Towards a Theory of Visual Concealment

by

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Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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Abstract

The goal of this dissertation is to take initial steps towards understanding concealment behaviour and ultimately developing a theory of visual concealment. Since there are relatively few studies of concealment in the literature and given the natural relationship between search and concealment, five strategies used in the development of traditional visual search theory and scene-based search theory were applied to the study of concealment. These strategies are: 1) establish a methodology, 2) identify dimensions, 3) categorize dimensions, 4) prioritize dimensions, and 5) integrate results into a theoretical framework that may involve inferences about the mechanisms involved. In Chapter 2, participants placed target objects within luggage in locations that were easy or hard to find (i.e., the placement task). Participants' subjective reports of their thought processes and strategies were analyzed to identify dimensions that are important during concealment in real-world settings. Once a list of dimensions was generated, the dimensions were then categorized into three categories: Stimulus Properties dimensions such as visual similarity, Embodiment dimensions such as confrontation, and Higher Order dimensions such as schema. In Chapter 3, the dimensions uncovered in Chapter 2 were used in a forced-choice task, and participants' choices were evaluated to determine whether the dimensions affected hiding behaviour. To further develop the methodological techniques available to study concealment behaviour and to examine the generalizability of previous findings, in Chapter 4, the placement task was used in another context – an office environment – and the locations chosen by participants to make objects easy or hard to find were coded on relevant dimensions. In Chapter 5, an initial attempt was made to prioritize the dimensions. The forced-choice task was used in a new

way to explore the relative importance of the dimensions by examining which dimensions participants chose to use over other dimensions. Finally in the General Discussion in Chapter 6, an attempt was made to integrate available results and previous theories and to make inferences about the mechanisms involved in visual concealment. Methodological considerations and future directions for the study of visual concealment are also discussed.

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CHAPTER 1: INTRODUCTION

People are often very good at placing objects in their environments so that they are easy or hard to find. For instance, people are inherently good at leaving a colleague a note so that it is easy to find, or at hiding Christmas presents so they are hard for their children or spouse to find. While these types of behaviours are common throughout our lives, relatively few studies have examined how people conceal objects and the strategies that people use when concealing objects or when making them easy to find. The overarching goal of this dissertation is to take initial steps towards understanding concealment behaviour and ultimately developing a theory of visual concealment. However, given that there are very few studies on concealment in the scientific literature, how would one go about constructing such a theory?

While visual concealment has received relatively little attention in the literature, what has been studied extensively is how people search for objects in simple computer displays (i.e., the classic visual search literature) and in real-world scenes. Naturally, visual search is often conducted to find something that is hidden, and therefore visual search and visual concealment are inextricably linked (i.e., objects that are well concealed will be harder to find). Smilek, Weinheimer, Kwan, Reynolds and Kingstone (2009) have suggested then that visual search theory can be extended to form the basis of a theory of visual concealment. To this end, two bodies of literature - the classic visual search literature and the related area of searching within real-world scenes – will first be briefly reviewed with a focus of examining the general strategies that have been employed in the development of search theory. As part of the review, several theories of search will be discussed. It is hoped that the examination of these more established fields of research will provide insight into the strategies that can be applied to the study of concealment behaviour and ultimately the development a theory of visual concealment.

Following the assessment of the strategies used in the search literature, the few existing studies of hiding behaviour will then be reviewed to examine what has been done so far in the concealment literature.

1.1 Visual Search

Consideration of the visual search literature with the goal of observing how search theory has been constructed reveals that there are a number of strategies that have been employed. These strategies include: 1) establishing a method to study visual search; 2) identifying dimensions that affect search and then compiling a comprehensive list of factors; 3) categorizing the dimensions; 4) prioritizing the dimensions into a hierarchy; and 5) theoretical integration that can involve inferences about the mechanics of visual search. These strategies have not necessarily been applied in a sequential fashion, as information gained from the application of one strategy will often inform other levels. For example, the formation of a new theory or theoretical framework based on available data may stimulate new research that identifies more dimensions. These new dimensions might in turn require the hierarchy of the dimensions to be updated or further alterations to be made to the theory; therefore the process can be quite cyclical. Each of the five strategies will be discussed in more detail below.

The first strategy employed was the development of a method or technique to be able to study visual search. Studies of visual search have traditionally involved participants looking for a target object that is embedded amongst a number of distracter items in a computer display. The target object can be defined by a unique feature (feature search) or a combination of features (conjunction search; Treisman & Gelade, 1980). An example of a feature search with colour as the feature would involve the search for a green circle among red circles. An example of a conjunction search using the features colour and shape would be the search for a red square

among green squares and red triangles. Successful conjunction search depends on identifying objects with a certain conjunction of features (red AND square). The amount of time required for participants to indicate whether the target is present or absent (i.e., the response time), or the accuracy with which participants make this decision, can be measured. The number of items in the display (i.e., the set size) can be varied to allow for the measurement of the efficiency of search. While search difficulty is generally measured by overall response times, search efficiency is obtained by calculating the slope of the function relating response time to set size. Varying the set size in feature search will typically not affect the amount of time required to find the target and the search slope will be near zero. In contrast, in conjunction search, typically the slope will increase as the number of items in the display increases. The relationship between the target and the distracter items can be varied on certain dimensions and the key question is how the dimension affects the overall response times and the search slopes.

Once a technique was established for the study of visual search, the second strategy was to identify dimensions that affect search difficulty or efficiency and to start building a comprehensive list of these factors. One important dimension that was identified by Treisman and Souther (1985) is how the presence versus the absence of a feature affects search. If a participant is searching for a circle that has an intersecting line through the middle of it (i.e., the presence of a feature) among a number of regular circles (i.e., absence of a feature), it does not matter how many items are in the display, meaning that the presence of a feature does not affect search efficiency. However, if the target is the circle (i.e., absence of the feature) among circles with lines, the time required increases linearly with the number of distracters. Factors that affect search difficulty and efficiency have been tested across a spectrum of complexity, from simple visual features such as colour and shape (e.g., Triesman & Gelade, 1980), to three-dimensional

shapes with more complex properties (e.g., Enns & Rensink, 1990), and also higher-level stimuli such as meaningful faces (e.g., Eastwood, Smilek, & Merikle, 2001) and semantic information (e.g., Moores, Laiti, & Chelazzi, 2003). For example, Eastwood, Smilek and Merikle (2001) had participants search among neutral distracter faces for the unique face expressing either a positive or a negative emotion. Search for the negative faces was more efficient than search for the positive faces. In a subsequent experiment when the faces were inverted to reduce holistic face perception, there was no difference between the slopes for locating the negative or positive faces, suggesting that it was indeed the perceived emotion that was affecting search efficiency and not some lower level visual difference between the two types of faces. One example of an attempt to compile a comprehensive list of features affecting search was done by Wolfe and Horowitz (2004). While the focus of Wolfe and Horowitz's review was on the basic features that guide attention, a list was created with all of the basic features that had been studied within the visual search literature.

Once a list of dimensions has been generated, a third strategy is employed, which is to categorize the dimensions. The features affecting search have been categorized in different ways. For example, there is differentiation between bottom-up, stimulus driven, exogenous factors and top-down, goal-driven, endogenous factors, and there has long been a debate within the visual search literature about the relative role of exogenous and endogenous attention in visual search. Bottom-up activation for a location or item is based on the local differences between that location and its neighbouring locations within the search display, and does not depend on the participant's knowledge of the specific search task. The more an item differs from its neighbours, the more it will stand out or "pop out". For example, when detecting a salient target using the "odd-man out" paradigm (i.e., without prior knowledge of the target),

participants were able to detect targets defined by either colour, motion or orientation (Northdurft, 1993). Indeed, a large majority of the visual search literature has examined these stimulus-driven attributes such as colour, motion, orientation, size, luminance onset, and shape (e.g., Wolfe & Horowitz, 2004). Top-down processes, on the other hand, are user-driven and depend on the goals and knowledge of the searcher. For example, in Wolfe's Guided Search model (1994, 2007), top-down processes involve the selection of a categorical aspect of a feature or features that are relevant to the task at hand (e.g., "red" for colour and "shallow" for orientation in a search for red horizontal lines). The effect of top-down processing can be seen by manipulating the instructions given to participants (e.g., Bacon & Egeth, 1997), by providing information about the target (e.g., Schmidt & Zelinsky, 2007; Chen & Zelinsky, 2006), and by implicit priming by preceding targets (e.g., Wolfe, Butcher, Lee, & Hyle, 2003). For example, Bacon & Egeth (1997) gave participants task instructions that induced a strategy that was either appropriate or inappropriate for the given search displays. Specifically, participants searched for a red horizontal line among varying proportions of green horizontal lines and red vertical lines, and one group of participants received the instruction "try to restrict your search to the horizontal elements, looking for the red line", while another group was told "try to restrict your search to the red elements, looking for a horizontal line". Since the proportion of the two types of targets varied across trials, the instructions would be helpful on trials in which the instructions led the participant to search through the less frequent distracter type (consistent instructions) and not as helpful when the instructions led the participant to search through the more frequent distracter type (inconsistent instructions). Participants were faster at finding the target on trials in which the instructions were consistent with the search displays than trials where they were inconsistent,

suggesting that attentional allocation in search is influenced by the searcher's top-down strategy to restrict search to elements sharing a particular feature.

A fourth strategy has involved prioritizing the dimensions and creating a hierarchy, whereby some factors are deemed to be more important or are used more consistently than other factors. Wolfe and Horowitz (2004) organized the attributes that have been found to guide attention into lists based on the strength of evidence that they are likely sources of guidance. Undoubted attributes include colour (e.g, Nagy & Sanchez, 1990; Treisman & Gormican, 1988), motion (e.g., Nakayama & Silverman, 1986; McCleod, Driver, & Crisp, 1988), orientation (e.g., Sagi & Julesz, 1987; Wolfe, Friedman-Hill, Stewart & O-Connell, 1992) and size (e.g., Treisman & Gormican, 1988). Probable attributes include shape (e.g., Treisman & Gormican, 1988; Quinlan & Humphreys, 1987), curvature (e.g., Fahle, 1991) and pictorial depth cues (e.g., Enn, Rensink, & Douglas, 1990). There have also been numerous attempts to determine the relative contributions of bottom-up and top-down guidance in visual search (e.g., Chen & Zelinsky, 2006; Theeuwes, 2004; Wolfe et al., 2003; Bacon & Egeth, 1994; Wykowska & Schubo, 2010). For example, Chen and Zelinsky (2006) examined the roles of top-down and bottom-up search guidance using pictures of common real-world objects as stimuli. Bottom-up guidance was defined by the salience of a colour singleton that appeared in the search display amongst grey-scaled target and distracter items. If search is captured by the coloured singleton distracter object, this is evidence for bottom-up guidance. Top-down guidance was defined in terms of the availability of a target preview. There was a condition in which top-down guidance was competing against bottom-up guidance, as well as conditions in which the two types of guidance were acting alone. With target preview, reaction times were faster and more initial eye movements were guided to the target, regardless of the saturation of the colour singleton. It was

only when there was no preview of the target (i.e., no top-down guidance) that participants preferentially fixated the colour singleton. The authors concluded that search for realistic objects is guided primarily by top-down control.

A fifth strategy, which has been employed at various points throughout the development of visual search theory, is the integration of available data with inferences about the mechanics of visual search. One such theory, Treisman and Gelade's (1980) Feature-Integration theory of attention, suggests that a set of basic features (e.g., colour, motion, size) can be processed across large portions of the visual field in an initial, parallel, preattentive stage. Items that are defined by a conjunction of properties then require attention for further processing, such as binding the features and object recognition. Because attention is resource-limited, items are selected and attended in a serial fashion, such that only one or at most a few items can be attended to at a time. Wolfe's (1994, 2007) influential Guided Search theory builds on Feature-Integration theory and posits that the output of the earlier preattentive stage could guide the spatial deployment of attention. This output may have contributions from bottom-up (stimulus-driven) and top-down (goal-driven) factors, and is conceptualized as an activation map that is a weighted sum of activations. Attention is then directed to areas of the map with the highest levels of activation. Another model of visual selection is the FeatureGate model (Cave, 1999). This model attempts to explain findings from visual search, spatial cuing and distracter interference. FeatureGate is a neural network consisting of a hierarchy of spatial maps. At each input location, the flow of information from all units (e.g., shape, color, or other features there) is jointly controlled by a bottom-up system that favours locations with unique features and a top-down system that favours locations with features designated as target features. Each gate will limit the flow of information to the next level of the hierarchy when that information would

potentially interfere with information from another location that is more promising or more important for the current processing goals. In addition to these theoretical models, there have also been attempts to understand the time course (e.g., Wykowska & Schubo, 2010) and the neural mechanisms (e.g., Weidner, Krummenacher, Reimann, Muller, & Fink, 2009; Mavritsaki, Allen, & Humphreys, 2010) responsible for the different processes involved in search.

1.2 Visual Exploration of Scenes

There has been a growing trend recently to study visual search in more complex real-world scenes. A series of strategies similar to the ones observed in the visual search literature have also been followed in developing a theory for how people explore and search for targets in pictures of real-world scenes.

As in visual search, the first strategy involved establishing suitable methods and techniques to study visual exploration of scenes. In the initial work, participants simply viewed the scenes (i.e., free viewing) and researchers were interested in where the participants fixated within the scene. For example, one of the first investigators to measure fixation location and duration while people viewed scenes was Buswell (1935). Buswell (1935) photographed on a moving film the eye movements of a group of participants while they looked at a series of pictures and found that people's eye movements are not evenly distributed over the pictures, but rather, concentrate on interesting and informative regions. Another early example is Yarbus' (1967) influential study in which he measured people's eye movements when they were simply viewing the painting, "An Unexpected Visitor", and also when they were given different task instructions such as estimating the material circumstances of the family, guessing the ages of the people, or surmising what the family had been doing before the arrival of the unexpected visitor. Yarbus (1967) found that "depending on the task in which a person is engaged, i.e., depending

on the character of the information which he must obtain, the distribution of the points of fixation on an object will vary correspondingly" (p.192). When participants received the instruction "estimate the material circumstances of the family shown in the picture", Yarbus noted that "the observer paid particular attention to the women's clothing and the furniture (the armchair, stool, tablecloth, and so on)". By contrast when given the instruction "give the ages of the people shown in the picture" he found that "all attention was concentrated on their faces" (p.192). While there were relatively few investigations of scene viewing during the 1970s and 1980s, this area has received much more attention in the last ten or so years (e.g., Henderson, 2003). Even more recently, researchers have examined search for target objects within scenes. Participants' eye movements are recorded while participants search for the target, and the location and duration of fixations are measured. Common measures of interest include the location of the first fixation and the total number of fixations to locate the target object, as well as the total amount of time required to locate the target. One advantage of using scenes is that they allow for the examination of many top-down processes that are difficult to examine using simple visual search displays.

A second strategy has involved the identification of dimensions that are important in real-world scene viewing and search for objects. Many of the initial dimensions were studied during free viewing (i.e., not with a specific search task), and the focus was on understanding why participants looked where they did within scenes. One method involved analyzing the locations that were fixated to determine whether they differed in some image property from other regions that were not selected for fixation (e.g., Mannan, Ruddock, & Wooding, 1997; Reinagel & Zador, 1999). Reinagel and Zador (1999) found that participants looked at image regions that had high spatial contrast, and that in the fixated regions, the intensities of nearby pixels were less

correlated with each other than in images selected at random. Another approach has been to create saliency maps based on image dimensions such as colour, intensity, contrast and edge orientation (e.g., Itti & Koch, 2000) and to correlate the salient points with observed human fixations to see if there is overlap (e.g., Parkhurst & Niebur, 2003; Bruce & Tsotsos, 2006). When participants have the task of searching for a target object, the visual system has been shown to be able to use scene context to guide eye movements within the scene (e.g., Neider & Zelinsky, 2006; Torralba, Oliva, Castelhano, & Henderson, 2006; Oliva, Wolfe, & Arsenio, 2004); contextual and semantic knowledge are used to identify regions in the scene that have a high probability of containing the target. The visual system can also use information about the target (e.g., Malcolm & Henderson, 2009; Zelinsky, Zhang, Chen, & Samaras, 2006); a representation of the target stored in visual working memory is matched against the scene.

The factors have been categorized [Strategy 3] in the scene literature as well. A similar differentiation between bottom-up and top-down processes exists in the scene literature (e.g., Henderson, 2003). The bottom-up factors are image-driven factors, such as colour, luminance and intensity, which are used to create saliency maps (e.g., Itti & Koch, 2000). Two main types of top-down processes that have been examined in the search literature using natural scenes are target template information (e.g., Malcolm & Henderson, 2009; Zelinsky, 2008) and scene context (Neider & Zelinsky, 2006; Torralba et al., 2006; Oliva et al., 2004).

The fourth strategy, prioritization of the dimensions and creation of a hierarchy, has been an area of focus in the recent literature examining real-world scene search. Because there has been considerable debate about the relative contributions of exogenous, bottom-up processes vs. endogenous top-down processes, a number of recent studies have used computational modeling to compare the performance of models that include low-level salience (a bottom-up form of

guidance) with models that include top-down information such as target template information or scene context, in terms of how well the models predict human fixation locations. For example, the *context guidance model*, which combines bottom-up saliency and scene context, outperformed a purely salience-driven model in predicting human fixation locations (Torralba et al., 2006). The Saliency Using Natural statistics (SUN) model (Kanan, Tong, Zhang, & Cottrell, 2009), which combines target information and low-level salience, outperformed a salience-driven model and also slightly outperformed the contextual guidance model in predicting human fixation positions during real-world image search. Ehinger, Hidalgo-Sotelo, Torralba, and Olivia (2009) found that models that combined low-level saliency, target template information and scene context accounted for a higher percentage of human fixation locations than any of the models that were generated using only one of the types of information. In addition to the computational model research, Malcolm and Henderson (2010) directly manipulated two types of top-down information, the specificity of the search template and the usefulness of the scene context, to see how the two types of information are used by the visual system. Target template specificity was manipulated by cuing the target with either an abstract cue (word) or a specific cue (an exact matching picture of the target). The scene context was manipulated by having the target appear in either a high-probability region of a scene (scene regions where the target would be likely to be found: e.g., staplers on desks, ceiling fans on the ceiling, etc.) or a low-probability region (scene regions less likely to contain the target object: e.g., staplers on the ceiling, ceiling fans on the desks, etc). Results indicated that participants used both types of top-down information to facilitate search by reducing fixation durations. When both types of information were available, the facilitation effects were additive, suggesting that the two types of top-down information were treated independently by the visual system.

As with the visual search literature, the fifth strategy, integrating available data and making inferences about the mechanics of search within scenes, has been applied at various points along the development of a scene-based search theory. Some of the models were mentioned above, such as the contextual guidance model and the Saliency Using Natural statistics (SUN) model. Zelinsky (2008) also proposed the Target Acquisition Model, a computational model of oculomotor target acquisition (i.e., aligning eye gaze with the target). In TAM, processing occurs dynamically through four broad stages: a) the creation of a target map, b) target detection, c) the visual routines involved in eye movement generation, and d) the rejection of fixated false targets. TAM relies on five core functions: 1) retina-transform the visual scene for every eye fixation, 2) represent visual information using high dimensional vectors of simple features, 3) use properties of the target to guide search, 4) use estimates of signal and noise in the target map to set model parameters, and 5) use a population code to program eye movements. Several measures indicate good correspondence in behaviour between the model and actual human subjects, suggesting that this model is a good predictor of human target acquisition behaviour.

1.3 Other Lessons Learned from Studies of Visual Search & Scene Viewing

In addition to the five overall strategies identified in studies of visual search and scene viewing, there are a number of other interesting themes that emerge from consideration of these two literatures. One of these themes concerns the different types of dimensions that have been studied in the two areas. Because the goal of much of the visual search research has been to uncover the basic features that guide attention during search, very simple displays have been used with geometric forms that do not offer much *context* to be used by participants. Not surprisingly, examination of the factors that have been studied reveals that they are primarily

low-level perceptual factors, and higher order factors such as schemata or prior knowledge have received less attention. These higher order factors have been studied to a greater degree in the scene viewing literature, which uses more complex displays that allow for the use of schema or expectation. To ensure that a full range of concealment behaviour is observed in the present experiments, it will be important to examine concealment behaviour in contexts that allow for the use of both higher order factors such as schemata and lower level visual factors. In addition, the difference in the types of factors studied in each of these literatures implies that context is important, as different dimensions become more relevant when different types of stimuli are used. Therefore, concealment behaviour will be examined in multiple contexts to explore whether there are differences in the types of concealment strategies used within different contexts. Another observation of much of the visual search literature is that researchers have examined the different factors in isolation and often do not consider the interaction of these factors or whether certain factors are more important than other factors within a given search (but see Chen & Zelinsky (2006) for an exception). For the study of concealment, it will be important to develop methods that will allow for the interaction of multiple factors to explore how these factors are used in cooperation or competition.

Reviews of the visual search and the scene viewing literatures reveal another critical difference between the two literatures. In the visual search literature, the researcher hypothesizes about what factors might affect search efficiency and then creates displays to test their hypotheses. Often the displays are simplified to such an extent that behaviour then becomes quite limited. This can be referred to as a *research-driven approach*, because the dimensions to be studied are generated by the researcher and the researcher constrains the behaviour of the observer to directly test a specific hypothesis. In contrast, in the scene viewing literature, the

scenes are more complex and allow for a wider range of behaviour that can then be examined by measuring where the participant chooses to look within the scene. This can be referred to as an *observation-driven approach* because the researcher is less involved in choosing specific dimensions of interest and he/she learns about the dimensions that might be important for scene exploration by observing the relatively free behaviour of the participant. The observation-driven approach is beneficial in that it allows for the examination of a range of behaviour in a large group of people, and the dimensions that emerge are not limited to what a single researcher or small group of researchers can generate or imagine. In the present experiments, an observation-driven approach will be taken one step further. In an attempt to obtain a broader and more comprehensive list of dimensions that people use when varying the degree of concealment, participants will first be given experience with concealing an object and then will be asked about their strategies and the factors that they considered. In this way, the creation of a list of dimensions will be driven by a large group of participants instead of a single researcher or small group of researchers. A researcher-driven approach will then be employed in subsequent experiments to specifically evaluate the dimensions uncovered by the observer-driven approach.

1.4 Visual Concealment

There have only been a handful of studies that have examined concealment behaviour. One such study, conducted by Cornell and Heth (1986), examined hiding and searching behaviour in children. They had 6 and 8 year-olds complete a "treasure hunt" where, in one condition, the children first hid 20 marbles in a large room containing 100 possible hiding locations (envelopes) organized into irregular clusters. Following a delay, the children then retrieved the marbles. Results indicated that children organized their choices spatially during both the hiding and recovery phases in 2 ways: children tended to concentrate their activity in

particular regions of the room (e.g., by the window) and were sensitive to clusters of hiding locations. The younger children were less likely than the older children to scatter marbles over clusters. Similarly, when recovering their marbles, younger children tended to use more compact search paths than the older children. The older children, however, were more likely to disperse their objects across clusters when hiding. The authors hypothesized that these two patterns of hiding behaviour in the younger and older children reflect potentially conflicting goals of selecting locations that are less likely to be found by someone else (i.e., locations that are more scattered), and selecting locations that they themselves can easily remember. The children might have scattered the marbles to the extent that they could remember the various locations, with older children scattering their objects more because they have a better memory for more distinct hiding locations than younger children. This interpretation suggests that children take into account (1) how others would search when looking for their hidden objects and (2) how well they will be able to remember their own hiding locations at a later time. The former point suggests that hiding strategies may be based upon the principles and strategies of searching, and that consideration of the searcher and where they might look is an important part of the concealment process.

Building on the Cornell and Heth (1986) study, Talbot, Legge, Bulitko and Spetch (2009) examined hiding behaviour of adults using a similar methodology. Talbot and colleagues (2009) had university students either hide or search for three plastic cylinders in nine white bins that were arranged in rows on the floor of a room. The locations chosen by participants differed systematically between searching and hiding. Specifically, participants moved farther from the origin and dispersed their choices more when hiding objects than when searching for hidden objects. At the end of the hiding or searching task, participants completed a questionnaire with

an open-ended question that asked them about the strategy that they used during the task. Participants reported using "*systematic strategies*" that reflected specific patterns in their choices (e.g., "Hide two close together and the third far away"; "I started out with a box that was far away, then progressed to a box that was closest"), and "*theory of mind strategies*" that involved thinking about other participants or concealment strategies (e.g., "Thought about putting object in unassuming bins, where people would likely not look or tend to skip over"). The reported "theory of mind strategies" provide further support for the idea that when a person hides an object, they do not only use a spatial strategy, but they also take into consideration where another person might search for that object.

Smilek, Weinheimer, Kwan, Reynolds and Kingstone (2009) used a different type of methodology to examine the factors that are important during visual concealment. Smilek et al. (2009) had participants complete a placement task where they were asked to arrange search objects (e.g., shapes, emotional faces and graphemes) to create displays in which the targets were in plain sight but were either easy or hard to find. The easy and hard displays were coded on factors that had previously been shown to influence search performance, such as target eccentricity, target-distracter similarity, and the presence vs. the absence of a feature. Analyses revealed that participants were able to use these factors to vary the difficulty of search across displays. In fact, when a different group of participants searched for the targets in the created displays, search was more difficult in the hard than the easy condition. Similar to previous studies (e.g., Talbot et al., 2009; Cornell & Heth, 1986), the results from Smilek et al. (2009) indicate that there is a close link between the factors that govern concealment and the factors known to influence search difficulty, suggesting that a visual search theory can form the basis of a theory of visual concealment.

Consideration of these three concealment studies reveals a number of tools and techniques that can be used in the present studies. The Talbot et al. (2009) study demonstrates that it is beneficial to not only examine the hiding locations chosen by participants, but to also collect subjective reports in which participants explain the strategies that they employed when selecting the locations. The placement task used in Smilek et al. (2009) will be a useful method to use in the future concealment studies because it allows for the comparison of easy and hard hiding locations. Much of the visual search literature compares targets that are easy to find (i.e., pop-out searches) with targets that are difficult to find as a way of understanding how factors affect search difficulty and efficiency. A similar strategy can be applied to the study of concealment to examine how participants use different dimensions to vary the degree of concealment.

While the small, emerging body of literature examining hiding behaviour in humans has made important steps towards identifying some initial factors that are involved in concealment (e.g., spatial factors such as dispersion of objects and proximity to origin, and basic visual factors such as target eccentricity), the situations used in these experiments have been fairly constrained and mostly devoid of higher-level factors such as schemata or expectation of where the object might be found. Consideration of hiding and searching in the real world reveals that our environment is full of meaningful, familiar, and contextualized information. In addition, we often develop schemata about our environment and come to expect that certain items are generally found in certain locations. The embodied nature of our being and our expectations for where specific items are often located might play a critical role in how we interact with our surrounding environment.

In line with these considerations, Neisser (1976) suggested that the way individuals interact with their environment might be best described as a perceptual cycle, consisting of three factors: (1) *object information* in the world; (2) a mental representation of a space or *schemata* within the individual; and (3) the *exploration* of the world by the individual. The relationship among these factors can be seen in Figure 1. As can be seen in the figure, information provided by the environment serves to modify and update the existing schemata. The anticipatory schemata in turn drive an individual's exploration of their environment. Exploration is thought to involve the whole embodied individual actively searching their environment. This embodiment guides physical and visual movements, with certain objects affording (Gibson, 1979) ease of viewing and physical interaction. Finally, the act of exploring changes the information that is picked up from the environment and the cycle begins anew. Neisser's model has been applied to different aspects of attention such as inattentional blindness and attention capture (e.g., Most & Simons; Most, Scholl, Clifford, & Simons, 2005; Horstmann, 2005). Neisser's three factors served as a loose framework throughout this dissertation to examine concealment in real world settings.

1.5 The Present Experiments

The purpose of this dissertation is to begin to understand concealment behaviour with the ultimate goal of developing a theory of visual concealment. The 5 strategies identified above from the examination of the development of search theory in the traditional visual search literature and the scene-based search literature will be loosely followed: 1) establish a methodology, 2) identify dimensions, 3) categorize dimensions, 4) prioritize dimensions, and 5) integrate results into a theoretical framework that may involve inferences about the mechanisms involved.

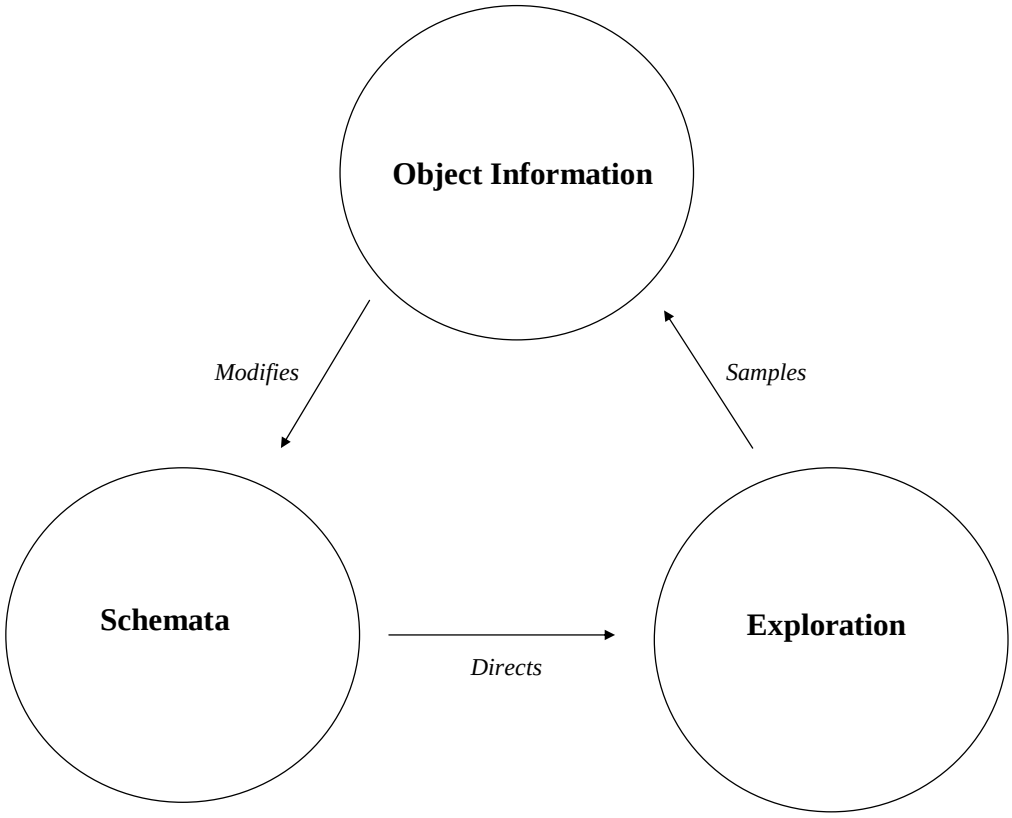

Figure 1. An illustration of Neisser's three factor Perceptual Cycle model.

