The Process of Communication between People with Categorical Knowledge: An Exploratory Study

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.

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

Mina Rohani Tabatabai

Abstract

This thesis investigates the process of communication between a person who has in-depth and technical knowledge about certain items and a person who has very broad and non-technical knowledge. For example, a doctor has detailed knowledge about all types of diseases, whereas, an ordinary person only knows a few common type of them.

People use categories to communicate; the language, which is used in communication, is categorical. In addition, knowledge can be expressed in categories, and the categories are formed based on the knowledge that the person has. If the person has a superficial knowledge about a specific subject, he then creates superficial categories; whereas, if he has in-depth knowledge, he creates detailed and technical categories. The communication process between a person with technical categories of knowledge and a person with non-technical categories can be presented by the way that they match their categories. Shared cognition is formed if a category exists or is formed that is completely understandable for both parties.

Literature on communication studies have never focused on the way that people with categorical knowledge communicate; therefore, an exploratory study is designed to figure out the process of communication when people have categorical knowledge. The task that is used in this study simulates the situation that two persons with categorical knowledge are communicating. The results of this thesis introduce a new representation for the communication process between a technical and non-technical communicators and the way that shared cognition can be analyzed.

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To Ali

In appreciation of all his support and encouragement in my life

Table of Contents

List of Figures

List of Tables

Chapter 1

Introduction

"Communication is one of those human activities that everyone recognizes but few can define satisfactorily" (Fiske, 1982). Therefore, communication studies look at the process of communication differently and researchers define communication from different perspectives (Littlejohn, 2001). Shepherd (1992) divides studies about human communication into rhetorical and relational studies. Rhetorical communication studies focus on how to influence and persuade others while relational communication focuses on the transaction and coordination of communication among people to reach a shared cognition (Richmond, V. P. & McCroskey, J. C., 2009). However, a classification, such as the one that is just mentioned, has not been helpful in guiding researchers to any integrated type of studies in communication. In the area of relational communication as well, several studies have focused on the way that communication works and shared cognition is formed; however, there are still difficulties in measuring and analyzing shared cognition.

People communicate to each other while they have different knowledge and backgrounds. In some cases, communication happens between a person who has in-depth knowledge about certain items and a person who has very broad knowledge. For example, a doctor has detailed knowledge about all types of diseases, whereas, an ordinary person only knows a few common type of them. The question arises that how the communication works between these two persons. How the shared meaning or shared cognition is formed between these two?

People use categories to communicate; the language, which is used in communication, is categorical. In addition, knowledge can be expressed in categories, and the categories are formed based on the knowledge that the person has. If the person has a superficial knowledge about a specific subject, he then creates superficial categories; whereas, if he has in-depth knowledge, he creates detailed and technical categories. For example, a doctor's categories of knowledge are different diseases, the symptoms, and treatment; whereas, a patient's categories of knowledge, which are formed based on his superficial knowledge, is curable and non-curable diseases.

The communication process between a person with technical categories of knowledge and a person with non-technical categories can be presented by the way that they match their categories. Shared cognition is formed if a category exists or is formed that is completely understandable for both parties.

Literature on communication studies have never focused on the way that people with categorical knowledge communicate. There are not enough theories and studies to build this research on; therefore, an exploratory study is designed to figure out the process of communication when people have categorical knowledge. The task that is used in this study simulates the situation that two persons with categorical knowledge are communicating.

The results of this thesis introduce a new representation for the communication process between a technical and non-technical communicators and the way that shared cognition can be analyzed. The remainder of the thesis is ordered as follow. Chapter 2 begins with a review on the theoretical background in communication and categorization. The chapter concludes by explaining the main problem focused in this study. Chapter 3 explains the methodology, which is used in the thesis. Chapter 4 focuses on the results of the experiments and shows the related statistical analysis. Chapter 5 analyzes the task and discusses the results of all the data from the experiment. Chapter 6 outlines the conclusion, the limitations of the study and the possible areas for future studies.

Chapter 2

Theoretical background

This thesis focuses on the communication process while people with categorical knowledge are communicating. This chapter provides a summary of the related literature; first, an overview of communication literature is presented. Second, the process of categorization is introduced, and at the end, the main problem is explained.

2.1 Communication

Katz and Kahn (1978) in their book “The Social Psychology of Organizations” define communication as “the exchange of information and the transmission of meaning which is the very essence of a social system”. Human communication consists of different basic components that frame the communication process. In this process, the message is sent by a sender thorough a communication channel to a receiver. The sender of the message encodes the message. The message is transmitted through the channel, and the receiver decodes the message. This process can be completed by communicating feedback from the receiver to the sender that can ensure the accuracy of the communication process. The message, sender, receiver, channel, encoding, decoding, transmitting, and feedback are basic parts of the communication process (Krone et al, 1987).

Different research areas in communication have focused on different elements of the communication process according to researchers' perspectives. For example, some researchers have paid attention to the communication channel and the transmission of a message; whereas, there are some studies that have concentrated on how the characteristics of sender and receiver affect the communication process (Krone et al, 1987).

One of the topics, which has been investigated extensively in communication, is the accuracy of the message in the process of communication (Powers, W. G. & Lowry, D. N, 1984). When a sender sends a message through a communication channel, there is no guarantee that the receiver understands the exact message. The message might be altered because of the noise in the channel or problems in the encoding/decoding process. In communication literature, this problem is called fidelity. However, various researchers use this term differently. Krone and others (1978) declare that "message fidelity refers to the extent to which a message is similar at two points on the channel", and they distinguish it from congruence, which refers to "consensus of meaning in interpreting events." On the other hand, in the Communication Fidelity Theory, Powers & Lowry (1984) define communication fidelity as "the degree of congruence between the cognitions of a source and a recipient".

