavy thing with you .	3
		So you're delivering something that you can take away from the product that allows you to take like keep it, but still move with it like a section. Like if Spencer had like a section, you could just .	3
		And then it would be portable that I could take it where I needed to go if I was going to wait for a day or weekend or whatever, that it would be portable.	5
		But it's cumbersome to take it if you're going away.	6
		Yeah, It just seems awkward carrying that big thing around it just wouldn't work very well. You'd be driving in a car for six hours and you have this silly thing going off or something.	6
		No, it's just good. You can take it with you. Throw it in your purse.	7
		As long as like if I were to go to the States and they wouldn't ask me at the border what's going on? Like, what is this contraption? Well, it would be easier not to, obviously, but if you have to, you have to.	8
		The other feature about this one is that this is a big case just like the Spencer but you can easily take out the day so if you're traveling you can probably like - it's very portable compared to some of these ones.	9
		So if I had to take medication in the middle of the afternoon or something like that, I could put it in my purse and take it with me and it would remind me, okay, because I don't have a cell phone.	10

		But the thing with the Spencer and you can see it's pretty big. And if you were to go on vacation, It's hard to take the whole thing with you, especially if you're flying.	17
		To some extent here, this is better I mean this is the bulk. A little bit wider too.	17
		But so because the other one's bulky, I don't think I would use them outside of home. So because of that, those - I would take the pills out early if I was going out so that I could, which kind of makes them not very useful for me.	19
		I say I think the biggest thing is most would not be usable or easily usable if you weren't at home 24/7.	19
		Exactly. It depends how long your vacation is. If you're going for a full month, then and you're actually staying in one place, then yes, it's worth taking. But if you're traveling, then it isn't, you know, if you're going from place to place.	20
		Well , like you say , Portability . I would like to be able if I go away for a weekend , I want to be able to take it and go away for a month . I want to be able to take it . I'm not taking this box . I'm not taking this computerized thing . So if I take this , I only need this and my pills . Although I probably wouldn't take this because I'd be out and about all day and I'm not bringing .	24
		Well, this (Medglider) is the only one that you would be able to take for a trip or something.	26
		And think about the portability of this thing. People are only carrying a cell phone with them nowadays, not a big purse or something.	31
		I have a small one that I fill each day and take it with me and keep it in my pocket.	32
Portable as part of device	Devices that include detachable components for portability, allowing to take a portion of the	I see . And in terms of portability too , I guess that would be easy to carry around if you're going on vacation year , whereas something like that , we haven't had that . So then you take that . And put it into this , Right . Right .	22

	device with them as needed.	To go away . So yeah , I , I can't say maybe I'm not that at that stage of my life yet that I need all this help . But I like still like this idea .	
		Now, see, I can take these come in little tubs, I'll call them. And there's all these on the top. But if I go somewhere, I can take whichever one I want. Put the lid on it and take it, put it in my pocket for the day. One for one meal or whatever	47
Ease of use & User-friendly	Devices that are straightforward to operate.	I just think it's a good size. Yeah, I think It was as user-friendly as any of them was. I think it'd be easier to figure it out. The size of it's good. Some of the other stuff seemed a bit small or whatever. So I think that if I had to pick one, I would pick that for sure.	1
		I just. I just thought it was the easiest. Once I figured it out, it seemed like the easiest one to use.	1
		I just think it's a good size. Yeah, I think It was as user-friendly as any of them was. I think it'd be easier to figure it out. The size of it's good. Some of the other stuff seemed a bit small or whatever. So I think that if I had to pick one, I would pick that for sure.	1
		More user friendly than this. Yeah, this is more mechanical but this Spencer guy, they just tell you what to do	3
		Seemed to be the easiest one to use. Doesn't take up a lot of space, pretty obvious the days are, easy to open. Easy because you can take the thing out. You can just dump it out for each little piece. So that works out well. It's easy to load.	7
		For me personally at this moment, probably the one that has the blister pack, that's a little bit easier to use.	19
		Easy, easy and fun and enjoyable and don't get frustrated. And I didn't have to diddle with stuff.	8
		It seemed to be the easiest to sort out. I think so.	12
Difficulty in battery	Challenges with inserting batteries into	Yeah. The battery was a little bit annoying, but once I figured out the battery it was okay.	1

insertion	devices.		
Easy battery insertion	Devices that offer easy battery insertion.	Well, it seemed easier to put the batteries in.	12
Difficulty in setting up the device	Devices that are complicated to set up.	That one I would never use…Yeah, just the hooking up or whatever it was. That one, no.	1
		I didn't like this one at all. I guess because I really struggled getting it hooked up or whatever. Like, I'm not very, very savvy with electronic stuff.	1
		For old people , like , you know . Yeah . Settings and all that . Yeah . And then was worn especially .	25
Difficulty in setting up alarm	Difficulty in setting up alarms on devices.	Well, this was the one we had the hardest time with the time and the alarms. I don't know why. I mean, I'm sorry. I forgot her name, but we all had trouble doing that. And I don't know why it was. It just seemed.	12
		And so setting just the whole setting business, it it just because, you know, you push the button. You helped with that you did. I just found that this whole setup business was awkward	12
		It would be an advantage. But if you decided to sleep in one day, it would be a nuisance. But you're upstairs. That alarm is going off and you have to run downstairs without killing yourself. It's like when I get to the stairs.	14
		That one way to difficult to set the settings, the alarms or whatever. It's like, you know different because I have difficulty I have setting the clock. Yeah yeah but but you don't know how to set the alarm. The the clock in the bedroom. Not really. You don't.	3
		Features setting the alerts, setting the time and date information and the alerts with the other one.	20
		So Well , I think any of the ones that you had use an alarm was hard .	25
		Yeah, this one is kind of a pain. Yeah, especially the alarm stuff.	
Preference for devices with	Devices that are easy to set up, including simple	Other than the key? Yes. Yeah. It just seemed easier to set the time and everything on this one. Yeah, I found this	12

easier set up	time and alarm settings.	one.	
		Well, it seemed easier to put the batteries in. Set the time. And while unlocking it was hard, but it just seemed easier to manage and work with.	12
		I like that one again because it had was easiest to set up and the displays were the most user friendly.	20
Dislike for hurried or rushed pace of set up	Dissatisfaction with devices that require a quick setup process.	The buttons are better on this , but the timing is . Is way too fast . Yeah , right , right . They need to give you because they're talking about older people so your reflexes are not quite as fast . So I like the setup , but it's too quick .	22
Button size – small button problems	Struggle with small buttons on devices.	I mean this, this one, it's kind of small. The buttons are small for, I think, for people that are older, the digital pillbox. These two had it were a little more friendly that way.	1
		Oh, my gosh, no. There's little tiny writings and those little, tiny, tiny buttons that are like a millimeter, you know, less than a size is horrible . Yes. I had to get a pen to open it. I thought, no, you're not going to want to get a pen every time you wanted to do this	3
		You know, this is such a cute guy, but still. Oh, it had these tiny little itty bitty buttons and. Oh, my.	3
		And some of them have such tiny buttons that I don't know what size of finger you need or you need to have a pen or something to do it.	8
		No, No small buttons. I have arthritis, so it's a little bit hard for me to press these.	8
		Terrible. This whole button thing's too small.	17
		Yeah I find it very difficult ..I think something that my fingers are not that fat right?	18
		Not painful, but I can see that some people might have trouble with that because it's such a fine thing. And I think you sort of get a bit of feedback that you're pushing those buttons.	19
		The buttons are fairly small, and it's almost like you need	26

		a tool to push them. These, again, are very small. Mm hmm. Yeah, on all of them the buttons are a little tiny.	
Dislike for Hard buttons	Difficult to press and sometimes painful to press buttons	I didn't like the buttons at all. I found them mainly. Really hard	5
		It's the buttons. The bottoms of the Epill are difficult to press on. Yeah. Especially if you had big hands. I think guys would not do well.	10
		Yeah, the buttons were that you couldn't push deeply. And it was hard to push.	16
		and the tiny little buttons that actually hurt when you push . Them because they . Should be rounded . Yeah , they actually hurt . So yeah .	24
		Yes . I like this . Except for the tiny little buttons that hurt when you press them .	24
		I find that this one is not stable In the place that it sits. It's hard to get out, hard to grasp. And when you try to push the buttons, it doesn't sit still.	26
Preference for Tactile / Easy to touch button	Preference for buttons that are tactile and easy to press	Yeah, this wasn't. I recall this wasn't too bad. It's out in the open. They're easier. They're easier to do. They're tactile.	17
		Okay , first of all , it has to be easy to touch button. It has to have a fair sized , a fair sized button . That's the first thing.	24
Lack of space between the buttons	Close proximity of buttons on devices leads to challenges in selecting the right one.	This one (E-pill) was like very close together, you know, to get the right one, you sort of had to some thinking.	9
Difficulty in button accessibility	Difficulty in pressing buttons, especially when they are too recessed or small	Well, I think buttons that are easier to press are the best. The other the blue one, it was very difficult and I have very small fingers, so I have to really like it was inserted. So you'd really have to sort of go at it to to depress it	20
Button labels	Visible and clear labels on buttons	. Yeah , You can see the buttons they have like the numbers on the buttons .	21
		Labels on the button itself? The labels, No, they're almost invisible.	26