Establishing a methodology for the study of visual concealment [Strategy 1] will be a strong focus throughout the dissertation. Given that visual concealment has not been studied extensively, especially in real-world scenarios, relatively few tools and techniques have been explored for the study of concealment behaviour. In the present experiments, a variety of techniques were employed at the level of experimental design, data collection and data analysis. Variations of the placement task (Smilek et al., 2009), where participants are required to make objects easy or hard to find, were developed to allow for the examination of placement behaviour in both unconstrained and constrained settings. In some experiments, participants completed the placement task in a complex and relatively unconstrained environment (e.g., an office) in which they were free to place the objects anywhere within the environment. Participants' subjective reports (Chapter 2) and their chosen hiding locations (i.e., free concealment behaviour; Chapter 4) were coded to examine which dimensions were used (Chapter 2) and how they were used by participants to make objects easy and hard to find (Chapter 4). In other experiments, placement behaviour was constrained to a choice between two locations (i.e., forced-choice task) and participants' hiding choices were evaluated (Chapters 3 and 5).

The second strategy that was used to develop theories of visual search and scene viewing was to identify relevant dimensions. Identifying dimensions that are used to vary the degree of concealment is also an important goal of this dissertation. Chapter 2 reports the findings from two exploratory studies in which participants placed objects within luggage to make them either easy or hard to find (i.e., the placement task). Participants' subjective reports were analyzed to identify dimensions that are important when varying the concealment of objects. Once a list a dimensions was generated, the dimensions were then categorized [Strategy 3]. To continue to develop the methodology and to further understand the dimensions that are important in

concealment, in Chapter 3, the dimensions identified in Chapter 2 were manipulated and used in a forced-choice task to determine whether the reported dimensions affect hiding behaviour. In Chapter 4, the placement task was used in two variations of an office environment. Instead of using subjective reports, images of the locations chosen by participants to make the objects easy or hard to find were coded on dimensions uncovered from previous experiments.

As a first attempt towards prioritizing the dimensions [Strategy 4], in Chapter 5 the dimensions are placed in competition with each other in both the luggage and office scenarios to examine the relative importance of the dimensions. Finally, in the General Discussion, an attempt was made to integrate the results into a theoretical framework and to make some inferences about the mechanics involved in visual concealment [Strategy 5].

In the process of applying the five strategies to concealment, both low level and high level dimensions will be considered. The dimensions will be evaluated across different contexts since people might be predisposed to use certain types of dimensions in one context, while other dimensions are more relevant in a different context. In the initial studies, an observation-driven approach is employed to generate a list of important dimensions, and then a more researcher-driven approach is utilized in later experiments to further understand and evaluate the dimensions both on their own and in combination.

CHAPTER 2: EXPLORATORY SUBJECTIVE REPORT LUGGAGE STUDIES

As an initial step in developing a methodology to study concealment [Strategy 1] and uncovering the factors that are important when people conceal objects in real-world settings [Strategy 2], concealment behaviour was examined in two studies where participants placed objects within luggage. Luggage was chosen as the stimulus for these studies because it provides a realistic scenario in which objects are concealed and searched for on a regular basis in the real-world. People are also likely to have at least some familiarity with packing their bags and having their bags searched while going through security at the airport or while crossing the border. There were 5 overall objectives for the two studies discussed in this chapter (Study 1a and 1b):

1) To develop a way to probe concealment behaviour [Studies 1a and 1b];
2) To identify some initial dimensions that people use to conceal objects in more realistic scenarios [Study 1a];
3) To examine the relative importance of these dimensions [Study 1a];
4) To explore the generalizability of the dimensions across studies involving different experimental scenarios [Study 1b];
5) To examine whether context matters to the relative use and judgments of the dimensions [Study 1b].

In order to do this, the placement task (Smilek et al., 2009) was used in two different scenarios involving luggage. In the placement task used in Studies 1a and 1b, participants were given an object and told to make it either easy or hard for another person to find within luggage. Participants were free to explore the pieces of luggage and to place the object anywhere they chose. Subjective reports were collected to obtain information about the dimensions that

participants considered and used while making the target objects easy and hard to find. The subjective reports from Study 1a were used in an exploratory analysis to begin to understand what dimensions might be important in a theory of visual concealment. Subjective reports were chosen as the source of data so that the generation of a list of dimensions would be *observation-driven* (as opposed to *researcher-driven*). In Study 1b, the scenario was changed slightly to examine whether the results would extend to a different scenario and to examine the role of context in the relative use of the factors.

2.1 Study 1a: Initial Luggage Study

The initial study sought to address the first three of the objectives described above: 1) to develop a way to probe concealment behaviour, 2) to identify some initial dimensions that people use to conceal objects, and 3) to examine their relative importance. Study 1a also served as a test of whether the placement task, which was used in a much more constrained setting in Smilek et al. (2009), would yield useful and informative results in a more real-world scenario involving actual pieces of luggage.

2.1.1 Method

Participants. Forty-eight undergraduate students from the University of Waterloo participated in a 30-minute experimental session for partial credit towards their psychology class. All participants reported normal or corrected-to-normal vision.

Materials. Two different pieces of luggage were used – a blue duffle bag and a green suitcase. The duffle bag was 59.5cm in length, 31cm in height and 27.5cm in width. The suitcase was 63cm in length, 42.5cm in width and 25.5cm in thickness. Both the suitcase and the duffle bag were packed with generic items that one might pack when traveling such as jeans, t-shirts, hooded sweatshirts, socks, toiletry items, glasses, towels, and magazines. The targets that

participants were asked to place within the pieces of luggage were two bags of coloured beads (one bag of green beads and one bag of pink beads). The dimensions of each bag of beads were 9.6cm by 5.2cm x 0.1cm.

Procedure. Participants were brought into a room that had the duffle bag and the suitcase on top of a table. The two pieces of luggage were closed with the zippers done up. On top of each piece of luggage was the bag of beads that the participants would be placing within that piece of luggage. Participants were instructed to imagine that they were trying to smuggle "illegal beads" across the border, and that the border guards will be checking their luggage. They were told that they were to place each of the bags of beads either within the suitcase or the duffle bag such that it would be either easy or hard for another person searching the luggage to find. Difficulty (easy, hard), luggage type (suitcase, duffle bag) and colour of beads (green, pink) were combined such that each person completed two trials: one where they placed one of the bags of beads in the suitcase in one level of difficulty and one where they placed the other bag of beads in the duffle bag in the opposite level of difficulty (i.e., if a participant placed the pink beads in the suitcase in an easy location, they hid the green beads in the duffle bag in a difficult location). An example of the instructions given to a participant who was in the condition where the green beads are placed in an easy location in the duffle bag and the pink beads were placed in a hard location in the suitcase are as follows:

> "Here you see a duffle bag and a suitcase filled with items such as clothes and toiletries that you might pack when traveling. Now imagine that you are trying to smuggle these "illegal beads" across the border, and that the border guards will be checking your bags. You are going to place the green beads in an easy spot within the duffle bag, but make sure they are still hidden. You will place the pink

beads in a spot in the suitcase that will be really hard to find. While you are choosing hiding spots, pay attention to your thought processes and any strategies that you use to hide the beads. Once you have chosen your hiding spots, I will ask you to reveal to me the locations you chose, and I will ask you to explain your thought processes and strategies."

Participants were videotaped as they revealed where they had placed the objects. The videos also captured their explanations of their thought processes and strategies. Participants also filled out a written subjective report measure that again asked them "Why did you think that the "easy" (or "hard") object would be easy (or hard) to find?" Both verbal and written subjective reports were obtained to capture the subjective experiences of participants regardless of their preferred mode of communication. Both the verbal and written reports were transcribed into a single document for further analysis.

2.1.2 Results

Subjective Report Coding. Using an inductive analysis, subjective reports were initially read through by the experimenter to pull out common themes that surfaced across multiple people's responses. Based on these common themes, a coding scheme was created with eight different dimensions. These eight dimensions were chosen because preliminary coding indicated that the majority of the ideas reported by participants fell within one of these eight categories. Each participant's subjective reports (verbal and written) for each trial were coded by the experimenter and an independent coder (who were both blind to the level of difficulty) for whether the participants mentioned the following eight dimensions in their descriptions:

1. **Visual similarity.** Visual similarity was defined as whether or not the participant explicitly mentioned using the physical similarity (or dissimilarity) of the target and

distracters as part of his/her strategy. This would include mention of colour, colour contrast, shape or size. For example, one participant reported "given the consistency of the items in the luggage, I thought the beads would *blend in the most with the makeup visually*."

2. **Audition.** Audition was defined as whether or not the participant explicitly mentioned placing the target in such a way as to either enable or reduce the possibility of being heard while the border guard searches the bag. For example, one participant reported "I stuck it inside one of the socks, and when I folded it, I just made sure to tuck this in, so when people are moving it around, *you wouldn't be able to hear it*."
3. **Tactility.** Tactility was defined as whether or not the participant explicitly mentioned using a particular distracter because of the texture or way the object felt. For example, one participant reported "I chose the jeans because they're hard, so *you wouldn't really feel them*."
4. **Confrontation.** Confrontation was defined as whether or not the participant mentions using visual confrontation, salience, or visibility as part of his/her strategy, regardless of whether the feature was used to hinder or facilitate search. For example, one participant reported "I just hid it in this separate compartment here because it's *very visible to see*, and you can just open it and you can *see that it's right there*" in the easy condition, while another participant reported "I placed it in a sock because there were numerous pairs so it's hard to keep track, and you can move fabric around so *even if someone were to look at it, it wouldn't be noticeable*" in the hard condition.
5. **Accessibility.** Accessibility was defined as whether or not the participant mentions using how easy or difficult it would be for the searcher to physically get to the target. For

example, one participant reported "It would be easy to find because the object was near the top of the pile, under a section of clothing that would *easy to grab and pick up first*" in the easy condition, while another participant reported "I placed it in a small nook in the plastic wheel well because *it's hard to get to*" in the hard condition.

6. **Theory of Mind.** Theory of mind was defined as whether or not the participant mentions what the searcher would *think, want* or *feel* while searching for the target. For example, one participant reported "I hid it in the bottom of the suitcase, in this plastic thing because on this side [other wheel] it's really firmly bolted, so if someone was to examine the bag, *they wouldn't necessarily think that you could put anything under it*."
7. **Search Schema.** Search schema was defined as whether or not the participant mentions conventions of how search is typically conducted or typical search behaviour. For example, one participant reported "I put it inside the sock here, mainly because *if you were searching for something, you would take out all the clothes…You wouldn't necessarily search through each of the clothing items*, and I guess if you were really searching, *you would go for pockets before you would go for inside a sock*."
8. **Schema for Function of Item.** Schema for function of an item was defined as whether or not the person mentions using the function or the typical use of the distracter(s) as part of their strategy. For example, one participant reported "I hid the pink bag of beads in a *pair of socks as this is not usually a storage area* and one would not first look in the socks compared to a *bag, which is typically used for storage*."

Upon examination of the eight dimensions that resulted from the analysis of the subjective reports, it was observed that the dimensions fell into three categories: Stimulus Properties dimensions, which includes visual similarity, audition and tactility; Embodiment

dimensions, which includes confrontation and accessibility; and Higher Order dimensions, which includes theory of mind, search schema and schema for function of an item. The formation of these three categories was also loosely informed by Neisser's three factor perceptual cycle model (1976). This model describes how object information in the environment (i.e., Stimulus Properties) serves to modify and update our existing schemata (Higher Order dimensions); it is then these schemata that drive how we explore our environments as embodied beings (Embodiment dimensions).

For each dimension, participants' responses for each trial were given a "1" if that particular dimension was mentioned in either their verbal or written subjective report, and a "0" if that dimension was not mentioned. If a dimension was mentioned more than once in a participant's response, it would still receive a "1". Inter-rater reliabilities for each dimension can be found in Table 1. As can be seen in the table, while the reliabilities are quite high for most of the dimensions, the reliability between coders was the lowest for the confrontation and accessibility dimensions. This is likely due in part to the variable nature of the subjective reports, since no two people use the exact same wording in their descriptions. In addition, for the confrontation and accessibility dimensions in particular, it was often difficult to differentiate between the visual (i.e., confrontation) and physical (i.e., accessibility) aspects of embodiment. There were a number of trials where one coder coded the participants' response as confrontation, while the other coder categorized it under the accessibility dimension. However, since the dimensions both come from the same category and analyses were performed at a category level, the lower reliabilities for confrontation and accessibility do not pose a critical problem. Given the overall high level of agreement between coders, the scores were averaged across coders for

Table 1. Inter-rater reliabilities[1] for coding of subjective reports in Study 1a.

Dimension	**Inter-rater**
Visual Similarity	0.82
Audition	0.94
Tactility	0.94
Confrontation	0.64
Accessibility	0.61
Theory of Mind	0.90
Search Schema	0.84
Schema for Function of Item	0.75

all analyses. The proportion of trials in which participants reported using each of the dimensions in the three categories as a function of difficulty can be seen in Table 2.

To examine the pattern of results at a Category level, participants' use of each category was coded using the following Category algorithm. Because the two coders' ratings were averaged, for each trial of each dimension a participant could receive: a score of "1", meaning that both coders had identified that particular dimension in the participant's description; a score of "0.5", meaning that only one of the coders had identified that dimension in the participant's description; or a score of "0" if neither of the coders had identified that dimension in the participant's description. The Category algorithm was then applied to the dimensions that fell under each category. If a given participant had received a "1" for one or more of the dimensions in a category, they would receive a "1" for that category indicating that they had used at least one dimension from the category. Participants would also receive a "1" for a category if they had scores of "0.5" for two or more of the dimensions in the category. If the participant only had a "0.5" for one of the dimensions in the category, they would receive a "0.5" for that category. Participants would receive a "0" for a category if they had not reported using any of the dimensions from that category in their subjective reports. This algorithm allowed for a relative weighting of category use for cases where only one of the coders had identified one of the dimensions in that category (which would receive a "0.5"), compared to cases where either multiple dimensions had been identified or both coders agreed on the assignment of a particular dimension (in both of these cases, the category would receive the full "1" point). The resulting proportion of trials in which participants used dimensions from each of the three categories can be seen in Figure 2.

Table 2. Average proportion of trials in which participants reported using each of the dimensions from each category as a function of difficulty in Study 1a.

	Difficulty	
Dimension	**Easy**	**Hard**
Stimulus Properties		
Visual Similarity	0.07	0.05
Audition	0.06	0.11
Tactility	0.04	0.14
Embodiment		
Confrontation	0.52	0.26
Accessibility	0.34	0.24
Higher Order		
Theory of Mind	0.07	0.29
Search Schema	0.43	0.61
Schema for Function of Item	0.13	0.17

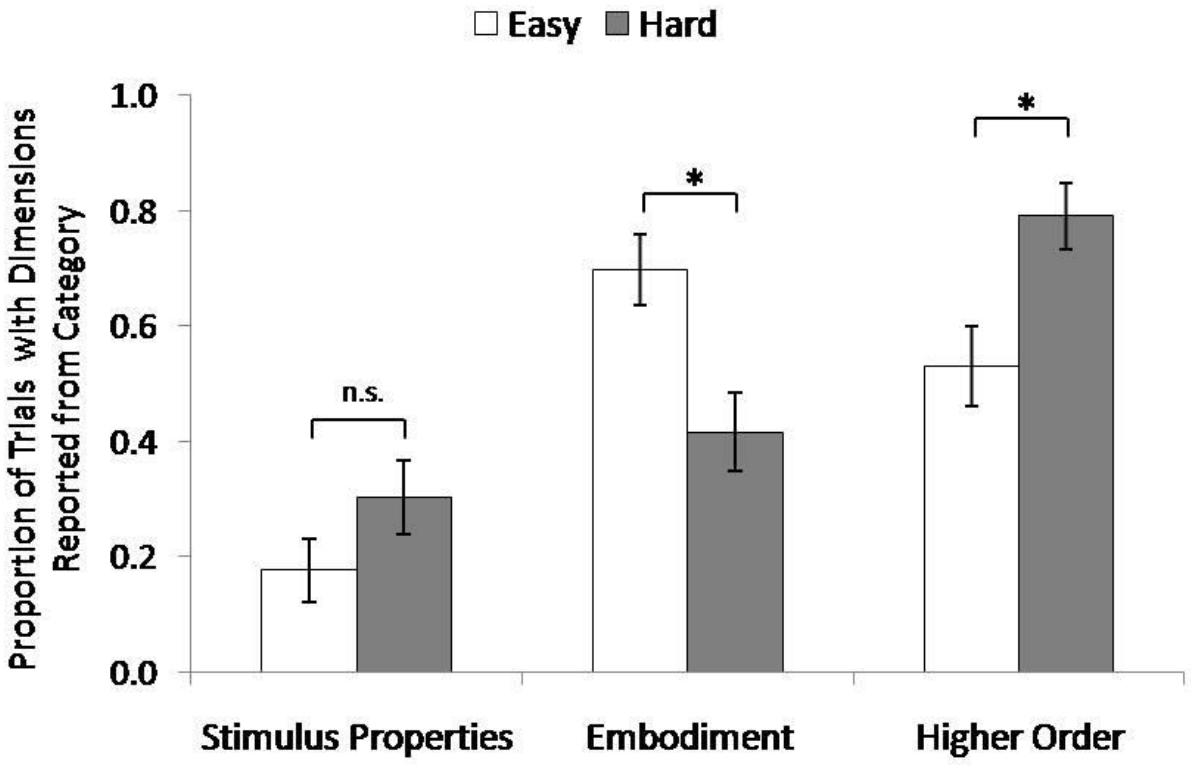

Figure 2. Average proportion of trials in which participants reported using dimensions from each Category as a function of difficulty in Study 1a. Error bars reflect one standard error of the mean. * represents $p < 0.01$ on repeated measures t-tests.

A 2 (difficulty: easy vs. hard) by 3 (category: stimulus properties, embodiment and higher order) by 2 (stimulus combination: duffle easy/suitcase hard vs. duffle hard/suitcase easy) repeated measures ANOVA revealed no main effect of stimulus combination and no significant interactions with this variable (all F's < 3, p's > 0.05); therefore the data was collapsed across this variable. The resulting scores were submitted to a 2 (difficulty: easy vs. hard) by 3 (category: stimulus properties, embodiment, and higher order) repeated measures ANOVA.

As can be seen in Figure 2, there was a significant difference across categories with respect to the proportion of participants who reported using dimensions from each category, $F(2,94) = 20.69$, $MSE = 0.22$, $p < 0.001$, with the dimensions from the Stimulus Properties category being reported less often than the Embodiment and Higher Order dimensions. There were no overall differences between the easy and hard conditions, $F(1,47) = 1.20$, $MSE = 0.07$, $p > 0.2$; however there was a significant interaction between difficulty and category, $F(2,94) = 8.67$, $MSE = 0.22$, $p < 0.001$.

To further explore this interaction and to examine the relative importance of the three categories, the categories were compared in pairs using three 2 (category) by 2(difficulty) repeated measures ANOVAs.

Stimulus Properties vs. Embodiment

When Stimulus Properties dimensions were compared to Embodiments dimensions, there was a significant effect of category, $F(1,47) = 23.43$, $MSE = 0.21$, $p < 0.001$; the Stimulus Properties dimensions were reported significantly less often than the Embodiment dimensions. There were no overall differences between the easy and the hard conditions, $F(1,47) = 2.03$, $MSE = 0.14$, $p > 0.1$. The interaction between category and difficulty was significant, $F(1,47) = 11.52$, $MSE = 0.17$, $p < 0.01$, meaning that the Embodiment dimensions were reported more

often in the easy condition than the hard condition while the Stimulus Properties dimensions were reported more often in the hard condition than the easy condition.

Stimulus Properties vs. Higher Order

When Stimulus Properties dimensions were compared to Higher Order Dimensions, there was also a significant effect of category, $F(1,47) = 43.32$, $MSE = 0.20$, $p < 0.001$; Stimulus Properties dimensions were reported significantly less often than Higher Order dimensions. There was a main effect of difficulty, $F(1,47) = 13.89$, $MSE = 0.13$, $p < 0.01$, with participants reporting dimensions from the two categories more often in the hard condition than in the easy condition. The interaction between category and difficulty was not significant, $F(1,47) = 1.05$, $MSE = 0.21$, $p > 0.3$.

Embodiment vs. Higher Order

When Embodiment dimensions were compared to Higher Order dimensions, there was no effect of category, $F(1,47) = 1.94$, $MSE = 0.27$, $p > 0.1$, indicating that participants reported dimensions from the Embodiment and Higher Order categories to the same extent. While there was no effect of difficulty, $F(1,47) = 0.06$, $MSE = 0.09$, $p > 0.8$, the interaction between category and difficulty was significant, $F(1,47) = 12.63$, $MSE = 0.28$, $p < 0.001$; participants reported Embodiment dimensions more often in the easy condition and Higher Order dimensions more often in the hard condition. This interaction makes sense when one considers the nature of the Embodiment and Higher Order dimensions. While participants did report choosing locations to try to reduce the likelihood of the target confronting or being accessible to the searcher in the hard condition, these Embodiment dimensions were much more likely to be reported in a way that facilitated search for the object in the easy condition. On the other hand, participants seemed to focus quite heavily on the Higher Order dimensions of theory of mind of the searcher

and schema for how the search would unfold, when choosing locations that they thought would be hard to find since the searcher would be less likely to look in that location.

2.1.3 Discussion

The three primary goals of Study 1a were to develop a way to probe concealment behaviour (Objective 1), to identify dimensions that participants use when concealing objects in a real-world scenario (Objective 2), and to examine their relative importance (Objective 3). The placement task from Smilek et al. (2009) was modified for use in the more complicated luggage scenario, and subjective reports were chosen as the unit of analysis. This proved to be a useful way to probe concealment behaviour as the analysis of participants' subjective reports revealed that when participants were trying to make the beads easy or hard to find, they used at least 8 different dimensions. Upon examination of the reported dimensions, it became apparent that the dimensions fell into three distinct categories. These categories included dimensions relating to the Stimulus Properties of the target object relative to the distracter items, Embodied dimensions relating to how likely an object is to confront or be accessible to a searcher, and dimensions relating to what the searcher would be thinking or wanting to do and expectations of how search would be carried out and how different objects would be used (i.e., Higher Order dimensions).

The relative importance of the dimensions was examined by comparing the proportion of participants that reported dimensions from each of the categories. While participants did report dimensions from all 3 of the categories, participants reported using dimensions from the Embodiment and Higher Order categories more often than the Stimulus Properties dimensions.

2.2 Study 1b: Border Guard Scenario

Study 1a addressed the first three objectives by developing one way of probing concealment behaviour (Objective 1), identifying a number of dimensions that people report using when trying to make objects easy or hard for a border guard to find within luggage (Objective 2), as well as providing some data about their relative use (Objective 3). In Study 1b, a different scenario involving luggage was used to try to further develop the methodology (Objective 1), as well as to address the remaining objectives of exploring the generalizability of the findings (Objective 4), and examining the effect of context on the relative use of the dimensions (Objective 5).

The placement task from Study 1a was modified slightly to reflect a border guard training scenario. In Study 1a, difficulty was simply manipulated by instructing participants to make the beads "easy to find" or "hard to find". In the present border guard training scenario, difficulty was manipulated by creating an invented scenario in which participants imagined they were training border guards with different levels of airport security experience. Participants were either told that the border guard was new to the training program (i.e., "novice") or close to graduating from the training program (i.e., "advanced"), and to place objects in a hiding location that would be challenging given the guard's level of training. This manipulation creates an easier and harder level of difficulty because it was assumed that when participants are told the searcher is a novice trainee they will place the beads in locations that will be easier to find than participants who are told that the searcher is an advanced trainee. It was expected that participants would still report using dimensions from all three of the categories, demonstrating some generalizability (Objective 4), but that the relative frequency of their use might differ from Study 1a given the change in the experimental scenario. For example, given the focus on the

characteristics of the searcher in the present scenario, it seemed possible that participants might report relatively more use of the Higher Order dimensions. This would mean that context affects the relative use of the dimensions (Objective 5). Because the manipulation of difficulty (i.e., hard to find for a novice vs. advanced guard) was more subtle than in Study 1a, one might expect the differences between difficulty conditions to be less than in the previous study.

Because the subjective reports from Study 1a proved to be so fruitful, another goal of Study 1b was to build on and improve the collection of subjective reports (Objective 1). A more thorough interview process was used to attempt to elicit more detailed subjective reports, and a questionnaire was created based on the dimensions found in Study 1a to obtain a more direct measure of the relative importance of each dimension**.** The questionnaire included questions about the specific context that they participants just completed, as well as questions that asked about hiding in general (i.e., context-general). Any differences found between these two types of questions will provide evidence for the effect of context (Objective 5).

2.2.1 Method

Participants. Thirty-two undergraduate students from the University of Waterloo participated in a 30-minute experimental session for partial credit towards their psychology class. All participants reported normal or corrected-to-normal vision.

Materials. The materials used in this study were identical to those used in Study 1a.

Procedure. Participants were told the following scenario:

> "Border guards undergo extensive training in visual search to prepare them for their jobs. Training occurs at different levels which the guards must complete in succession. Imagine that your job is to develop these training programs for new border guards who will be searching luggage at customs for various illegal goods.

> For one of the exercises, you hide these bags of beads in these luggage pieces to see if the guards are able to locate them."

The instructions for the novice trainee condition were:

> "Imagine that you are designing this exercise for guards who are *new* to the program and have received *no training*. You are going to hide this bag of beads in the _____ (suitcase/duffle bag) for them to find. You want to hide the beads in a location that will be challenging for this new guard to find given their skill level. Take a moment to think about your strategy and then proceed."

The instructions for the advanced trainee condition were:

> "Now imagine that you are designing this exercise for guards who are *close to graduating* from the program and have received *extensive training*. You are going to hide this bag of beads in the _____ (suitcase/duffle bag) for them to find. You want to hide the beads in a location that will be challenging for this highly trained guard to find given their skill level. Take a moment to think about your strategy and then proceed."

As in Study 1a, participants were told to think about their thought processes and the different strategies they considered and used while hiding the beads. Border guard training level (novice trainee vs. advanced trainee) and type of luggage (suitcase vs. duffle bag) were fully crossed such that each participant completed all four conditions (i.e., four trials). Participants completed both trials for one type of luggage, followed by both trials for the other type of luggage. The order in which they completed the two types of luggage, as well as the order of completion of each level of border guard training was randomly assigned. After each trial (i.e., each time a location for the beads was chosen), participants revealed where they had hidden the beads and

answered a series of questions about their choice. The bag was videotaped during this process so that there would be a visual record of where the beads were hidden as well as an audio recording of the participants' responses to the following questions:

1. Why did you choose to hide the bag of beads where you did?
2. What factors did you consider?
3. What other ideas did you have about where to hide the beads? *(If needed, ask why they did not end up using these ideas)*
4. Why would this be a challenging location for a guard who is ***very new*** **(or *very advanced)*** to the training program?
5. Did you take level of training into consideration when completing the task? If so, how did it affect your strategy?

The verbal reports were transcribed for further analysis.

At the end of the study, participants filled out the Dimension Rating Questionnaire (Luggage) that asked them to rate the dimensions identified in Study 1a (see Appendix A). Participants first completed the **context-specific questions** that asked them whether they had <u>considered</u> each of the dimensions, and then whether they had <u>used</u> each of the dimensions while they were hiding the beads. Participants rated each dimension on a scale from 1 (did not consider/did not use) to 7 (considered a lot/used a lot). Participants then completed the **general hiding questions** that asked them how <u>important</u> each dimension was when hiding objects in general (i.e., not just in the scenario that they completed). Participants rated each dimension on a scale from 1 (not at all important) to 7 (very important).

2.2.2 Results

Subjective Reports. The responses from the first question of each trial were coded on the same eights dimensions as in Study 1a (Stimulus Properties dimensions: visual similarity, audition, tactility; Embodiment dimensions: confrontation, accessibility; and Higher Order dimensions: Theory of mind, search schema, schema for function of an item).

As in Study 1a, participants were given a "1" if that particular dimension was mentioned in their subjective report and a "0" if that dimension was not mentioned. Inter-rater reliabilities for each dimension can be found in Table 3. Because of the relatively high reliabilities, the scores were averaged across coders for all analyses.

The proportion of trials in which participants reported each of the dimensions as a function of border guard training level and type of luggage can be seen in Table 4. As can be seen in the table, all of the dimensions reported in Study 1a were again reported by participants in the border guard training scenario. Therefore, even with the change to the experimental scenario, there is generalizability across the studies.

The Category algorithm described in Study 1a was used to determine which categories a participant reported in their subjective report for each location chosen by each participant. A 2 (border guard training level: novice vs. advanced) by 3 (category: stimulus properties, embodiment and higher order) by 2 (type of luggage: duffle bag vs. suitcase) repeated measures ANOVA revealed that there was no overall difference between the two types of luggage, as well as no significant interactions with type of luggage (all F's < 1, p's > 0.3); therefore, the data was averaged across type of luggage.

Table 3 . Inter-rater reliabilities[1] for coding of subjective reports in Study 1b.