The Communication Fidelity Theory is comprised of basic communication fidelity (BCF), which focuses on the source of the message and listening fidelity (LF), which concentrates on the receiver. They (Powers, W. G. & Witt, P.L., 2008) state that "fidelity researchers agree that a communication event occurs when cognitions within a receiver are created, modified, and/or reinforced in response to the symbolic interpretation of the communication behaviour selected by a sender to stimulate a specific cognition in the mind of the receiver". Although many researchers followed the idea of having shared cognition in relational communication, there are still difficulties in measuring the shared cognition (Powers, W. G. & Lowry, D. N, 1984). In addition, a precise definition of shared cognition is not provided; different disciplines use the same word in different meanings, and different words are used the same meaning. For instance, in communication literature, shared meaning; shared perspective (Richmond, V. P. & McCroskey, J. C., 2009); shared cognition (Powers, W. G. & Lowry, D. N, 1984) are used equally.

The idea of shared cognition will be developed based on the categorical knowledge in this research. In addition, the study will elaborate on how the process of encoding and decoding, which is influenced by individuals' categorical knowledge, might lead to miscommunication.

2.1.1 Shannon's Information Theory

Claude Shannon (1984) introduces *Information Theory*, which is considered one of the fundamental theories in communication. He measures the amount of information transmitted from sender to receiver by applying logarithmic formulas. In terms of communication quality, he mentions that the sender's encoding process, the channel of transferring the message, and the receiver's decoding process, affect the message by adding to its meaning or distorting it. Therefore, the communication accuracy depends on the process of decoding and encoding as well as message transmission through the communication channel.

He states that the communication system of information theory consists of five essential elements (Shannon, 1948):

- *Information source* produces a message or sequence of messages to be communicated to the receiver.
- *Transmitter* operates on the message in some way to produce a signal suitable for transmission over the channel.
- *Channel* is the medium used to transmit the signal from transmitter to receiver.
- *Receiver* performs the inverse operation of that done by the transmitter, reconstructing the message from the signal.
- *Destination* is the person or thing for whom the message is intended.

The way that this theory approaches communication systems is based on the amount of information, the capacity of the channel, efficient coding processes that may be used to change a message into a signal, and the effects of noise (Weaver, 1949). One *bit* of information is the amount of information that reduces the variety of possible outcomes to half. For example, assume that person A wants to communicate a number between 1 to 8 to person B; if he says the selected number is "odd", he reduces the variety of the set from 8 possible items to 4 possible outcomes. Therefore, he communicates one bit of information. If the selected number is known to person A, for example 6, and he communicates message "6", then he passes 3 bits of information and reduces the 8 possible outcome to 1 ($\log_2 8 = 3$).

In the field of human communication, Information Theory has its supporters and opponents (Purdy, 1989). While some researchers commend it as the most important theory in communication area (Severin, W.J. & Tankard, J.W., 1979), other researchers doubt about the usefulness of Information Theory in social context (Chapanis, 1971). However, Information Theory has been useful in psychology particularly in the area of perception (Purdy, 1989). It also provides researchers with quantifiable way of measuring information (Garner, 1962).

Considering that communication is a way to reduce the variety in sets, it is necessary to ensure that the set that the sender refers to, is the same as the set that the receiver refers to. In the previous example, if person A's set is all numbers from 1 to 8, but person B's set is even numbers from 1 to 100, then the message "odd" would not be one bit of information. Although "odd" reduces the variety of person A's own set to half, person B's set would not be reduced. In Shannon's terms, no communication happens in this example. This problem in communication occurs because the set that the sender and receiver refer to are not identical. It happens in daily communication as well; for instance, a patient goes to a doctor for check-up, and the doctor tells him that he is suffering from *leukemia*. This word is one of the items in the category[1] (or set) of diseases in the doctor's mind; however, it is not defined in the patient's category (or set) since he is unfamiliar with this word. Therefore, the doctor sends the message *leukemia,* and he reduces the category of

[1] I will use the term "category" equal to "set" in the rest of the thesis

diseases from many different types of diseases to only one item; however, the message is not understood by the patient because no reduction happens in his category of diseases (Figure 0-1).

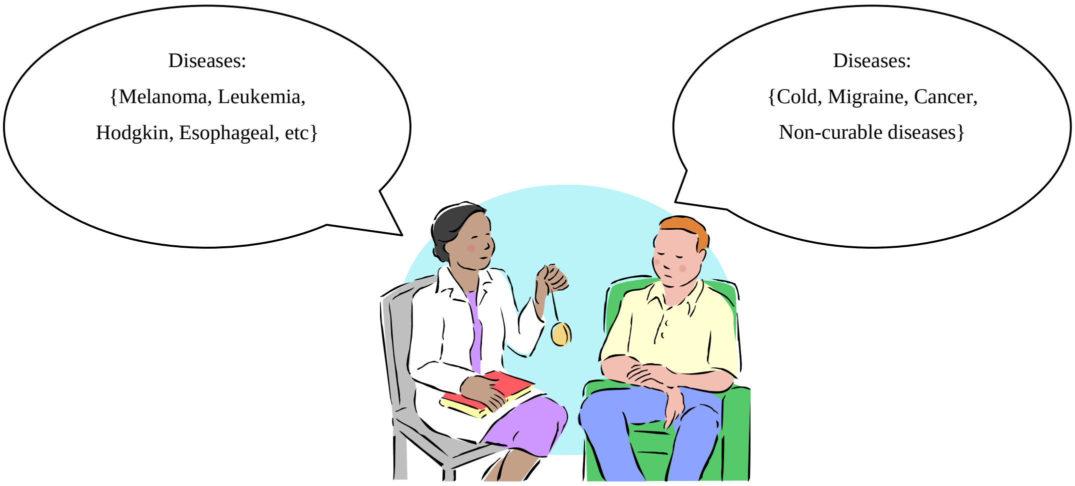

Figure 0-1 Graphical representation of differences in categories in communication

2.2 Language and categorization

As mentioned in the previous section, problems might occur because of differences in sets of knowledge between individuals. Individuals' categories or sets might be different because of their background, the context, or even their culture. This section first will explain why people's knowledge is represented in a categorical structure; next, shows how categories are shaped, and finally, it describes why these categories are different between individuals even for the same concrete item.

2.2.1 Categorical knowledge representation

Many studies have shown that people have a limited capacity for processing information (Macrae, C. N. & Bodenhausen G. V., 2001); therefore, people try to categorize received information based on some features of received information. One familiar example of this phenomenon is stereotyping, in that a person chooses a character (e.g., geographic location, race) and, then, categorizes people accordingly. He then bases his communication on specific stereotypes(Kunda, 1999). Gestalt laws explain that people categorize items following specific rules, such as proximity and similarity of items (Rollinson, 2005).