		And I like the , the buttons on the top two that are clearly labeled what they are .	62
Preference for large capacity devices	Devices with large storage capacity	I would prefer still the two weeks. I'd rather drag this along than be filling daily.	7
		Okay. The only thing with this one, it only gives you 28. What happens if you're taking pills every three hours.	14
		No . The little pill boxes in boxes she had to take . She had to fill two of those for every day . Oh , so this wouldn't be good for a cancer patient at all ? Or if someone takes it , Took all the three pills in one was fine and probably took about six , 5 or 6 . But if you have to take any more than that , not going to work .	24
Dislike for small capacity devices	Dislike for devices with small capacity especially for users who require multiple pills or supplement.	This is - works quite well, but it's maximum one day.	31
		Yeah, probably a matter of money. It's like a Swiss watch with a little chip over here. Probably going to make more money. But the biggest feature that is not acceptable is that it's only for three compartments.	31
		Like, this is small, but it only covers three days.	32
		Yeah . And my problem is that with the part where the ones that divide the bulk and they're not large enough to hold all of my nonmedical pills , my vitamins	62
		Some of them are fairly bad compared to the calcium and water . They vitamins to be fairly large . Okay . So that's just a little bit too small . Okay .	62
Compartment capacity – Preference for bigger compartments		Um, yeah. I mean, I think that one, the compartments can be a little bigger. I mean, it might be a little bigger just.	1
		Yeah, to get fingers into it or whatever	
		Well, these are not large enough sometimes to fill all the medication compartments. Sure. I think it might get confusing. Like, I took a look at this and it's set up for 29 slots right here. 29 or 30 slots. And I'm thinking if we put in, like, two calcium tablets, forget anything else.	3
		What did you think of the size of the compartments in that product that you tested? Like the size where to put all your pills. Do you think your pills would all fit?	3

		Well, mine probably wouldn't. Yeah, that's like 8 pills I've got to take a day.	
		And this one's sort of more squared. Probably this is the better size, especially if you like, if you have trouble with your fingers. I wouldn't be putting them in there. But even so, like, yeah, this one I think just because of the size of the compartment.	12
		No, not if you're on multiple meds they don't fit in there.	26
		No. Other than the fact that it doesn't hold- If I were taking more medications, it wouldn't hold enough pills.	20
Preference for compartment division with time-of-day labels	Divisions within compartments that include time-of-day labels	…I guess it would be helpful if it was labeled for the for the day. Mm hmm. Just, I mean, I, I guess most people probably would start with sunday, but. I don't know, maybe not. It would be. I think it. And you need when you're older, you need to have something that says, yeah, this is sunday. Like, I don't know what date to use. I mean, that one's good like that where it's really obvious what day it is. And this was good that way as well.	1
		And putting them in there, that was the next confusing part where you got to take the pills in the morning. You got to take them at night.	3
		But I do think like if they have compartments for morning for different time of the day, it is more useful.	5
		Well, it's just easily morning, noon hour, afternoon and evening isn't it.	6
		The only thing it didn't do was distinguish by times of day. Yeah. So you had to. You still had to go back to the pill bottle to know which one they had to take one and then two.	7
		Like the the here that separating like a breakfast lunch sometime or bedtime? Yeah. Time of the day is important because some like this one or even this one you know you go for one day but you have to remember which one you take when and that's hard.	8
		Oh, I suppose ideally if if you were taking medications 3	12

		or 4 times a day, it would be ideal to have one for each slot, like one for each time. Yeah. I'm sorry. That's what I thought	
		This would have, like, the morning, noon, evening, at night, so that you can put this is a seven day dosette. So you could put all your morning pills here? And the one for the evening? The one for the bedtime. Well, you would you prefer using this if you have more medications?	16
		That's what I don't understand . Now that I look at it , because you said to me to take out whatever it was , today morning or something . But if when you look at it , what is that ? So , yeah , there's no days . There's no morning after .	22
		But this I would want to see it more specific . I like I would want to see it as marked as 15 days or each of these morning and evening .	22
		No, I still don't like all the pills in one day together. Oh, it's like there is no division for morning, noon. And I don't like that.	47
		That is one of the problems with the way I do it right now . I would like to get something that is more divided up . I have tried to find them and I've tried to a different times from the drugstore .	62
		The only thing wrong I found with this . Was simply that I could not divide the pills up into the the times of day that I need to take them . If that was there , I would be an improvement on what I have now .	62
		Yes . The ones that do not divide your medication up to into different parts of the day . I would not touch them .	62
Problems due to slide out compartment design	Problems with Slide-out compartments such as prone to accidental opening, leading to potential medication	It's so easy to push it a little too much. And you get. Yeah. Yeah. The first thing I did when I opened it, the first. Two compartments came out with the first. Push. Yeah. And I thought, oh, that's no good. Okay. And I thought at first that was kind of neat. But for that reason,	14

	mix-ups.	now.	
Width and depth of compartment	Problems due to narrow compartments or compartments with narrow opening	To some extent here, this is better I mean this is the bulk. A little bit wider too.	17
		On in the morning . So just say though , like when you are trying to take out the Or when you're organizing your medication . Yeah . And let's say you're filling for a Tuesday evening , but the slots are pretty narrow so you accidently put it in Wednesday morning . You have to go back and dig it out and you say , I guess the depth of these compartments , it's like a little too deep	22
		But it failed in ergonomic. You're going to put your finger into the (blank). Too narrow, yeah, yeah.	31
Customization of compartment	Ability to customize compartments, such as removing or adjusting sections.	But when you had someone with dementia, as I was telling the girls, he got to the point I would take out like one strip, which would be double aligned to this. And I put it on the table.	14
Issue with multiple compartments	Issue with multiple compartments like the effort required to open each one.	So to have multiple compartments open is a good thing. It just requires what you're telling me is more effort to do it because you've got to Open every one Of them.	3
Separate cover/lid for each compartment	Need for separate covers for compartments to prevent pills from other compartments spilling out.	Yeah . Or maybe compartments with a cover to cover the other ones	21
		Well, these two are awkward because like if you have the four compartments, how are you going to keep the other three compartments from falling out when you're trying to get your the one day in?	26
		I mean, the whole concept seems to be fairly decent, but some of the things about it like that for instance, is - I don't know how you would fix it. When I first saw it, I think that would be really neat (Ennovea). But I don't think it'll work... And	26
		But the way it is now, I think it's just too complicated. And if they all fall out, you're not going to know which is which and what goes where.	26
Hard to open	Difficulty in opening	However , the little pill packets that go with it were the	24

compartments / medication packages/door	compartments or medication packages	worst . You know .Because they were too hard to open .	
		Oh , opening It was kind of difficult . And if I had arthritis , I need scissors .	24
		And that little door is very hard to open.	26
Easily opening compartments	Compartments that are easy to open	Second thing , it has to be easily opened . If I have arthritis and I do get arthritis and then I can't even hold a knife or fork . So the compartments easy to open .	24
Dislike for complex devices	Devices with confusing features	I don't understand why it has two levels. Is that the case you're taking, like a whole bunch of meds or?	1
		Oh, it just looks so confusing, those stupid dials.	6
		For people who have complex, the setup would be a bit time consuming, but once it was set up, it would be the simplest to use.	5
		Yeah. Yeah, that one. I'm just loading it up and getting it open and like, I found these, these awkward. Just the whole thing was awkward.	12
		The last one (MedReady) was just horrible. There was nothing positive about it. It was just an awkward, hard thing to do. And I just I wouldn't touch it with a ten foot pole.	18
		Yeah , because organizing it like you organize your pill box , right ? Yeah . Once a week . Yeah , that takes 20 minutes or two . But , I mean , you're going to open . This wide open and I've got a really bad shake . And first of all , I've got to get all those pill bottles open , and I got to get all those pills in the right tiny slot with a shake . Yeah , I don't see it . No , I don't see that , you know , And that , I think , is just that's ridiculous . Jones Yeah , this one makes no sense to me . There's just nothing on there that tells me anything I've got .	22
		I found them all to be very complex and burdensome. Not helpful at all.	26
		The Medglider is a total waste of time. Very badly designed. I don't see why it's even on the market.	26
		That's more like my iPad isn't foreign to me. All that has	47

		technology too, but that looks more daunting.	
		Yeah . I don't like the idea that you have to go to a store that is going to provide your pills and this sort of game changer , adding that complexity to it , adding in the the need for a a connection .	62
Time consuming to use/fill /learn to use the device	Devices that are time-consuming to fill or require a steep learning curve	I think these ones here with the cups and you got to unscrew the cups. Kind of time-consuming.	5
		Yes. Yes. So for me to take that product and use it. Mm hmm. It would take a long time, I think, to figure out how and fill it.	5
		Like I tried two weeks and it took too long to fill it.	16
		If someone has a quite a number of medications and one day a week he sits down (to fill a pill organizer) for it's probably 15 or 20 minutes in the morning and then they're ready for the week. I mean I guess, I don't know,	9
		I don't think I'd even bother trying. I wouldn't even try it. Yeah, that's a fair assessment, right? The amount of time it takes to learn it isn't worth	18
Require lot of effort and stressful to use devices	Devices that are complex and require significant effort to use	Not that retired people have a lot to do but no it just yeah it's just a lot of effort as opposed to the other ones where you just open it. They're all there.	1
		It was kind of stressful.	1
Concerns about technology reliability and failure	Worry about the dependability of tech-based medication management devices	So you go the blister. Maybe the blister pharmacist is still there. You know, simple. You don't have to be concerned with any technology. You don't have to be concerned with a blackout, you know, through internet or electricity goes out. Yeah, that's another issue with the technology. Yeah. You know, unless it has, it's like a laptop that could charge it. When you plug it in, then you can use it. But that's temporary too. So that's another issue with technology, not the high tech stuff	3
		It has to work to be connected very properly because we're dealing with medication and it Makes us nervous. It makes me a bit nervous relying totally untethered on technology.	3