Dimension	**Inter-rater**
Visual Similarity	0.70
Audition	0.91
Tactility	0.84
Confrontation	0.69
Accessibility	0.71
Theory of Mind	0.78
Search Schema	0.86
Schema for Function of Item	0.86

Table 4. Average proportion of trials in which participants reported each of the dimensions within each category as a function of border guard training level and type of luggage in Study 1b. The Average values were obtained by averaging across type of luggage.

	Type of Luggage					
	Suitcase		Duffle Bag		Average	
Dimension	**Novice**	**Advanced**	**Novice**	**Advanced**	**Novice**	**Advanced**
Stimulus Properties						
Visual Similarity	0.00	0.08	0.00	0.02	0.00	0.05
Audition	0.10	0.16	0.06	0.09	0.08	0.13
Tactility	0.18	0.19	0.09	0.23	0.13	0.21
Embodiment						
Confrontation	0.27	0.16	0.08	0.09	0.17	0.13
Accessibility	0.08	0.13	0.14	0.08	0.11	0.10
Higher Order						
Theory of Mind	0.23	0.06	0.19	0.27	0.21	0.16
Search Schema	0.61	0.53	0.64	0.44	0.63	0.48
Schema for Function of Item	0.06	0.03	0.03	0.09	0.05	0.06

The resulting scores were submitted to a 2 (border guard training level: novice vs. advanced) by 3 (category: stimulus properties, embodiment, higher order) repeated measures ANOVA to examine the relative use of the categories. The proportion of trials in which participants reported dimensions from each category can be found in Figure 3. As can be seen in the figure, there was an overall main effect of category, $F(2,62) = 33.77$, $MSE = 0.10$, $p < 0.001$, with participants reporting dimensions from the Higher Order category the most often. There was no overall effect of border guard training level, $F(1,31) = 0.09$, $MSE = 0.09$, $p > 0.7$. Since border guard training level was considered a way of manipulating whether the beads were easier or harder to find, this result is similar to Study 1a where there was no effect of difficulty. The interaction between category and difficulty was marginally significant, $F(2,62) = 3.06$, $MSE = 0.07$, $p = 0.05$.

As in Study 1a, to further examine the relative importance of the categories, the categories were compared in pairs using three 2 (category) by 2(difficulty) repeated measures ANOVAs.

Stimulus Properties vs. Embodiment

When Stimulus Properties dimensions were compared to Embodiments dimensions, there was no effect of category, $F(1,31) = 0.12$, $MSE = 0.07$, $p > 0.7$; dimensions from the Stimulus Properties and Embodiment categories did not differ in the degree to which they were reported by participants. There was also no overall difference between the novice and advanced conditions, $F(1,31) = 0.40$, $MSE = 0.08$, $p > 0.5$, however the interaction between category and difficulty was significant, $F(1,31) = 4.84$, $MSE = 0.05$, $p < 0.05$, meaning that the Embodiment dimensions were reported more often for the novice guards and the Stimulus Properties dimensions were reported more often for the advanced guard condition.

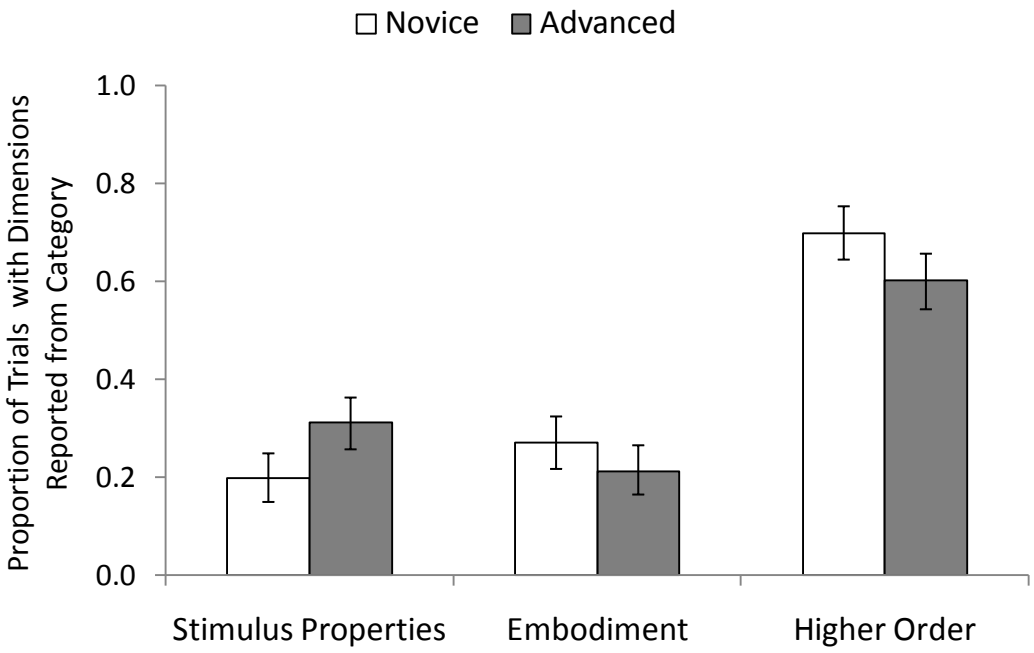

Figure 3. Average proportion of trials in which participants reported dimensions from each Category as a function of border guard training level in Study 1b. Error bars represent one standard error of the mean.

Stimulus Properties vs. Higher Order

When Stimulus Properties dimensions were compared to Higher Order dimensions, there was a significant effect of category, $F(1,31) = 48.25$, $MSE = 0.11$, $p < 0.001$; Stimulus Properties dimensions were reported significantly less often than Higher Order dimensions. There was no main effect of difficulty, $F(1,31) = 0.03$, $MSE = 0.08$, $p > 0.8$, however the interaction between category and difficulty was significant, $F(1, 31) = 4.38$, $MSE = 0.09$, $p < 0.05$. Participants reported more Stimulus Properties dimensions in the advanced guard condition and more Higher Order dimensions in the novice guard condition.

Embodiment vs. Higher Order

When Embodiment dimensions were compared to Higher Order dimensions, there was a significant effect of category, $F(1,31) = 38.75$, $MSE = 0.14$, $p < 0.001$, such that participants reported dimensions from the Embodiment category less often than dimensions from the Higher Order category. There was no effect of difficulty, $F(1,30) = 2.02$, $MSE = 0.10$, $p > 0.1$, and the interaction between category and difficulty was not significant, $F(1,30) = 0.24$, $MSE = 0.07$, $p > 0.6$.

Similar to Study 1a, participants in the border guard scenario reported dimensions from all three of the categories (Stimulus Properties, Embodiment, Higher Order). One interesting difference between the two studies is the relative use of dimensions from the Higher Order category. Participants in the border guard training scenario reported higher use of the Higher Order dimensions relative to the Embodiment and Stimulus Properties dimensions, compared to Study 1a. Thus, it appears that the stronger focus on the skill level of the searcher in the border guard training scenario predisposed the participants towards using schema and theory of mind

while choosing the locations. This finding highlights the importance of context in both searching and hiding in the real world.

Questionnaire. The average ratings[2] for the context-specific and general hiding questions of the Dimension Rating Questionnaire (Luggage) can be seen by dimension in Table 5. To examine the differences between the types of questions at a category level, the ratings for the dimensions that fall under each category were averaged and can be seen in Figure 4. A comparison of the context-specific questions to the general hiding questions provides a direct measure of the effect of context. Participants might report that they think that a given dimension is important when hiding in general, but that they did not consider that dimension in the border guard training scenario, indicating that the use of a dimension depends on the context. Repeated measures t-tests were used to compare the context-specific questions that asked participants whether they had used the dimensions when choosing hiding locations for the beads to their ratings of how important the dimensions are in general hiding (context-general) for each category. There was a significant difference between the context-specific and general hiding questions for the Stimulus Properties dimensions, $t(25) = 4.41$, $p < 0.001$; participants' ratings indicated that they thought the Stimulus Properties were important in hiding in general, but that they did not use them as often in the specific border guard training scenario that they had just completed. This was also the case for the Higher Order dimensions, although to a lesser degree, $t(25) = 2.51$, $p < 0.05$. There were no differences between the context-specific and the general hiding questions for the Embodiment dimensions, $t(25)= 0.15$, $p > 0.8$.

In summary, while the results from participants' subjective reports across the two studies provide indirect evidence that context affects the relative use of the dimensions, the results from

Table 5. Average ratings on the Dimension Ratings Questionnaire (Luggage) for each dimension of each category as a function of question type in Study 1b. Participants rated each dimension on a scale from 1 (did not consider/did not use/not at all important) to 7 (considered a lot/used a lot/very important).

	Question Type		
	Context-specific		General Hiding
Dimension	**Consider**	**Use**	**Important**
Stimulus Properties			
Visual Similarity	3.33	3.23	5.41
Audition	4.00	4.15	5.30
Tactility	4.70	4.69	5.48
Embodiment			
Confrontation	6.19	5.73	5.81
Higher Order			
Theory of Mind – liberal	5.96	5.69	6.41
Theory of Mind - conservative	5.15	5.00	5.96
Search Schema	5.89	5.77	5.67
Schema for Function of Item	5.33	5.04	5.41

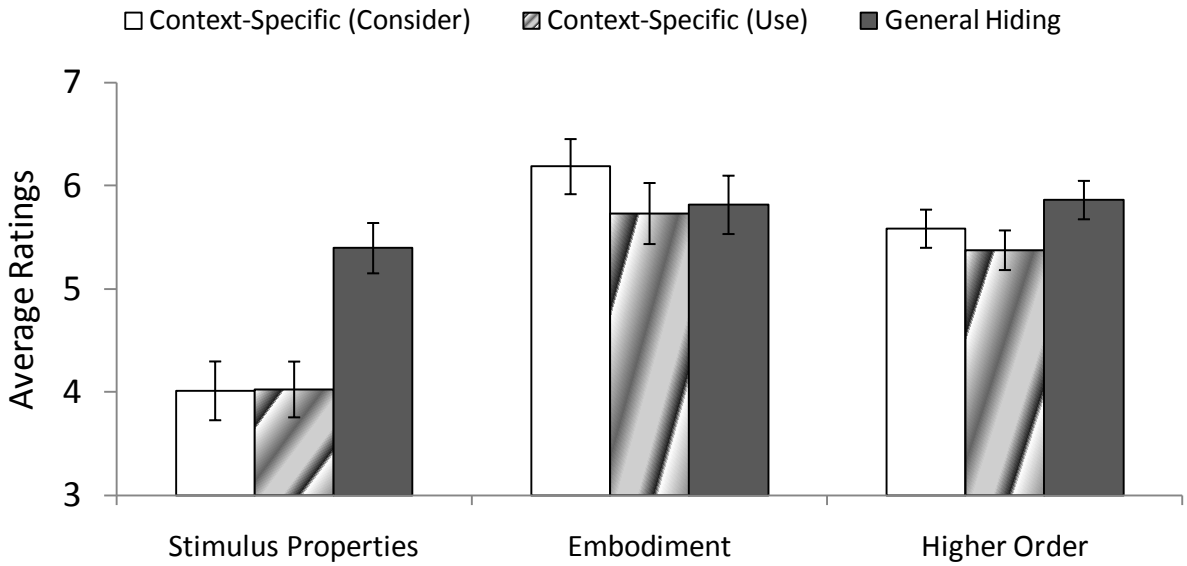

Figure 4. Average ratings on the Dimension Rating Questionnaire (Luggage) as a function of Category and type of question for Study 1b.

the questionnaire provide more direct evidence of the importance of context. When asked about the specific context that they just completed, participants reported that they did not consider or use the dimensions from the Stimulus Properties category very often, but when rating the importance of these dimensions in general, participants indicated that they were important. This difference highlights the importance of context; not all dimensions are going to be relevant and useful to participants in all contexts.

2.2.3 Discussion

In Study 1b, an imaginary border guard training scenario was used, where difficulty was manipulated by varying the degree of experience of the searcher (i.e., the border guard in training). Interestingly, while participants did report dimensions from all three of the categories, dimensions from the Higher Order category were reported much more frequently than those in the Stimulus Properties and Embodiment categories.

When the results from Study 1a and 1b are compared, it is apparent that the results are generalizable since the same dimensions were reported in both studies; however the importance of context is also clear. The relative use of the dimensions from the three categories differed across the different experimental scenarios used in the two studies; in Study 1a, the Embodiment and Higher Order dimensions were reported more often than the dimensions from the Stimulus Properties category, while in Study 1b, the Higher Order dimensions were reported significantly more often than dimensions from the other two categories. This difference is likely due to the increased focus on the abilities of the search in the border guard training scenario.

The questionnaire results from Study 1b provide direct evidence of the importance of context, as participants rated the Stimulus Properties and Higher Order dimensions higher in terms of importance when hiding in general, than they did for the specific border guard training

scenario that they had just completed. Therefore, participants are aware that different dimensions might be more relevant in different situational contexts.

2.3 Overall Discussion

There were five main objectives for Study 1a and 1b – 1) to develop one way of probing concealment behaviour; 2) to identify dimensions that participants use when concealing objects in real-world and complex scenarios; 3) to examine the relative importance of the dimensions; 4) to explore the generalizability across studies; and 5) to examine the effect of context across different experimental scenarios. To fulfill these objectives, the approach taken in Studies 1a and 1b was to give participants experience with concealing an object in a more real-world and complex scenario, and then to collect their subjective strategies and thought processes. This approach yielded rich and interesting subjective reports that not only show that there are consistencies in the strategies participants use when varying the degree of concealment, but also that there are many different types of dimensions used by participants. The dimensions fell into three categories: Stimulus Properties, Embodiment and Higher Order dimensions. As would be predicted from the visual search literature, some participants focused on the Stimulus Properties of the target relative to the distracters and varied visual similarity. Interestingly, participants also used the auditory and tactile features of the target, which was not something that was predicted a priori. Participants also considered the 3-dimensional nature of the luggage and how someone might interact with the items in the luggage (i.e., Embodiment dimensions). And finally, participants considered what the searcher might be thinking as they are completing the search and how people would likely search the luggage (i.e., Higher Order dimensions).

The relative use of the dimensions from the three categories was considered within each study. The finding that the Stimulus Properties dimensions were consistently reported less often

across the two studies is not what would be expected from the traditional visual search literature, which primarily has examined how low-level visual characteristics affect search efficiency. Additionally, these studies demonstrate that new dimensions can emerge in more complicated scenarios. Dimensions such as schema and theory of mind have received little attention in the traditional visual search literature and based on the findings of Studies 1a and 1b could be an important factor in both visual search and concealment.

Studies 1a and 1b also highlight the importance of context in two ways – 1) by comparing the results across the two studies; and 2) by comparing the context-specific and context-general findings from the questionnaire. While dimensions from all three categories were reported in both studies, their relative use differed when the context changed across studies. This is important to keep in mind when developing a theory of concealment, since the factors that are important when concealing objects in one context might be different than those that are important in a different context. Additionally, differences were found in the questionnaire when participants were asked about whether they had used each of the dimensions when choosing locations within the luggage (context-specific), compared to how important each of the dimensions would be when hiding in general (context-general). The role of context will be explored further in later experiments to further understand how the dimensions vary with context.

The present results suggest that participants have a sophisticated understanding of the factors that govern visual concealment, and that this understanding is far broader than the traditional visual search literature would have us believe. Participants have an understanding of the ways in which many different dimensions affect concealment and are opportunistic in that

they use the situational context to determine how to use or apply the various possible concealment dimensions.

Consideration of the 5 Strategies identified for the development of a theory of concealment – 1) establish a methodology, 2) identify dimensions, 3) categorize dimensions, 4) prioritize dimensions, and 5) integrate results into a theoretical framework that may involve inferences about the mechanisms involved – reveals that the studies in Chapter 1 were successful in addressing the first three strategies. A way to probe concealment behaviour (i.e., subjective reports) was developed [Strategy 1]. A number of dimensions were identified and also categorized, thereby providing information for Strategies 2 and 3 as well.

CHAPTER 3: EXAMINING THE EFFECT OF EACH DIMENSION: FORCED-CHOICE LUGGAGE EXPERIMENTS

The placement tasks in Chapter 2 uncovered a number of dimensions that participants reported when hiding objects in scenarios involving luggage. While these studies were fruitful in terms of generating a list of dimensions that might be important to a theory of concealment [Strategy 2], they are limited in two important ways – 1) the complexity of the stimuli and the scenarios make it difficult to determine which factors a participant used by examining only the hiding behaviour (i.e., not considering the subjective reports); and 2) they do not provide any direct evidence that the dimensions identified from the subjective reports influence hiding behaviour. The purpose of the experiments reported in Chapter 3 was to reduce the complexity of the experimental scenario to be able to examine whether each of the reported dimensions influences hiding behaviour. This strategy provides more information about the dimensions that are important in concealment [Strategy 2], but it also develops another technique – a forced-choice task – for the study of concealment [Strategy 1]. On each trial, a single dimension was manipulated to provide a choice between two or more locations to make the target object either easy or hard to find. For example, to test whether colour similarity would have an influence on participants' hiding behaviour, participants chose to place the blue target object next to either a red sweatshirt or a blue sweatshirt. Participants' choices were recorded and subjective reports were also collected to confirm that participants were in fact using the intended dimension when making their choice.

3.1 Experiment 2: Forced-Choice Task 1

In Experiment 2, dimensions from each of the three categories – Stimulus Properties, Embodiment, and Higher Order – were used in a forced-choice task. The Stimulus Properties

dimensions reported in Studies 1a and 1b were visual similarity, audition and tactility. For the purposes of the forced-choice task, visual similarity was broken down into two different aspects: **colour similarity** and **shape similarity**. Audition did not lend itself to the forced-choice task as it was difficult to create choices that only differed on how easy or hard it would be hear the target object, and not on any other dimensions. **Tactility** was manipulated by varying the thickness of the material. Four Embodiment dimensions were created based on the confrontation and accessibility dimensions uncovered in the placement tasks (Studies 1a and 1b). These dimensions included degree of **embeddedness** or the amount that the target object is enveloped by distracter items**; horizontal eccentricity**, which was strongly based on the similar dimension from the visual search literature; how many layers deep the object was placed (i.e., **depth**); and use of the **main vs. outer** compartment. A single Higher Order dimension, **schema**, was used. Each dimension is described in detail below.

3.1.1 Method

Participants. Thirty-two undergraduate students from the University of Waterloo participated in a 30-minute experimental session for partial credit towards their psychology class. All participants reported normal or corrected-to-normal vision.

Materials. A blue suitcase packed with t-shirts, jeans, socks, sweatshirts and shoes was sitting on the table (Figure 5). The two target objects that were used were a blue toothbrush and a yellow Exacto knife.

Stimulus Properties Dimensions

Colour Similarity. For the toothbrush, participants chose between placing the blue toothbrush next to a red hooded sweatshirt (incongruent colour) or a blue hooded sweatshirt

Figure 5. The suitcase that was used as a reminder of the context in Experiments 2, 3a, 3b, 8a and 8b.

(congruent colour). For the Exacto knife, participants chose between placing the yellow knife next to a black t-shirt (incongruent colour) or a yellow t-shirt (congruent colour). See Figure 6 for the choices. Based on the visual search literature on colour similarity (e.g., Nagy & Sanchez, 1990), it was predicted that participants would choose to place the target objects next to the congruently coloured shirts when instructed to make the targets hard to find because the targets would blend in against the congruently coloured background. It was expected that when trying to make the targets easy to find they would make the opposite choice and choose to place the target objects next to the incongruently coloured piece of clothing to make the target object stand out.

Shape Similarity. For the toothbrush, participants chose between placing the toothbrush in a bag filled with small and round items such as a bar of soap, a round perfume bottle and deodorant (dissimilar shape), or longer and skinnier items such as combs, nail files, and eyebrow pencils (similar shape). All distracter items were toiletry items (i.e., from the same category as the toothbrush). For the knife, participants chose between placing the knife in a bag filled with round objects such as a roll of duct tape, pliers, a bottle of paint (dissimilar shape), or longer items such as tubes of glitter, markers, and a similarly shaped cutter used in scrapbooking (similar shape). All distracter objects were items one might use for crafts (i.e., from the same category as the knife). See Figure 6 for the choices. Based on the visual search literature that has examined target-distracter similarity (e.g., Duncan & Humphreys, 1989), it was predicted that when participants are instructed to make the target objects hard to find, they would choose to place the target in the bags with items that are congruently shaped because the target objects would blend in with the similarly shaped distracters. As with the colour similarity dimension, the opposite choice would be expected when participants are instructed to make the target objects

Figure 6. The choices for each of the Stimulus Properties dimensions as a function of target type (blue toothbrush vs. yellow knife) in Experiment 2.

easy to find (i.e., participants will place the target objects in with dissimilarly shaped distracter items).

Thickness of Material. Tactility was manipulated using the thickness of the material. For the toothbrush, participants chose between rolling the toothbrush up in a blue t-shirt (thinner material) or in a pair of blue jeans (thicker material). For the knife, the choice was between using a brown t-shirt (thinner material) or a brown hooded sweatshirt (thicker material). See Figure 6 for the choices. It was predicted that participants would choose the thicker material to make the target harder to find because it would be harder to feel the target, and the thinner material to make the target object easier to find.

Embodiment Dimensions

The degree to which the target object was embedded or enveloped in layers of distracters was manipulated in a more controlled and conservative way in the Embeddedness (controlled) dimension, and in a more realistic way in the Embeddedness (realistic) dimension.

Embeddedness (controlled). For both the toothbrush and the knife, participants chose between placing the target object inside 1 box (low degree of embeddedness) or inside 3 nested boxes (highly embedded). See Figure 7 for the choices. It was predicted that participants would choose to place the target objects inside the 3 nested boxes when instructed to make the target hard to find because of the extra steps required to search for the target. Conversely, it was expected that participants would chose to place the target inside 1 box when trying to make the target easy to find.

Embeddedness (realistic). For the toothbrush, the choice was between placing it directly in the pocket of the jeans (low degree of embeddedness) or first rolling it up inside a pair of socks which were then placed inside the pocket of the jeans (highly embedded). For the knife,

Figure 7. The choices for the Embodiment dimensions as a function of target type (blue toothbrush vs. yellow knife) in Experiment 2.

participants chose between placing it directly in the pocket of the hooded sweatshirt (low degree of embeddedness), or first placing it inside a small drawstring bag which was then placed inside the pocket of a rolled up hooded sweatshirt (high degree of embeddedness). See Figure 7 for the choices. Similar to the Embeddedness (controlled) dimensions, it was predicted that participants would choose the higher degree of embeddedness when trying to make the target hard to find, and the low degree of embeddedness when trying to make the target easy to find.

Horizontal Eccentricity. For both the toothbrush and the knife, two red, folded towels were placed on top of the items in the suitcase. The towels were folded so that they were the same size as the suitcase and covered all the items in the suitcase. The suitcase was closed and then opened so that one towel was flush up against the lid and the other towel lay flat in the suitcase. Participants chose between putting the target object either in the centre of the towel (low degree of eccentricity) or towards the edges and surrounding parts of the towel (high degree of eccentricity). See Figure 7 for the choices. Based on the visual search literature on target eccentricity (Carrasco, Evert, Chang, & Katz, 1995), it was predicted that participants would place the target towards the surrounding regions when trying to make the target hard to find, and in the centre when trying to make the target easy to find.

Depth. For both the toothbrush and the knife, participants were given a stack of five white t-shirts and could place the target object anywhere within the stack. See Figure 7 for the choices. It was predicted that participants would choose to place the target objects closer to the bottom of the pile of t-shirts when trying to make it hard to find, and close to or right on top of the stack of shirts when making it easy to find.

Main vs.Outer. For both the toothbrush and knife, participants chose between placing the target object somewhere within the main compartment of the suitcase or somewhere within the

outer pocket. See Figure 7 for the choices. There were no clear a priori predictions as to whether participants would choose to place the target object in the main compartment or in the outer pocket to make the target either easy or hard to find.

Higher Order Dimension

Schema. For the toothbrush, participants could place the toothbrush in a pencil case containing items such as pens, pencils, and glue sticks (incongruent schema), or in a toiletry bag containing eyebrow pencils, combs, and razors (congruent schema). For the knife, participants chose between the toiletry bag containing eyebrow pencils, combs and razors (incongruent schema) or a bag containing craft and tool items such as paintbrushes, scrapbook cutter (congruent schema). Items within the two pairs of bags were similar in shape to each other. See Figure 8 for the choices. It was predicted that when instructed to make the target objects hard to find, participants would place to target in with items from a different category (i.e., incongruent schema) because of the idea that people would be less likely to look in a pencil case for a toothbrush or a toiletry bag for a knife.

Procedure. Participants were first shown the suitcase and its contents, while receiving the following instructions:

> " This suitcase is full of items - such as socks, jeans, t-shirts, and hoodies - that you might find in someone's suitcase when they are travelling. In this study, you will be given a target item and your goal is to choose locations with-in the suitcase that will make that item really hard *(/easy*) to find. On each trial, you will be given a choice of locations, and you will choose which of those locations you think would make the item harder (*/easier*) for someone searching the suitcase to find. When you are given a choice between two places, you are to

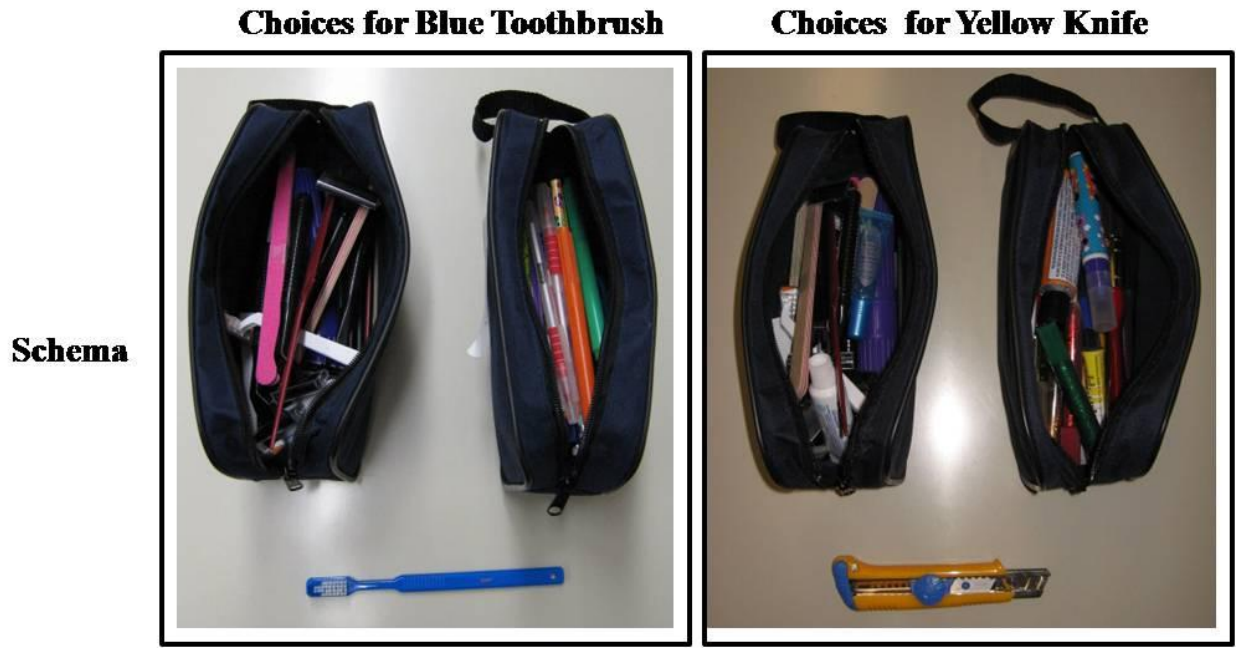

Figure 8. The choices for the Higher Order dimension as a function of target type (blue toothbrush vs. yellow knife) in Experiment 2.

assume that everything else in the bag would be exactly the same between the choices, except for the specific thing we are asking you about. For all of the choices, imagine that you are placing the object so that it would be really hard *(/easy)* for another person searching to suitcase to find; you want to imagine the choices in the context of the suitcase. You will tell me your choice and then you will write down your reason for making that choice on this piece of paper."

Participants were randomly assigned to either the Easy condition, where they were instructed to choose the option that would make the target object easy to find, or the Hard condition, where they were instructed to choose the option that would make the target object hard to find. Half of the participants completed the nine trials for the toothbrush first, followed by the nine trials for the knife; while the other half of participants completed the knife trials, followed by the toothbrush trials. The first trial for the first target object was always the Colour Similarity trial since pilot testing revealed that participants were slightly confused by the instructions until they saw the Colour Similarity materials since they were so salient. The remaining eight trials for that target object, as well as the nine trials for the second target object were presented in a random order. Each random order was used for one participant in the Easy condition and one person in the Hard condition. The placement of the choices (left side vs. right side) was also randomly generated.

The questions used for each dimension (i.e., for each trial) for the toothbrush were as follows:

- *Colour Similarity* – "If you wanted to make this toothbrush really hard *(/easy*) to find in the suitcase, would you choose to place it next to this shirt (*point to shirt on* left) or this shirts (*point to shirt on right*)?"

- *Shape Similarity* – "Assuming these two bags were in the suitcase, if you wanted to make this toothbrush really hard *(/easy*) to find, would you choose to place it in this bag (*point to bag on left*) or in this bag (*point to bag on right*)?"
- *Thickness of Material* – "If you wanted to make this toothbrush really hard *(/easy*) to find within in the suitcase, would you roll in up in the jeans or roll it up in the t-shirt?"
- *Embeddedness (controlled)* **– "**If you wanted to make this toothbrush really hard *(/easy*) to find, would you choose to place it in this box or in this box which inside this box and this box?"
- *Embeddedness (realistic)* – "If you wanted to make this toothbrush really hard *(/easy*) to find within the suitcase, would you choose to place it in the pocket of this pair of jeans or rolled up in these socks which are then placed inside the pocket of the jeans?"
- *Horizontal Eccentricity* – "If you wanted to make this toothbrush really hard *(/easy*) to find in the suitcase, would you choose to place it in the centre of the towel or in the surrounding area?"
- *Depth* – "If you wanted to make this toothbrush really hard *(/easy*) to find, where would you place it among the t-shirts?"
- *Main vs.Outer* – "If you wanted to make this toothbrush really hard *(/easy*) to find, would you place it in the main compartment or the outer pocket of the suitcase?"
- *Schema* – "Assuming these two bags were in the suitcase, if you wanted to make this toothbrush really hard *(/easy*) to find, would you put it in this bag (*point to bag on left*) or in this bag (*point to bag on right*)?"