People not only think categorically, but also talk in a categorical way. When people want to talk and transfer a message, which is in their mind, they put the message into words (Searle, 1998). However, words are category themselves. For example, the word “chair” can refer to many different types of chairs. The sender of the message might have a concrete example of a chair in his mind; however, by sending the message “chair”, the receiver might not understand the same item as the sender has in his mind. This problem comes up because of the “categorical relationship” (Duimering & Safayeni, 1998) between words and categories. Bertrand Russell (1927) articulates that when a word is expressed it is considered to be a single entity; however, a word is a set of more or less similar events. The meaning of the word is specified according to its context. In this sense, “words are like categories” that are labeled for a set of similar entities (Duimering & Safayeni, 1998).

Moreover, people have a tendency to talk in general and put events into categories. The tendency of using broad and general words for a specific item increases when the word is associated with "positive valence" (Lewin, 1935), which is created through social forces (Duimering & Safayeni, 1998). Duimering and Safayeni (1998), in their research on the role of language and formal structure, found out that, in the organization they investigated, a buzzword such as *team* is credited and legitimated by higher-level managers, and then employees try to put their tasks into this category (i.e. team) to legitimate what they are dealing with. In addition, Rosch (1978) noticed in an experiment that when adults want to communicate about an item they use the category that the item belongs to as a message.

2.2.2 Forming categories psychologically

People form categories to make the variety in the world manageable. For example, it would be hard to process information about all animals. Classifying them into the mammals, reptiles, bird, etc helps us to attribute the general properties of one class to all members of it, but how are categories formed? This question can be answered differently. Rosch (1978) articulates that categories are formed in such a way that "the maximum information with least cognitive effort is achieved if categories map the perceived world structure as closely as possible" (Rosch, 1978). In this method, one or more characters of the inner structure is considered to be a common feature among members of the categories, and then the categories are formed in such a way that the similarities are maximized within the category and minimized between the categories. The common feature might be chosen differently based on an individual's perceptions or the context.

In the second method (Canas & Safayeni, 1985), categorization is formed based on the perceived variety in the set and the purpose of the task. Therefore, the common feature of each category is recognized if the need to have that category is perceived. For example, if specific part of a man's car does not work, he needs to know whether this item is expensive or cheap, and he will make two categories for himself: expensive parts and cheap parts.

2.2.3 Differences in individuals' categories

As mentioned in the previous section, categories are made by individuals grouping items according to a common feature of the set of items or needed properties. In both scenarios, people pick up the properties although their knowledge and background is different. For example, a doctor, who has technical knowledge about all diseases, categorizes a specific disease such as leukemia into the category of *blood cancers,* whereas a patient with superficial knowledge about the disease categorizes it into *non-curable* category.

Even if the communicators know the item, they might categorize the item differently, and either put it in various categories or express it with different words. This situation happens because they pick different features. For instance, a table could be referred by the general term *table* because it has the physical characteristics of the category *table*, or it might be referred by the term *bench* because it is outside and used as a bench.

2.3 Main problem

Having all these backgrounds in mind, let us go back to the example of the communication between the patient and the doctor. In this example, the doctor has knowledge about all diseases, their symptoms, and the treatments. Therefore, he can categorize all this knowledge by classifying it according to physiological or biological properties. On the other side, the patient is not familiar with the in-depth knowledge of diseases. Therefore, he categorizes the diseases superficially based on his understanding. As a result, he has categories such as *curable diseases* and *non-curable* diseases. If the doctor uses technical terminology, such as leukemia, to inform the patient of his problem, the patient might find it hard to understand. Since his categories are different, he does not know which category can be matched to leukemia. On the other side, it would be hard for the patient to communicate with the doctor. For example, when he explains about the symptoms that he has experienced, he talks about simple symptoms that can be matched to many different categories of diseases that the doctor has knowledge of.

In daily communication, the above-mentioned problem happens regularly. For instance, an ordinary person takes his car to a mechanic; the driver categorizes problems, which he experienced, superficially, such as “it is noisy”. These problems can be matched to many different problems. It does not give the mechanic enough information about the main fault with the car. On the other hand, when the mechanic figures out the problem, throwing technical terminology at the customer is not helpful because it cannot be matched to the driver’s superficial categories such as “needs to be changed”, “expensive parts”, and “cheap parts”.

This process is also recognized in the organizations. In the field study that Bechky (2003) did in a manufacturing company, she recognizes that there are difficulties in the communication between designers and assemblers. Their tasks are defined in different contexts, making misunderstanding likely. She notices that technicians' knowledge lies conceptually between the assemblers' and the designers' knowledge, and thus plays a helpful role in smoothing the communication.

There are rich literature on both communication and categorization areas; however, I have not found any research that joins both disciplines and represents communication process through categorical knowledge. In addition, studies on communication between technicians and on-technicians (or experts and novices) focus on either the optimum way of speech communication (Roter D. et al, 1988) or creating a mutual belief between communicators (Isaacs E. A. & Herbert H.C., 1987), and therefore, is not able to provide a suitable theoretical background for this study. To address the problem of communication, which is focused in this study, an exploratory study is run to elaborate on how the communication works between an expert, with technical knowledge, and a non-expert, with general and abstract knowledge. A task is set up by which I can simulate the properties of a person with technical categories of knowledge and a person with broad and nontechnical categories of knowledge. The goal is, (1) to explain how the communication works when a message is sent from an abstract and general level to a technical and detailed level of knowledge and the other way round, (2) how the communication is improved by certain adjustment, and, (3) how miscommunication can lead to dissatisfaction and conflicts.

2.4 Summary

So far, one of the problems in the communication process has been explained in terms of mis-matched categorical knowledge between technical and non-technical persons. Although there are many studies focused on miscommunication from different perspectives, I have not found any research that directly focuses on the process of matching categorical knowledge. Therefore, I started an exploratory study to see how the process works. I will explain the methodology in the next section and then focus on analyzing the results.