		It's all technology. What happens is, like, with with your computer, it goes down. You don't know what you know, like why it for failure. Now it comes back up again. What happens is the button start beeping at 4:00 and you were supposed to take your medication. 3:00	3
		Internet and such? No, not much of anything. Actually, I don't set my thermostat that way or anything else.	7
Lack of technology-based knowledge and age-related challenges	Struggle with using high-tech devices due to a lack of familiarity or confidence with technology.	Yeah. Just because, like I say, I'm not very savvy with electronic stuff. But ah, anyway. Yeah, it was. Yeah, it's kind of fun	1
		Well, I'm going to go back to my parents because they weren't very good electronic and they didn't have a phone. Neither one of them had a cell phone and never did. And I do. And I only a fairly recent user when I worked, I had a cell phone. And when I stopped work, they stopped. I mean, I'm pretty proficient at using my cell phone at this point in time. So having that might be more like more at my age where, you know, but for my parent's age, I have to say that they So it would have been in the 90s at this point and my dad would be 96, my mom would have at 92 or 3. Now I was constantly having to go down to fix her TV because they pressed the wrong button.	5
		You're in a bunch of Luddites like me that aren't familiar with computers that don't, you know, cozy up to the technology People older than me that aren't going to be as simple as, you know, your guy by the time you get up there will just all be so simple.	7
		I was not raised with technology, so that makes a big difference. I think, you know, for people my age, none of them work. They're (devices) too techy, and	16
		I can use my cell phone. Just the phone. Receive phone calls. But I don't know what all these buttons are for.	13
		I think I think they're wonderful for people who could cope with that. Lots of people here use computers that are	13

		really whizzes on computers. But then there's people like me that aren't.	
		No. Everything is far too advanced for me mentally. I'm not all that, so I can't even use a cell phone properly. So I need Something Simple like this. That's the one with the lid that comes up. I could never handle that machine.	13
		You're getting into a group of people who are older and not as savvy with their phones and apps and all that stuff like younger people are , and which makes . Makes this one good . Like , like I said , if you could take that right and make it more specific to the morning and evenings also or have something about it more than you just do .	22
		I'm old. No. I just think we're going to far with technology. I prefer sort of a hands on, like the dosette	26
		I just don't have that knowledge? I haven't learned some of this things for for the techie part.	47
Challenges and frustrations in learning new technology		But they would my mom would be looking at the laptop and she didn't know what she did. So they just get really confused about that learning when they're learning at a later part of their life. Right. And even I find sometimes now I get frustrated with learning too much new stuff	5
		Well, that's what the alarms about. I'm just glad I don't have to take multiple pills. But, you know, it's hard for me to grasp, you know, if I was taking lots of pills,	6
		Can't even get around to using a cell phone. That (Jones) would not be helpful for me. And I think as I got older, it probably wouldn't be helpful because I'd have to learn to use the cell phone.	10
Preference for Technology-Aided Medication Management	Despite challenges, some users prefer technology-aided systems for their potential to simplify medication management.	Like I think those you can put in a drawer and forget, I mean I think something's up there and it's going to ding and make it easier I think so I'm always in favor of technology that will help you.	17
		Yeah, I think mobile applications to remind you take medication. I think that would be the best because you could have it set up. So now it depends on once again, the	20

		individual	
		Well, I think this one I like this one (MedCenter). But I'd recommend the first one (Jones). Yeah. Because if it comes with like, you know, an app of some sort, then that would be easy to deal with.	20
Technology and Data Privacy issues	Concerns over data privacy and unauthorized access to personal information	I'm a little touchy on the privacy side, and too many people seems can get into that kind of thing. And baby monitors to temperature setting for the whole thing. Kind of scary.	7
Lack of internet access and using connected devices		Yeah . I find I go to places where the there is no internet . Right . Basically there is no cell phone or the cell phone is problematical . Mm hmm . So that would be I know the only one I would consider in any way would be the that center	
Key Accessibility Issue and challenges for seniors who may easily lose such items.	Challenges with devices which requires a physical key to open	You couldn't get the. I couldn't get the key to work. I couldn't get it open.	3
		The key is over here, and the unit is over here. Yeah. Right. But getting the key to go into the.	3
		I thought, what? you have to have a key to get in. But a senior could easily lose things like that is just an awful, awful device.	3
		Yeah, that key was silly too. I didn't know how to lock and unlock.	6
		First of all, you have to open it with a key. What if you lose the key?	8
		, I mean, it doesn't really matter where it is. It's just the fact that there is a key and that you have to not forget where you put it.	8
		The opening is very shallow. Yeah, you can insert the key inside. So we prefer like a regular key just to put inside.	19
		But the one with the lock (GMS). But if you're not at home then I don't know how you do the work around to get it to open early. Like for somebody like my brother,	19

		he wouldn't be able to know how to do that	
		I don't want it. I'm dropping it on the floor but I don't want it to be actually locked up at home.	18
		And the key . So that's where the key . Thing that first of all , get rid of that or . It can get lost so easily . I'm old , I drop it , it goes under the stove , it goes under the table , I can't get at it , therefore I can't get up my pills for the day . So yeah , that key is definitely I understand why it's there , but I don't think it's necessary .	24
Concerns about locking mechanism and preference for combination lock	Users express concerns about physical keys and show a preference for combination locks for ease of use.	Its not like a light switch, not on and off. It's just. Yeah.	3
		I would probably say this one (GMS) with the key and it having to tip it over to get the key in.	26
		A combination lock? That would be better than the key, let's put it that way. Okay. Because then even. Let's say you lose the key. Yeah. Now, what do you do? Now you got to get another one.	3
Simplicity in Locking System Preferred	A simpler, more user-friendly locking system is preferred to avoid complexity and facilitate easier access	So I could see having a lock or having some way to open it. But I don't think it has to be quite that difficult	19
Preference for lock on top	Users suggest that having the lock on the top of the device would make it easier to use.	First of all, if it could be locked from the top so that you don't have to turn it upside down like that just adds another. Trying to juggle how you hold it. So I don't know if it could be done from the top and if it could be done with a larger key, even that would make it easier to hang on to. I think it's a fairly tiny key.	19
		Would be better . But it's not . Yeah . Especially with your vision getting if , if it gets worse or if you're in like I'm .	21
		I don't understand why it even has a key (Medglider), but that should be at the top, not at the bottom.	26
		I didn't like the fact that it has a key. And that the keyhole is on the bottom. Like why isn't it on the top?	31
Need for	A locking mechanism is	Well, I think you have to have some security. Because	19

locking mechanism	seen as necessary for security reasons, particularly to prevent accidental or unauthorized access.	otherwise, if somebody was frustrated and thought they hadn't taken their pills or whatever, they might accidentally open it and take things they shouldn't be taking.	
		It is useful . You're getting to the point if you're at the point where you need alarms and clocks and reminders and you probably need it locked .	22
Alternative locking options	Users suggest alternative locking methods, such as codes, which might be easier to manage than physical keys.	Well, code would be good. But I would maybe remember it, but maybe somebody else might not.	8
Concerns About Childproofing features	Concerns about making devices childproof without making them too difficult for adults to use.	Well, grandchildren. Your grandchildren come in and look at them saying, Oh, those are those look colorful. So, so alone. Oh, yeah, you have to. But to make it childproof, it's a bit much. Or if you're going to do that, then have it someplace where it's easier to access, you know.	17
Durability of device material and chances of accidental breakage/damage	Users express concerns about the durability and potential for accidental damage of the medication management devices	So back to your point, with the children coming over and stuff like that, that too, could be because it's plastic.	3
		Yeah. I hated that thing. Oh, yeah? Oh, yeah. Correct. The round. The one with the blue cover. Yeah. Oh, yes. Hated it. Yeah. It's like flimsy plastic,	3
		Yeah, about this? Not the best idea to use cardboard for that. Really, it's not smart. You've got this plastic part that could've been engraved, which means it wouldn't wear out because you're not directly touching it. But with cardboard, the moment I open it and accidentally touch it, the whole thing shifts. Suddenly, it's showing a completely different day, and I didn't even notice	24
Visibility of medication inside device/compa	Being able to see the medication inside the device is important for users	So I guess the fact the you could see the pills and so on, like you could see them sort of in front of you, whereas with Spencer and the package and all that, you couldn't really see what you were taking, I guess.	12