The questions for the knife were asked in a very similar manner, with only the details of the choices changing to match the dimension choices for the knife described in the Materials section above.

3.1.2 Results

With the exception of the Depth dimension, for each dimension of each target object, participants received a "1" if they chose the option that was expected for the "hard" condition, and a "0" if they chose the expected "easy" option (for the Main vs. Outer dimension, the main compartment was arbitrarily chosen as the option for the "hard" condition because there were no a priori predictions). For the Depth dimension, the layer where the participant chose to place the target object was recorded, and later recoded into a dichotomous variable such that participants received a "0" if they chose to place to target between the 2nd and 3rd layers or higher, and a "1" if they placed the target in the 3rd t-shirt or anywhere lower. With this conversion, all dimensions were now coded with "0's" and "1's". The proportion of participants who selected each choice as a function of difficulty for the toothbrush and the knife can be seen in Appendices B and C, respectively.

The scores for each dimension of each target object were then averaged such that for any given dimension, a participant could have a score of "0" if they chose the "easy" option for that dimension for both the toothbrush and the knife, a "0.5" if they chose the "hard" option for that dimension for either the toothbrush or the knife, or a "1" if they chose the "hard" option for that dimension for both the toothbrush and the knife.

The average proportion of trials in which participants selected each choice for each dimension is shown as a function of difficulty in Table 6. Independent sample t-tests comparing

Table 6. Average proportion of trials in which participants selected each choice as a function of dimension and difficulty in Experiment 2.

Dimension	Choices	Easy	Hard
Colour Similarity	Incongruent colour	0.94	0.03
	Congruent colour	0.06	0.97
Shape Similarity	Dissimilar shape	0.78	0.19
	Similar shape	0.22	0.81
Thickness of Material	Thin	0.84	0.41
	Thick	0.16	0.59
Embeddedness (controlled)	Inside 1 box	0.94	0.00
	Inside 3 boxes	0.06	1.00
Embeddedness (realistic)	Inside 1 item	0.53	0.41
	Inside 2 items	0.47	0.59
Horizontal Eccentricity	Centre	0.84	0.25
	Surrounding area	0.16	0.75
Depth	Closer to top	1.00	0.00
	Closer to bottom	0.00	1.00
Main vs. outer	Outside	0.47	0.37
	Main	0.53	0.63
Schema	Same category	0.53	0.44
	Different category	0.47	0.56

the easy and hard conditions were conducted for each dimension. Results are discussed for the dimensions in each category in turn.

Stimulus Properties Dimensions

Colour Similarity. Participants used colour similarity as predicted; participants chose to place the target object next to a congruently coloured distracter significantly more often in the hard condition than in the easy condition, $t(30) = 17.13$, $p < 0.001$. Responses from participants' subjective reports confirmed that participants were using colour similarity as expected; participants in the hard condition reported placing the target next to a congruently coloured item because it would "blend in" or "camouflage", while in the easy condition participants reported that the target would "stand out" or "contrast" with the incongruently coloured item.

Shape Similarity. Participants also used shape similarity as predicted, with participants in the hard condition choosing to place the target object in with distracter items that are similar in shape significantly more often than participants in the easy condition, $t(30) = 5.91$, $p < 0.001$. While the results from participants' choices are in line with expectations of how shape would be used, examination of participants' subjective reports revealed that only 44% of participants reported using the shape of the objects. In fact, of the 56% of participants who did not appear to notice the difference in shape between the items in each bag, 47% tried to find differences between the two bags in terms of what category particular items belonged to and were therefore using a strategy involving conceptual similarity or expectation of which bag the target object belonged in more. This finding suggests that 1) shape is not a very salient feature; 2) it is difficult to create stimuli that are perfectly matched for schema, and differ only in terms of shape; and 3) participants appear to be predisposed to apply higher order strategies.

Thickness of Material. As predicted, for the tactility dimension (i.e., thickness of material), participants in the hard condition chose the thicker material significantly more often than participants in the easy condition, $t(30) = 3.64$, $p < 0.005$. Despite this significant difference, examination of the subjective reports revealed that 50% of participants did not report using the thickness dimension as expected. While the reported reasons all had to do with different aspects of the material, the majority of participants (25%) who did not use the thickness of material in the strictest sense, commented on the relative differences in amount of material since the t-shirt and jeans (used for the toothbrush), and the t-shirt and fleece sweatshirt (used for the knife) differed amount of material and how tightly they could be rolled.

Embodiment Dimensions

Embeddedness (controlled). Participants used the more controlled embeddedness dimension in line with what was expected; participants were much more likely to place the target objects inside the 3 nested boxes (i.e., high degree of embeddedness) when trying to make the target objects hard to find than when trying to make the target easy to find, $t(30) = 15.00$, $p < 0.001$. Participants' subjective reports confirmed that the controlled embeddedness dimension was being used as expected; participants in the hard condition reported placing the target inside the 3 nested boxes because it would "require more work to open multiple boxes" and "take more time to find". In contrast, in the easy condition participants reported placing the target inside the 1 larger box because "there is only one lid to open", "it would be easier to retrieve", and "there is less to look through to find the object".

Embeddedness (realistic). Participants did not use the realistic version of the embeddedness dimension in the way that was expected, as there were no differences between the easy and hard conditions in terms of the likelihood that participants chose a higher degree of

embeddedness (i.e., placing the target object inside 1 article which was then placed inside the pocket of a piece of clothing), $t(30) = 0.88$, $p > 0.3$. Examination of subjective reports revealed that only 42% of participants reported using the dimension as expected (i.e., using more layers or a higher-level of embeddedness to make the object hard to find). The remaining participants reported two predominant strategies when explaining their choice to only use 1 level of embeddedness in the hard condition – 1) it would be less bulky and would draw less attention; and 2) it would be less suspicious than if the socks were in the pocket (because people do not expect socks to be in a pocket), making it less likely that the pocket would be searched. The opposite strategies were reported in the easy condition.

Horizontal Eccentricity. As predicted, participants chose to place the target objects in the surrounding areas of the towel (as opposed to in the centre of the towel) more often in the hard condition than in the easy condition, $t(30) = 4.41$, $p < 0.001$. In general, participants' subjective reports confirmed that horizontal eccentricity was used as expected, however there were a number of participants (17%) that mentioned placing the target object in the centre because it would be less likely to fall out.

Depth. In line with predictions for the depth dimension, all of the participants who were in the hard condition chose to place the target objects closer to the bottom of suitcase, while all of the participants in the easy condition chose to put the target closer to the top. In fact, 69% of participants in the easy condition placed the target objects right on top of the stack of 5 shirts, while another 19% put the target inside the top shirt. An independent measures t-test could not be conducted on the depth dimension because of the lack of variability in participants' responses. Participants' subjective reports revealed that participants were not simply using a rule that deeper is more difficult; in the hard condition, participants consistently reported choosing to place the

target object somewhere in the middle layers, but closer to the bottom, because "people are more likely to search the top and the very bottom". Participants also reported placing the target inside a t-shirt (as opposed to just between layers) to make it more embedded and less likely to fall out.

Main vs. Outer. There were no clear consistencies in participants' selections for whether it would be harder to find the target objects in the main compartment vs. the outer pocket of the suitcase, $t(30) = 0.57$, $p > 0.5$. Examination of subjective reports revealed that participants had many different and often conflicting ideas about the differences between the main and outer compartments. While some participants chose to place the target object in the main compartment to make it easy to find because they thought that the main compartment would be more likely to be searched, other participants chose the main compartment to make the target hard to find because there were more items and more space to hide the target within. The distinction between the main compartment and the outer pocket of a suitcase does not appear to be a useful one in terms of concealment behaviour.

Higher Order Dimension

Schema. Participants did not consistently use the schema dimension in the way that was predicted; there were no differences between the easy and the hard conditions in terms of the proportion of participants who chose to place the target objects in with items from a different category (i.e., incongruent schema), $t(30) = 0.59$, $p > 0.5$. Examination of subjective reports revealed that participants were using two main strategies to make the target object hard to find – 1) choosing to place the target object in with items from the different category because people would be less likely to look in a pencil case for a toothbrush and in a toiletry bag for a knife (which is what was predicted a priori and was reported by 53% of participants); and 2) choosing to place the target object in with items from the same category because the target would blend in

with the items (reported by 30% of participants). This latter strategy suggests that participants were using conceptual similarity. The opposite strategies were reported in the easy condition. One possible explanation for the second strategy is that the items in the bag were influencing participants and biasing them to consider what the target would look like among the distracter items, as opposed to considering which categorical bag would be more likely to be searched by the border guard.

3.1.3 Discussion

The purpose of Experiment 2 was to examine whether the dimensions that were reported in the placement tasks in Chapter 2 influence participants' hiding behaviour using a forced-choice task. Overall, the results from Experiment 2 confirm that the dimensions do in fact influence participants' hiding behaviour in ways that would be predicted. For dimensions that did not show clear effects in the choice data (i.e., the behavioural data), the subjective reports were able to account for the lack of effect as participants were often interpreting the dimension in unintended and unexpected ways. Even for some of the dimensions that appeared to have been used as expected based on significant differences in the choice data, examination of the subjective reports revealed that participants were using an entirely different dimension (e.g., using schema instead of shape similarity). This finding highlights the importance of gathering subjective reports even in a simple forced-choice task, as it is possible that participants are not using the strategy that would be expected based on the behavioural results.

Another interesting finding from Experiment 2 is the prevalence of the use of strategies involving higher order factors. Despite the fact that the schema dimension did not show significant effects, it appears from subjective reports that participants often employ a strategy that involves schema or expectation even when that was not intended based on the choice of

stimuli. For example, for the shape similarity dimension, almost half of the participants used a strategy that involved narrowing in on particular items in the bags and choosing the bag that contained items that were "more related" to the target object, even though an attempt was made to ensure that the items from both bags were from the same category. Participants also employed a strategy involving schema or expectation for the embeddedness (realistic) dimension. In this case participants did not choose to embed the toothbrush inside the socks before placing it in the pocket of the jeans in the hard condition because participants felt that it would be suspicious and violate the searchers' expectation if the socks were in the jeans' pocket. Again this use of schema highlights the importance of higher order factors.

3.2 Experiment 3a: Forced-Choice Task 2

The goal of Experiment 3a was to replicate the results from Experiment 2 for the dimensions that were used as expected, and to refine the dimensions that participants did not use consistently and/or as expected. The changes that were made from Experiment 2 included removing the shape similarity dimension since the majority of participants were picking up on different categorical aspects of the items in the bag (i.e., schema) and not using the shape of the items. The main vs. outer dimension was also removed since participants were not using the dimension in any clear and consistent manner. To remove the confound of bulkiness or amount of material in the thickness of material dimension, square pieces of identical size were cut out of each type of fabric. To examine one of the reported aspects of the embeddedness (realistic) dimension from Experiment 2, a bulkiness/affordance dimension was created. One last important change was made to the schema dimension; based on subjective reports from Experiment 2, schema was split into two dimensions: schema – expectation and schema – conceptual. In Experiment 2, approximately half of the participants reported placing the target in with items from a different category to make it hard to find because people would be less likely to look in, for example, a pencil case for a toothbrush (an expectation or theory of mind strategy), while approximately one third of participants choose to place the target object in with items from the same category to make the target hard to find because the target would blend in with the items (a conceptual similarity strategy). Therefore, the schema – expectation was created in which one choice is definitely consistent with the schema for the target object, while the other choice is a strong violation of schema. The schema – conceptual dimension was very similar to the schema dimension in Experiment 2, with the exception that instead of the participants looking at the objects inside the bag and inferring the category, the bags were closed

and had labels on the outside explicitly telling the participant which category the items belonged to. All changes are discussed in detail below.

3.2.1 Method

Participants. Thirty-two undergraduate students from the University of Waterloo participated in a 30-minute experimental session for partial credit towards their psychology class. All participants reported normal or corrected-to-normal vision.

Materials. The same suitcase from Experiment 2 was used. The target objects were still a blue toothbrush and a yellow Exacto knife, but the knife was a more slender version of the knife used in Experiment 2 to try to more closely match the shape of the two target objects.

Stimulus Properties Dimensions

Colour Similarity. The same materials from Experiment 2 were used.

Thickness of Material. The same type of materials as in Experiment 2 were used, however square pieces measuring 20cm by 15cm were cut from the material. It was predicted that using pieces of material that were identical in size would control for the amount of material and would encourage participants to focus solely on the thickness of the material. As in Experiment 2, it was predicted that participants would choose the thicker material to make the target harder to find because it would be harder to feel the target, and the thinner material to make the target object easier to find.

Embodiment Dimensions

Embeddedness (controlled). The same materials from Experiment 2 were used.

Horizontal Eccentricity. The same materials from Experiment 2 were used.

Depth. The same materials from Experiment 2 were used.

Bulkiness/Affordance. For both the toothbrush and the knife, the choice was between using thin, black dress socks (less bulky) or thick wool socks (more bulky) to roll the object up in and then the socks (with the object inside) would be placed in the pocket of the jeans. This dimension was created to try to test one of one of the interpretations of the Embeddedness (realistic) dimension of Experiment 2. For the Embeddedness (realistic) dimension, participants could choose to place the target object directly inside a pocket (either a pocket in a pair of jeans or a pocket in a hooded sweatshirt), or to first place the target in another item (either a pair of socks or a small drawstring bag) which was then placed inside the pocket. A number of participants chose to put the target directly in the pocket in the hard condition, which was opposite of what was expected. Examination of the subjective reports of those participants revealed that one reason participants gave for this choice was that it would be less bulky and would not stick out as much as the sock or bag would. Therefore the Bulkiness/Affordance dimension was created to test this idea. For this dimension, level of embeddedness was held constant, and it is simply the thickness of the material in the socks that differed between the two choices. It was predicted that participants would choose the thinner socks to make the target object hard to find because they would be less bulky and less likely to stick out and catch the attention of the searcher. The thicker socks would then be chosen in the easy condition since they are bulkier and would be more likely to be noticed by the searcher.

Higher Order Dimensions

Schema – Expectation. This dimension was created to try to make a more extreme version of the schema dimension from Experiment 2. For the toothbrush, participants chose between putting the toothbrush inside a toothbrush holder (fits with schema) or inside a flashlight (violates schema). For the knife the choices were between putting the knife inside a tool belt

(fits with schema) or inside a shampoo bottle (violates schema). It was predicted that when trying to make the target objects hard to find, participants would choose to violate the schema for where the toothbrush and the knife would expect to be found. Therefore, participants would place the toothbrush in the flashlight and the knife in the shampoo bottle in the hard condition because people would not expect the target objects to be in those containers and would therefore not search inside them.

Schema - Conceptual. This dimension is similar to the Schema dimension in Experiment 2, but to reduce the possibility of participants being influenced by how the target would look in amongst the items in the bag instead of considering which bag would be more likely to be searched based on the categorical level, labels were used. For the toothbrush, participants could place the toothbrush in a bag labeled "Toiletry bag" (same category) or in a bag labeled "Pencil case" (different category). For the knife, participants chose between a bag labeled "Tool bag" (same category) and a bag labeled "Toiletry bag" (different category). It was predicted that participants would choose to place the target object in the bag containing items from a different category when trying to make the target hard to find because people would be less likely to search in a pencil case for a toothbrush or in a toiletry bag for a knife. The opposite would be true for the easy condition; participants would choose to place the target object in the bag containing items from the same category because that is where one would expect those items to be.

Procedure. The same general procedure from Experiment 2 was used, but the following changes were made to the questions asked on each trial:

- *Thickness of Material* – "If you wanted to make this toothbrush really hard *(/easy*) to find within in the suitcase, would you roll in up in this type of material or this type of materials?"
- *Bulkiness/Affordance* – "Here your choice is between the two pairs of socks. If you were going to choose one of the pairs of socks to first roll the toothbrush up inside and then put the socks (with the toothbrush inside) into the pocket of the jeans, would you choose these socks (*point to one on left)* or these socks (*point to one of right)*?"
- *Schema – Expectation* – Would you choose to place the toothbrush within the toothbrush holder or in the flashlight to make it really hard (/easy) to find?
- *Schema – Conceptual* – "If these two bags were in the suitcase and you wanted to make this toothbrush really hard *(/easy*) to find, would you put it in this bag (*point to one on left*) or this bag (*point to one on right*)?

3.2.2 Results

The average proportion of trials in which participants selected each choice for each dimension is shown as a function of difficulty in Table 7 (the proportion of participants who selected each choice as a function of difficulty for the toothbrush and the knife can be seen in Appendices D and E, respectively). Independent sample t-tests comparing the easy and hard conditions were conducted for each dimension. Results are discussed for the dimensions in each category in turn.

Stimulus Properties Dimensions

Colour Similarity. The results from Experiment 2 for the Colour Similarity dimension were replicated in the present experiment. All of the participants in the hard condition chose to

Table 7. Average proportion of trials in which participants selected each choice as a function of dimension and difficulty in Experiment 3a.

Dimension	Choices	Easy	Hard
Colour Similarity	Incongruent colour	1.00	0.00
	Congruent colour	0.00	1.00
Thickness of Material	Thin	0.81	0.12
	Thick	0.19	0.88
Embeddedness (controlled)	Inside 1 box	1.00	0.06
	Inside 3 boxes	0.00	0.94
Horizontal Eccentricity	Centre	0.81	0.22
	Surrounding area	0.19	0.78
Depth	Closer to top	1.00	0.00
	Closer to bottom	0.00	1.00
Bulkiness/ Affordance	More bulky (thicker socks)	0.50	0.44
	Less bulky (thin socks)	0.50	0.56
Schema – Expectation	Fits with schema	0.94	0.09
	Violates schema	0.06	0.91
Schema – Conceptual	Same category	0.91	0.16
	Different category	0.09	0.84

place the target object next to a congruently coloured distracter, while all of the participants in the easy condition chose to place it next to the incongruently coloured distracter. An independent measures t-test could not be conducted on the Colour Similarity dimension because of the lack of variability in participants' responses.

Thickness of Material. The results from Experiment 2 for the Thickness of Material dimension were also replicated in the present experiment. Participants in the hard condition chose the thicker material significantly more often than participants who were instructed to make the target easy to find, $t(30) = 5.97$, $p < 0.001$. Comparison of the results in the hard condition of Experiment 2 to the present results suggests that using identically sized pieces of each type of fabric (as opposed to the t-shirt and jeans, and the t-shirt and fleece hooded sweatshirt) removed some of the variability in response. Examination of subjective reports confirmed that 77% of participants used the Thickness of Material dimension in the way that was predicted, however participants' explanations fell into 2 categories – 1) 53% of those participants commented on the feel of the material (i.e., using the thicker material to make the object hard to feel); and 2) 47% commented on how the thicker material would make it harder to see the outline of the object. Therefore, participants were using both tactile and visual properties of the thicker material.

Embodiment Dimensions

Embeddedness (controlled). Participants again used the Embeddedness dimension as expected (and in the same way as in Experiment 2); participants were much more likely to use a high level of embeddedness (i.e., inside 3 nested boxes) in the hard condition than the easy condition, $t(30) = 15.00$, $p < 0.001$.

Horizontal Eccentricity. The Horizontal Eccentricity dimension also replicated; participants were more likely to place the target object in the surrounding areas of the towel in the hard condition than in the easy condition, $t(30) = 4.37$, $p < 0.001$.

Depth. As in Experiment 2, an independent measures t-test could not be conducted on the Depth dimension because of the lack of variability in participants' responses. All of the participants in the hard condition chose to place the target closer to the bottom of the suitcase, while all of the participants in the easy condition placed the target closer to the top.

Bulkiness/Affordance. Participants did not consistently use the Bulkiness/Affordance dimension in the way that was predicted; there were no differences between the easy and the hard conditions in terms of the proportion of participants who chose the thin socks (which were predicted to be chosen in the hard condition because they would be less likely to be bulky and stick out), $t(30) = 0.36$, $p > 0.7$. Examination of subjective reports revealed that participants were interpreting the Bulkiness dimension in two different ways: 1) the thicker socks would make the target harder to find because it would be harder to see or feel the object (and the opposite logic for the easy condition; strategy used by 34% of participants); and 2) the thinner socks would make the target object hard to find because the socks would be less bulky and not stick out as much (which was what was predicted; strategy used by 53% of participants).

Higher Order Dimensions

Schema – Expectation. Participants used the Schema – Expectation dimension in the way that was predicted; participants chose to place the target object inside the item that violated the schema for where the target would be expected significantly more often in the hard condition than in the easy condition, $t(30) = 10.51$, $p < 0.001$. Subjective reports confirmed that participants were using the Schema – Expectation dimension as expected as 88% of participants

reported a strategy that involved violating expectation to make the target objects hard to find and placing the target object where expected in the easy condition.

Schema – Conceptual. Participants also used the Schema – Conceptual dimension in the way that was predicted; participants chose to place the target object in the bag that contained items from a different category significantly more often in the hard condition than in the easy condition, $t(30) = 8.28$, $p < 0.001$. Examination of subjective reports revealed that 81% of participants used the Schema – Conceptual dimension as expected. While there were still 11% of participants who thought placing the target object in with items from the same category would make the target hard to find because it would blend in (and the opposite logic for the easy condition), the majority of participants reported choosing the bag from a different category in the hard condition because people would not expect the target to be there.

3.2.3 Discussion

Experiment 3a involved a replication of certain factors from Experiment 2 and a refining of other factors. The Higher Order schema dimensions were refined successfully into two separate dimensions that influenced participants' behaviour in ways that were expected. The bulkiness/affordance dimension, which was created based on the results from Experiment 2, was not used consistently as was predicted.

Additionally it is interesting to note that dimensions from each of the categories (including schema) influence hiding behaviour. This finding confirms the results from Chapter 2, which showed that participants reported using dimensions from all three categories when trying to make objects easy and hard to find.

3.3 Experiment 3b: Forced-Choice Task 3

The main goal of Experiment 3b was to replicate the findings from Experiment 3a to ensure that the dimensions are in fact consistently affecting participants' behaviour. Additionally, one small change was made to the order of trials to ensure participants' choices in Experiments 2 and 3 were not biased by the fact that the first trial was always a Colour Similarity trial.

3.3.1 Method

Participants. Thirty-two undergraduate students from the University of Waterloo participated in a 30-minute experimental session for partial credit towards their psychology class. All participants reported normal or corrected-to-normal vision.

Materials. The materials used in this experiment were identical to that of Experiment 3a.

Procedure. The procedure used in this experiment was identical to that of Experiment 3a, with the exception that Colour Similarity was not always the first trial. Recall that pilot testing revealed that participants were slightly confused by the instructions until they saw the Colour Similarity trial, and thus Colour Similarity was always included as the first trial in Experiments 2 and 3a to ensure that participants understood the instructions. However, it is also possible that having Colour Similarity as the first trial could have biased the participants' choices on later trials. Therefore in the present experiments the order of trials was random.

3.3.2 Results

The average proportion of trials in which participants selected each choice for each dimension is shown as a function of difficulty in Table 8 (the proportion of participants who selected each choice as a function of difficulty for the toothbrush and the knife can be seen in

Table 8. Average proportion of trials in which participants selected each choice as a function of dimension and difficulty in Experiment 3b.

Dimension	Choices	Easy	Hard
Colour Similarity	Incongruent colour	0.97	0.00
	Congruent colour	0.03	1.00
Thickness of Material	Thin	0.94	0.09
	Thick	0.06	0.91
Embeddedness (controlled)	Inside 1 box	0.91	0.06
	Inside 3 boxes	0.09	0.94
Horizontal Eccentricity	Centre	0.94	0.44
	Surrounding area	0.06	0.56
Depth	Closer to top	0.94	0.00
	Closer to bottom	0.06	1.00
Bulkiness/ Affordance	More bulky (thicker socks)	0.22	0.69
	Less bulky (thin socks)	0.78	0.31
Schema – Expectation	Fits with schema	0.97	0.06
	Violates schema	0.03	0.94
Schema – Conceptual	Same category	0.84	0.25
	Different category	0.16	0.75

Appendices F and G, respectively). Independent sample t-tests comparing the easy and hard conditions were conducted for each dimension. Results are discussed for the dimensions in each category in turn.

Stimulus Properties Dimensions

Colour Similarity. As in Experiments 2 and 3a, significantly more participants in the hard condition chose to place the target objects next to the congruently coloured distracters than in the easy condition, $t(30) = 31.00$, $p < 0.001$.

Thickness of Material. Similar to Experiment 3a, significantly more participants in the hard condition chose the thicker type of material than in the easy condition, $t(30) = 10.51$, $p < 0.001$.

Embodiment Dimensions

Embeddedness (controlled). Participants again chose to place the target objects inside the 3 nested boxes (i.e., a high degree of embeddedness) significantly more often in the hard condition than the easy condition, $t(30) = 10.51$, $p < 0.001$.

Horizontal Eccentricity. Similar to Experiments 2 and 3a, significantly more participants in the hard condition chose to place the target objects in the surrounding regions on the towel than in the easy condition, $t(30) = 3.51$, $p < 0.001$.

Depth. As in the two previous forced-choice experiments, participants chose to place the target objects closer to the bottom of the suitcase significantly more often in the hard condition than in the easy condition, $t(30) = 15.00$, $p < 0.001$.

Bulkiness/Affordance. Contrary to the results of Experiment 3a and to what was predicted, significantly more participants chose the thinner socks in the easy condition than in the hard condition, $t(30) = 2.98$, $p < 0.005$. For the Bulkiness/Affordance dimension, the choice

was between a thick wool sock and a thin dress sock. The target object would be rolled up inside the socks and then placed in the pocket of the jeans. It was predicted that participants would choose the thinner socks in the hard condition because the socks are less bulky and would not protrude out of the pocket as much as the thick, wool socks would. However, participants did not use the dimension in this way. Examination of the subjective reports revealed that 63% of participants used the dimension in the way that would be predicted for the Thickness of Material dimension (i.e., using the thick socks to conceal the shape and feel of the object, and the thin socks to make it easier to see the outline or feel the object), while only 20% reported using the bulkiness factor as expected.

Higher Order Dimensions

Schema – Expectation – As in Experiment 3a, participants chose to place the target objects in the object in which you would not expect them to be found (e.g., placing the toothbrush inside a flashlight) significantly more often in the hard condition than in the easy condition, $t(30) = 17.13$, $p < 0.001$.

Schema – Conceptual – As in Experiment 3a, participants chose to place the target objects in the bags containing items from a different conceptual category significantly more often in the hard condition than in the easy condition, $t(30) = 4.68$, $p < 0.001$.

3.3.3 Discussion

While the results for 7 out of the 8 dimensions from Experiment 3a were replicated in the present experiment, interestingly, the results for the bulkiness/affordance dimension were quite different from both the results from Experiment 3a and from what was predicted a priori. This dimension does not appear to be very well defined or reliable.

Overall, the results from Experiments 2-3b demonstrate that the reported dimensions do influence participants' hiding behaviour in ways that would be expected. These experiments also demonstrate that a forced-choice task is another useful tool to probe concealment behaviour [Strategy 1].

CHAPTER 4: IS CONCEALMENT BEHAVIOUR SYSTEMATIC?: USING THE PLACEMENT TASK IN AN OFFICE ENVIRONMENT

Having shown that participants reported dimensions from three distinct categories when hiding objects within luggage (Chapter 2), and that these dimensions do in fact influence participants' hiding behaviour (Chapter 3), the next questions of interest were:

1) Will concealment behaviour be systematic in a complex office environment?

2) Will participants use dimensions from the three categories when choosing locations to make objects easy or hard to find within an office setting?

In the experiments discussed in Chapter 4, participants completed the placement task (Chapter 2) in two different office environments. In Experiments 4a and 4b, participants chose locations to make target objects easy or hard to find on a bookcase, and in Experiment 5, participants chose locations within an entire mock office set-up. Instead of analyzing subjective report data as was done when the placement task was used previously, the locations chosen by participants when they are free to place the target objects anywhere (i.e., participants' free concealment behaviour) were analyzed, thus developing another way to probe concealment behaviour behaviour [Strategy 1]. Photographs were taken of the chosen locations and then coded on relevant dimensions from the three categories.

A similar approach was used in Smilek et al. (2009), as participants created search displays that they thought would make the target object either easy or hard to find, and these displays were coded on factors known to influence search efficiency. However, in the present experiments, the environment in which the participants placed the target objects was much more realistic and complex, while still providing enough control to be able to examine and code the behaviour.

4.1 Experiment 4a: Placement Task in the Bookshelf Scenario: Occlusion Allowed

To ensure that the locations chosen by participants in complex scenarios could in fact be coded in a manner that was consistent and yielded interpretable results, the bookcases were chosen for the first scenario because while they do involve real-world objects, they are relatively simple. It is also relatively easy to manipulate factors such as colour and line of sight within the bookcases.

Because of the many differences between the luggage (Chapter 2) and the bookcases (the present studies), not all of the dimensions from previous experiments were relevant when coding locations in the bookcases. This is another example of how important context is, as the dimensions that are relevant and appropriate in one context might not apply in a different context. Nonetheless, the same general categories were used.

4.1.1 Method

Participants. Sixteen undergraduate students from the University of Waterloo participated in a 30-minute experimental session for partial credit towards their psychology class. All participants reported normal or corrected-to-normal vision.

Materials. Two identical bookcases were placed against one wall of lightly furnished office (see Figure 9). The contents and their organization on the bookshelves were carefully chosen. The two bookcases were mirror images of each other with respect to the row of blue journals and the row of white journals that were either on the top or bottom shelves, and a red box and a black box that were either on the 2^{nd} or 4^{th} shelves. To provide more variability and choice of distracters for the participants to make use of, the shelves also contained an assortment of blue, red, white, black and green binders, as well as a yellow notepad and a tan-coloured

Figure 9. Depictions of the bookcases used in Experiments 4a, 4b and 6.

folder. The two sets of objects used as targets in this experiment can be seen in Figure 10. Half of the participants used the blue journal and black stapler (Figure 10a), while the other half used the white journal and red stapler (Figure 10b).