Chapter 3

Methodology

3.1 Stimulus

A well-defined task is needed to simulate the behaviour that is expected in communication between technical and non-technical persons. Each task, as a stimulus, imposes some characteristics on the situation and leads to a particular behaviour. In this research, the attention is not on how the categories are formed, but on how the communication works when people have different levels of categorical knowledge. Therefore, it is necessary to make sure that the task shows the process of the communication in which people try to use their categorical knowledge. The task considered for this experiment is "finding a randomly selected number from 1 to 10 through the communication of three people in the group".

This task is designed in such a way that could meet certain properties of the problem. First, it provides individuals with technical and non-technical knowledge about numbers. In this task, technical knowledge refers to properties of numbers such as *Odd, Even, Prime, Perfect Square root (SR),* and *perfect Cube root (CR)*; whereas non-technical knowledge refers to broad and superficial properties of number such as *Big* and *Small*. Second, it can simulate the condition in which one general category can be matched to many different categories (e.g., Big numbers can be both Odd and Even in the same way that curable diseases can be matched to many different types of diseases). In addition, the task shows the process of choosing a category to represent an item when categories have an overlap, and an item can be shown by different categories (e.g. number 3 can be matched to Odd and Prime in the same way that fever can be a symptom (item) in many different (categories of) diseases). Moreover, having a person in the middle, as a translator, gives us the opportunity of simulating a person with middle-level conceptual knowledge, who can facilitate the process of communication. Finally, one important aspect of this task is the fact that playing around with numbers and their familiar properties (e.g., odd, even) enables us to analyze a very complicated communication process in a simpler way.

3.2 Task

In this experiment, three persons, isolated in individual stations (cubicles), are communicating to find out a selected number between 1 and 10 known to one party. However, communication is limited to the cards (categories) that are available in each station. Each person is settled in a station, and the stations are called A, B and C. The communication always starts from station A, then B and at the end C. Stations are provided either by the set of *"Big" & "small"* cards or the set of *"Odd", "Even", "Prime", "Cube Roots" and "Square Roots"* cards. Station A communicates the selected number to Station B using one of the cards in the set, which is available to him. Each time only one card is communicated. Station B translates the received card to the third person using his own cards that are also available to C. Station C chooses a number based on the card that he receives from station B and shows it to Station A. Station A gives feedback to the group whether the selected number is correct or incorrect. If the answer is not correct, the group continues trials until they find the correct number. Otherwise, the round is finished, and a new number must be found out in the next round.

While performing the task, participants are not allowed to talk. The only means of communication is using the cards provided for each station to communicate choices of cards and numbers.

The task is performed in two different communication directions: *Abstract to Technical* and *Technical to Abstract*. Next section explains each direction separately.

3.2.1 "Abstract to Technical" direction

The experiment is run in two directions. In the first direction, which is called Abstract to Technical, the first station is provided with broad categories of knowledge about numbers: "Big" and "Small." The third station, station C, is provided with technical categories of knowledge about numbers: "Odd", "Even", "Prime", "Square root", and "Cube root". Each category is written on a card. The second station, station B, is supposed to translate the received message (card) from person A to the categories (cards) that are available to C. Each station is given those cards that they need to use in the communication (Figure 0-1).

The task continues until the group finds the number. Initially, the group continues the game for six rounds (i.e., they are given a new number six times). Then, the station in the middle, B, is allowed to create a new category to help the group perform the task better, and they continue the game for six more rounds in that they can use the new category as well. As a result, in total they perform 12 rounds.

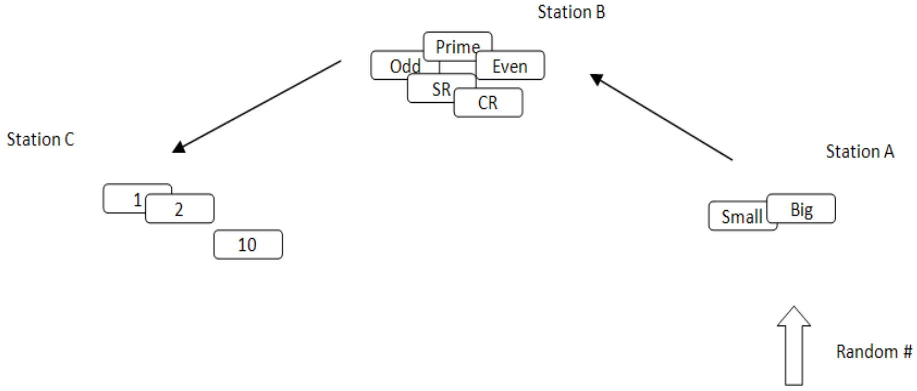

Figure 0-1. Graphical presentation for first direction (Abstract to Technical)

3.2.2 “Technical to Abstract” direction

In the second direction, which is called the Technical to Abstract direction, station A is provided with technical categories, whereas, station C is provided with broad categories of knowledge. Station A passes one of the categories (cards) to station B based on the given number. Station B translates it to general categories that are provided for C, and he is supposed to find the number according to the received category (Figure 0-2).

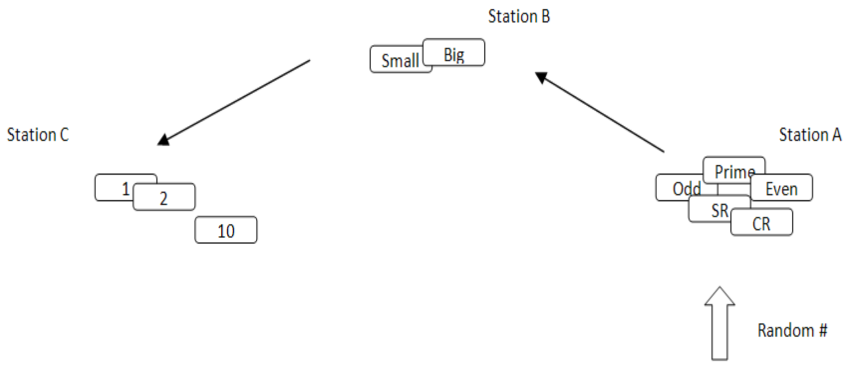

Figure 0-2. Graphical presentation for second direction (Technical to Abstract)

As in the previous direction, the group performs the game in two parts. Initially, they continue for six rounds (i.e. a new number is given six times); then, person B is allowed to create a new category, and the group continues the game for six more rounds, including the new category as well.