rtment/packag e			
Dislike for Instructions in foreign language	Instructions in a foreign language can be a significant barrier to understanding how to use the device	We bought some of these like off pharmacy sites, Amazon. And one of them actually came with Chinese instructions, Japanese instructions. So even we couldn't figure out how to use it.	3
		Yes. Well I thought that all there was was Chinese. Like wrong language.	8
		The instructions are always unsatisfactory, I find. a camera or something like this small. It's written in 14 languages nowadays.	31
Difficulty due to lack of instruction reading	Users admit to not reading instructions, which can lead to difficulties in using the devices correctly.	And most people Often Don't do that. They don't read the instructions. When you look at it you think it's simple. You just push the buttons, and you say, I can figure this out myself. That's instead of taking two minutes and reading construction, getting to that point and some of the instructions	3
Unclear and incomplete instructions	Incomplete or unclear instructions can confuse users, making it hard for them to use the device effectively.	…it doesn't say AM and PM, you got to figure that out yourself. Okay. Sorry to hear. So so that Would confuse me as an older person	3
		Well, I've found some of the instructions were just not complete. But that's not just for these type of machines. Often they're in lot of instructions are not complete in this day and age.	5
		It was, well I found it and once again, not clear.	18
		Some of them didn't have morning afternoon evening and then also evening is not a good word. It should be breakfast, lunch, supper, bedtime. Because what's evening? Is evening when you eat supper or when you go to bed because evening is actually from six until about midnight around there. So it has to be that it's easy to understand.	8
		I find by and large, instructions for anything, no matter what you're getting electronic device or anything you get, are - they're not well done. Yeah, I do find it difficult	17

		sometimes to read them. I just don't understand why they they do it the way they do but they're all that.	
		But this one I found really confusing because well, first of all, when you gave me the device, the sides were actually already pressed in. Right. But the description or the visual image here is really the opposite of what you had to put it in. So I actually had it with that facing up, but it didn't work that way. You had to flip it over and then it worked.	20
		So this one definitely had something missing on it. I can't remember what was missing now, but plus it didn't really have any indication unless you put the little template on it and it didn't tell you to put the template on it unless I missed it. But in going through it, didn't tell you to add the template that we put on it that had the four times a day? It's not listed here as something that you had to use in conjunction with this one	20
		On on this one . You can barely see some of the the photos and the reproduction are so grey . That you can't really . Yeah . You can't really see what it's pointing at or where it is on the device . Like this line . Where are the . How do I find that line on here ?	24
		Well , you really had to read the directions . And it was complicated. Was it ? Well .	25
		This one said to set the alarm. It says push the alarm button one. Well it doesn't show you where alarm button one is so you have to push alarm and button one. It doesn't say that.	26
Lack of preference to detailed instructions		For example, the instructions that came with this thing I looked at and I thought, I'm not ready. No, no. But I mean, if you need an older person, if you need that many instructions for an item or that level, I'm not going to do it, I'll give up on it .	3
		. The one little thing like not all like it's too much to read.	8
Preference	Overly detailed	So five instructions would be ideal like "connect this",	3

for clear, concise and step-by-step instructions	instructions can overwhelm users, leading to a preference for simpler, more straightforward instructions	"open this". and that's it. Yeah, yeah, yeah, yeah, yeah. Let's not make it too complicated. Exactly. Keep it simple. Keep it simple. Keep it simple. Yeah. So not like this. Hated this.	
		If the instruction is like disbelieving, it has instruction to be just like. Giving the button one button to end editing. I order the instruction with like step by step one, do this or step two, and	5
		Yeah, the instructions were pretty good with this one, actually. You know, it was pretty good, that one. So it didn't leave a lot to, you know, sort of have to there was something missing and then have to figure out what it is that was missing.	5
		Probably written instructions except for we have the written instructions and we still couldnt sort it out but obviously written, Nice big written instructions are helpful.	12
		And on that one, I think just accessing the pills, which I guess if you had instructions, it would say, you know, pull this or do whatever. But I didn't know what to do. And then when I did, I pushed the thing back and the pill was stuck underneath and I didn't know where the pill was, blah, blah, blah. Yeah	12
		The dates of the month were on everything the date, year on day and dates were there and they were separated into morning, afternoon and evening.	9
		They're clear enough . But I'm a person that I used to rewrite product manuals and they type in one , two , three , press enter , type in four , five , six , press tab . So I'm extremely detailed in what questions is someone going to ask me ? Where do I go now ? So I write down every single step and this is pretty good	24
		Like, once again, it was this one because I found that the instructions, the written instructions corresponded with the actual product. There weren't any that were missed	20

		and everything was very, very clear. The batteries had the information in terms of how to actually insert the batteries, which you should know. But at the same time, it's always useful to have an indication that you're doing it correctly.	
		Well, I think that it was the fact that the instructions were accurate and they reflected exactly what the module had. It was also much more visible in terms of how pressing the buttons were.	20
		The description of the whole module identified exactly which number each section was. And then it went on to tell you what number, what button to press. So once you realized that that was number seven, then, you know, I think it would be really easy to learn.	20
		This one actually , this one was pretty easy . Yeah . With , with this . With these , with these instructions . They had , like , pictures step by step . That's exactly right . That's exactly right . And they didn't confuse you . They said step one and do that . Step two . This one is one six , seven , eight . And they're all over the place . And they're little . So , no , this . This was the most . This was the easiest use of it .	24
		But they just need to make sure that the written instructions are clear and they're okay.	26
Easy learning after initial learning curve	How users quickly become proficient with a new product following a brief period of initial adjustment and learning	The blister pack is that you just have to figure out which way do you push, hold it, you know, pull back a strip. And then it's easy then to to do it. But I think, again, it's you know, when somebody tells you what what it is that this particular oh, you figure it out for the first time, then you, you know, you're on your way after that.	5
		And it seems to set out the various pieces. Once you figure out that one little issue about the alarms versus you setting the time.	7
		Right. After the first time, you'll know how to open it. When I was testing this, though, I also had the same	9

		problem. I was like trying to open it, could not see the indent either.	
		I think once I got onto it, I think the setup of a lot of these things takes a bit of time and understanding. But once you got on to it, it would be easier.	19
		Yeah, once you get on to into the menu. Just finding the menu for some people might be a little difficult, but once you're in, once you've done it a couple of times, I think.	17
		Well, I wasn't sure if I was supposed to puncture it or remove the green tab and then puncture it. But, you know, once you know that, yes, this is how you do it, then it's just trying to figure out initially, once you know how it's done, then you would just do that.	20
		And you know and once you realize that that you put the package in was easy after that , you know . Yes . You know , you just go by the directions . Yes . But yeah , first of all , you might have somebody say , well , you put the whole package in . You know what I mean ?	25
Preference for picture instructions	Many users prefer instructions that include pictures or diagrams, finding them easier to understand and follow than text-only instructions.	Always pictures. Yeah the more you can add. The bigger it is and the more you can.	17
		I like this instruction, And the reason is it has a picture and where it's located.	16
		I definitely prefer. Yes, I prefer instructions that are accurate and that are visual	20
		Yeah . There was something that just showed me what to do , and that . Ones were Actual pictures . And if that was perfect , this was perfect . Yeah , that was perfect .	22
		This one actually , this one was pretty easy . Yeah . With , with this . With these , with these instructions . They had , like , pictures step by step .	24
		No, it's got the alarm bell on it. So I have that on my alarm clock so I know what that means.	32
Challenges with external online/video	Some users find accessing online or video instructions	But how you'd have to have a separate video for this, right. Like on your phone or whatever. Yeah, I guess it'd be handy. Yeah. But don't you see this all As soon as that	12

instructions	challenging, particularly if it requires additional technical skills or equipment they do not possess.	Youd need to have a certain level of technical expertise and a lot of people, especially older people, do not. So right off it's You just think, Oh, I can't do this	
		Not necessarily, because that would be too extreme. It would make it a much more expensive product again. And where there's no place for something like that here. And other than adding a CD or something to it.	26
		I can read it. The instructions. But about video I'm not really tech savvy.	47
Preference for external video instructions	Users appreciate having online video instructions available, finding them helpful for understanding how to use a device step by step.	And certainly I would think that with any of these that you would want to have something that is accessible online to accompany it, like a YouTube video that tells you how to step by step, you know, because when you actually see something being used, it's much easier than even reading it.	20
		Oh , you can for me ? Yeah . Interesting . I do not have a computer that takes a disk anymore . I have an iPad , and every time I say , Hey , Siri , how can I find here ? She gives me 3 or 4 different options and I find them all very confusing . So , yeah , no , I . Anything . Well , everything comes with the CD , and I don't have anything to read them with anymore , so it's garbage to me .	24
Challenges with internal video instructions	Difficulty in navigating internal video instructions, such as rewinding or repeating specific parts, can be frustrating for users.	Yes . The only thing is . Yeah . If you miss it . This is what I have problems with . If you miss it . How do you go back ? You have to start all over .	24
Colour coded instructions	Instructions that are color-coded can enhance understanding and ease of use for some users	Well, the instructions were all color coded.	9
Individual specific	Users acknowledge that learning preferences	I'm a visual learner. So for me I had to look on there to see it. But like I said, if somebody is not a visual learner	8

differences in choice of instruction type	vary; some prefer visual aids while others might learn better from written instructions.	and all they do is read, that's how they learn things.	
Preference for directly getting instructions from healthcare providers or pharmacist	Some users prefer to receive instructions directly from healthcare providers or pharmacists, finding personal demonstrations more effective for learning.	They're starting to just use pictures, which is not always somebody's strength in terms of. But what I do find is that, you know, you have alternatives in terms of, you know, you can go to your pharmacist and ask them if you bought purchased it through a pharmacy or wherever you purchased from. And most people know how to operate them. And I'm much better if somebody shows me first because I'm more patient in terms of how I learn things.	5
Similarity with other device of daily life	Familiarity with similar devices in daily life can make learning to use new devices easier, as users can draw parallels between them.	I have to laugh because of my second career in life was a professional cat sitter. I had my own business. So, anyway, so I looked at it and I thought, it looks like an automatic feeder because some my clients had an automatic feeder. Right. Same thing. And it just dispenses. Just dispenses You fill the sections with cat food as you do with the medication in that one. And then it moves. Oh, it moves clockwise or whatever to uncover that certain portion of food. I see. Yeah. So it's kind of like that. Very, very much like that. Like, here's your meds for the day. Same. The same thing. Same principle.	3
		I was able to follow the instructions quite clearly . And as soon as it got into the setting of the Times and everything , it's . So much the same as any other little digital clock that you really do	
Familiarity about how to use device	Devices that are intuitive to use or become familiar over time are preferred, as they reduce the effort required to operate them.	So it just just seemed more intuitive after I did the first one and kind of with the that one, that's not that one, but this one, after I did that one, I kind of knew what the timer and everything was. That was a piece of cake afterwards, right? It was just a piece of cake .	5
Importance of	Regular use of a device	Although sometimes I know people that, you know,	17