In constructing the layout of the bookcases, there were enough potential hiding spots that participants would be able to choose locations that maximized congruence across multiple dimensions (e.g., a location where colour similarity, crowdedness, and schema violations were all in effect) or maximized some dimensions while ignoring others (e.g., a location that maximized colour similarity, but was in a sparse area on the bookshelf). Because of the variety of locations, it was possible to examine each dimension independently, but it was also expected that participants might use multiple dimensions when choosing thei hiding spot.

Procedure. Participants were required to place each of the target objects somewhere on one of the bookcases so that they would be easy or hard for someone else to find. At the start of the first trial, participants were brought into the office so that they could familiarize themselves with the bookcases. Participants were then given one of the target objects to place somewhere on one of the bookcases. For each of the target objects, participants placed the object on the bookcase twice: once where it would be easy for someone else to find and once where it would be hard for someone else to find. Participants were allowed to place the objects anywhere within the bookcases as long as they did not make any major alterations to the arrangement of the contents. The placement of each object in each difficulty condition was photographically recorded using a Cannon Power Shot A530 digital camera. The order in which participants placed the target objects was randomly assigned, and the order of the easy and hard conditions for each target was counterbalanced across participants.

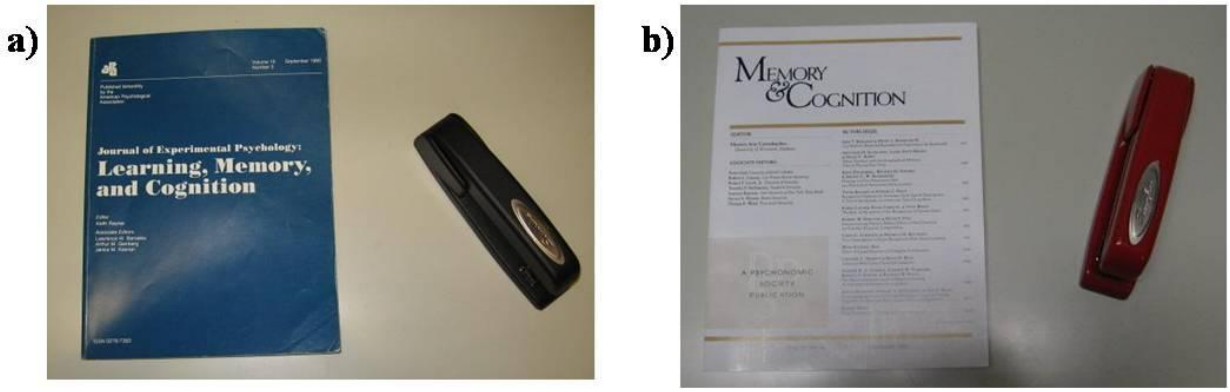

Figure 10. Target objects used in Experiments 4a, 4b and 6. Participants either used the blue journal and black stapler (a) or the white journal and red stapler (b).

4.1.2 Results

Photographs of the easy and hard locations were coded on a set of dimensions that was loosely based on the dimensions uncovered from the luggage scenario studies (Chapter 2), but was modified to reflect the differences in the bookcases, as not all of the dimensions used with the luggage were applicable in the bookcase scenario. For the Stimulus Properties category, **colour similarity** from previous experiments was used, and **crowding** was added. Crowding was defined as the degree to which the target object was surrounded by and close to distracters. For the Embodiment category, photographs of chosen locations were coded on the likelihood that the target would be in a person's **line of sight** and the degree of **occlusion**. For the Higher Order category, photographs were coded for the degree to which the object was placed in a location that would be expected (**schema for location**). The dimensions are described in turn below[4].

All dimensions were coded by the experimenter and an independent coder on a 7-point Likert scale, and analyses were performed on the average of both raters' scores as the inter-rater reliabilities for each dimension were high (see Table 9). In order to examine how each dimension was being used to make the target easy or hard to find, the resulting scores for each dimension were analyzed using a separate 2 (difficulty: easy vs. hard) by 2 (target object: journal vs. stapler) repeated measures ANOVA. When target combination (blue journal/black stapler vs. white journal/red stapler) was added as a between-subjects factor to each ANOVA, there was no effect of which combination of targets was used; therefore the data were averaged across target combination.

Stimulus Properties Dimensions

Crowding. Crowding was defined as the degree to which the target object was surrounded by and close to distracters, and a chosen location for a target object was scored as a

Table 9. Inter-rater reliabilities[3] for Experiment 4a.

Dimension	**Inter-rater**
Crowding	0.95
Colour Similarity	0.93
Schema for Location	0.89
Line of Sight	0.98
Occlusion	0.98

"1" when the target object was completely surrounded by and close to the distracters in its immediate surroundings, and was scored as a "7" when the object was completely isolated from the distracters in its immediate surroundings. Table 10 shows the mean scores on the crowding dimension for the locations chosen in the easy and hard conditions for each target object. The two target objects did not differ with respect to the extent that they were placed in crowded locations, $F(1,15) = 0.75$, $MSE = 1.68$, $p > 0.3$. More importantly, the targets were placed in more crowded locations in the hard condition compared to the easy condition, $F(1,15) = 26.07$, $MSE = 3.93$, $p < 0.001$, suggesting that crowding was used to make the targets difficult to find. There was no interaction between object and difficulty, $F(1,15) = 0.08$, $MSE = 1.74$, $p > 0.7$. Repeated measures t-tests revealed that the effect of difficulty was significant for both the journal and the stapler (see Table 10). It appears that crowding is a dimension used by participants to vary the degree of concealment in the more controlled bookcase environment.

Colour Similarity. The use of colour similarity was also coded on a 7-point Likert scale, with scores of "1" given when the colour of the target object was very similar to the distracters in its immediate surroundings and scores of "7" being used when the colour of the target was distinct from that of the distracters in its immediate surroundings. Table 10 shows the mean scores on the colour similarity dimension for the locations chosen in the easy and hard conditions for each target object. The target objects differed in the extent to which they were placed next to distracter items of similar colour, $F(1,15) = 18.75$, $MSE = 2.95$, $p < 0.01$; the stapler was more likely than the journal to be placed next to items that were distinct in colour. Critically, the targets were placed next to distracters of similar colour more often in the locations chosen in the hard condition than in the easy condition, $F(1,15) = 7.86$, $MSE = 3.59$, $p < 0.05$. The interaction between object and difficulty was also significant, $F(1,15) = 6.61$, $MSE = 3.32$, $p < 0.05$;

Table 10. Mean scores for each dimension as a function of target object and difficulty in Experiment 4a. All t-tests are repeated measures, two-tailed t-tests. Difference scores were calculated by subtracting easy from hard difficulty conditions.

	Difficulty				
Dimension	**Easy**	**Hard**	**Difference**	**t**	**p**
Crowding					
Journal	4.7	2.3	2.4	3.7	< .01
Stapler	5.1	2.4	2.6	4.9	< .001
Colour Similarity					
Journal	4.4	1.9	2.5	3.4	< .01
Stapler	5.1	5.0	0.16	0.27	> .7
Line of Sight					
Journal	5.2	2.2	3.0	6.1	< .001
Stapler	5.6	1.3	4.3	7.6	< .001
Occlusion					
Journal	5.4	2.6	2.8	6.1	< .001
Stapler	6.0	1.7	4.3	7.2	< .001
Schema for Location					
Journal	4.4	4.7	-0.3	0.36	> .7
Stapler	4.5	1.6	2.9	7.9	< .001

repeated measures t-tests revealed that there was a significant effect of difficulty for the journal, but not for the stapler (Table 10). Colour similarity was another dimension employed by participants to vary the degree of concealment of the target objects.

Embodiment Dimensions

Line of sight. Line of sight was defined as the probability that the target object will be in the person's view when he/she is standing in front of the bookcase. A score of "1" was given when the target will not be in a person's view, and a score of "7" was given when the target will be within a person's view when he/she is standing in front of the bookcase. For example, an object that was fully occluded would receive a "1" and an object that was on the bottom shelf would be given a score of "2". Objects placed on the top shelf would receive a "6", unless there was an attempt to place the object right in the middle of the shelf or in a way that would place it directly in the line of sight, in which case that location would then receive a "7". Objects placed in the middle shelves, would receive scores between 3 and 5, depending on their positioning. Table 10 shows the mean scores on the line of sight dimension for the locations chosen in the easy and hard conditions for each target object. The target objects did not differ in terms of the likelihood that they would be placed in view, $F(1,15) = 0.46$, $MSE = 1.44$, $p > 0.5$. Target objects were placed more within the line of sight in the easy condition than in the hard condition, $F(1,15) = 54.65$, $MSE = 3.95$, $p < 0.001$. The interaction between object and difficulty was also significant, $F(1,15) = 10.51$, $MSE = 0.63$, $p < 0.01$, with there being less of a difference between the easy and hard conditions in terms of line of sight for the journal than the stapler. In summary, participants manipulated line of sight to vary the degree of concealment of the objects in the more controlled bookcase environment.

Occlusion. The photographs were further coded to examine the degree of occlusion. A score of "1" was given when objects from the surrounding environment have been used to occlude the target object completely, and a score of "7" was given when the entirety of the object can be seen with no objects from the surroundings occluding the target object. Table 10 shows the mean scores on the occlusion dimension for the locations chosen in the easy and hard conditions for each target object. The two target objects did not differ in the degree to which they were occluded, $F(1,15) = 0.17$, $MSE = 2.32$, $p > 0.6$. Critically, target objects were occluded to a greater degree in the hard condition than in the easy condition, $F(1,15) = 54.93$, $MSE = 3.63$, $p < 0.001$. The interaction between object and difficulty was also significant, $F(1,15) = 10.0$, MSE = 0.90, $p < 0.01$; there was a greater difference between the easy and hard conditions in terms of degree of occlusion for the stapler than for the journal. Occlusion was another factor that participants used to manipulate the degree of concealment of objects within the bookcases.

Higher Order Dimension

Schema for Location. Schema for location was defined as the expectation or schema of where the object should be in the bookcase. Here a score of "1" was given when the target object was placed in a location that violated the schema for where that target object would be expected to be found, and a "7" was given when the target object was placed in a location that was consistent with the scheme for where that target object would be expected to be found. Table 10 shows the mean scores on the schema dimension for the locations chosen in the easy and hard conditions for each target object. The target objects did differ in terms of whether they were put in locations that were consistent with or violated their schemata, $F(1,15) = 12.58$, $MSE = 2.69$, $p < 0.01$; the journal was placed more often in locations that were consistent with the

schema for where a journal would be expected to be found (e.g., with the other journals) than the stapler was placed in locations that were consistent with the schema for where a stapler would be found (e.g., in the open spaces on the shelf, as opposed to behind or inside other objects). It is possible that the journal is more strongly associated with the bookcase than the stapler, and there are therefore more locations in the bookcase that would be considered consistent with the schema for where a journal would be expected to be. Target objects were placed in locations that were consistent with their schemata more often in the easy condition than in the hard condition, $F(1,15) = 10.65$, $MSE = 2.53$, $p < 0.01$. Therefore, participants chose to violate schema to make target objects more difficult to find. However, there was a significant interaction between object and difficulty, $F(1,15) = 11.39$, $MSE = 3.50$, $p < 0.01$; there was a significant effect of difficulty for the stapler, but not for the journal (Table 10).

4.1.3 Discussion

The goals of Experiment 4a were to examine 1) whether concealment behaviour would be systematic, and 2) whether participants would choose to vary dimensions from the three categories when selecting locations within the office to make target objects easy or hard to find. The results from Experiment 4a demonstrate that concealment behaviour was systematic (i.e., people hid things in predictable and consistent locations). In fact, it was possible to code the locations chosen to make the objects easy or hard to find, and the chosen locations systematically differed between difficulty conditions on dimensions from all three of the categories. Interestingly, there were some differences between the targets, suggesting that the nature of the relationship between the target and the environment is critical. Here, the environment was the same, but the targets differed, providing a different way to conceptualize "context". In previous studies, context was more about the scenario as communicated by instructions (Chapter 2), and

differences were found between the different scenarios. In this case, differences are found between the two target objects because each target object has different characteristics that interact with the environment, and these differences can be thought of as another kind of context.

4.2 Experiment 4b: Placement Task in the Bookshelf Scenario: Full Occlusion Not Allowed

The goal of Experiment 4b was to replicate the findings from Experiment 4a, in particular the target difficulty interactions. It is possible that some of the results found previously were due to allowing occlusion. If there are still differences between the two targets, this provides further evidence for another type of context effect (i.e., the use of different targets within the same environment). The procedure and materials used in the present experiment were identical with the exception that participants were instructed that the target objects must be visible from some angle.

4.2.1 Method

Participants. A second group of 16 undergraduate students from the University of Waterloo participated in a 30-minute experimental session for partial credit towards their psychology class. All participants reported normal or corrected-to-normal vision.

Materials. The materials used in this experiment were identical to that of Experiment 4a.

Procedure. The procedure used in this experiment was similar to that of Experiment 4a. As in Experiment 4a, participants placed each of the target objects in one of the bookcases so that it would be easy or hard for someone else to find. However, in this experiment the target objects had to be placed on the bookcases such that they were visible from some angle.

4.2.2 Results

Photographs of the easy and hard locations were coded by the experimenter and an independent coder on the same set of dimensions as in Experiment 4a. Analyses were performed on the average of both raters' scores as the inter-rater reliabilities for each dimension were high

(see Table 11). As in Experiment 4a, in order to examine how each dimension was being used to make the target easy or hard to find, the resulting scores for each dimension were analyzed using a separate 2 (difficulty: easy vs. hard) by 2 (target object: journal vs. stapler) repeated measures ANOVA. When target combination (blue journal/black stapler vs. white journal/red stapler) was added as a between-subjects factor to each ANOVA, there was no effect of which combination of targets was used; therefore the data were averaged across target combination.

Stimulus Properties Dimensions

Crowding. Table 12 shows the mean scores on the crowding dimension for the locations chosen in the easy and hard conditions for each target object. The two target objects differed with respect to the extent that they were placed in crowded locations, $F(1,15) = 19.01$, $MSE = 0.84$, $p < 0.01$; the journal was placed in more crowded locations than the stapler. More importantly, the targets were placed in more crowded locations in the hard condition compared to the easy condition, $F(1,15) = 65.57$, $MSE = 1.53$, $p < 0.001$, suggesting that crowding was used to make the targets difficult to find. There was no interaction between object and difficulty, $F(1,15) = 0.02$, $MSE = 1.02$, $p > 0.9$. Repeated measures t-tests revealed that the effect of difficulty was significant for the both the journal and the stapler (see Table 12). Crowding was again used by participants to vary the degree of concealment in the bookcases when full occlusion was not allowed.

Colour Similarity. Table 12 shows the mean scores on the colour similarity dimension for the locations chosen in the easy and hard conditions for each target object. The target objects differed in the extent to which they were placed next to distracter items of similar colour, $F(1,15) = 22.71$, $MSE = 1.19$, $p < 0.001$; as in Experiment 4a, the stapler was more likely than the journal

Table 11. Inter-rater reliabilities[3] for Experiment 4b.

Dimension	**Inter-rater**
Crowding	0.93
Colour Similarity	0.93
Line of Sight	0.93
Occlusion	0.92
Schema for Location	0.94

Table 12. Mean scores for each dimension as a function of target object and difficulty in Experiment 4b. All t-tests are repeated measures, two-tailed t-tests. Difference scores were calculated by subtracting easy from hard difficulty conditions.

	Difficulty				
Dimension	**Easy**	**Hard**	**Difference**	**t**	**p**
Crowding					
Journal	4.6	2.1	2.5	6.1	< .001
Stapler	5.6	3.1	2.5	6.4	< .001
Colour Similarity					
Journal	5.5	2.0	3.5	5.2	< .001
Stapler	5.8	4.3	1.5	3.0	< .05
Line of Sight					
Journal	5.8	3.1	2.7	6.1	< .001
Stapler	5.6	2.2	3.4	6.9	< .001
Occlusion					
Journal	5.6	3.2	2.4	5.6	< .001
Stapler	6.3	2.5	3.8	9.0	< .001
Schema for Location					
Journal	4.6	5.5	-0.9	1.4	> .1
Stapler	4.0	2.4	1.6	4.7	< .001

to be placed next to items that were distinct in colour. Critically, the targets were placed next to distracters of similar colour more often in the locations chosen in the hard condition than in the easy condition, $F(1,15) = 58.96$, $MSE = 1.76$, $p < 0.001$. The interaction between object and difficulty was marginally significant, $F(1,15) = 3.71$, $MSE = 4.18$, $p < 0.08$; repeated measures t-tests revealed that there was a significant effect of difficulty for both the journal and the stapler, but that the effect was larger for the journal (Table 12). This result is different than Experiment 4a when there was a significant effect for the journal, but not the stapler. This suggests that when full occlusion is not allowed, colour similarity was used differently for the stapler. Overall, colour similarity was again used by participants to vary the degree of concealment of the target objects.

Embodiment Dimensions

Line of sight. Table 12 shows the mean scores on the line of sight dimension for the locations chosen in the easy and hard conditions for each target object. The target objects differed in terms of the likelihood that they would be placed in view, $F(1,15) = 5.87$, $MSE = 0.86$, $p < 0.03$; the journal was more likely to be placed in the line of sight than the stapler. Target objects were placed more within the line of sight in the easy condition than in the hard condition, $F(1,15) = 74.16$, $MSE = 1.98$, $p < 0.001$. The interaction between object and difficulty was not significant, $F(1,15) = 1.28$, $MSE = 1.47$, $p > 0.2$. Participants again manipulated line of sight to vary the degree of concealment of the objects in the bookcases.

Occlusion. Occlusion was coded in much the same way as Experiment 4a, but because full occlusion was not allowed, objects that were placed in locations in which only part of the object was visible from an obscure angle would receive a "1" (in Experiment 4a, a rating of "1" was used when objects were fully occluded). Table 12 shows the mean scores on the occlusion

dimension for the locations chosen in the easy and hard conditions for each target object. The two target objects did not differ in the degree to which they were occluded $F(1,15) = 0.02$, $MSE = 1.05$, $p > 0.9$. Critically, target objects were occluded to a greater degree in the hard condition than in the easy condition, $F(1,15) = 108.82$, $MSE = 1.41$, $p < 0.001$. The interaction between object and difficulty was also significant, $F(1,15) = 5.11$, MSE = 1.48, $p < 0.04$; there was a greater difference between the easy and hard conditions in terms of degree of occlusion for the stapler than for the journal. Occlusion was again used by participants to vary the degree of concealment of objects within the bookcases.

Higher Order Dimension

Schema for Location. Table 12 shows the mean scores on the schema dimension for the locations chosen in the easy and hard conditions for each target object. The target objects did differ in terms of whether they were put in locations that were consistent with or violated their schemata, $F(1,15) = 18.97$, $MSE = 2.77$, $p < 0.01$; the journal was placed more often in locations that were consistent with the schema for where a journal would be expected to be found than the stapler was placed in locations that were consistent with the schema for where a stapler would be found. In contrast to Experiment 4a, target objects were not placed in locations that were consistent with their schemata more often in the easy condition than in the hard condition, $F(1,15) = 0.81$, $MSE = 2.79$, $p > 0.3$. In fact participants chose to put the journal in locations that were consistent with the schema for a journal more often in the hard condition than the easy condition (although this did not reach significance). There was a significant interaction between object and difficulty, $F(1,15) = 16.39$, $MSE = 1.53$, $p < 0.01$. As in Experiment 4a, there was a significant effect of difficulty for the stapler, but not for the journal (Table 12). This pattern of

results again shows the effect of context of the two target objects since schema was used differently for the journal than for the stapler.

4.2.3 Discussion

In general, Experiment 4b replicated the results from Experiment 4a; participants' concealment behaviour was systematic and it was possible to code the locations chosen by participants on dimensions from each of the categories. Dimensions from the Stimulus Properties category and the Embodiment category were used to vary the degree of concealment for both target objects. Interestingly, there was once again a significant interaction between difficulty and target object for the schema for location dimension (from the Higher Order category); participants placed the stapler in locations that were consistent with the schema for a stapler more often in the easy condition than in the hard condition, whereas there was no difference between the easy and hard condition for the journal. This result again points towards the importance of using multiple target objects to examine the effect the context each target object creates within the environment in which it is placed.

4.3 Experiment 5: Placement Task in an Office Environment

The results of Experiments 4a and 4b indicated that concealment behaviour is systematic and locations chosen by participants within the more constrained bookcases can in fact be coded on relevant dimensions and do show differences according to difficulty. The question of interest was now whether concealment behavioiur would be systematic in a very complex environment? In the present experiment, a complex office environment was used, and participants again placed target objects anywhere within the office to make the target objects easy or hard to find. Because of the increased complexity of the office, four target objects were used, allowing for the further examination of the effect of the context created by the different relationship each target object has with the environment. As in Experiments 4a and 4b, photographs of the locations chosen by participants were coded on dimensions from the three categories.

4.3.1 Method

Participants. Twelve undergraduate students from the University of Waterloo participated in a 1-hour experimental session in return for partial course credit towards their psychology class. All participants reported normal or corrected-to-normal vision.

Materials. Data were collected in a laboratory room that was set up to look like a typical graduate student office (see Figure 11). The dimensions of the office were nine feet by eight feet, with nine and a half foot high ceilings. The office was furnished with two desks, two chairs, a filing cabinet, a bookshelf, and a coffee table. Office equipment consisted of two computer workstations, a whiteboard, a lamp, an empty storage box, and a wastebasket. The office was equipped with various office supplies including pens, pencils, markers, paper, academic journals, and textbooks. Also in the office were food items including mugs, plates, and a coffee maker as well as personal items such as pictures and teddy bears. One of the desks was

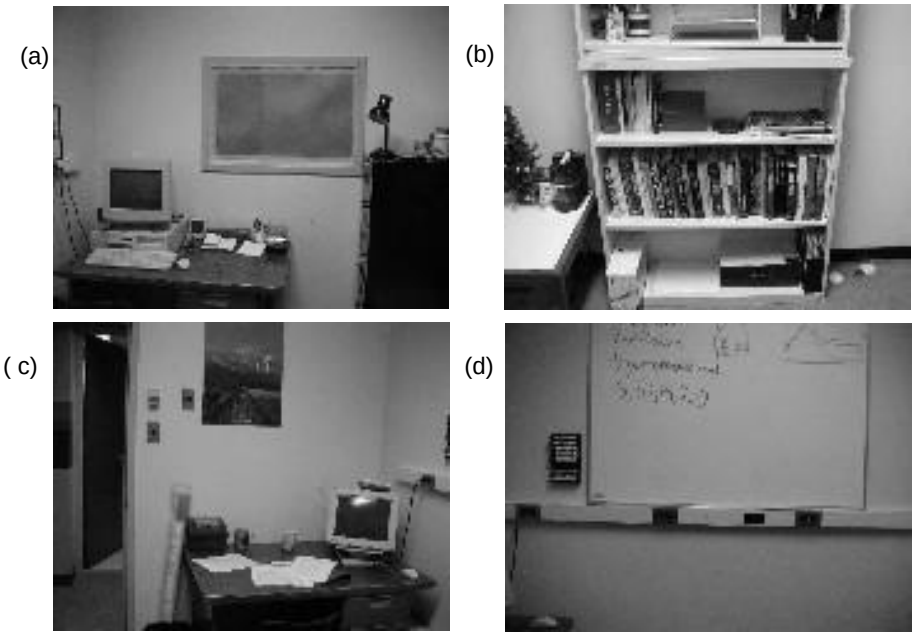

Figure 11. Depiction of the office used in the Experiment 5: (a) north wall, (b) east wall, (c) south wall (d) west wall.

set up to appear to be in an obvious state of use, with a working computer, notebook, pens, and paper arranged on the desk surface, while the other desk was set up to appear to be in a state of disuse, with a dismantled computer and papers scattered on the desk surface. The four objects used as targets in this experiment can be seen in Figure 12. They included a blue marker, a maroon mug, a lime green piece of paper, and a black academic journal.

Procedure. Participants were required to place each of the four target objects in the office such that it would be easy or hard for someone else to find. Participants were instructed that the target objects had to be placed in the office such that they were visible from some angle. This restriction prevented the complete occlusion of objects to allow for other dimensions to be utilized when making the objects easy or hard to find.

Before the first trial, participants were brought into the office so that they could familiarize themselves with its layout. Participants were then given one of the target objects to place in the office. For each of the four target objects, participants placed the object in the office twice: once where it would be easy for someone else to find and once where it would be hard for someone else to find. Participants were allowed to place the objects anywhere within the room as long as they did not make any major alterations to the layout of the office and the arrangement of its contents. The placement of each object in each difficulty condition was photographically recorded using a Nikon Coolpix 2200 digital camera. The order in which participants placed the target objects was randomly assigned, and the order of the easy and hard conditions was counterbalanced across participants.

4.3.2 Results

Photographs of the easy and hard locations were coded on four of the dimensions from Experiments 4a and 4b (crowding, colour similarity, line of sight, schema for location), as well

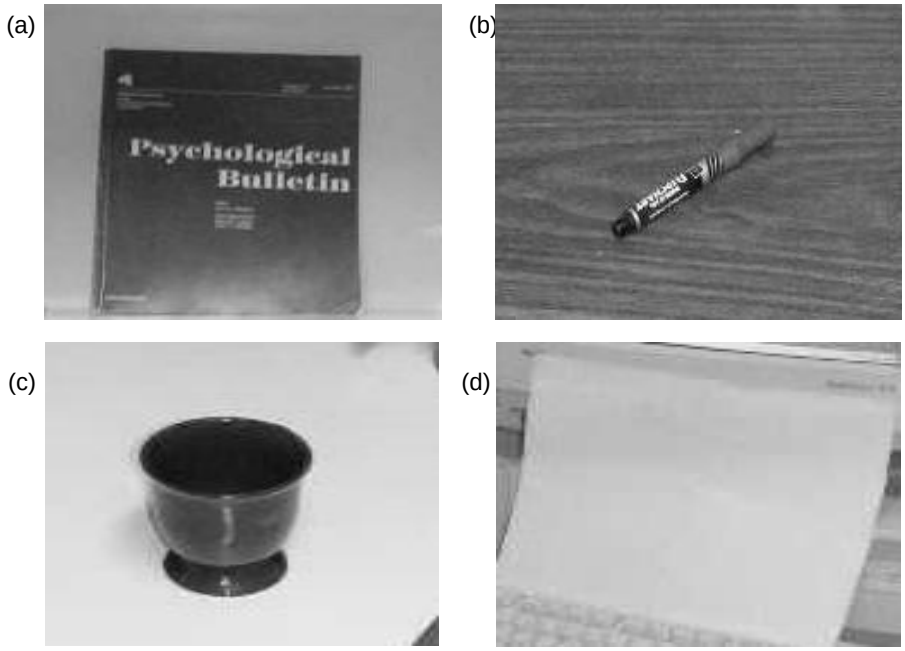

Figure 12. The objects used as placement stimuli: (a) academic journal, (b) marker, (c) mug, (d) sheet of paper.

as two new dimensions – shape similarity and physical interaction. While there was not enough variability of shapes within the bookcases to code for shape similarity, it was possible to code this dimension in the more complex office setting. In the bookcases, it was difficult to distinguish between visual and physical interaction; however the complexity and variability in the office allowed for the addition of the physical interaction dimension. All dimensions were coded by two independent coders, and analyses were performed on the average of both raters' scores as the inter-rater reliabilities for each dimension were high (see Table 13). In order to examine how each dimension was being used to make the target object easy or hard to find, the data for each dimension was analyzed using a separate 2 (difficulty: easy vs. hard) by 4 (target object: marker, mug, paper, journal) repeated measures ANOVA.

Stimulus Properties Dimensions

Crowding. As in Experiments 4a and 4b, crowding was defined as the degree to which the target object was surrounded by and close to distracters. A chosen location for a target object was scored as a "1" when the target object was completely surrounded by and close to the distracters in its immediate surroundings, and was scored as a "7" when the object was completely isolated from the distracters in its immediate surroundings. Table 14 shows the mean scores on the crowding dimension for the locations chosen in the easy and hard conditions for each target object. The target objects did not differ with respect to the extent that they were placed in crowded locations, $F(3,33) = 1.4$, $MSE = 3.09$, $p > 0.2$. More importantly, the targets were placed in more crowded locations in the hard condition compared to the easy condition, $F(1,11) = 18.9$, $MSE = 1.35$, $p < 0.02$, suggesting that crowding was used to make the targets difficult to find. There was no interaction between object and difficulty, $F(3,33) < 1$, $MSE =$

Table 13. Inter-rater reliabilities[3] for Experiment 5.

Dimension	**Inter-rater**
Crowding	0.86
Colour Similarity	0.85
Shape Similarity	0.81
Physical Interaction	0.79
Line of Sight	0.92
Schema for Location	0.83

Table 14. Mean scores on the *Stimulus Properties* dimensions (crowding, colour similarity and shape similarity) as a function of target object and difficulty in Experiment 5. All t-tests are repeated measures, two-tailed t-tests. Difference scores were calculated by subtracting easy from hard difficulty conditions.

	Difficulty				
Dimension	**Easy**	**Hard**	**Difference**	**t**	**p**
Crowding					
Marker	3.5	3.1	0.4	0.6	.55
Mug	4.9	3.2	1.7	2.8	<.05
Paper	4.7	3.9	0.8	1.9	.08
Journal	4.7	3.5	1.2	2.4	<.05
Colour Similarity					
Marker	4.3	4.2	0.1	0.1	.94
Mug	4.7	4.9	-0.2	0.4	.68
Paper	6.2	3.8	2.4	3.0	<.05
Journal	4.9	3.1	1.8	3.2	<.01
Shape Similarity					
Marker	4.3	5.0	-0.7	1.0	.32
Mug	5.2	4.9	0.3	0.4	.70
Paper	3.8	2.6	1.2	1.3	.22
Journal	3.8	4.0	-0.2	0.3	.81

2.01, $p > 0.4$. Repeated measures t-tests revealed that the effect of difficulty was significant for the mug and the journal, marginally significant for the paper and not significant for the marker (see Table 14). Overall, these findings suggest that participants used crowding to vary the degree to which objects were concealed in plain sight in the office.