3.3 Participants

Participants in this experiment were 96 undergraduate students enrolled in course MSCI311- Organizational Design and Technology. Since the experiment was run in two directions, participants were divided into two groups of 48, which formed 16 groups of three in each direction. Participation was voluntarily, and students received 1% bonus mark toward the total mark for one and half hour of participation. They were able to book their session through an on-line registration system by which they were able to receive a confirmation email, reminder email and any changes in the appointment.

3.4 Procedure

The experiment was run in the Uncertainty Lab at the Management Science Department over two weeks. The Uncertainty Lab is equipped with five cameras, and therefore, all sessions were recorded. Participants sat at a round table, which was divided to three stations separated by wooden dividers. Stations were labeled “Station A”, “Station B”, and “Station C” accordingly. The experiment always started from station A in both directions. Participants selected their stations randomly as they entered the Lab.

After participants settled, recording started, and the instructions were read to the group by an observer. The instruction, available in Appendix A, explained the task and the way that the group performed it. The instructions were supported by examples to make the task as clear as possible.

In both directions, they accomplished six rounds. Each round could take several trials; there was a possibility of one to 10 trials. After six rounds, station B had to come up with a new category. The new category was written on a new blank card, and participants continued the task for six more rounds, considering the new category as well. When they finished the task, a questionnaire was given to each station. If participants were interested, they stayed in the lab until everyone finished the questionnaire and then discussed the task and the way they performed it. The questionnaire is presented in Appendix B.

3.5 Measurements

3.5.1 Performance

3.5.1.1 Number of trials

To perform the task, group members needed to communicate through the predefined categories (cards) provided for them. One of the aspects that this research focuses on is whether the communication from an abstract level to a technical level is different from the communication that starts at a technical level and goes to an abstract level. If the communication directions are different, then the performance of each direction should differ from the other. In addition, if the small adjustment in the communication, which occurred by creating a new category, is helpful in communicating, then the group's performance should be better after one member creates a new category. In this task, Performance is defined as the number of trials needed for a group to find the number. For example, if number 8 is given to the first station, and the group finds the number after five trials (or guesses) the performance is equal to 5. The performance of the groups before they have the chance of creating a new category is the average for the numbers of trials in the first six rounds. Since station B, the person in the middle, creates a new category after round six, the performance of the group after creating a new category is the average for the number of trials in rounds 7 to 12.

3.5.1.2 Individuals' judgment on performance

In addition to measuring performance by the number of trials, group members are asked to rate the group's overall performance and each station's performance by a Likert scale in the questionnaire. Most of the time, when individuals are asked to measure their performances, they have different reporting approaches. First, performance can be considered in respect to individuals' effort (i.e. whether they did their best). In this case, even though they might not have reached the desired outcome, they are satisfied with their performance because they did their best. In the next approach, they might report their performance in respect to their capability to accomplish the task. In other words, considering their limitation, how well they performed the task. Therefore, participants were asked to rate their performance in both approaches separately.

3.5.2 Matching strategies

One of the focuses of this research is to determine how people match up their categorical knowledge to understand the point that they wanted to communicate. To observe the strategies used by individuals in matching up their categories, each station received a note (Appendix C) for each round in which they kept a record of all categories that had been passed through that station. All notes were gathered up at the end of each round, and a new series of notes was given out before a new number was given to the group. Arranging notes from all stations allowed the observer to determine the strategies that participants had used during the experiment.

3.5.3 Questionnaire

Each participant was given a questionnaire at the end of the experiment. Participants were asked to rank the performance from different perspectives in questions 1 to 6. In addition, some general concerns about individuals' perspective were asked in the questionnaire (Table 3-1).

Table 3-1. Concerns and corresponding measures

Questions	***Concerns***
Q1 to Q6	Performance measurement.
Q7	Measures the pressure on individuals during the performing the task.
Q8	Measures the effect of task on forming leadership role.
Q9-Q10	Measures the participants’ satisfaction of each others.
Q11-Q12	Measures the difficulties of task from participants’ points of view.

Chapter 4

Results

Three main questions to be answered in the study were posed in Section 2.4, which are answered through the experiment. These questions are

- How does the communication work when a message is sent from an abstract level to a technical level of knowledge and the other way round?
- How is this communication improved by certain adjustments?
- How does miscommunication lead to dissatisfaction and conflicts?

This section shows the results of the experiment in such a way as to answer the above questions. All data from the experiment is presented in Appendix D.

4.1 Performance

4.1.1 Group performance in each condition

The performances of groups were studied to determine whether the communication process was different in different communication directions. If these performances differed, then communication directions did influence the communication of the groups in the experiment. In the first direction, a message is sent from the abstract level to the technical level, whereas, in the other direction, the message is sent from a technical level to an abstract level. In both directions, participants performed the experiment in two parts. In the first sections, the group used the existing categories that were available to them and were given six numbers to find out. In the second part, station B was allowed to create a new category and passed it to station C; therefore, station B and station C had an extra category during the game. The group was given six more numbers to find in the second part as well. Table 4-1 shows all four conditions investigated in this research, and the groups' performance scores under each condition, which are the average number of trials.

Table 4-1. Means for group performances in each condition

Directions	**N**	**Existing categories**	**Extra category** (New category is created in the group)
Direction1- *Abstract to Technical*	16	(Condition 1) 5.1667	(Condition 2) 3.7083
Direction2- *Technical to Abstract*	16	(Condition 3) 4.5833	(Condition 4) 3.4583

Performance data followed the normal distribution (Appendix E); therefore, it is possible to run the t-tests to check differences among conditions. When groups completed the task by using existing categories (Table 4-2), a t-test showed that there was a marginal significant difference between performances in the two directions (t=1.741, p=.092), whereas, no significant difference was observed between performances for the two directions when the groups had an extra category (t=.770, p=.447) (Table 0-3).