Regular Use for Ease and familiarity	can help maintain familiarity and ease of use, while infrequent use may lead to challenges in remembering how to operate it.	they'll send a picture, they'll send a picture on email, but then they don't do it for a month. "How do I send a picture?" You know, you just, you know, it's a whole new you if you don't do a lot. I think it's true for everybody. But if you don't do it a lot, you get rusty, it's not as easy to do.	
Lack of counter space	The physical size of devices and the need for placement space can be a concern for users with limited available space.	I actually see a lot of seniors, um, like us, we have a very small house, very small bathroom, and not a lot of counter space. Where the heck would we put it?	3
		Well, yeah, I guess, but it takes up a lot of room. I don't have room on my counter to begin with.	8
		Yeah, that's sort of the one downside of it is because it's for a month, right? So it is a little excessive in that sense. Like you'd have to have a lot of space at home.	20
		Yeah , the pill organizers . This is takes up too much room	24
		But at the same time, as I say, it just it takes up that area. And in places that we don't have a lot of counter space. And I don't know, this one's just bulky	26
		Yes. it's kind of large. It wouldn't sit on my table	47
		. I guess if it's a matter of right now , my pillowcases are quite small , quite manageable . It doesn't take any extra room . And I have my the pills of the container in a special place in the medicine cabinet so it doesn't take much room . That is just too big for my usage	62
Privacy considerations due to bigger size of devices and potential placement in private areas	The visibility of medication management devices in living spaces can raise privacy concerns for users.	So from a logistic or even from privacy like that's another thing, You know, do you want to keep your medications private, do you want anybody to see that?	3
		You'd never have company because you look at this thing and they think "these people are sick, i'm out of here "	3
		But you know, like when no. One it it's had an open concept so she wouldn't want it sitting out. She might put it in her bedroom or something where it's a bit more private.	5

		You would want to keep it so that it's easily accessible for you. But you're quite right. Like if someone came in, I don't know if I'd want everybody to know all the pills I'm taking.	20
Support from others to use/fill/set-up device	Assistance from others, such as family members or healthcare providers for setting up and using complex devices	If you had a lot of medications, what would you do? Like, and you wanted to dispense for like 30 days or say someone daughter came in and sorted out like 30 days worth of meds.	3
		If I had to you use something like that, someone else would have to be filling it for me.	10
		They're (devices) too techy, and unless they had a child that would come and set it for them. My grandson probably can set that. But for me, no.	16
		So and I think probably going forward, I would need to have some sort of device to help me and somebody could load it for me perhaps,	17
		And then when the thing is completely empty, I would hope to give it to the drug druggist, the pharmacist. And he would put the pills in where he would put in my blister pack, and then I would start taking them every day.	13
		It seems pretty good for someone who need that extra bit of help with their meds. But setting it up? That's another story. I think someone with cognitive challenges might struggle to do it on their own, so it's probably a job for a caregiver. And once it's all set, they'd need to figure out how to switch off that alarm."	24
Relying on other to organise medications- to avoid mistakes	Users prefer having medications pre-organized by pharmacists to reduce the risk of errors.	They're filled by the pharmacist, and all you have to do is plump them out. So organization is key because that is what someone else is taking over that function. That's right. Yeah, that's right. Okay. I'd rather have somebody else do that. So I'm sure I don't make a mistake. Yeah .	3
		And the general pharmacist did it. That would be good if I was taking multiple meds.	6
		Well, I think there's less likely to be a mistake if the pharmacist has organized it. And this if it's working well,	9

		as you'd like.	
		or you could do it yourself or somebody to oversee that you get the right pills at the right place because when you do it yourself, and you're a little confused. There's no mistake. You might be putting them in the wrong slot?	17
		Well, it's a matter of getting used to it. And I'm afraid I might tear off the wrong one.	13
Automatic communication with the pharmacist	Some users are interested in devices that can communicate automatically with their pharmacist for medication management	I guess it could be automatically connect to your pharmacist. Oh, okay. You know, I think I've seen that through your phone, too. I don't know if you can do that, but.	5
Availability of technical Help and Support	Access to help or customer support for addressing technical issues with devices.	I think so. I mean, it's like a computer. You know, you have to call the help line. That's all right. You	10
Preference for devices pre-filled/ Pre-packaged with medications	Devices that come pre-filled with medications from the pharmacy are preferred for their convenience and accuracy	And you didn't have to do anything on your own yet. You didn't have to organize your pills. Yeah. You don't have any of that. I mean, it comes from the pharmacy, right? Yeah.	3
		If I had to you use something like that, someone else would have to be filling it for me.	10
		This is as useful because although if your pharmacist puts them in that and it dispenses it at the right time of day, that would be very useful	9
		Yeah. Versus this device where it's already prepackaged by the pharmacy. And all you have to do is click a button and they'll just dispense	9
Prepackaged devices and inability to incorporate OTC	The inability of pre-packaged devices to include over-the-counter medications as a limitation for users	But also, when you take several over-the-counter meds that wouldn't be included in that. So that would just be a bigger problem.	26

medications	with complex medication regimens.	No, that wouldn't do either, because I take so many things that didn't come from the pharmacy. Well, everything from the pharmacy, but not by prescription.	47
Medication retrieval/access challenges	Difficulty in accessing medications from packaging or devices	The only difficulty I had was opening that. But there was an arrow that I missed.	3
		Well, I found that getting the medication out of that one harder.	5
		I just think those blister packs, you know, they can pop out easy.	6
		it's hard to get the pills out. If you want to get pill number one out, you've got to stick your finger down at the others so they don't all come out.	7
		Yes. Taking off the top to open to get into the blister pack. It is hard to get it all off and from the little square to get the pills out. Often I have to go back and pull and push around and get them to get the covering off to get the pills out. And that's why I thought your your one that you have a lid that comes up, you take your pills and you put the lid down, that would be perfect.	13
		So. Well, I think accessibility, like getting in, even getting to them. For example, I found that one awkward, so just that you can easily access your medication. And like the Spencer packet, I had a very hard time getting it open. May have just been me. But it needs a little, you know, like a little neck to pull. I couldn't find it. Maybe itsI there, but yeah	12
		You didn't mention the blister packs. Yeah, I guess there's some - have sort of a plastic blister like that. You have to break it open. Yeah, and they're awkward, too. And people can't. Break them. Some don't have to drill a hole in them, first of all. Then do it. I mean it's.	18
		As you can see for the Ennovia, it's pretty deep. If you were to only, like in the task, only get it for morning you'll have to like kind of cover the other sections. Yeah, a bit awkward to get into that.	17

Preference for automatic dispensing rather than manual retrieval	Automatic dispensing features are appreciated for their convenience and for reducing the risk of errors during manual retrieval	Yeah, it's nice in the things come out too. So you can actually you can just pull one out, instead of dumping half of it.	7
Easy access method by lifting a lid	Simple mechanisms for accessing medications, such as lifting a lid, are preferred for their ease of use.	Well, because you could lift the lid. Take your pills out and put the lid back down	13
Difficulty due to smaller font size	Small font sizes on devices and instructions and associated difficulties	There's little tiny writings and those little, tiny, tiny buttons that are like a millimeter, you know, less than a size is horrible	3
		Small font size. And it was just kind of confusing	19
		Sometimes you get this font that's like six point or something. You can't see that.	8
		Are you mean these numbers? Oh, no. Those are pretty small.	9
		Some of them you could hardly read like. The font is . Yeah .It was so small as an alarm and time and it was terrible . I couldn't hardly read it . Yeah .	25
		The instructions are too small .	62
Preference for large font size	Large font sizes are preferred for both device displays and written instructions for better visibility and readability	Yeah the writing on the alarm - the display was large, the font size was big.	10
		Nice big written instructions are helpful.	12
		And I think certainly for older people, the larger the font size, the better it is. So, yes, I found the display quite, quite easy to read.	20
		And the font is big . Yeah , it's bright enough . Is that . Is that . Are those all .	25