Colour similarity. As in Experiments 4a and 4b, the use of colour similarity was also coded on a 7-point Likert scale, with scores of "1" given when the colour of the target object was very similar to the distracters in its immediate surroundings and scores of "7" being used when the colour of the target was distinct from that of the distracters in its immediate surroundings. Table 14 shows the mean scores on the colour similarity dimension for the locations chosen in the easy and hard conditions for each target object. The target objects differed marginally in the extent to which they were placed next to distracter items of similar colour, $F(3,33) = 2.6$, $MSE = 1.96$, $p < 0.07$. Critically, the targets were placed next to distracters of similar colour more often in the hard locations than in the easy locations, $F(1,11) = 11.3$, $MSE = 2.03$, $p < 0.01$. The interaction between object and difficulty was also significant, $F(3,33) = 3.87$, $MSE = 2.53$, $p < 0.02$; there was a significant effect of difficulty for the paper and the journal, but not for the marker and mug (see Table 14). Colour similarity was another dimension employed by participants to vary the degree of concealment of the target objects within the office.

Shape similarity. The use of shape similarity was coded on a 7-point Likert scale, with a "1" given when the shape of the target object is very similar to the distracters in its immediate surroundings, and a "7" given when the shape of the target object is distinct from that of the distracters in its immediate surroundings. Table 14 shows the mean scores on the shape similarity dimension for the locations chosen in the easy and hard conditions for each target object. Shape similarity was used differently across the four target objects, $F(3,33) = 5.29$, MSE

= 2.95, $p < 0.01$; the marker and the mug were placed next to objects that were more distinct from themselves, as compared to the paper and the journal. The easy and hard locations did not differ in terms of how similar the target object was to the surrounding distracter items, $F(1,11) = 0.09$, $MSE = 5.17$, $p > 0.7$, and there was no interaction between target object and difficulty, $F(3,33) = 1.50$, $MSE = 2.73$, $p > 0.2$. Overall, these findings suggest that shape similarity was not used by participants to vary the degree of concealment of the target objects.

Embodiment Dimensions

Physical interaction. Physical interaction was defined as the probability that the target object will physically confront a person as he/she enters the office and uses the computer. A score of "1" was given when the target will not physically confront a person, and a score of "7" was given when it was very likely that the target will physically confront a person as he/she enters the office and uses the computer. Table 15 shows the mean scores on the physical interaction dimension for the locations chosen in the easy and hard conditions for each target object. The target objects did not differ in the extent to which they would be physically encountered during normal use of the office, $F(3,33) = 0.95$, $MSE = 1.25$, $p > 0.4$. Critically, target objects in the easy condition were placed in locations that were more likely to result in physical interaction during normal office use than were objects in the hard condition, $F(1,11) = 44.92$, $MSE = 1.78$, $p < 0.001$. This suggests that varying the likelihood of physical interaction was used to vary the degree of concealment of the objects within the office. There was no interaction between these dimensions, $F(3,33) = 1.25$, $MSE = 0.76$, $p > 0.3$.

Line of sight. As in Experiments 4a and 4b, line of sight was defined as the probability that the target object will be in the person's view when he/she is standing at the door of the office. A score of "1" was given when the target will not be in a person's view, and a score of

Table 15. Mean scores on the *Embodiment* dimensions (physical interaction and line of sight) as a function of target object and difficulty in Experiment 5. All t-tests are repeated measures, two-tailed t-tests. Difference scores were calculated by subtracting easy from hard difficulty conditions.

	Difficulty				
Dimension	**Easy**	**Hard**	**Difference**	**t**	**p**
Physical Interaction					
Marker	4.0	1.8	2.2	8.2	<.001
Mug	3.7	2.1	1.6	5.3	<.001
Paper	4.3	2.3	2.0	4.0	<.01
Journal	4.0	2.6	1.4	2.8	<.05
Line of Sight					
Marker	6.0	1.0	5.0	12.5	<.001
Mug	6.3	1.7	4.6	11.1	<.001
Paper	6.0	1.4	4.6	8.1	<.001
Journal	4.3	1.8	2.5	3.0	<.05

"7" was given when the target will be within a person's view when he/she is standing in the doorway. Table 15 shows the mean scores on the line of sight dimension for the locations chosen in the easy and hard conditions for each target object. The target objects differed marginally in how much in view they were placed, $F(3,33) = 2.57$, $MSE = 1.49$, $p = 0.07$. Target objects were placed more within the line of sight in the easy condition than in the hard condition, $F(1,11) = 140.41$, $MSE = 2.99$, $p < 0.001$. The interaction between object and difficulty was also significant, $F(3,33) = 4.32$, $MSE = 1.71$, $p < 0.02$, with there being less of a difference between the easy and hard conditions in terms of line of sight for the journal. In summary, participants manipulated the line of sight to vary the degree of concealment of the objects within the office.

Higher Order Dimension

Schema for location. Schema for location was defined as the expectation of or schema for where the object should be in the office. Here a score of "1" was given when the location of the target object within the office violated its schema, and a "7" was given when the location of the object within the office was consistent with its schema. An example of a violation of expectation of location would be placing the mug on the ground behind the garbage can. On the other hand, placing the mug on the desk beside the computer would be an example of a location that is consistent with the schema. Table 16 shows the mean scores for the easy and hard locations for each target object. The extent to which target objects were presented in locations where they would be expected differed across objects, $F(3,33) = 3.00$, $MSE = 1.24$, $p < 0.05$, with the schema for location being violated most often for the marker. More importantly, expectation of location was violated more often in the locations chosen in the hard condition than those in the easy condition, $F(1,11) = 20.2$, $MSE = 3.64$, $p < 0.01$. This suggests that participants used the expectation of where the target objects ought to be to vary the degree of concealment of

Table 16. Mean scores on the *Higher Order* dimension (schema for location) as a function of target object and difficulty in Experiment 5. All t-tests are repeated measures, two-tailed t-tests. Difference scores were calculated by subtracting easy from hard difficulty conditions.

	Difficulty				
Dimension	**Easy**	**Hard**	**Difference**	**t**	**p**
Schema for Location					
Marker	5.1	2.3	2.8	4.6	<.01
Mug	6.0	3.2	2.8	5.1	<.001
Paper	4.2	4.3	-0.1	0.1	.98
Journal	4.9	3.4	1.5	2.6	<.05

the objects in the office. There was also a significant interaction between target object and difficulty, $F(3,33) = 4.64$, $MSE = 2.42$, $p < 0.01$; expectation of location was violated more often in the hard than easy condition for the marker, mug and journal, but was used equally across difficulty conditions for the paper. Schema for location was again used to vary the degree of concealment in the complex office environment.

4.3.3 Discussion

In summary, locations chosen by participants in the more complex office environment were also able to be coded on a number of dimensions that revealed differences between the easy and hard conditions. While participants did use dimensions from all three of the categories to vary the degree of concealment, the dimensions from the Stimulus Properties dimensions were not used as consistently as those from the Embodiment and Higher Order categories. Interestingly, this pattern is very similar to what was found from the subjective report data when participants placed bags of beads within luggage in Chapter 2, when participants reported using dimensions from the Stimulus Properties category less often than those from the Embodiment and Higher Order categories.

As in Experiments 4a and 4b, differences were found between the four different target objects used in the present experiment, suggesting that the nature of the relationship between the target and the environment is critical. It is important to include multiple target objects as another measure of the effect of context.

Overall, the three experiments in the present chapter also demonstrate the development of another type of methodology, coding of free concealment behaviour, which can be used to probe concealment behaviour [Strategy 1].

CHAPTER 5: PLACING FACTORS IN COMPETITION: FORCED-CHOICE EXPERIMENTS

The experiments in Chapter 3 established that the dimensions reported by participants in the placement tasks (Studies 1a and 1b) do in fact influence participants' placing behaviour in forced-choice tasks. The goals of the experiments in Chapter 5 were: 1) to further develop the methodology for the study of concealment by using the forced-choice task in a new way [Strategy 1]; and 2) to explore the relative importance of the dimensions by examining which dimensions participants choose to use over other dimensions [Strategy 4].

Recall that when participants were asked to place beads within luggage in locations that were either easy or hard to find (Studies 1a and 1b), participants reported using dimensions from the Embodiment and Higher Order categories more often than Stimulus Properties. Additionally, on a questionnaire that asked participants to rate how much they considered and used each of the dimensions, dimensions from the Stimulus Properties category received the lowest ratings (Study 1b). Overall it would seem that stimulus properties are of secondary importance in concealment behaviour in real world scenarios – a finding that is of interest and importance given the prominence given to stimulus properties in the standard laboratory visual search literature. However, given that previous studies (Studies 1a and 1b; Experiments 4a, 4b, and 5) have highlighted the importance of context, it was important to examine the relative importance of the dimensions in different contexts. In the four experiments reported in this chapter, a Stimulus Properties dimension (colour similarity), was put in competition with Embodiment and Higher Order dimensions (line of sight and schema, respectively) to examine whether participants will choose to use the lower level dimension (colour similarity) or the higher-level dimensions (line of sight and schema) when they are able to only use one of them in different experimental

scenarios. In Experiment 6, colour similarity, was put in competition with an Embodiment dimension, line of sight, within the bookcase scenario (from Experiments 4a and 4b). In Experiment 7, colour similarity was then pitted against a Higher Order dimension, schema, in an office environment (from Experiment 5). Finally, in Experiments 8a and 8b, colour similarity was put in competition with schema in the luggage scenario.

5.1 Experiment 6: Line of Sight vs. Colour Similarity Using the Bookcases

The first two dimensions that were placed in competition with each other were colour similarity (from the Stimulus Properties category) and line of sight (from the Embodiment category). Because dimensions from the Stimulus Properties category were reported less often in participants' subjective reports (Study 1a) and were rated as being considered and used less often than the Embodiment dimensions (Study 1b), colour similarity was made very salient to "stack the deck" in favour of colour similarity. It is possible in previous experiments that colour similarity was not used as often because it was not very salient. Therefore, in the present experiment, colour was made salient by selecting high contrast colours to see whether the Embodiment dimension would trump the Stimulus Properties dimension as in previous experiments, or whether colour similarity would now trump line of sight. These dimensions were manipulated using the bookcases because in previous experiments using the bookcases (Experiments 4a and 4b), both colour similarity and line of sight showed strong differences between locations that were chosen by participants to make the target object easy or hard to find in plain sight. The bookcases also allowed for the manipulation of both colour similarity and line of sight in a controlled manner.

5.1.1 Method

Participants. Thirty-two undergraduate students from the University of Waterloo participated in a 30-minute experimental session for partial credit towards their psychology class. All participants reported normal or corrected-to-normal vision.

Materials. The bookcases and two sets of target objects (the blue journal and black stapler, or the white journal and red stapler) from Experiments 4a and 4b were used in this experiment (see Figure 9 for the bookcases and Figure 10 for the target objects).

The forced-choice trials emerged out of all possible pair wise combinations of the colour similarity and line of sight dimensions (Figure 13). The resulting trials fall into four categories: 1) two ways of assessing *colour similarity*; 2) two ways of assessing *line of sight*; 3) one way to assess colour similarity and line of sight working in *cooperation* with each other, such that one choice is the easy option for both colour similarity and line of sight, while the other choice is the hard option for both colour similarity and line of sight; and 4) one way to assess colour similarity and line of sight in *competition* with each other, such that one choice is the easy option for colour similarity and the hard option for line of sight, while the other choice is the easy option for line of sight and the hard option for colour similarity. The specific choices for each type of trial are described below.

1) Colour Similarity

For the trials in which colour similarity was assessed, participants were given a choice between placing the target object next to distracter items that were either congruent in colour with the target object or incongruent in colour with the target object. There were two trials for each target object; one trial had both choices in the participant's line of sight and the other trial

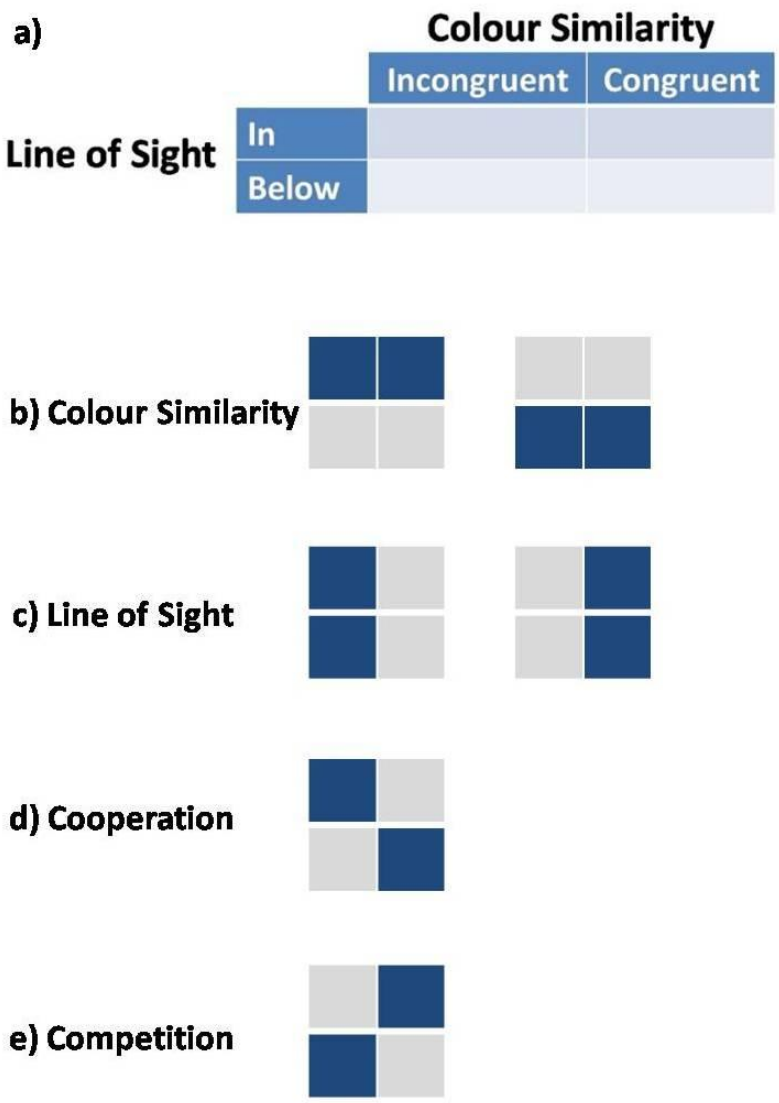

Figure 13. Illustration of all the possible pair wise combinations of colour similarity and line of sight (a). There are two ways to assess similarity - one in which both choices are in the line of sight and one in which both choices are below the line of sight (b). There are also two ways to assess line of sight - one in which both choices are incongruent in colour with the target and one in which both choices are congruent in colour with the target. There is one way to assess the two dimensions working in cooperation with each (d), and one way to assess the two dimensions working in competition with each other (e).

had both choices below the participant's line of sight. For the trials in which the journal was the target, participants were given a choice between two possible places: one in which the journal was congruently coloured with the other journals on the shelf, and one in which the journal was incongruently coloured with the other journals on the shelf. On one trial, the congruently and incongruently coloured journals were on top shelf (i.e., in the line of sight), while on the second trial, the journals were on the bottom shelf. See (a) and (b) in Figure 14 for the choices for the when the blue journal was the target object. For the trials in which the stapler was the target, participants were given a choice between placing the stapler on top of a box that was congruently coloured box with the stapler or on top of a box that was incongruently coloured with the stapler. The boxes were both placed either on the 2nd shelf from the top (i.e., at the line of sight) or the 4th shelf from the top (i.e, below the line of sight). It was predicted that participants would use colour similarity as in previous experiments; participants would place the targets amongst or on top of congruently coloured items in the hard condition and amongst or on top of incongruently coloured items in the easy condition.

2) Line of Sight

For the trials that assessed line of sight, participants were given a choice between placing the target object so that it would be in the line of sight of an observer standing in front of the bookcase, or placing the target object so that it would be below the observer's line of sight. There were two trials for each target object; in one trial, both of the choices were congruent in colour with the target object, and in the other trial both of the choices were incongruent in colour with the target. For one of the trials in which the journal was the target, participants were given a choice between placing the journal amongst other congruently coloured journals that were either on the top shelf (at the line of sight) or the bottom shelf (below the line of sight). For the

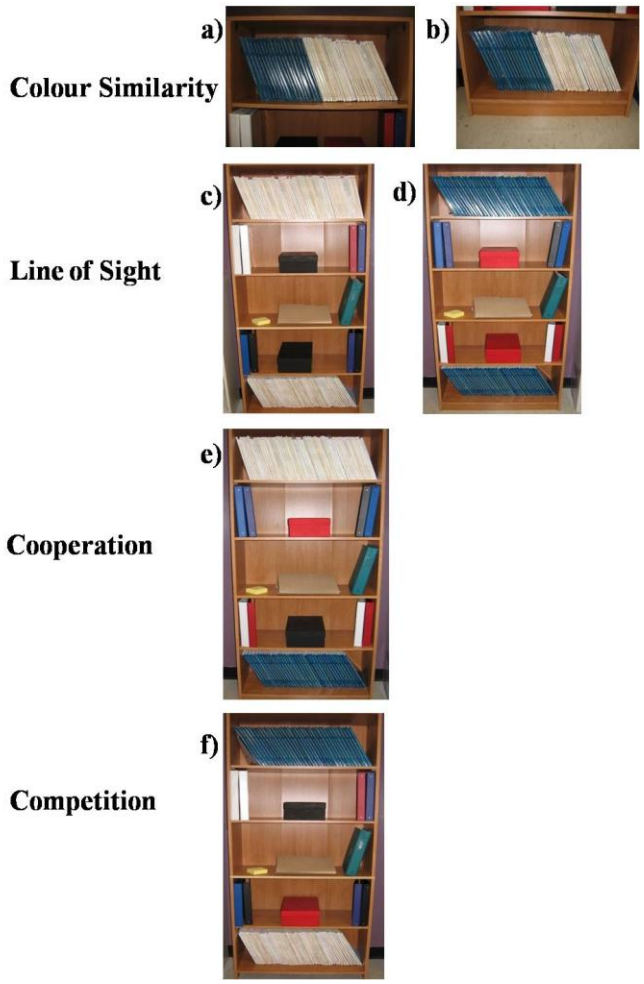

Figure 14. Choices for the blue journal as a function of trial type for Experiment 6. For the two trials assessing *colour similarity*: one trial had both colour choices on the top shelf (a) and one had both choices on the bottom shelf (b). For the two trials assessing *line of sight*, participants chose between the journals on the top shelf or the bottom shelf: in one trial the choices were both incongruent in colour with the target journal (c), in the other trial they were congruent in colour with the journal (d). For the trial in which colour similarity and line of sight were in *cooperation* (e), one choice had the easy options for both dimensions (white top shelf), and the other choice had the hard options for both dimensions (blue bottom shelf). For the trial in which colour similarity and line of sight were in *competition* (f), the easy choice for line of sight was paired with the hard choice for colour similarity (white top shelf) and vice versa (blue bottom shelf).

other trial in which the journal was the target, the journals were incongruently coloured and again participants were given a choice between placing the journal on the top shelf or the bottom shelf. See (c) and (d) in Figure 14 for the choices for when the blue journal was the target object. For one of the trials in which the stapler was the target, participants chose between placing the stapler on top of a congruently coloured box that was either on the 2nd (in the line of sight) or on the 4th shelf (below the line of sight). For the other trial in which the stapler was the target, the boxes were both incongruent in colour with the stapler and participants again chose between placing the stapler on top of the box that was on the 2nd shelf or on top of the box on the 4th shelf. It was predicted that participants would choose to place the target objects at the line of sight in the easy condition and below the line of sight in the hard condition.

3) Cooperation

For the trials in which colour similarity and line of sight were in cooperation with each other, one choice had the easy option for both colour similarity and line of sight, while the other choice had the hard option for both colour similarity and line of sight. There was just one trial in which the two dimensions were working in cooperation with each other for each target object. For the trial in which the journal was the target, participants were given a choice between placing the journal in with incongruently coloured journals on the top shelf (the easy options for both colour similarity and line of sight) or among congruently coloured journals on the bottom shelf (the hard options for colour similarity and line of sight). See (e) in Figure 14 for the choices for when the blue journal was the target object. On the trial in which the stapler was the target, participants were given a choice between placing the stapler on top of an incongruently coloured box on the 2nd shelf from the top (the easy option for colour similarity and line of sight) or on top

of a congruently coloured box on the 4th shelf from the top (the hard option for both colour similarity and line of sight).

4) Competition

For the trials in which colour similariy and line of sight were in competition with each other, one choice had the easy option for colour similarity and the hard option for line of sight, while the other choice had the easy option for line of sight and the hard option for colour similarity. There was just one trial in which the two dimensions were placed in competition with each other for each target object. For the trial in which the journal was the target object, participants were given a choice between 1) placing the journal amongst incongruently coloured journals on the bottom shelf (the easy option for colour similarity and the hard option for line of sight), and 2) placing the journal amongst congruently coloured journals on the top shelf (the hard option for colour similarity and the easy option for line of sight). See Figure 14f for the choices for when the target object was the blue journal. For the trial in which the stapler was the target, participants were given a choice between 1) placing the stapler on top of the incongruently coloured box on the 4th shelf (the easy option for colour similarity and the hard option for line of sight), and 2) placing the stapler on the congruently coloured box on the 2nd shelf (the easy option for line of sight and the hard option for colour similarity). For both target objects, it was assumed that if participants chose the first option in the hard condition, they were using line of sight, while if they chose the second option, they were using colour similarity to make the target object hard to find.

Procedure. Participants were randomly assigned to either the Easy condition, where they were instructed to choose the option that would make the target object(s) easy to find, or the Hard condition, where they were instructed to select the option that would make the target

object(s) hard to find. Participants were first shown the bookcases (at a distance of approximately 2 feet away from the bookcases) and given the following instructions:

> "In this study, you will be given a target item and your goal is to choose locations with-in the bookcases that will make that item really hard *(/easy*) to find. On each trial, I will tell you which target object you are to consider, and then I will give you a choice of locations. You are to imagine that the searcher will be standing approximately where you - in front of the bookcase, approximately 2 feet away. You will choose which of those locations you think would make the item harder (*/easier*) to find for someone searching the bookcase. You will tell me your choice and then write your reason for choosing that option on this piece of paper."

Participants completed all 12 trials (i.e., 2 trials assessing colour similarity per target object, 2 trials assessing line of sight per target object, 1 trials in which the two dimensions were in cooperation per target object, and 1 trial in which the two dimensions were in competition with each other per target object) in a random order. Each random order was used for one participant in the Easy condition and one participant in the Hard condition.

5.1.2 Results & Discussion

As in the previous forced-choice tasks (Experiments 2-3b), participants received a "1" for the "hard" choice and a "0" for the "easy" choice for each trial of each target object. The data for the two trials assessing colour similarity and for the two trials assessing line of sight were averaged for each target object. As there was a similar pattern of results for each target object, the scores for each trial type were averaged across target object (the proportion of participants who selected each choice for journal and the stapler as a function of difficulty can be seen in Appendix H). The average proportion of trials in which participants selected each choice for

each trial type is shown as a function of difficulty in Table 17. Independent sample t-tests comparing the easy and hard conditions were conducted for each trial type.

Colour similarity was used as expected; participants chose to place the target objects in with and on top of congruently coloured items more often in the hard condition than in the easy condition, $t(30) = 20.95$, $p < 0.001$. Line of sight was also used as expected; participants chose to place the target objects below the line of sight more often in the hard condition than in the easy condition, $t(30) = 15.96$, $p < 0.001$. On the trials in which the two dimensions were working in cooperation with each other, as expected, participants chose the congruently coloured items below the line of sight (i.e., the hard options for colour similarity and line of sight) significantly more often in the hard condition than the easy condition, $t(30) = 17.13$, $p < 0.001$. The trials that were of most interest were the trials in which colour similarity and line of sight were placed in competition with each other. On these trials, participants chose to use colour similarity over line of sight, as they were more likely to choose to place the target objects on or amongst congruently coloured items, even though they were in the line of sight, in the hard condition than in the easy condition, $t(30) = 5.06$, $p < 0.001$.

In summary, when colour similarity and line of sight were placed in competition with each other, colour similarity trumped line of sight. It appears that when the dimension of colour is made salient by selecting colours of high contrast, it is used more often by participants than the Embodiment dimension, line of sight. This result is different than what was expected based on previous experiments that found that participants reported using dimensions from the Embodiment category more often than those from Stimulus Properties (Study 1a) when choosing locations to make objects easy or hard to find within luggage. This is another situation where

Table 17. Average proportion of trials in which participants selected each choice for each trial type as a function of difficulty in Experiment 6.

Trial Type	Choices	Easy	Hard
Colour Similarity	Incongruent colour	0.92	0.00
	Congruent colour	0.08	1.00
Line of Sight	In line of sight	0.92	0.02
	Below line of sight	0.08	0.98
Cooperation	Incongruent colour/ In line of sight	0.94	0.03
	Congruent colour/ Below line of sight	0.06	0.97
Competition	Incongruent colour (easy)/ Below line of sight (hard)	0.78	0.22
	Congruent colour (hard)/ In line of sight (easy)	0.22	0.78

context matters; a different pattern of results emerged when the situation was simplified and constrained, as opposed to when participants were given more control over their behaviour. Another possible explanation for the difference is that in the present experiment, the target objects were being placed in plain sight, whereas in the luggage scenario, the objects were occluded. This important difference will be explored further in later experiments.

5.2 Experiment 7: Schema vs. Colour Similarity in the Office Environment

Even though dimensions from the Embodiment category were reported significantly more often than dimensions from the Stimulus Properties category (Study 1a), when line of sight (an Embodiment dimension) was put in competition with colour similarity (a Stimulus Properties dimension), colour similarity, trumped line of sight (Experiment 6). The next question then was whether colour similarity would also trump a Higher Order dimension, schema. This question was of interest because, similar to the Embodiment category, dimensions from the Higher Order category were reported significantly more often than the Stimulus Properties category when participants chose locations within luggage that were easy or hard to find (Studies 1a and 1b). In the present experiment, colour similarity was put in competition with schema to see whether colour similarity would also trump schema. Colour was again made salient by selecting colours of high contrast. An office setting was used because there is a strong schema for where objects are expected to be within an office (e.g., a mouse is expected beside a computer), allowing for the manipulation of schema in plain sight.

5.2.1 Method

Participants. Thirty-two undergraduate students from the University of Waterloo participated in a 30-minute experimental session for partial credit towards their psychology class. All participants reported normal or corrected-to-normal vision.

Materials. A white mouse was used as the target object. Schema was manipulated using a desk with a computer (congruent for schema with the mouse) and an empty bookcase (incongruent for schema with the mouse). Colour was manipulated using black and white pieces of paper that were used as background on the desk and on the bookcase.

As in Experiment 6, there were 4 types of trials:

1) Colour Similarity

For the trials in which colour similarity was assessed, participants were given a choice between placing the target object (a mouse) on a congruently coloured piece of furniture or on an incongruently coloured piece of furniture. There were two trials; one trial in which both colour choices were on the piece of furniture that was consistent with the schema for the mouse (the desk), and one trial in which both colour choices were on the piece of furniture that was inconsistent with the schema for the mouse (the bookshelf). Therefore, for one trial participants were given a choice between placing the white mouse on a white desk or a black desk. For the other trial, participants were given a choice between placing the white mouse on a white bookshelf or a black bookshelf. See (a) and (b) in Figure 15 for the choices for the two trials that assessed colour similarity.

2) Schema

For the trials in which schema was assessed, participants were given a choice between placing the mouse on the desk (consistent with the schema for the mouse) or on the bookshelf (inconsistent with the schema for the mouse). There were two trials; one trial in which both the desk and the bookshelf were congruent in colour with the mouse and one where the desk and bookshelf were incongruent in colour with the mouse. Therefore, for one trial, the choice was between placing the white mouse on a white desk or a white bookshelf. For the other trial, the choice was between placing the white mouse on a black desk or a black bookshelf. See (c) and (d) in Figure 15 for the choices for the two trials that assessed schema. It was predicted that, as in previous forced-choice experiments, participants would choose to violate the schema for the mouse to make it hard to find and therefore would choose to place the mouse on the bookcase in the hard condition and on the desk in the easy condition.