Table 4-2. T-test for comparing performances between conditions 1 and 3 with existing categories

Directions	**Frequency of group**			**T-test for Equality of Means**				
							95% Confidence Interval of the Difference	
	n	**Mean**	**SD**	**t**	**df**	**P**	**Lower**	**Upper**
Abstract to Technical	16	5.1667	.93887	1.741	30	.092	-.10096	1.26763
Technical to Abstract	16	4.5833	.95646					

Table 0-3. T-test for comparing performances between conditions 2 and 4 with the extra category

Direction	**Frequency of group**			**T-test for Equality of Means**				
							95% Confidence Interval of the Difference	
	n	**Mean**	**SD**	**t**	**df**	**P**	**Lower**	**Upper**
Abstract to Technical	16	3.7083	.75154	.770	30	.447	-.41279	.91279
Technical to Abstract	16	3.4583	1.0584					

4.1.2 Comparing the group performance and random performance

To address the way that the communication works, the performance of the group in each direction was compared to random performance. In this case, random performance means performing the same task without considering the explained communication set up. If we assume that a random number from 1 to 10 is given to an individual, then how many guesses (trials) does he need on average to find the number? To answer this question, assume that variable x_i shows that the given number is found in i^{th} trial with probability $p(x_i)$, then the expected value of x (E(x)) shows the average of trials needed to find the number.

$$E(x) = \sum x_i * p(x_i) \qquad (4\text{-}1)$$

The minimum number of trials is one (i=1), which means that the number is found with an individual's first guess, and the maximum is 10 (i=10), which means all the numbers from 1 to 10 are guessed, and the selected number is found in the 10th trial. Table 4-4 elaborates on how p(x_i) is calculated.

Table 4-4. Elaboration on how the p(xi) is calculated

Trial (guess) x_i	**The probability of finding the number in i^{th} trial P(x_i)**	**Explanation**	$x_i * p(x_i)$
1	$\frac{1}{10}$	The number is found in the 1st trial.	1 * 1/10
2	$\frac{9}{10} * \frac{1}{9} = \frac{1}{10}$	The guessed number is wrong in the 1st trial and correct in the 2nd trial.	2 * 1/10
3	$\frac{9}{10} * \frac{8}{9} * \frac{1}{8}$	Guesses in 1st and 2nd trial are wrong but the number is found in the 3rd trial.	3 * 1/10
4	$\frac{9}{10} * \frac{8}{9} * \frac{7}{8} * \frac{1}{7}$	Guesses in the 1st, 2nd and 3rd trial are wrong but the number is found in 4th trial.	4 * 1/10
5	$\frac{9}{10} * \frac{8}{9} * \frac{7}{8} * \frac{6}{7} * \frac{1}{6}$	Guesses in trial 1 to 4 are wrong but the number is found in 5th trial.	5 * 1/10
6	$\frac{9}{10} * \frac{8}{9} * \frac{7}{8} * \frac{6}{7} * \frac{5}{6} * \frac{1}{5}$	Guesses in trial 1 to 5 are wrong but the number is found in 6th trial.	6 * 1/10
7	$\frac{9}{10} * \frac{8}{9} * \frac{7}{8} * \frac{6}{7} * \frac{5}{6} * \frac{4}{5} * \frac{1}{4}$	Guesses in trial 1 to 6 are wrong but the number is found in 7th trial.	7 * 1/10
8	$\frac{9}{10} * \frac{8}{9} * \frac{7}{8} * \frac{6}{7} * \frac{5}{6} * \frac{4}{5} * \frac{3}{4} * \frac{1}{3}$	Guesses in trial 1 to 7 are wrong but the number is found in 8th trial.	8 * 1/10
9	$\frac{9}{10} * \frac{8}{9} * \frac{7}{8} * \frac{6}{7} * \frac{5}{6} * \frac{4}{5} * \frac{3}{4} * \frac{2}{3} * \frac{1}{2}$	Guesses in trial 1 to 8 are wrong but the number is found in 9th trial.	9 * 1/10
10	$\frac{9}{10} * \frac{8}{9} * \frac{7}{8} * \frac{6}{7} * \frac{5}{6} * \frac{4}{5} * \frac{3}{4} * \frac{2}{3} * \frac{1}{2} * 1$	Guesses in trial 1 to 9 are wrong but the number is found in 10th trial.	10 * 1/10
			E(x) = $\sum x_i * p(x_i)$ = 5.5

Therefore, without any predefined communication set up, a random number from one to 10 would be found in 5.5 trials on average. Now the question arises as to whether this communication set up and the knowledge that people are provided with are helpful or not? Do they perform better with this help than with random guessing? To answer this question, the performances of the groups in all four conditions are compared to random guessing to test whether any differences occur between each condition’s performance and random guessing. Table 0-5 shows the results of one-sample t-test, which compares the performance of each condition with the performance during random guessing.

Table 0-5. One-sample t-test for comparing performances between each condition and random guessing

Conditions	Frequency of group			One- sample t-test (Test value = 5.5)				
							95% Confidence Interval of the Difference	
	n	Mean	SD	t	df	P	Lower	Upper
Abstract to Technical *Existing categories*	16	5.1667	.93887	-1.420	15	.176	-.8336	.1670
Technical to Abstract *Existing categories*	16	4.5833	.95646	-3.834	15	.002	-1.4263	-.4070
Abstract to Technical *Extra category*	16	3.7083	.75154	-9.536	15	.000	-2.1921	-1.3912
Technical to Abstract *Extra category*	16	3.4583	1.0584	-7.715	15	.000	-2.6057	-1.4776

Table 0-5 shows that under the Abstract to Technical direction, before the new category was created, the performance of the group was not significantly different from when they are guessing the number (t= -1.420, p =.176); whereas, in other cases, there is a significant difference between the groups’ performance and random performance.

4.1.3 Comparing the performance before and after creating a new category

One of the questions behind this research is how communication is improved when communicators have different categorical knowledge. In the experiment, station B was asked to help the group by creating a new category. If the new category improved the performance, then it means that station B was able to adjust the differences in categorical knowledge between station A and station C.