Concerns about cost of devices and government coverage	The cost of medication management devices and the lack of government or insurance coverage as significant barriers to access.	Spencer's going to because it's a very advanced technology. They're going to charge $50 at the least a month for anybody for who OHIP does not cover. So that's going to be a limitation For a lot Of people. Like that's a big. So if they had to organize, they would have to buy one of these. They're not great by any means, but this is the challenge we're going to face with that one was that the company that told me they're going to charge you	3
		Plus, it's connected to that cloud service that tells people whether you've taken your pills or not, but notifies you. Yeah. So that's going to be a big limiting factor, I imagine, because that's a lot of money	3
		I don't have a lot of benefits. Right. So I would you know, money's always an issue. I mean, the government only pays so much. So I don't know where that falls in terms of whether they, you know, they have what the government pays covers for the blister packs. Most of the time. My pain, because I don't use a lot of medication, but I do use medication. I don't even meet the requirement that the government expects me to do every year. So I have to pay out of pocket.	5
		One. But, I mean, if I was in person that was taking multiple ones, I guess that would be good. Must be very expensive, right?	6
		I wouldn't want to pay extra money, like I wouldn't want to pay $50 a month for something that's high tech.	6
		I'd recommend it to have somebody if I knew that they could handle the $90. You know, obviously they're seniors that are pretty tight. You know, the $90 might be prohibitive. Could it be on their insurance? Some people have private insurance.	17
		Started a few hours every, you know, five hours, and it just kind of built up. He took a variety of pills for different times. If we had gotten anything like this, it would have been a fortune.	14

		Probably not. If there was a system where there was not a monthly charge, I think I would probably tend to go with that	12
		No, if I had to pay for it though, no I wouldn't.	8
		It once again, depends on your income. Right. For a senior who is living exclusively off meagre pensions, either government pensions or very no pension. Yeah, that would definitely be difficult to handle. Are there additional costs kind of thing?	20
		Um , I just don't think it's practical . I know that this is going to be an expensive piece of machinery to have in my house . It's a subscription fee of , I think . Yeah . You know what ? Or people don't like parking with money . Parting with money . Believe me . And believe me , $50 a month . It wouldn't happen . It wouldn't happen	24
		So this dispenser is only cost prohibitive . That's the only thing I can think that people wouldn't use it .	24
		Spencer, but again it's way too expensive.	26
Willingness to Pay for a Reliable Medication Device	Users are willing to pay for devices that they perceive as reliable and helpful in managing their medication accurately.	And I would pay what I pay $100 a month for that. Because if I knew that it was very, very important to take the pills when they're supposed to be taken in, in great quantities. And it, it would all be set up, it would be sort of worry free. I think it would be worth it.	17
Preference for vibration alert	Vibration alerts are preferred	The way off is the pitch versus the volume. And you know, especially when you're carrying something around with you, it kind of like to be discreet having it go off in an elevator and everyone say, hey, what's that? I'm going to be bombed, you know, So it's but then, you know, if it's discreet, you might not be able to hear it. So that may be where on the spectrum it is to the vibration that could worked as well. You keep that in your pocket. At least you could feel it.	7
		Vibration is great. Yeah, that's what wakes me up in the morning.	10

		And something that would be good is something that you could carry the reminder with you, and it would vibrate.	10
Preference for Visual alert/reminder		The light if I saw it. Yeah, that helps. The flashing light helps. Since I don't hear so.	10
		But I think it's important because we don't all hear as well as you think you can see; I can't hear behind me as well as you know. So I think it's important to have an alarm that the volume can be adjusted and a flashing light reminder.	17
Voice Reminder as an Effective Feature for dementia	Voice reminders are seen as an effective feature for assisting users with memory impairments.	If there was some way you could record a voice in The voice said, Thank you. Take your 10:00 pills. And if the pills had not been removed in five minutes, like, take your 10:00 pills. That's what I find with Alexa quite often. You can set that. I can set that same message every two minutes if I want	14
Need for Attention-Getting Alerts	Users require loud and noticeable alerts to ensure they don't miss medication times.	As you noticed, my kids laugh at me. I have the loudest, most annoying sound on my phone because it gets my attention.	14
Preference for loud alarm volume	Loud alarms are preferred	The alarm seemed to be very audible.	9
Customizable of alarm volume	Ability to adjust alarm volume is preferred	But setting the alarm times, tones well there because sometimes you need a louder you need adjusting	17
		And how to shut it off I was setting the alarms because you can do it for loud and extra loud was helpful.	10
		I would think that as long as they're adjustable. These aren't, . think it helps if they are adjustable and if they go off with a flashing light also, you know, because - But I think it's important because we don't all hear as well as you think you can see; I can't hear behind me as well as you know. So I think it's important to have an alarm that the volume can be adjusted and a flashing light reminder	17
		They're not necessarily going to pay attention. That with Alexa. The advantage also is you can adjust your volume	14

		higher and lower. And if she wants something with a volume, adjust	
Alarm frequency customization	Ability to adjust alarm frequency is preferred	. I can set that same message every two minutes if I want.	14
		You are able to set it for the four different times during the day.	20
Portable alarm	The concept of portable alarms are favored for their convenience and the ability to carry reminders	And then you've got to set the alarm. If you're nowhere near the alarm, the alarm could go off forever.	3
		And something that would be good is something that you could carry the reminder with you, and it would vibrate.	10
		Yeah , Yeah , actually . And I think of it , people who use their smartwatches are programmed your pills and or have someone do it . Because it's on them. And it's on and they're and it doesn't , they don't take it off . Mm . Yeah . It goes in the water , it goes to bed with you you know .	24
Consideration of individual needs for alarms and medication reminders	Medication reminder needs vary among users	I like alarms. I think that's good. Like when, if and when I have to take lots different times. Yeah, that would be helpful. But as I said now I just take everything in the morning and the set, so. Okay.	8
		For me personally, because I don't have complex needs, then I would be looking for just something very simple that would remind me that I was needing to take my medication at a certain time.	5
		But I think sometimes people do need to be remembered because I think sometimes when watching my parents who did take some medications but not not a really complex regimen of medication, I don't much think I saw my mom sometimes say I'm not sure I took my blood pressure pill this morning or not,	5
		So I think everybody's needs are a little bit differently. And then I think it depends what your particular needs are in terms of do I need an alarm or can I do I use you remember that I take my pills at first thing in the morning and last thing at night ?	5
		Right now it would be a little complication with a timer	62

		on it that I don't feel I need actually I don't want and it doesn't give me anything extra . Okay .	
Alarm for every compartment	Prefer devices that provide specific alarms for each medication compartment	This one I like because it would have alarms going off for every compartment that one can go to .	5
Preference for AM/PM Format Over 24-Hour Time	Users find the AM/PM format simpler and less confusing than the 24-hour format	Setting and checking alarm times, time to 24 hour formats. Well, don't do 24 hour formats because that confuses people. I think older people, are not used to. So I think you need to have a good size, AM/PM, but pretty well, like I don't know anybody who can't tell the difference between 2 a.m. and 2 p.m. That's pretty straightforward. Is that like. Like my. I got things. I got a microwave. Yeah. You know, they want me to put on AM or PM Well, I think I know if it's two in the morning, or two in the afternoon. But for sure not the 24 hour thing. So I think that that's difficult	17
Phone alarms		So it'd be easier for me to take a small pill container and set an alarm on my phone to say, "Hey, take your pill" sort of thing. So I don't know, but that's me	19
		I would learn how to set my my alarm on my phone and have my phone with me. Usually I have my phone with me.	6
		But if you're comfortable with using an app on your phone or even having it set up on a watch, then it's right there. It sort of notifies you right away. Whereas if an alarm goes off and you're doing something outside. Mm hmm. You don't hear it necessarily.	20
Daily routine		I get up in the morning, my pill container is on the dining room table. So when I have breakfast, I usually notice that and take them. That's my morning coffee. Okay. And in the afternoon, my cell phone goes off at an alarm at 3:00 and hopefully I have the Tylenol with me. So that and water because I can't take those without. And then at 745, my husband in his pill containers, I put my pills.	19

		And so when his alarm goes at 725, I take my pill out of his container because he always has to have with them. And I take two right away and then I save the other one until bedtime.	
		And if I don't put it literally right in the middle here in the table, I'll forget to take it. Okay. It has for the regular medication which I've taken for years, is in the bathroom, has its own little spot. And I go to bed at night. That's thing I do. Pull them out and line up the bottles. So in the morning, first thing you see when you go in and oh yeah, you gotta take your pills. Where the other one, If I'm having a company or somebody come over for dinner, you know, you straighten things out put the bottles away then I can forget it for a day or two and think where are those?	14
		I take them right away in the morning . Okay . And then I take more in the evening . So I put the other . I had that . I have a container . I was telling the girls , you know , morning and night . You know , the pill box . Yeah . And I put . But I put them on top of a because I want to take four at night . And I find that if I put them inside , I forget to take them .	25
		We take them at breakfast, lunch, dinner and bedtime,	26
		Well, I had them filed, so I take some in the morning. And some in the evening. And some at night, at bedtime.	47
		But a typical day , you get up first thing in the morning and I take my heart medication . So as soon as I get up ,	62
		Yeah . And I think that I take my vitamins as with my breakfast , usually with breaking that up into before and after my breakfast . And then I don't take any more pills than until just before I got it that I just before I go to bed , I take the cholesterol and a hard place medicine . Hmm . So those are not it's not working too badly . But every once in a while I do forget that little of that and . Mm hmm .	62