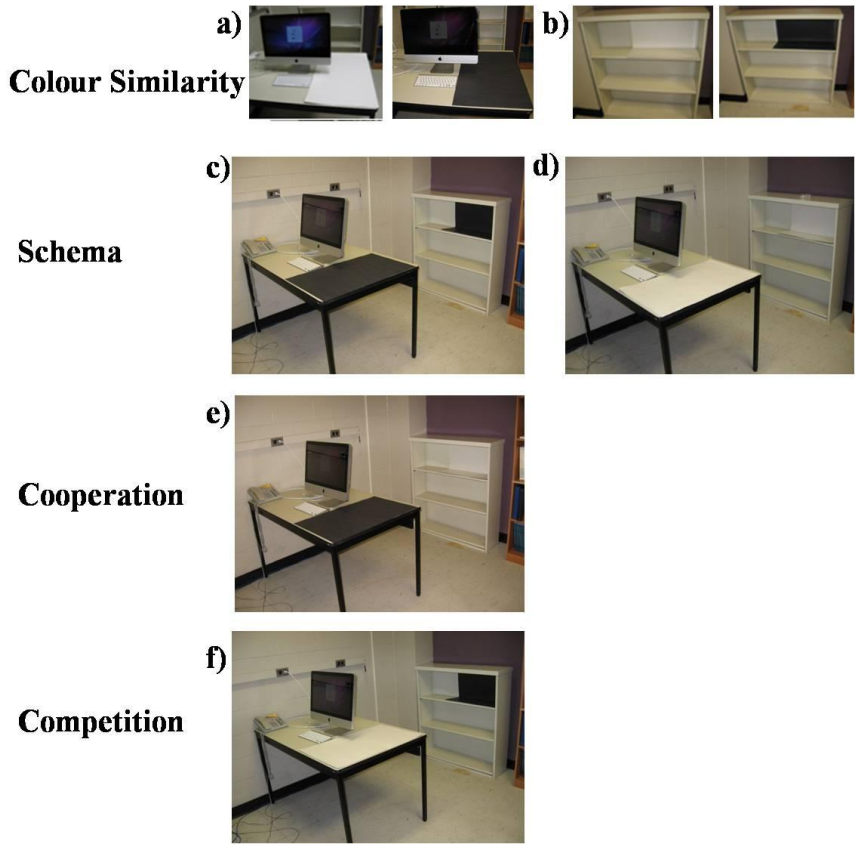

Figure 15. Choices for the white mouse as function of trial type in Experiment 7. For the two trials assessing *colour similarity*, one trial had both colour choices on the desk (a) and one had both colour choices on the bookcase (b). For the two trials assessing *schema*, participants chose between the desk and the bookcase: in one trial the choices were both incongruent in colour with the target mouse (c), in the other trial they were congruent in colour with the mouse (d). On the trial in which colour similarity and schema were in *cooperation* (e) one choice had the easy option for both dimensions (black desk), and the other choice had the hard options for both dimensions (white bookshelf). For the trial in which colour similarity and schema were in *competition* (f), the easy choice for schema was in paired with the hard choice for colour similarity (white desk), and vice versa for the other choice (black bookcase).

3) Cooperation

There was just one trial in which colour similarity and schema were working in cooperation. Participants were given a choice between placing the white mouse on a black desk (i.e., the easy options for both colour similarity and schema), or placing the white mouse on a white bookcase (i.e., the hard options for both dimensions). See (e) in Figure 15 for the choices for the trial in which colour similarity and schema were in cooperation.

4) Competition

There was just one trial in which colour similarity and schema were put in competition with each other. Participants were given a choice between 1) placing the white mouse on a white desk (i.e., the easy option for schema and the hard option for colour similarity), or 2) placing the white mouse on a black bookcase (i.e., the easy option for colour and the hard option for schema). See (f) in Figure 15 for the choices for the competition trial. It was assumed that if participants in the hard condition chose the first option, they were using colour similarity over schema; while if they choose the second option in the hard condition they were using schema over colour similarity.

Procedure. As in previous forced-choice experiments (Experiments 2-3b, 6), participants were randomly assigned to either the Easy condition or the Hard condition. Participants were first shown the mouse outside of the office environment and were given the following instructions:

> "In this study, you will be trying to make this (*show white mouse*) hard (/*easy)* for someone else to find. In other words, you want it to take a really long time for the person to find this (/*you want the person to find this as quickly as possible)*. I will be taking you to another room and giving you choices between locations to place

the mouse to make it really hard (/*easy)* for someone else to find when they walk into the room. You will tell me which location you choose and then you will write on this paper here why you chose that location…why you thought it would be hard (/*easy*) for another person to find this."

Participants completed all of the choices from the doorway so that they were at the same perspective as someone entering the room. Participants completed all 6 trials (i.e., 2 trials assessing colour similarity, 2 trials assessing schema, 1 trial in which colour similarity and schema were in cooperation, and 1 trial in which colour similarity and schema were in competition) in a random order. Each random order was used for one participant in the Easy condition and one participant in the Hard condition.

5.2.2 Results & Discussion

The data were processed in the same way as in Experiment 6. The average proportion of trials in which participants selected each choice for each trial type is shown as a function of difficulty in Table 18. Independent sample t-tests comparing the easy and hard conditions were conducted for each trial type.

Colour similarity was used as expected; all of the participants in the hard condition chose to place the mouse on the congruently coloured desk and bookcase, while all of the participants in the easy condition chose to place the mouse on the incongruently coloured items. Schema was also used as expected; significantly more participants chose to violate the schema and place it on the bookcase in the hard condition than in the easy condition, $t(30) = 3.70$, $p < 0.001$. When colour similarity and schema were working in cooperation with each, as expected, participants were more likely to choose the congruently coloured bookcase (i.e., the hard choices for both

Table 18. Average proportion of trials in which participants selected each choice for each trial type as a function of difficulty in Experiment 7.

Trial Type	Choices	Easy	Hard
Colour Similarity	Incongruent colour	1.00	0.00
	Congruent colour	0.00	1.00
Schema	Fits with schema	0.87	0.41
	Violates schema	0.13	0.59
Cooperation	Incongruent colour/ Fits with schema	0.87	0.06
	Congruent colour/ Violates schema	0.13	0.94
Competition	Incongruent colour (easy)/ Violates schema (hard)	0.56	0.12
	Congruent colour (hard)/ Fits with schema (easy)	0.44	0.88

colour similarity and schema) in the hard condition than in the easy condition, $t(30) = 7.68$, $p < 0.001$. When colour similarity and schema were placed in competition with each other, significantly more participants chose to place the mouse on the congruently coloured desk (even though the desk is where the mouse would be expected), in the hard condition than the easy condition, $t(30) = 2.84$, $p < 0.01$. Therefore, colour similarity also trumps schema in this office context in which the target object is being placed in plain sight.

5.3 Experiment 8a: Schema vs. Colour Similarity in the Luggage Scenario (black/blue stimuli)

In Experiment 7, when participants were trying to make a mouse easy or hard to find within an office environment they chose to use colour similarity more often than schema. In the experimental set-up used in Experiment 7, the mouse was placed in plain sight. To further examine whether colour similarity would still be chosen over schema in a different scenario, in Experiment 8a, colour similarity was placed in competition with schema in the luggage scenario. In this scenario, the target objects were placed *inside* distracter items, meaning that the target objects were fully occluded. This is an important difference from the office environment, where the target object was placed in plain sight. The question then was whether colour similarity would still trump schema when the target object was occluded.

In all of the previous forced-choice experiments in which colour similarity was included (Experiments 2-3b, 6-7), the choice was always to put the target object *next to* a distracter item that was either congruent or incongruent in colour with the target object, meaning that the target was being hidden in plain sight. In the present experiment, the target object is no longer in plain sight and is occluded when it is placed inside the distracters items. It was predicted that participants would still use colour similarity as in previous experiments, and choose to place the target object inside a congruently coloured item to make it hard to find and inside an incongruently coloured item to make it easy to find; however it is possible that colour similarity might be used in different ways given that the target object is no longer in plain sight and colour similarity might not be as salient of a dimension. It is also possible then that participants will choose to use schema more often than colour similarity.

5.3.1 Method

Participants. Thirty-two undergraduate students from the University of Waterloo participated in a 30-minute experimental session for partial credit towards their psychology class. All participants reported normal or corrected-to-normal vision.

Materials. Two pairs of target objects were used; one half of the participants received a blue toothbrush and a green marker, while the other half of participants received a black toothbrush and a maroon marker. For the toothbrushes, schema was manipulated by using toothbrush holders (one blue and one black) as the object that the toothbrush would be expected to be found within, and flashlights (one blue and one black) as the object where the toothbrush would not be expected. For the markers, schema was manipulated by using bags labeled with "pencil case" (one green and one maroon) and bags labeled with "toiletry bag" (one green and one maroon).

There were 4 types of trials:

1) Colour Similarity

There were trials in which colour similarity was assessed; on one trial, the two colour choices were both congruent with respect to schema with the target objects, and on the other trial the choices were both incongruent with the target objects. For one of the trials in which the toothbrush was the target, participants were presented with a choice between placing the toothbrush inside the congruently coloured toothbrush holder or placing the toothbrush inside the incongruently coloured toothbrush holder. On the other trial for the toothbrush, participants chose between placing the toothbrush inside the congruently coloured flashlight or inside the incongruently coloured flashlight. See (a) and (b) in Figure 16 for the choices. For the trials in

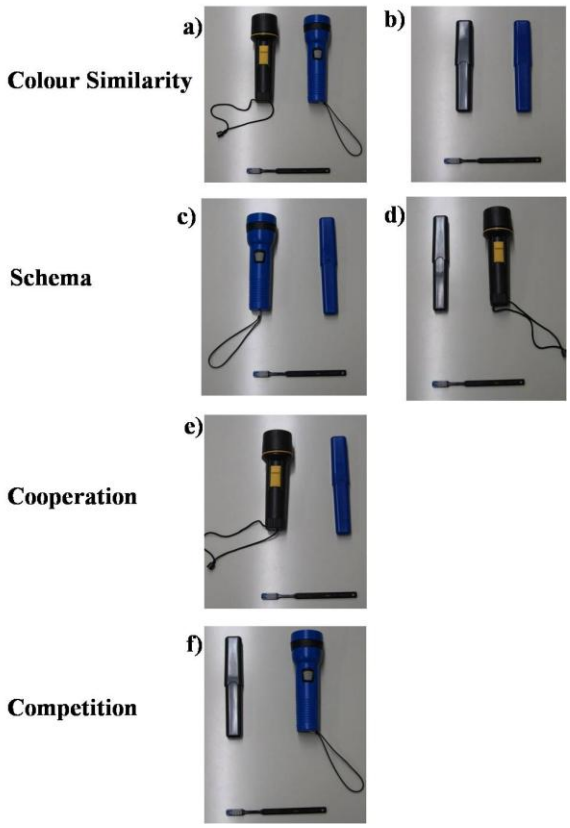

Figure 16. Choices for the black toothbrush as a function of trial type for Experiment 8a. For the two trials assessing *colour similarity*, participants chose between a congruently or incongruently coloured object: on one trial both objects were flashlights (a), on the other trials the objects were both toothbrush holders (b). For the two trials assessing *schema*, participants chose between the toothbrush holder and the flashlight: in one trial the choices were both incongruent in colour with the target toothbrush (c), in the other trial they were congruent in colour with the toothbrush (d). For the trial in which colour similarity and schema were in *cooperation* (e) one choice was easy for both dimensions (blue toothbrush holder), and the other choice was hard for both option dimensions (black flashlight). In the trial in which colour similarity and schema were in competition with each other (f), one choice had the easy option for schema paired with the hard choice for colour similarity (black toothbrush holder), and vice versa for the other choice (blue flashlight).

which the marker was the target object, participants were presented with a choice between placing the marker inside a congruently coloured bag or inside an incongruently coloured bag. On one trial, the bags were both labeled "pencil case", and on the other trial the bags were both labeled "toiletry bag". It was predicted that participants would use colour similarity as in previous experiments; participants would place the targets inside congruently coloured items in the hard condition and inside incongruently coloured items in the easy condition.

2) *Schema*

There were two trials in which schema was assessed; on one trial both choices were congruent in colour with the target object, and on the other trial the choices were both incongruent in colour with the target object. For the toothbrush, the choice was between placing the toothbrush inside a toothbrush holder or inside a flashlight. See (c) and (d) in Figure 16 for the choices for the two schema trials for the toothbrush. For the marker, the choices were between putting the marker inside the bag labeled "pencil case" (i.e., fits with schema) or inside the bag labeled "toiletry bag" (i.e., violates schema). It was predicted that, as in previous forced-choice experiments, when trying to make the target object hard to find, participants would choose to violate the schema for where the target object would be expected to be found. Accordingly, when the toothbrush was the target object, participants would choose to place it inside the flashlight in the hard condition and inside the toothbrush holder in the easy condition. When the marker was the target object, participants would chose to place it inside the pencil case in the hard condition and inside the toiletry bag in the easy condition.

3) Cooperation

There was just one trial in which colour similarity and schema were in cooperation with each other for each target object. For the trial in which the toothbrush was the target object,

participants were given a choice between 1) placing the toothbrush inside an incongruently coloured toothbrush holder (the easy options for both dimensions), or 2) placing the toothbrush inside a congruently coloured flashlight (the hard options for both dimensions). See (e) in Figure 16 for the choices for the trial in which colour similarity and schema were in cooperation with each other and the target object was the black toothbrush. For the trial in which the marker was the target object, participants were given a choice between 1) placing the marker inside an incongruently coloured bag labeled "pencil case" (the easy options for both dimensions), or 2) placing the marker inside a congruently coloured bag labeled "toiletry bag" (the hard options for both dimensions).

4) Competition

There was just one trial in which colour similarity and schema were placed in competition with each other for each target object. For the trial in which the toothbrush was the target object, participants were given a choice were between 1) placing the toothbrush inside a congruently coloured toothbrush holder (the easy option for schema and the hard option for colour similarity), or 2) placing the toothbrush holder inside an incongruently coloured flashlight (i.e, the easy option for colour and the hard option for schema). See (f) in Figure 16 for the choices for the incongruent combination trial for the toothbrush. For the trial in which the marker was the target object, participants were given a choice between 1) placing the marker inside a congruently coloured bag labeled "pencil case" (the easy option for schema and the hard option for colour similarity), or 2) placing the marker inside an incongruently coloured bag labeled "toiletry bag" (the easy option for colour and the hard option for schema). It was assumed that if participants in the hard condition chose the first option they were using colour

similarity over schema; while if they chose the second option in the hard condition they were using schema over colour similarity.

Procedure. Participants were randomly assigned to either the Easy condition or the Hard condition. Participants completed all 12 trials (i.e., 2 Colour Similarity trials per target object, 2 Schema trials per target object, 1 congruent combination trial per target object, and 1 incongruent combination trial per target object) in a random order. Each random order was used for one participant in the Easy condition and one participant in the Hard condition.

5.3.2 Results

The data were processed in the way described in Experiment 6 and the resulting average proportion of trials in which participants selected each choice for each trial type is shown as a function of difficulty in Table 19 (the results for the toothbrush and marker separately can be seen in Appendix I). Independent sample t-tests comparing the easy and hard conditions were conducted for each trial type.

Colour Similarity. Colour similarity was not used as expected; participants were no more likely to place the target objects inside the congruently coloured distracter items in the hard condition than in the easy condition, $t(30) = 0.31$, $p > 0.7$. Examination of subjective reports revealed that participants were interpreting the colour similarity choices in three different ways. When trying to make the target objects easy to find, 44% of participants used colour similarity as expected (i.e., a colour similarity strategy), reporting that they chose to place the target object inside a distracter item of a different colour because the object would stand out; 31% of participants used a colour association strategy (e.g., "blue goes with blue, so I put the blue toothbrush inside the blue holder since someone would expect it to be there"); while 25% of participants considered the colour of the distracter object relative to the bag and chose the

Table 19. Average proportion of trials in which participants selected each choice for each trial type as a function of difficulty in Experiment 8a.

Trial Type	Choices	Easy	Hard
Colour Similarity	Incongruent colour	0.41	0.36
	Congruent colour	0.59	0.64
Schema	Fits with schema	0.97	0.14
	Violates schema	0.03	0.86
Cooperation	Incongruent colour/ Fits with schema	0.97	0.16
	Congruent colour/ Violates schema	0.03	0.84
Competition	Incongruent colour (easy)/ Violates schema (hard)	0.09	0.81
	Congruent colour (hard)/ Fits with schema (easy)	0.91	0.19

toothbrush holder that they thought would grab the attention of the searcher as they searched the suitcase. When trying to make the target object hard to find, 59% of participants used colour similarity as expected, reporting that they chose to place the target object inside a distracter item of the same colour because the object would blend in (i.e., a colour similarity strategy); 25% of participants used a colour association strategy (e.g., "blue goes with blue so I put it in the black one because you would not expect it to be there"); and 13% considered the colour of the distracting object relative to the bag. The two latter strategies were not expected as participants in previous forced-choice experiments almost always selected the congruent colour in the hard condition and the incongruent colour in the easy condition. However, there is one important difference in the present experiment – the target object was placed *inside* the distracter item, rather than *next to* the distracter item as it had been in all colour similarity trials of previous forced-choice tasks. This important distinction will be discussed further below.

Schema. Schema was used as expected; significantly more participants chose to violate schema in the hard condition than in the easy condition, $t(30) = 13.87$, $p < 0.001$.

Cooperation. As expected, participants were more likely to choose the congruently coloured distracter item that violated schema (i.e., the hard choices for both colour similarity and schema) in the hard condition than in the easy condition, $t(30) = 12.04$, $p < 0.001$.

Competition. Significantly more participants chose the distracter that violated schema, even though it was incongruent in colour with the target object, in the hard condition than the easy condition, $t(30) = 8.95$, $p < 0.001$. Using the original logic of the experiment, this result would suggest that participants used schema over colour similarity. However, since colour similarity was not used as expected, this conclusion is not as clear. The data can also be analyzed using an alternative method. When the choices for the cooperation and competition

trials are considered together, the dimension that remains constant across the two trials can be assumed to be the one that the participant was using. In this case, if a participant in the hard condition chose the flashlight in both the cooperation and competition trials (i.e., when the holder was incongruent and congruent with the target object), it can be assumed that the participant was using schema over colour similarity because the colour of the object does not change their choice. Alternatively, if the participant chose the congruently coloured flashlight in the cooperation trial and the congruently coloured toothbrush holder in the competition trial, then it would be assumed that the participant is using colour similarity over schema. When the data are analyzed this way, 88% of participants in the easy condition and 97% of participants in the hard condition used schema over colour similarity. Interestingly, when the data are considered for the toothbrush and the marker separately (see Appendix I), 100% of participants in the easy and hard conditions for the toothbrush use schema, while 75% in the easy condition and 94% in the hard condition used schema when choosing locations for the marker. The differences between the toothbrush and the marker provide further evidence for the importance of context in visual concealment.

5.3.3 Discussion

Overall, the results from Experiment 8a suggest that schema trumps colour similarity as participants chose to violate schema in the hard condition, regardless of whether the choice was congruent or incongruent in colour with the target object. This is the opposite result to what was found in Experiment 7 when schema and colour similarity were put in competition in the office environment. Recall that in Experiment 7, the target object (a mouse) was being hidden in plain sight. However, in the present experiment the target objects are fully occluded inside the distracter items. Therefore it appears that the distinction between hiding in plain sight vs. full

occlusion is an important one, and one that affects which dimension participants choose to use when the two dimensions are put in competition.

Comparison of the results in Experiments 7 and 8a also reveals an interesting effect of the saliency of the dimensions. In Experiment 7, because the target object was being hidden in plain sight and the background colours (black and white) were very high in contrast, colour similarity was very salient. On the other hand, the manipulation of schema (i.e., putting the mouse on the desk or the bookcase), was less salient. While the mouse is definitely more likely to be on the desk beside the computer, it is not a gross violation of the schema for a mouse to have the mouse on the bookcase since the bookcase still fits in the general theme of the office (as opposed to the toothbrush being placed inside a flashlight which is not at all related to the toothbrush). The results reflect these degrees of saliency, as colour similarity is used extremely consistently, while schema is not used as consistently. When colour similarity and schema were in competition, colour similarity trumps schema. In contrast, in Experiment 8a, the manipulation of schema was more salient, especially for the toothbrush. The toothbrush is expected to be found inside a toothbrush holder, and is definitely not expected to be found within a flashlight. Indeed, the toothbrush being inside the flashlight is a strong violation of the expected use of the flashlight. In this case, colour similarity is not used as consistently or as expected, and schema is used quite consistently (especially for the toothbrush; see Appendix I). When colour similarity and schema were in competition, schema trumps colour similarity.

An interesting and unexpected finding in Experiment 8a was that despite the robust colour similarity effect in all previous forced-choice experiments, colour similarity was not used as expected in the present experiment. Upon initial examination of the data, it was observed that participants were selecting the congruent colour far more often than expected. Examination of

the subjective reports revealed that many of the participants who chose the congruent colour in the easy condition (which is opposite of what would be expected with the colour similarity strategy) were using an association that like colours "go with" like colours, and one would therefore expect that the blue toothbrush would be inside the blue toothbrush holder, (and vice versa for the hard condition). It appears that when objects are fully occluded and not in plain sight that colour similarity is not as salient, and some people employ a colour association strategy that is reminiscent of a schema or theory of mind strategy. It seems that the manipulation of schema, and more specifically the violation of schema, is so salient in this situation that it biases participants' into a "schema mode of thinking", thus applying a higher order schema interpretation to a low level visual feature (i.e., colour).

Another strategy that was reported was considering how likely the distracter item (i.e, the toothbrush holder or flashlight) would be to stand out amongst other items in the bag. The toothbrush holder and flashlights were black and blue, and were therefore not perfectly matched for brightness. Some participants picked up on this and reported that they would put the blue toothbrush in the blue toothbrush holder in the easy condition (which is opposite of what would be expected with the colour similarity strategy), since the blue toothbrush holder would stand out more in the suitcase. This strategy is reminiscent of the embodiment dimensions, when participants consider the three dimensional nature of search and how the searcher might interact with or be affected by the items in the environment.

The employment of alternative strategies for colour similarity, which seems like such a simple and salient dimension, again points towards the importance of context, as what was predicted to be straightforward becomes more complex when the context changes from hiding in plain sight to full occlusion.

5.4 Experiment 8b: Schema vs. Colour Similarity in the Luggage Scenario (red/green stimuli)

In Experiment 8a, colour similarity was not used as expected, which then made the overall conclusions not quite as straightforward. One of the ways in which colour similarity was used differently was that participants were considering how likely the distracter item would be to stand out or blend in within the suitcase when someone was searching the suitcase. This was primarily only an issue for the toothbrush. A blue and black toothbrush holder and flashlight were selected because they were the only colours that both the toothbrush holder and flashlight were available in stores. In Experiment 8b, the toothbrush holder and flashlight were spray painted with green and red paint that were matched on brightness.

5.4.1 Method

Participants. Thirty-two undergraduate students from the University of Waterloo participated in a 30-minute experimental session for partial credit towards their psychology class. All participants reported normal or corrected-to-normal vision.

Materials. The materials were identical to Experiment 8a (see Figure 16), with the exception that the blue items were replaced with green items and the black items were replaced with red items. Two pairs of target objects were used – half of the participants received a red toothbrush and a green marker, while the other half of participants received a green toothbrush and a maroon marker. For the toothbrushes, the distracters were a red toothbrush holder and a green toothbrush holder, and a red flashlight and a green flashlight. The materials from Experiment 8a for the marker were used.

Procedure. The procedure was identical to Experiment 8a.

5.4.2 Results

The data were processed as described in Experiment 6 and the resulting average proportion of trials in which participants selected each choice for each trial type is shown as a function of difficulty in Table 20 (the results for the toothbrush and marker separately can be seen in Appendix J). Independent sample t-tests comparing the easy and hard conditions were conducted for each trial type.

Colour Similarity. As in Experiment 8a, colour similarity was not used as expected and how it was previously used in the forced-choice experiments involving hiding in plain sight, $t(30) = 1.46$, $p > 0.2$. Examination of subjective reports revealed that in the easy condition, only 16% of participants used colour similarity as expected (i.e., colour contrast), and 66% of participants used a colour association strategy (i.e., "green goes with green"). In the hard condition, 34% of participants used colour similarity as predicted, and 55% of participants used the colour association strategy (e.g., "green goes with green so I put it in red, wouldn't expect it there").

Schema. Schema was used as expected, with significantly more participants violating schema in the hard condition than in the easy condition, $t(30) = 14.57$, $p < 0.001$.

Cooperation. As expected and similar to Experiment 8a, participants were more likely to choose the congruently coloured distracter item that violated schema (i.e., the "hard" choices for both colour similarity and schema) in the hard condition than in the easy condition, $t(30) = 14.76$, $p < 0.001$.

Competition. As in Experiment 8a, significantly more participants in the present experiment chose the distracter that violated schema, even though it was incongruent in colour

Table 20. Average proportion of trials in which participants selected each choice for each trial type as a function of difficulty in Experiment 8b.

Trial Type	Choices	Easy	Hard
Colour Similarity	Incongruent colour	0.20	0.41
	Congruent colour	0.80	0.59
Schema	Fits with schema	0.98	0.14
	Violates schema	0.02	0.86
Cooperation	Incongruent colour/ Fits with schema	0.97	0.09
	Congruent colour/ Violates schema	0.03	0.91
Competition	Incongruent colour (easy)/ Violates schema (hard)	0.03	0.84
	Congruent colour (hard)/ Fits with schema (easy)	0.97	0.16

with the target object, in the hard condition than the easy condition, $t(30) = 12.04$, $p < 0.001$. The data can also be analyzed using the alternative method described in Experiment 8a where the choices for the cooperation and competition trials are considered together, and the dimension that remained constant between the two trials is assumed to be the one that the participant was using. Using this method, 94% of participants in both the easy and hard conditions used schema.

Overall, the results of Experiment 8a and 8b suggest that when objects are fully occluded, schema trumps colour similarity.

5.5 Overall Discussion

The goals of the experiments in Chapter 5 were 1) to further develop the methodology for the study of concealment by using the forced-choice task in a new way [Strategy 1]; and 2) to explore the relative importance of the dimensions by examining which dimensions participants choose to use over other dimensions [Strategy 4]. The first goal was accomplished as the strategy of using all possible combinations of pairs of variables to create trials that assessed each variable separately, as well as the variables in cooperation and cooperation, proved to be a very fruitful method to examine the relative importance of the variables.

Previously, when participants were asked to place beads in locations within luggage that were either easy or hard to find (Chapter 2), participants reported using dimensions from the Embodiment and Higher Order categories more often than Stimulus Properties. Additionally, dimensions from the Stimulus Properties category received the lowest ratings when participants were asked to rate how much they considered and used each of the dimensions (Study 1b). Thus it was expected that when Embodiment and Higher Order dimensions were put in competition with a Stimulus Properties dimension, that the Embodiment and Higher Order dimensions would be chosen over the Stimulus Properties dimension. However the pattern of results that accrued

was somewhat more complex. When a Stimulus Properties dimension, colour similarity, was put in competition with an Embodiment dimension, line of sight, colour similarity was chosen over line of sight (Experiment 6). When colour similarity was put in competition with a Higher Order dimension, schema, in plain sight, colour similarity trumped schema (Experiment 7). When colour similarity was then put in competition with schema in a scenario that involved occlusion, schema trumped colour similarity (Experiments 8a and 8b). Thus, it appears that the specific characteristics of the scenario (e.g., plain sight vs. occlusion) are important when determining which dimension will be employed by participants to make objects easy and hard to find. When objects are occluded, schema becomes more salient; if an object is concealed within another object in which one would not expect it to be, it is less likely to be searched. Therefore, colour becomes less relevant; if the searcher is not going to look inside the flashlight, it does not matter if the toothbrush is blue or red. Additionally, if the schema violation is not enough to stop people from finding the objects and the searcher does look inside the flashlight for the toothbrush, then colour similarity will likely not matter, as anything other than batteries is going to stand out, regardless of the colour. In contrast, when objects are in plain sight, colour similarity becomes more important because one must search for items against different coloured backgrounds. People correctly intuit that a coloured object that is placed on or in front of a similarly coloured object will blend in and be harder to find.

CHAPTER 6: GENERAL DISCUSSION

The purpose of this dissertation is to begin to understand concealment behaviour with the ultimate goal of developing a theory of visual concealment. The five strategies identified from the examination of the development of search theory in the traditional visual search literature and the scene-based search literature, were applied here in the context of visual concealment. The five strategies are: 1) establish a methodology for the study of visual concealment, 2) identify the dimensions that people use to vary the degree of concealment of objects, 3) categorize the dimensions, 4) prioritize the dimensions and possibly create a hierarchy, and 5) integrate the findings into a theoretical framework that makes inferences about the mechanics of visual concealment. These strategies will be discussed below in the context of the results of the experiments in this dissertation.

The first strategy was to establish a method to study concealment behaviour. Because visual concealment is a relatively undeveloped area, this was an important goal in the present dissertation since it is necessary to develop methods to allow for the study of the dimensions that are important when someone is concealing an object and to examine how these dimensions differ across contexts. A variety of tools and techniques were developed and refined in the present experiments. Through this process, it was determined that concealment behaviour can be probed through subjective reports (Chapter 2), free concealment behaviour (Chapter 4), and a 2-alternative forced-choice task (Chapters 3 and 5). The combination of these techniques proved to be effective for identifying [Strategy 2], categorizing [Strategy 3], and prioritizing [Strategy 4] some initial dimensions that are important in visual concealment.

In Chapter 2, participants' subjective strategies and thought processes were probed after they had experience placing bags of beads within luggage in locations that they thought would

make the beads easy or hard to find. The subjective reports were analyzed and a number of dimensions were identified [Strategy 2]. Examination of the reported dimensions revealed that they fell into three main categories [Strategy 3]. Participants reported using *Stimulus Properties* dimensions relating to the physical characteristics of the target object relative to the distracter items. They also reported *Embodiment* dimensions, such as how accessible the target object is and how likely the searcher is to interact with the target object. Finally, dimensions from a *Higher Order* category were also reported, such as schemata and theory of mind. The subjective report studies also provided some preliminary information about the relative use and importance of the dimensions from each of the categories [Strategy 4]. In one scenario, dimensions from the Embodiment and Higher Order categories were reported more often than the Stimulus Properties dimensions, while in a different scenario, dimensions from the Higher Order category were reported more often those from the Embodiment and Stimulus Properties categories. This suggests that the relative use of the dimensions depends on the context. The importance of context was confirmed when differences were found between context-specific and context-general questions on a questionnaire asking participants to rate each dimension in a number of different ways. When participants were asked about the specific context that they just completed, participants reported that they did not consider or use the dimensions from the Stimulus Properties category very often, but when rating the importance of these dimensions in general, participants indicated that they were important. This difference highlights the importance of context, as not all dimensions are going to be relevant and useful to participants in all contexts.

In Chapter 3, dimensions from each of the three categories uncovered in the subjective report data in Chapter 2 were manipulated and used in a forced-choice task. These experiments

were successful in developing another type of methodology (i.e., the forced-choice task), which can be used to study concealment behaviour [Strategy 1]. The results of the forced-choice experiments also provided more information about the identified dimensions [Strategy 2]; through a progression of experiments, the dimensions were refined and it was found that dimensions from all three of the categories did in fact affect participants' selection of hiding locations.