Table 4-6. Paired samples t-test for comparing performances before and after creating a new category under the *Abstract to Technical* direction

Condition*	**Frequency of groups**			**Paired samples t-test for equality of means**					
								95% Confidence Interval of the Difference	
	n	**Mean**	**SD**	**Mean Difference**	**t**	**df**	**P**	**Lower**	**Upper**
Existing categories	16	5.1667	.93887	1.45833	4.802	15	.000	.81097	2.10570
Extra category	16	3.7083	.75154						

* Abstract to Technical direction

Table 4-6 presents the situation of a message going from abstract to technical in which creating a new category influences the performance; the difference between performances is significant (t=4.802, p< .001). The performance is improved since the performance, which is the average number of trials to find the number, is reduced from 5.17 to 3.70 (lower number of trials is better performance).

In the same way, the performance improved after a new category was created as a message went from technical to abstract. Table 4-7 displays the significant difference between performances before and after new category creation (t=3.984, p=.001). The average number of trials reduces from 4.58 to 3.45.

Table 4-7. Paired samples t-test for comparing performances before and after creating a new category under the *Technical to Abstract* direction

Condition*	**Frequency of groups**			**Paired samples t-test for equality of means**					
								95% Confidence Interval of the Difference	
	n	**Mean**	**SD**	**Mean Difference**	**t**	**df**	**P**	**Lower**	**Upper**
Existing categories	16	4.5833	.93887	1.12500	3.984	15	.001	.52310	1.72690
Extra category	16	3.4583	.1.0384						

* Technical to Abstract direction

4.1.4 Comparing performances among all conditions

Previous sections showed the differences between performances in two cases: (1) differences when the direction of the communication is changed, and (2) differences when a new category was introduced in the group. One question arises as whether these two cases have any interaction effect or not. In other words, is the effect of communication direction conditional upon or mediated by the effect of having an extra category while performing the task. To answer this question, 2*2 factorial ANOVA is used. The results of the ANOVA test (Appendix F, Table F.1) showed that communication direction had the marginal main effect on the performances ($F = 3.179$, $p = 0.08$). In addition, introducing a new category showed the main effect on the performance ($F = 30.681$, $p < .001$); However, when two factors were considered together, no interaction effect was observed in the experiment ($F = .514$, $p = .476$). In other words, the two factors did not influence each other.

4.2 Learning

With groups performing the task for 12 rounds (six rounds before and six rounds after creating a new category), one interesting question is whether any learning happened in the groups. Learning means that the performances of the groups improve from round to round. Therefore, we would like to see correlation between group performance and the number of rounds. The average of performance is calculated for each round, and then the correlation is tested between the performance and the number of rounds.

If the correlation of the performances and rounds is considered in all 12 rounds, the results showed that, correlation between round and performance was significant (R=-.855, p<.001) (Appendix F, Table F.2). Figure 0-1 shows the pattern of learning, which is followed in both conditions. Although the correlation test showed significant correlation, the figure shows that the correlation included considerable variation. If the correlation of the performances and rounds considered only for the first six rounds in which the group performed the task with existing categories, no significant correlation was observed in the data (R=-.212, p= .668) (Appendix F, Table F.3). In the same way, when the correlation was calculated for the second six rounds in which an extra category was introduced, no relationship was shown by correlation test (R= -.390, p=.444) (Appendix F, Table F.4).

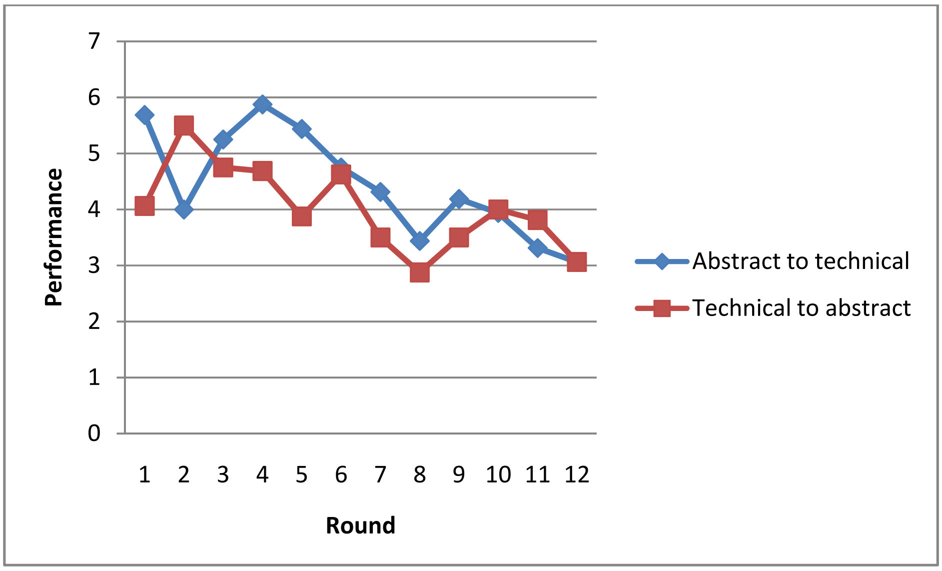

Figure 0-1. Correlation between rounds and performances

4.3 Individuals' judgment

Participants were asked to judge their own performance as well as that of others in respect to two properties (Section 3.5.1.2): individuals' effort and capability. Both measures are aggregated together, and a new variable performance judgment was formed in the statistical analysis.

4.3.1 Each station ranks others differently

Performance judgment was investigated to determine whether the difficulties in the communication set up was attributed to individuals' inability during the experiment; therefore, significant differences might be observed among stations when each participant judged others' performance.

To determine whether the above proposition is correct, we need to test differences using statistical tests. Since data related to individual judgment does not follow the normal distribution, a nonparametric test, the Friedman test, was used to identify any differences among stations when one station judges itself and others.

4.3.1.1 Direction one: Abstract to Technical

Before making a new category, when station A judged others as well as itself, there is no significant difference among stations A, B and C ($\boldsymbol{X^2 = .205, p = .903}$) (Appendix F, Table F.5). Therefore, when a group was using the existing categories, station A rated everyone equally, and he assessed everyone's performance to be almost at the same level. However, when a new category was introduced (Appendix F, Table F.6), the significant difference was observed in station A's judgments ($\mathbf{X^2 = 8.773, p = .012}$). Figure 0-2 shows the mean of judgments when A judges each station's performance.