Alexa		I highly recommend. Recommend Alexa or a similar thing to any senior.	14
Watch with alarm		Well, if it's all the time, I guess I just have to remember. All right, I probably get a watch that has an alarm on it.	8
		. If I'm working out and I know a lot of people have alarms on their watches , especially if they're wearing smart watches . So I do know lots of people who take their medication from their smartwatches .	24
Dosettes		Just a little, little box. And I do take it four at a time, so there's eight in there. So let's say Monday, Monday, Wednesday. So I know what day and which way to go. So, yeah, that's the only thing.	17
Keeping medicines in easily noticeable locations		Or you know what I would do? I would put it on my kitchen table. When I eat, I say, Oh yeah, I'm eating supper. Gotta take this.	8
		You just I keep I have two medications . I keep them in the kitchen above the sink so that in the morning I have my breakfast . I take one pill that I take every day and the pill that I take once a week , I take out the night before . Usually I take them on Sunday . I take it out on Saturday , leave it on the counters that I know . I have to take it on Sunday . Right .	24
		I have them on my counter in the kitchen container , and I put them all out for the morning	25
		I keep my pillowcase right there . So I think by talking to the blood pressure and the blood thinner right away .	62
Phone Notification		Probably, because once this alarm goes away, it's gone right notififcation is inside your phone, It's presumably there. You tap on it or whatever. Yeah	12
Preference for simple design	Preference for simplicity in device design which is easy to understand and follow	My mother's was a whole concept and just it was a clear case that said. Morning, noon, afternoon, evening or something like that. It had little issues on it.	6
		For me personally, because I don't have complex needs, then I would be looking for just something very simple that would remind me that I was needing to take my	5

		medication at a certain time.	
		I'm getting to the point where for my own getting a little forgetful, so I would probably go to some version, probably not even the electronic version. Just set out a regular blister pack. Yeah, I like that one. Yes.	6
		So it'd be easier for me to take a small pill container and set an alarm on my phone to say, "Hey, take your pill" sort of thing. So I don't know, but that's me.	19
		It's effortless. You don't have to think about it. You just just have to figure out what it is.	17
		No. I can't handle many things. No, I need simple things.	13
		I prefer uncomplicated things. Sometimes people and companies complicate things so much when they don't need to be complicated.	8
		Though, they want it really big and fancy and they figure, Oh, wow, this does this and this and the people will love it. But you know what? Sometimes you don't need something so complicated.	8
		the less complicated, the better. And you know, for me, so not too bad, but somebody who's getting a little bit senile or Alzheimer's or forgetting things, the more complicated, the harder it would be.	8
		Yeah . No , that's just too much . Yeah , that would be mine . So if I had to pick one of them , I'd pick this . But I Wanted it to Change…Okay . So just better labels . Better labels and not have the the alarm . Timer so quick , you know And also fix this . Yeah , yeah , yeah , yeah. And make that set your time first , because you have to have the time before you can have an alarm . And then . So this should be step one and this should be two and it should be three . And then I think that that would be the one that would be the most user friendly to me .	22
		Yeah . And I know a lot of people like the simplicity of that because you press a button and it gives you the dose that you need to take for all the medications at the	25

		specific time .	
		Well, you just have to push the button that tells you to and, and it dispenses.	26
Preference for Larger display/screen	A larger display on devices is preferred for easier reading and interaction	Well, I suppose larger is better just because it's easier to see. Yeah, this one wasn't too bad, but yeah, it definitely is small. All right. Yeah	12
		Like that's the big advantage to Spencer how you feel because it's a fairly big display and it's a fairly big area that you could touch. And so I think that would be way easier for him	19
		Like that's the big advantage to Spencer how you feel because it's a fairly big display and it's a fairly big area that you could touch. And so I think that would be way easier for him	19
		Well, the display was definitely quite clear. It was bigger.	20
		Well , seeing as I don't need glasses to read these displays, but most people my age do need glasses to read anything that small and I don't know . Yeah , I can see them going like this .	24
		The large display It was large and easy to read.	26
Challenges with Small Display/ screen size	Difficulty to read and interact with small screens	Well, just small displays, smaller displays are trouble.	17
		"These are too small for the screen. Small... That one wasn't as bad. That one I could read easier."	14
		The displays are too small. My eyes aren't good.	47
Importance of display contrast for people with vision problems	High contrast between text and background on displays is preferred	But you know, like I'm fairly early stages macular at this point, and one eye is not as bad as the other. But I do have cataracts that are developing as well. So I need I like to have contrast. That is a good contrast from here. Just because of the light background and the black lettering. People really forget about that in terms of how important that is in terms of sight, the contrast is sometimes between cataracts and macular or whatever. As people are aging, the contrast is actually much more important sometimes than even the font size.	5

High contrasts display		Easier, but better buttons and brighter letters, you know, like, wasn't easy to use because you couldn't even see them that clearly on the display.	20
Light inside display	Internal lighting in displays is appreciated	And then right away , there's a light . You can shine it right away . You can set the . You can turn off . Right . So . And you not only hear that , so . Yeah , I know . I . That's an asset , I would think , to older people	24
Colour preferences on devices	Users prefer devices with bright, distinct colours that stand out	. It's like anything that's different than what you would have like I would use maybe bright yellow or you know hot pink or something that's different than your regular stuff.	8
		You mean the appearance of it? I suppose the color on here matches the color on the instructions, which is about the same. I	9
		It's the colors make it easy so that anyone should be able to read with the dates and	9
		As you get older, your eyes have a hard time distinguishing colours. So golden brown. I think this is a brown, ruster, maroon or whatever dark colour. That's fine,	8
		One because they have things in different colour. Mm hmm. Ours? The minutes on those Roberts minutes. Hmm. They should also. My suggestion would be on the top two. The alarm and the bell on the right. Put them in two different colours.	14
		No , no , I like that different colors . It just . It's easier . Mm hmm	24
		Exactly. And the colour too, it should be a colour that stands out, not blend in.	26
		Yeah it's helpful to have different colour buttons.	47
Problems due to same colour fonts	Difficulty arises when fonts and backgrounds are the same colour	Oh, actually, one of the vials that I didn't know how to open because I couldn't read the instructions because it was just embossed on there, not rather than different colour.	8
		It's kind of hard to see the numbers . Right . Like they are	21

		raised , but it's the same color as the background .	
Need for labels		I want labels. I'm a real label person.	8
		You start here. Did your extras or something? I don't know. Or you forget something. Yeah. The more labels you can have, the better.	8
		Yeah, exactly. And it also it has, like, the labels for each time for the day.	10
Customizable labels	Ability to customize labels and times, catering to individual medication schedules	Because morning, noon. Okay. You have evening bed or evening? You mean 6:00. So if you took your pills at 12, the symptoms like five hours, it would be better if the Times could be clustered. Yeah, like we can change the time and labels	14
Interactive feature of device	Devices that offer interaction, such as talking or providing feedback, are appreciated	Yeah, because it talked to you and it was interactive and it was nice and not frustrating.	8
		Yeah, it wasn't annoying, but on a regular basis I'd probably have something to say to it. But I mean, it's obviously in that it tells you when your next alarm is going to go off and, I guess as long as you have it set up properly, it would be very helpful.	9
		So we started to say, Your girlfriend is talking to you, and then he would pay attention to. But then they knew what we were talking about.	14
		Yeah, I found that very difficult just to deal with physically. Yeah. So I found this one was very good because it had the feedback.	20
		So , you know , I don't know what my future is going to be like , but this one interacts with you . So , you know , I like I like that about that one .	20
Talking feature to help people with visual problems		It reminds me more of which is interesting of - for people with difficulty in seeing because those in IP have clocks and you press things and they'll talk to you and stuff like that.	10
		There were voice commands. And also you could confirm that what you had done was correct. And I found it easier to manipulate, like to go back and forth.	20

		I did . It was too loud or , like an annoying know. You know, it reminded me of this lady I help out. So every week she could hear that . She could hear that . And it's more productive for her to hear it than to see it being because she'll be watching TV . And these are in the kitchen with her pals . So and people with lifeline systems , you know , they all have they all have voice activation . Mm hmm . And they're allowed so that they can catch that person wherever they are , you know ? Yeah , I've seen that happen , too . So , yeah , no , I think I think for an older person , this was the best that the med center was the best . Alarm .	24
		Numbers . I can . I can press the button 23 times . Yeah . Without her telling me or the . The the alarm . Yeah . I mean , what it is when I stop pressing the button . Yeah . Okay , Come on . With the telling me what I've got . I've got a confirmation .	62
Challenges due to physical impairment	Physical challenges which could influence the proper use of devices	Yeah, just to rotate it and open it for you. I mean. Yeah. Or pressing, like, which would what? What would be more easy for you? For manipulation? Like, for arthritis. You have arthritis. So it was.	8
		That you have to really have a lot of dexterity. And older people, myself included, don't have that. It wasn't set up, I don't think, for older people.	12
		even the battery to insert the battery. It was a very deep and it was a deep compartment. And I have arthritic arthritis in my hands and a very small little connector that I was trying to get into, a very deep compartment. So I found that very hard.	5
		But you know, pills, you have to line them up and if you are narrow and do the bottles well, but it's simple enough to do something like that that you just turn something over to the lines up and click it. And try if your hands are a little shaky, to put that in.	17
		But I can't imagine how it could be . No , because if	22