In Chapter 4, participants completed the placement task with multiple objects in two variations of an office environment. The goals of these experiments were: 1) to develop another methodology, free concealment, to probe concealment behaviour [Strategy 1]; 2) to examine whether free concealment behaviour is systematic (or whether each person does something different); and 3) to examine whether participants would use dimensions from the three categories when choosing locations within the office that would make the target objects easy or hard to find. Photographs of the locations chosen by participants were coded on dimensions from each of the three categories, and the locations chosen in the easy and hard conditions were compared. Results indicated that concealment behaviour – even in very complex, real-world environments – is systematic. Additionally, participants used dimensions from each of the categories to vary the degree of concealment of the target objects. Interestingly, there were differences found in how the different dimensions were used across the different target objects, suggesting that the nature of the relationship between the target and the environment is critical.

The goal of Chapter 5 was to further explore the relative importance of the dimensions [Strategy 4] using a 2-alternative forced-choice task in a new way [Strategy 1]. Because the dimensions from the Stimulus Properties category were reported less often than those from the Embodiment and Higher Order categories (Chapter 2), a Stimulus Properties dimension, colour

similarity, was made very salient and then compared first to an Embodiment dimension, line of sight, and then to a Higher Order dimension, schema, to see whether the Embodiment and Higher Order dimensions would still be used more often than the Stimulus Properties dimension. When colour similarity and line of sight were placed in competition with each other within the bookcases, colour similarity was used by participants much more often than line of sight (Experiment 6). When colour similarity was put in competition with schema in an office environment that involved placing the target object in *plain sight*, colour similarity trumped schema (Experiment 7). However, when colour similarity was put in competition with schema in the luggage scenario, the opposite result was found. In this case, when the target objects were *occluded* inside distracter items, schema then trumped colour similarity (Experiments 8a and 8b).

6.1 Theoretical Integration

A fifth and final strategy in the development of visual concealment theory, as modeled after the development of visual search theory and scene-based search theory, is to integrate available results and previous theories and to make inferences about the mechanisms involved in visual concealment. For example, in the search domain, Feature Integration Theory (Treisman & Gelade, 1980) made a distinction between processes that require attention and those that are defined by a single basic feature, and the Target Acquisition Model (Zelinsky, 2008) made inferences about the mechanics involved in directing eye gaze to the target object.

The present results put forth several initial principles for a theory of visual concealment:

1. Hiding behaviour is systematic; even in complex environments, people behave in similar ways when selecting hiding spots.
2. There is agreement between subjective report data and objective probes of hiding behaviour (i.e., free concealment and 2-alternative forced-choice task).

3. There are three important categories of dimensions – dimensions relating to the Stimulus Properties of the target object relative to the distracter items, Embodiment dimensions such as line of sight and physical interaction, and Higher Order dimensions such as theory of mind and search schemata.
4. Higher level factors are important and can trump lower-level, visual factors; however this depends on the characteristics of the context.
5. The dimensions that people use to conceal objects are available to conscious awareness.
6. People show considerable sophistication in their knowledge of the dimensions that govern visual concealment and how the dimensions are affected by context.
7. The use of dimensions is very context-specific, dynamic and nuanced by the participants; participants assess the situation and use the factors appropriately.

The present results suggest that when people select hiding spots, they first assess the object that they want to conceal and the environment in which they are going to conceal the object. When participants were selecting hiding locations for different objects in an office environment (Chapter 4), there were differences found between the objects in terms of how the dimensions were used. This suggests that the relationship between the target and the environment is critical, and that people's concealment behaviour will be affected not only by the environment, but by the object that is to be concealed.

In addition to assessing the object and the environment, it is suggested that people access a) their prior hiding experiences, and b) their knowledge of dimensions that are important in concealment. People's past experiences with concealment will likely affect the selection of future hiding spots. Based on this, it is predicted that when people complete several hiding trials, they might perseverate and continue to use similar strategies once they have found a strategy that

has been effective. In addition to their prior experiences, people also consider dimensions from the three categories in an opportunistic fashion. The present experiments provide evidence that people consider dimensions from the three categories, but that the use of dimensions depended on the context. Based on this, it is predicted that people do not necessarily use dimensions from each of the categories in a given context, but that they select the applicable salient and relevant characteristics in a non-algorithmic manner.

These ideas about what types of information people assess and access when selecting hiding locations are consistent with the search-based theory of visual concealment proposed by Smilek et al. (2009). Smilek and colleagues proposed a preliminary theory of visual concealment that was based on the fundamental assumption that participants have *access* to the dimensions that influence basic mechanisms of visual search, and that this information will then influence participants' selections of hiding locations. It is clear from subjective report data and the way in which participants used the dimensions, that participants have access to a variety of dimensions that influence search. The key question though is *how* do people have access to these dimensions? Previously, Smilek et al. (2009) suggested three ways in which participants can access the dimensions that influence search. First, participants could access *propositional knowledge* (see Pylyshyn, 1973, 1981), or explicit knowledge about dimensions that influence search. This knowledge could be gained from prior experience with hiding or finding things in our everyday lives. Second, participants could use *visual images* (see Kosslyn, 1976, 1980) to create mental simulations of possible hiding locations and then internally test how effectively their search mechanisms will guide them to the target. Third, participants could also manipulate the *external environment* and physically try out different hiding spots to test how effectively their search mechanisms will guide them to the target. The current results provide some insight into

these possibilities, but by no means do the results rule out or select any particular possibility. The fact that participants were able to verbalize their strategies and thought processes when selecting hiding locations suggests that participants are accessing their knowledge about dimensions that will affect search, which has been gained from prior experience with searching or hiding. However, it is also possible that participants created a mental simulation of a potential hiding spot and tested it internally, and then inferred reasons based on their simulation, which they then verbalized. There was some support for the possibility that participants manipulate the external environment and test their hiding spot, as a handful of participants first placed the object in a location, stepped back to observe it, and then decided to move the object to another location. However, participants were not randomly placing the objects and testing them in multiple different locations, suggesting that they were first accessing prior knowledge or creating simulations and then testing their selections out in the external environment. Therefore, it seems likely that it is not one of these three possibilities that is the correct one that people use, but rather a hybrid of these possible ways that people access the dimensions.

While "search-based" referred to basic visual search theory (i.e., based on the traditional visual search literature) in Smilek et al. (2009), the present results suggest that the search-based theory of concealment can be extended to include scene-based search theory (i.e., based on search in real-world scenes). In scene-based search theory there is much more of an emphasis on the higher-level, top-down processes (e.g., scene context) as compared to traditional visual search theory. Given the prevalence of the use of higher level dimensions in the present experiments, it seems appropriate to extend the definition of "search" to include dimensions from the scene-based search theory as well. Therefore, in addition to having access to the factors that influence the basic mechanisms of visual search, people also have access to higher-level factors

such as how someone might interact with an environment or how their search might be affected by their prior knowledge or expectation. If a search-based theory of concealment is to be used going forward, any of the higher-level dimensions that were reported and used by participants (e.g., theory of mind) must be shown to influence search.

6.2 Methodological Considerations

A key distinction between the approach taken in this dissertation and the approach used in the traditional visual search research is that the approach used here to generate the list of important dimensions was *observation-driven,* while in the traditional visual search research the selection of dimensions is *researcher-driven*. Typically, researchers will select dimensions that they think will be important or will yield differences between conditions, and then they manipulate the dimensions one at a time and test their hypotheses. In the present work, participants were initially given experience with concealing objects within a complex environment and then subjective reports were gathered. A list of dimensions was created based on these subjective reports, and these reported dimensions were then used in subsequent experiments (in a more researcher-driven approach. Therefore, the selection of dimensions in the experiments was observation-driven. This approach is particularly useful when trying to generate a more exhaustive list of the types of dimensions that people use, since it is not relying on a single researcher or group of researchers to generate the factors that they personally think will have an effect or that they find interesting. Going forward in the development of the theory of concealment, the observation-driven approach should be used whenever possible, especially in the early stages of trying to generate all possible dimensions that are important in a given context.

A variety of experimental designs and data analysis techniques were employed in the present experiments. In the initial studies, subjective report data was obtained after participants had completed a placement task where they could place the target objects anywhere within luggage. In another set of experiments, participants were also able to place target objects anywhere within a complex environment (i.e., free concealment), but the unit of analysis was the chosen locations, which were coded for the use of the different dimensions. In other experiments, participants' choice of placement of the target object was limited to 2 choices to be able to examine the dimensions in isolation and to start to prioritize the dimensions. While each of these approaches has its advantages, each also has its disadvantages. When participants' behaviour is not constricted in the free concealment task, a wide range of behaviour is obtained, but analysis of this data is more challenging and specific conclusions and comparisons cannot always be made. On the other hand, when behaviour is restricted to a forced-choice to allow for direct comparison, there is no opportunity to examine variability within the behaviour. Because of this trade-off between sampling the full range of behaviour and being able to isolate behaviour and make specific comparisons, it will be important to employ a variety of methods and techniques when studying concealment behaviour in the future to be able to address both of these concerns.

The present results clearly demonstrate the critical role that context plays in participants' selection and use of the various dimensions. It is important to note that context can be manipulated in a variety of ways. One way context can be manipulated is by varying the instructions given to participants. For example, in Chapter 2 the same materials or environment were used across the two studies (i.e, the luggage), but the instructions given to the participants changed. This instructional manipulation resulted in a different relative use of dimensions from

the three categories across the two experiments. Another way to manipulate context is to change the environment in which the object is being placed. In the present work, an environment involving luggage and the contents expected in luggage was used (Chapters 2, 3, 5), as well as two different office environments (i.e., an entire mock office in Chapter 4, and a more limited bookcase environment in Chapter 4 and 5). While it can be difficult to directly compare across contexts that differ on many aspects, different and new dimensions might be uncovered in different types of environments. A third way that context can be manipulated is through the use of multiple target objects within a given environment. When participants placed four different target objects in locations within the office that they thought would be easy or hard to find (Experiment 5), differences were found across the four targets in terms of which dimensions were used to vary the degree of concealment for the different objects. For example, participants placed the piece of paper and journal next to distracters of similar colour more often in the hard condition than the easy condition, but there were no differences between the easy and hard condition for the marker and the mug on the colour similarity dimension. The target objects can then be analyzed for characteristics that differ between them, as well as differences in the target-environment relationships that might explain the differential use of the dimensions.

6.3 Future Directions

Because of the critical role context plays in people's relative use of the different dimensions, an important step in the development of a theory of concealment will be to identify key contexts and the critical ways in which they differ (i.e., *critical contextual distinctions*). One initial critical contextual distinction discovered in the present experiments is whether the objects are placed in plain sight or are fully occluded. For example, when colour similarity was placed in competition with schema, colour similarity trumped schema in a context where the object was

placed in plain sight (Experiment 7). However, when the object was fully occluded, schema trumped colour similarity (Experiments 8a and 8b). Future research could use different types of experimental scenarios that involve either hiding in plain sight or using occlusion to examine whether there are consistent differences between the two. While allowing for occlusion does make the task of examining the concealment behaviour more complicated, it is critical to continue to develop methods to allow for occlusion since it is an important aspect of concealment. Consideration of both the traditional visual search literature and the scene-based search literature reveals that the target objects are almost always hidden in plain sight amongst the distracter items or within the scenes on a computer display. It will also be a challenge for search researchers to develop methods to allow for the study of search for targets that are fully occluded.

Another critical approach will be to continue to conduct studies that vary the salience of the different dimensions. For example, in the 2-alternative forced-choice experiment in Chapter 5, colour similarity was made quite salient by using colours that are high in contrast (e.g., blue and white, black and white). Future studies should vary the degree of contrast to examine whether colour similarity will still be used over line of sight when the target and distracters are different shades of the same colour. For example, instead of the choice being between placing a blue journal in with white journals or blue journals, the choice could be between placing the blue journal in with journals of the same shade of blue or journals of a slightly different shade of blue. It is possible that line of sight might become more salient in this case, and line of sight might possibly trump colour similarity. Additionally in the experiments comparing colour similarity and schema, in the office scenario colour similarity was more salient and extreme, while the manipulation of schema was more subtle. In this case, colour similarity trumped schema

(Experiment 7). When colour was made less salient by having the target object fully occluded in the luggage scenario, and a stronger manipulation of schema was used, schema then trumped colour similarity (Experiments 8a and 8b). While these differences between experiments could be explained on the basis of hiding in plain sight vs. using full occlusion, these differences need to be explored further in experiments that manipulate saliency of the dimensions in a controlled manner.

While the present experiments did consider some object-related features such as colour and shape similarity, there are many other perceptual attributes that could be explored in future research. For example, Gestalt grouping principles such as figure-ground organization (e.g., Monk & Brown, 1975) and proximity (e.g., Quinlan & Wilton, 1998) could be measured explicitly in a free concealment task or varied systematically in a forced-choice task and the resultant effect on hiding behaviour could be measured. In addition, other dynamic principles that may also affect the visibility of an object, such as visual masking (e.g., Breitmeyer, 1984), could be explored in future concealment research.

Another direction to consider is how to conceptualize and study dimensions from the Higher Order category, such as schema and theory of mind. It is clear that these types of dimensions were reported quite often when participants were free to select hiding locations within complex environments. However, it was often difficult to categorize responses as to whether they would be considered search schema (i.e., having a script or idea of how search is likely to unfold) or theory of mind (i.e., considering what the searcher would be thinking or wanting to do while searching). Future research can further examine the distinction between these concepts, and indeed decide whether this is a useful distinction. Another consideration that is very relevant to the study of the use and effect of schemata is whether or not the hider is to

assume that the searcher knows what the target object is. Consideration of how search occurs in the real-world reveals that in some instances we do know exactly what we are searching for, while there are other times when we do not know the exact target. For example, when we are trying to find the stapler on our colleague's messy desk, we know the general shape, size, and possibly colour, of the stapler. In contrast, when border guards are searching luggage, they know that they are searching for illegal items such as guns, knives, or drugs, but they do not often have a picture of the exact target object in mind (e.g., a target template). This is an important distinction to consider when designing future concealment studies. This is particularly an issue when studying how schemata are used because if the searcher does not know exactly what they are searching for, schemata can become less relevant. For example, in the forced-choice task where participants could choose to place the target object (e.g., toothbrush) inside an object where it would be expected to be found (e.g., a toothbrush holder) or inside one in which it would not be expected (e.g., a flashlight), if the searcher does not know that the item they are searching for is a toothbrush, then this choice does not really make sense.

Given the natural relationship between concealment and search, future research could use studies in which participants try to find the hidden target objects (i.e., finding studies) to confirm some of the present results. Target objects that were placed in easy and hard locations by one group of participants, can then be searched for by another group of participants. Presumably it should take longer to find the target objects in the locations chosen by participants to make the objects hard to find than the locations chosen by participants to make the objects easy to find. It is also possible that participants might not be able to find all of the target objects, and that more of the targets in locations that were meant to be hard to find will not be found compared to targets in locations that were chosen to be easy to find. Differences between the easy and hard

conditions in terms of search time and accuracy would serve as an empirical validation of participants' judgments of what would be easy or hard to find. This validation would be important because of previous cases where participant's intuitions about their behaviour were not in line with their actual behaviour. More specifically, participant's intuitions about whether they would be able to detect changes that are often not detected (i.e., change blindness blindness) revealed that participants tend to overestimate their ability to detect visual changes (e.g., Levin, Momen, Drivdahl, & Simons, 2000). While there has been disagreement in the literature as to whether people are aware of the factors that are necessary to successfully detect changes as scene complexity increases and how this ability is affected by artificial laboratory settings, (e.g., Beck, Levin & Angelone, 2007; Smilek, Eastwood, Reynolds & Kingstone, 2008), the suggestion that people's intuitions might not be reflected in effects on behaviour can be addressed in future studies by combining subjective report measures with measurement of finding behaviour in real world situations.

In summary, this dissertation has laid down some of the ground work towards uncovering the factors that are important to include in a theory of visual concealment, as well as developing methods and tools to be able to study concealment behaviour in complex, real-world environments. It is hoped that these methods and tools will continue to be developed and will be used to open up the field of the study of visual concealment. In turn, results from the study of visual concealment can then be used to inform visual search research, both in simple computer displays and in complex real-world environments.

Appendix A: Dimension Rating Questionnaire (Luggage)

The following questions pertain to your strategy and thought processes **<u>while you were hiding the beads</u>**.

1. Did you consider how people search **in general**? *(search schema)*

1	2	3	4	5	6	7
Did not Consider						**Considered a lot**

2. Did you consider how **border guards** would search the bag or where **border guards** would look? *(theory of mind – liberal)*

1	2	3	4	5	6	7
Did not Consider						**Considered a lot**

3. Did you consider what border guards might be **thinking or wanting to do** while they search? *(theory of mind – conservative)*

1	2	3	4	5	6	7
Did not Consider						**Considered a lot**

4. Did you consider the **typical/expected use** of the props in the bag or of parts of the bag itself? E.g., This case is usually used to hold glasses *(schema for function of item)*

1	2	3	4	5	6	7
Did not Consider						**Considered a lot**

5. Did you consider the **visibility** of the beads or the **obviousness** of the hiding spot? (c*onfrontation)*

1	2	3	4	5	6	7
Did not Consider						**Considered a lot**

6. Did you consider the **feel** of the beads or how they might be **felt** by border guards? *(tactility)*

1	2	3	4	5	6	7
Did not Consider						**Considered a lot**

7. Did you consider the potential **sound of the beads** for a given location or how they might be **heard** by border guards? (i.e., if someone shook the item)? *(audition)*

1	2	3	4	5	6	7
Did not Consider						**Considered a lot**

8. Did you consider the **similarity** of the beads to the items in a particular hiding spot in terms of **visual characteristics**? (i.e., contrast, colour, shape, etc.) *(visual similarity)*

1	2	3	4	5	6	7
Did not Consider						**Considered a lot**

The following questions pertain to your strategy and thought processes **<u>while you were hiding the beads</u>**.

9. Did you make use of knowledge of how people search **in general**? *(search schema)*

1	2	3	4	5	6	7
Did not Use						**Used a lot**

10. Did you make use of knowledge of how **border guards** would search the bag or where **border guards** would look? *(theory of mind – liberal)*

1	2	3	4	5	6	7
Did not Use						**Used a lot**

11. Did you make use of knowledge about what border guards might be **thinking or wanting to do** while they search? *(theory of mind – conservative)*

1	2	3	4	5	6	7
Did not Use						**Used a lot**

12. Did you use the **typical/expected use** of the props in the bag or of parts of the bag itself? E.g., This case is usually used to hold glasses. *(schema for function of item)*

1	2	3	4	5	6	7
Did not Use						**Used a lot**

13. Did you use the **visibility** of the beads or the **obviousness** of the hiding spot? (*confrontation)*

1	2	3	4	5	6	7
Did not Use						**Used a lot**

14. Did you use the **feel** of the beads or how they might be **felt** by border guards? *(tactility)*

1	2	3	4	5	6	7
Did not Use						**Used a lot**

15. Did you use the potential **sound of the beads** for a given location or how they might be **heard** by border guards? (i.e., if someone shook the item) *(audition)*

1	2	3	4	5	6	7
Did not Use						**Used a lot**

16. Did you use the **similarity** of the beads to the items in a particular hiding spot in terms of **visual characteristics**? (i.e., contrast, colour, shape, etc.) *(visual similarity)*

1	2	3	4	5	6	7
Did not Use						**Used a lot**

The following questions pertain to how important you think each of the factors is when **hiding objects in general.**

17. How important is knowledge of how people search **in general**? *(search schema)*

1	2	3	4	5	6	7
Not at all Important						**Very Important**

18. How important is knowledge of how **the searcher** would search the bag or where **the searcher** would look? *(theory of mind – liberal)*

1	2	3	4	5	6	7
Not at all Important						**Very Important**

19. How important is knowledge about what the searcher might be **thinking or wanting to do** while they search? *(theory of mind – conservative)*

1	2	3	4	5	6	7
Not at all Important						**Very Important**

20. How important is using the **typical/expected use** of the props or parts of the environment? E.g., This object is usually used for this purpose. *(schema for function of item)*

1	2	3	4	5	6	7
Not at all Important						**Very Important**

21. How important is the **visibility** of the object being hidden or the **obviousness** of the hiding spot? (c*onfrontation)*

1	2	3	4	5	6	7
Not at all Important						**Very Important**

22. How important is the **feel** of the object being hidden or how it might be **felt** by the searcher? *(tactility)*

1	2	3	4	5	6	7
Not at all Important						**Very Important**

23. How important is the potential **sound of the object** hidden in a given location or how it might be **heard** by searcher? (i.e., if someone shook the item) *(audition)*

1	2	3	4	5	6	7
Not at all Important						**Very Important**

24. How important is the **similarity** of the object being hidden to the items in a particular hiding spot in terms of **visual characteristics**? (i.e., contrast, colour, shape, etc.)
(visual similarity)

1	2	3	4	5	6	7
Not at all Important						**Very Important**

Appendix B: Proportion of participants who selected each choice for the **toothbrush** as a function of dimension and difficulty in Experiment 2.

Dimension	Choices	Easy	Hard
Colour Similarity	Incongruent colour	0.94	0.00
	Congruent colour	0.06	1.00
Shape Similarity	Dissimilar shape	0.62	0.31
	Similar shape	0.38	0.69
Thickness	Thin	0.87	0.62
	Thick	0.13	0.38
Embeddedness (controlled)	Inside 1 box	0.94	0.00
	Inside 3 boxes	0.06	1.00
Embeddedness (realistic)	Inside 1 item	0.75	0.44
	Inside 2 items	0.25	0.56
Eccentricity	Centre	0.81	0.31
	Surrounding area	0.19	0.69
Depth	Closer to top	1.00	0.00
	Closer to bottom	0.00	1.00
Main vs. outer	Outside	0.56	0.44
	Main	0.44	0.56
Schema	Same category	0.56	0.37
	Different category	0.44	0.63

Appendix C: Proportion of participants who selected each choice for the **knife** as a function of dimension and difficulty in Experiment 2.

Dimension	Choices	Easy	Hard
Colour Similarity	Incongruent colour	0.94	0.06
	Congruent colour	0.06	0.94
Shape Similarity	Dissimilar shape	0.94	0.06
	Similar shape	0.06	0.94
Thickness of Material	Thin	0.81	0.19
	Thick	0.19	0.81
Embeddedness (controlled)	Inside 1 box	0.94	0.00
	Inside 3 boxes	0.06	1.00
Embeddedness (realistic)	Inside 1 item	0.31	0.37
	Inside 2 items	0.69	0.63
Eccentricity	Centre	0.87	0.19
	Surrounding area	0.13	0.81
Depth	Closer to top	0.94	0.06
	Closer to bottom	0.06	0.94
Main vs. outer	Outside	0.37	0.31
	Main	0.63	0.69
Schema	Same category	0.50	0.50
	Different category	0.50	0.50

Appendix D: Proportion of participants who selected each choice for the **toothbrush** as a function of dimension and difficulty in Experiment 3a.

Dimension	Choices	Easy	Hard
Colour Similarity	Incongruent colour	1.00	0.00
	Congruent colour	0.00	1.00
Thickness of Material	Thin	0.81	0.19
	Thick	0.19	0.81
Embeddedness (controlled)	Inside 1 box	1.00	0.06
	Inside 3 boxes	0.00	0.94
Horizontal Eccentricity	Centre	0.75	0.19
	Surrounding area	0.25	0.81
Depth	Closer to top	1.00	0.00
	Closer to bottom	0.00	1.00
Bulkiness/ Affordance	More bulky (thicker socks)	0.50	0.44
	Less bulky (thin socks)	0.50	0.56
Schema – Expectation	Fits with schema	0.94	0.06
	Violates schema	0.06	0.94
Schema – Conceptual	Same category	1.00	0.12
	Different category	0.00	0.88

Appendix E. Proportion of participants who selected each choice for the **knife** as a function of dimension and difficulty in Experiment 3a.

Dimension	Choices	Easy	Hard
Colour Similarity	Incongruent colour	1.00	0.00
	Congruent colour	0.00	1.00
Thickness of Material	Thin	0.81	0.06
	Thick	0.19	0.94
Embeddedness (controlled)	Inside 1 box	1.00	0.06
	Inside 3 boxes	0.00	0.94
Horizontal Eccentricity	Centre	0.87	0.25
	Surrounding area	0.13	0.75
Depth	Closer to top	1.00	0.06
	Closer to bottom	0.00	0.94
Bulkiness/ Affordance	More bulky (thicker socks)	0.50	0.44
	Less bulky (thin socks)	0.50	0.56
Schema – Expectation	Fits with schema	0.94	0.12
	Violates schema	0.06	0.88
Schema – Conceptual	Same category	0.81	0.19
	Different category	0.19	0.81

Appendix F. Proportion of participants who selected each choice for the **toothbrush** as a function of dimension and difficulty in Experiment 3b.

Dimension	Choices	Easy	Hard
Colour Similarity	Incongruent colour	1.00	0.00
	Congruent colour	0.00	1.00
Thickness of Material	Thin	1.00	0.06
	Thick	0.00	0.94
Embeddedness (controlled)	Inside 1 box	0.94	0.00
	Inside 3 boxes	0.06	1.00
Horizontal Eccentricity	Centre	0.94	0.44
	Surrounding area	0.06	0.56
Depth	Closer to top	0.94	0.00
	Closer to bottom	0.06	1.00
Bulkiness/ Affordance	More bulky (thicker socks)	0.19	0.69
	Less bulky (thin socks)	0.81	0.31
Schema – Expectation	Fits with schema	1.00	0.00
	Violates schema	0.00	1.00
Schema – Conceptual	Same category	0.87	0.31
	Different category	0.13	0.69

Appendix G. Proportion of participants who selected each choice for the **knife** as a function of dimension and difficulty in Experiment 3b.

Dimension	Choices	Easy	Hard
Colour Similarity	Incongruent colour	0.94	0.00
	Congruent colour	0.06	1.00
Thickness of Material	Thin	0.87	0.12
	Thick	0.13	0.88
Embeddedness (controlled)	Inside 1 box	0.87	0.12
	Inside 3 boxes	0.13	0.88
Horizontal Eccentricity	Centre	0.94	0.44
	Surrounding area	0.06	0.56
Depth	Closer to top	0.94	0.12
	Closer to bottom	0.06	0.88
Bulkiness/ Affordance	More bulky (thicker socks)	0.25	0.69
	Less bulky (thin socks)	0.75	0.31
Schema – Expectation	Fits with schema	0.94	0.12
	Violates schema	0.06	0.88
Schema – Conceptual	Same category	0.81	0.19
	Different category	0.19	0.81

Appendix H. Average proportion of trials in which participants selected each choice for the journal and the stapler as a function of trial type and difficulty in Experiment 6.

		Journal		Stapler	
Trial Type	**Choices**	**Easy**	**Hard**	**Easy**	**Hard**
Colour Similarity	Incongruent colour	0.91	0.00	0.94	0.00
	Congruent colour	0.09	1.00	0.06	1.00
Line of Sight	In line of sight	0.94	0.03	0.91	0.00
	Below line of sight	0.06	0.97	0.09	1.00
Cooperation	Incongruent colour/ In line of sight	1.00	0.06	0.94	0.00
	Congruent colour/ Below line of sight	0.00	0.94	0.06	1.00
Competition	Incongruent colour/ Below line of sight	0.87	0.12	0.69	0.31
	Congruent colour/ In line of sight	0.13	0.88	0.31	0.69

Appendix I. Average proportion of trials in which participants selected each choice for the toothbrush and marker as a function of trial type and difficulty in Experiment 8a.

		Toothbrush		Marker	
Trial Type	**Choices**	**Easy**	**Hard**	**Easy**	**Hard**
Colour Similarity	Incongruent colour	0.31	0.34	0.50	0.37
	Congruent colour	0.69	0.66	0.50	0.63
Schema	Fits with schema	1.00	0.00	0.94	0.28
	Violates schema	0.00	1.00	0.06	0.72
Cooperation	Incongruent colour/ Fits with schema	1.00	0.00	0.94	0.31
	Congruent colour/ Violates schema	0.00	1.00	0.06	0.69
Competition	Incongruent colour (easy)/ Violates schema (hard)	0.00	1.00	0.19	0.63
	Congruent colour (hard)/ Fits with schema (easy)	1.00	0.00	0.81	0.37

Appendix J. Average proportion of trials in which participants selected each choice for the toothbrush and marker as a function of type of trial and difficulty in Experiment 8b.

		Toothbrush		Marker	
Trial Type	**Choices**	**Easy**	**Hard**	**Easy**	**Hard**
Colour Similarity	Incongruent colour	0.19	0.41	0.22	0.41
	Congruent colour	0.81	0.59	0.78	0.59
Schema	Fits with schema	1.00	0.03	0.97	0.25
	Violates schema	0.00	0.97	0.03	0.75
Cooperation	Incongruent colour/ Fits with schema	1.00	0.00	0.94	0.19
	Congruent colour/ Violates schema	0.00	1.00	0.06	0.81
Competition	Incongruent colour (easy)/ Violates schema (hard)	1.00	0.00	0.94	0.31
	Congruent colour (hard)/ Fits with schema (easy)	0.00	1.00	0.06	0.69

Footnotes

1. Inter-rater reliabilities in Studies 1a and 1b were calculated using the Phi correlation for binary variables.
2. There were only 26 completed questionnaires included in this study because the first 4 participants did not fill out the questionnaire, 1 participant did not complete all the questions and 1 questionnaire was lost.
3. Inter-rater reliabilities for Experiments 4a, 4b, and 5 were calculated using a Pearson correlation coefficient.
4. It was important in the present studies to give people the freedom to place the target anywhere they wanted so as not to restrict behaviour in any way. However, participants did occasionally fully occlude the target object (e.g., by placing it inside one of the boxes or behind the row of journals). It was still possible to code these locations the same way for the majority of the dimensions (i.e., if an object was fully occluded, it would be considered completely out of the line of sight), however it made coding colour similarity a little bit more complicated. This was dealt with by coding colour similarity as though the occlusion was removed (i.e., if the person searching were to move the journals or open up the box).

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