		you're . If you are shaking or have tremor, you're really likely to make mistakes . Yes . Through the bite and . Also with the time and the tiny buttons . Right . Yeah . I'm kind of going .	
		You know . Right . And then when you have to take the medication , well , dump it . Yeah .You've got to use that key and get it in.	
		What else ? Oh , these little ones . These little things really hard to open . I know that . I know that over time , they wear out . Yes . But , man , they're hard to open . And if I have arthritis , I'd never get them open .	24
		And I don't know, this one's just bulky. It's hard to move like, I have arthritis in my hands.	26
		Well, in the case of this, yes. If you could just open one of the compartments. Yeah, that would work. Just a flip top for one of the compartment and you would have your numbers on the outside of the lid, and that would work.	26
		Well certainly I think it would be easier to have the buttons more accessible. I just found it physically difficult to a) unlock and then to lock again. Physically, it was very difficult to to manipulate.	20
Challenges due to vision impairment	Vision challenges which could influence the proper use of devices	Maybe if you. Yeah, maybe if you had a bit of a vision problem. More than I have, it would be more difficult.	12
		For me, I can't see what they are - I can see that there's something there.	47
Challenges due to memory impairment	Memory challenges which could influence the proper use of devices	Oh, yeah. But He's got dementia. He Can't handle. Anything.	13
		And that's why they have these, But they have the, the the problem is they're going to ignore it They just have To. They'll ignore it totally Mm hmm. Why is it I mean, like, if they hear the sound, they will not try to switch it off or something.	14
		This thing? Way too small. It's just not going to work for someone older, or anyone who's got trouble remembering	24

		things. Like, who cares about the exact hour for taking meds if you can't even remember what day it is, right? I might set my mind to take it at 10, but then decide to just do it at 7 because I'm worried I'll forget by 10. So, this tiny gadget? Not a fan. It's not friendly for folks who are getting on in years. I mean, I do like how it gives out the pills. That part's cool. But the lock on it? That's a headache waiting to happen."	
		I'm not going with technology . And I when I quit working , I decided I wasn't going to try to learn too much . I just like I have a flip phone that is never on . So , you know , I don't I don't work with technology well . I get very frustrated easily , so and I can't see that improving as I age . It'll only get worse as I age . Now , a lot of people who are aged have children or grandchildren who will come and program their TV and program their phone , and I don't have any of that . So I just don't do it .	24
		And I don't think that that's , you know , the time that I start needing that kind of help . I won't even be able to respond to all this stuff on .	21
		Because if I didn't have a key and I had cognitive issues and I was trying to get at my pills again, you'd smash it if it was really important to you	19
Challenges due to touch impairment	Touch impairments which could influence the proper use of devices	Yeah, with neuropathy, it's hard to tell if you're pressing hard enough.	16
Challenges due to hearing impairment	Hearing impairment which could influence the proper use of devices	What I use is very simple . I use my cell phone for cell phone for keeps , for texting . My . My family . I don't hear too well . I use the phone because it connects directly to my ears . My hearing aids . Yeah . So I can hear much better . I use it to control my hearing aids and for a few other little things , but for For pill taking . Complex .	62
Environmenta	Users are concerned	Well, it seemed like it just doesn't make sense. But it	12

l Concerns	about the environmental impact of disposable parts of medication management devices	seemed like a lot of environmentally unfriendly stuff. Like each time you get your pills, you've got this little plastic packet and we're trying to cut back on packaging. So whereas in this you know, you put them in. They're there. Mm hmm. Yeah. So the little, little packets, I think. I think I can see where a lot of people, myself included, would not be happy with those	
		Well, the tops that you take off then what happens to them? So you just discard them into the garbage.	13
Power source preferences and concerns	Concerns about battery life and the cost of replacements highlight the need for efficient power sources	but then you have to think like you're using battery power, right? So how many batteries in there? You know, it takes more power, right?	12
		If I hate this is the battery that goes with it. What happens when you need a battery and you know when you need a battery, you got to put it in. And so I say here is not going to want to go out and get a new battery right on this. No, it's probably the $50 battery	3
		So first thing was , um . They were all they all use batteries as power . But I think when the batteries die , I never have any to replace them . You know , like and I think most people don't keep batteries .	22
Medication intake tracking	Features that allow family members or healthcare provides or caregivers to track medication intake	So that's a good idea. That's it. Yes, it does help the family track if. Yeah. If someone is taking it or not.	16
Less number of steps to use	Preference for devices with less number of steps to use	Because Jones's doesn't have many steps and technology and all that. Whereas these guys, you have to set alarms, too.	16
Lack of user-centered approach in designing devices	Concern that devices may not be designed with the end user in mind, especially older adults with various impairments.	None of them were that easy you know. You know you to get those small buttons and whatnot. They're not they're not that easy and taking the pills out is not easy. They're difficult to take out with like you said they're they're designed by young engineers that aren't thinking or thinking the end user as much as they should sometimes.	17

		So I think that sometimes people they make a product that they forget about it and say "I'm done, you look after it."	17
		. I think all of them could get some rethinking and to think about the users - sometimes the engineers who design those they able to ease of use where they say, well, this is what I do. So I think you'd have to rethink all of the thumb or a finger that hasn't been on a phone for years and years. And this never texts, you know, and now they're born with thumbs that work, right?	17
		. I think it depends where ou are. Oh, you can use your dexterity, and clarity of mind, sight is another another one. And hearing. But yeah, you can get around that.	10
		The second thing I noticed with almost all the devices, except for one (referred to as Spencer), was the menu layout. It is a concerns for people with larger fingers or hands. It seemed like most devices weren't designed with them in mind. I felt that if my fingers were larger or if I had pudgy hands, I would struggle to set or use these devices	24
		I was thinking about my parents , and I'm like , my parents would never be able to fully , you know , figure this out . And often people who are developing these are younger engineers who've been given the task . So I'm really grateful that you're helping us show everybody that , you know , these are not helpful , that we need to design better . We need to involve our older adults when we're designing these products so that it can actually help them at home .	25
		Not fiddle around . Well , I found that their their iPod connection , I found out I find those things very frustrating because as a computer professional , when I see somebody developing something and putting it on the market and they really shouldn't because they should have done a lot more research and testing the people who are going to use that first . Yeah , it's . It's not very user .	62

		Friendly . Frustrating for a professional to have got that . Okay . And I find that not only with these things , I find that with our website designs . Yeah . I mean I go online and I see the website site and myself . Oh well what are you doing ?	
Diverse Needs and Preferences	Devices may not be designed with the end user in mind, especially older adults with various impairments.	Because not everybody is the same. So depending on what issues they have. Some would work much better. For some. Than for others.	10
		The only thing I find with this, it's fine if you take four times a day, but anybody who has to take it more than four times a day, you know, it doesn't seem like good jobs.	14
		Well, it depends on the individual. For me this would actually work, this would be the easiest to work with because I only take one pill twice a day and the rest is just singles. But for someone who is taking, you know, multiple pills at specific times of day, then that one is definitely more useful.	20
		And that to me would make the most sense to have two weeks . Just really you don't need I don't need maybe some people need all of these times in the day right . For me I just need two times .	22
Preference for traditional methods of medication management and Resistance to adapt to changes	Users prefer traditional methods of medication management and show resistance to adopting new technologies	She's like me, You got the pill bottle. That's what you need. That's all you need. I don't need any of this. Yeah, I just need the pill bottle and know	3
		I'm not sure what her I think with her she hesitated sometimes to learn new things…. I find that as I get older, I've said in my way, this is what I do. I do my laundry and Monday I don't do it on Tuesday, I do it Monday. I don't want to change. Don't make me Change.	3
		But yeah, every day you got to fill itI. So you're going away on holidays. You take this with you, but you still got to take all the pill bottles with you to fill it up. So if	3

		I'm going to take all the pill bottles with me, I might as well just go by the old method that I used.	
		Because it's got the dates all there . It's got the time , all there . And so , you know , and I think it's a week . Yes , yes . For a full week . So every Sunday you can take things over and organized because for me I've got my morning ones , but then I also have a night time .	22
Age-related differences in learnability	Recognition that ability to learn new technologies may diminish with age	Maybe the best blister packs for that. I mean doesn't itI come a time though you know if a senior gets very very can't really care for them. They don't have the capability to do anything like this for themselves that they would need someone else to do it. Nevertheless, for them, like a caregiver or what have you. So, so, so this is more targeted to seniors, I suppose, like us, that still have the wherewithal and maybe a little bit because there is learn ability involved	3
		Like you said, you know, you get to a certain age or not everybody ages the same, but some people may find it really challenging to learn a new system. Right?	3
Prolonging home stay through effective medication management	Devices can prolong the ability of seniors to live independently at home.	Yeah, but if you are capable of doing it, then we want to make sure that you find the right thing. Yes. Yeah. And that you can use that for as long as possible, which allows you to stay in your home really late.	3
Complexity in medication regimes and the need for devices	Devices that simplify complex medication schedules are highly valued, especially for users taking multiple medications at different times	So but if I think if you had like four times a day that you take your medication and it and they vary, they're not even the same. Yeah, they're not even the same medication. So the you know, I'm picking a, you know, red pill at this time and a orange peel at this time and two white pills at that time. And it's it just gets too complicated. So that kind of simplifies that whole process at that point, I think	5
		Now, it wouldn't work if you were taking a lot of pills, like a lot of different medications. But I think it would	20

		work if, you know, you had a certain number. I'm not sure what. I'm not sure what the average number of medications.	
Appreciation for advancement in technologies for medication management	Acknowledgment of the potential benefits of technological advancements in medication management	You know, it's always something that advances, and that's where having an appeal. But getting to know what they took it or not, that's that's where we should be looking at ways of doing that. You know, I'm sure there's a lot of people, a lot of people thinking about it. Without putting a treasure on the people that go down and, you know, lets somebody in Silicon Valley know that John took his pill. It'll come to that, I suppose.	17
Limitations and need for devices	Devices need to consider the specific limitations and needs of their users	Like , if I was if I was a paraplegic or something that , you know , in a wheelchair and stuff like that , I could see myself for years and years having to take meds , and I could see myself needing that stuff in my home .	21