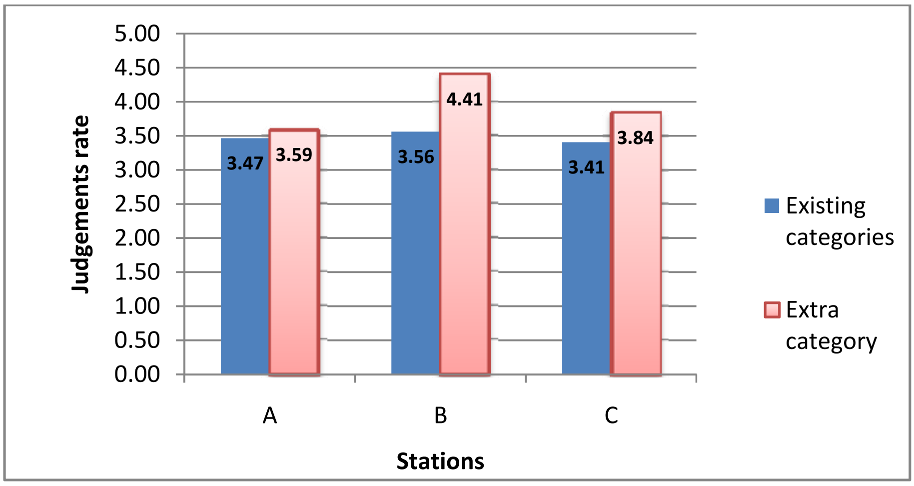

Figure 0-2. Graph representation of mean differences when A rated all stations (Abstract to Technical)

In the same way, station B rated all stations' performance when the groups were dealing with existing categories as well as the new category. In both conditions, there was no significant difference between judgments. Before introducing the new category,$X^2 = .542$, the P-value was .763 (Appendix F, Table F.7), and while the group performing the task including extra category, $X^2 =$

3.476, and P-value was .176 (Appendix F, Table F.8). Figure 4-3 shows the means of judgments in each condition.

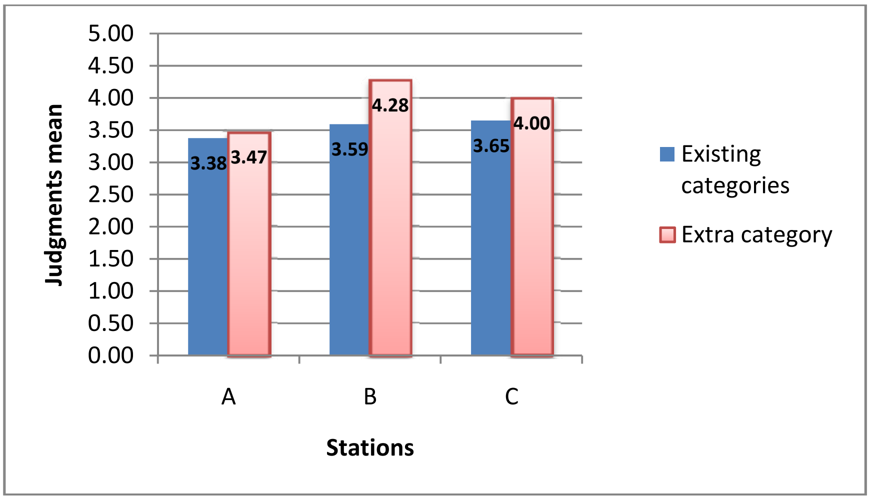

Figure 0-3. Graph representation of mean differences when B rated all stations (Abstract to Technical)

As did the previous stations, station C had the opportunity to judge others as well as itself before and after the new category is introduced. The results of the Freidman test (Appendix F, Table F.9) showed that there was a significant difference among stations when C rated them before creating the new category (X^2= 9.174, p=.01). This difference happened because station C judged station B very low compared to A and C (Figure 4-4). However, the difference was not observed any more (X^2= .744, p= .689) when the new category was used in the group (Appendix F, Table F.10).

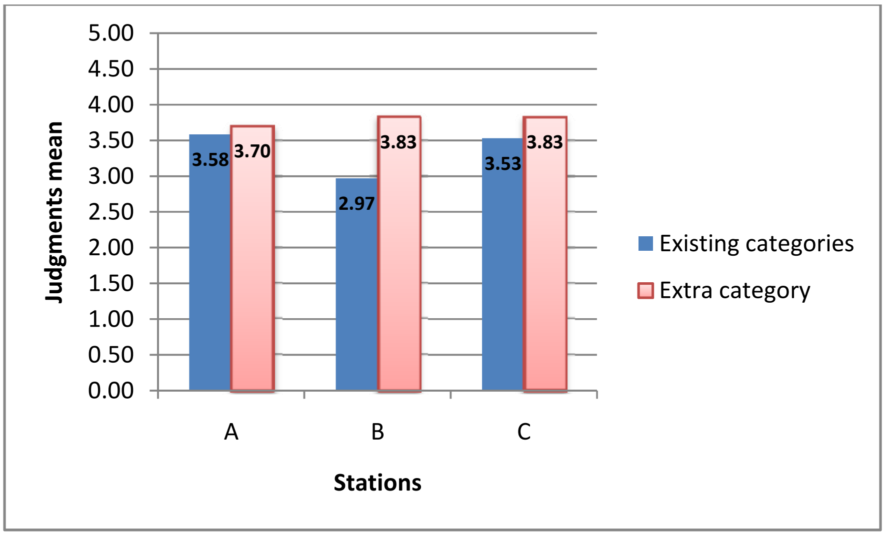

Figure 4-4.. Graph representation of mean differences when C rated all stations (Abstract to Technical)

4.3.1.2 Direction 2: Technical to Abstract

In the second direction as well, each station was asked to judge the performance of others and itself while they used existing categories plus a new one. As in the previous section, the non-parametric Freidman test was used to check the differences among judgments made by each station. Figure 0-5 shows the judgments mean for both conditions. Station A did not differentiate among stations when he rated other stations either in dealing with existing categories (X^2=.491, p=.782) or using the extra category (X^2=1.389, p=.499) (Appendix F, Table F.11 & F.12).

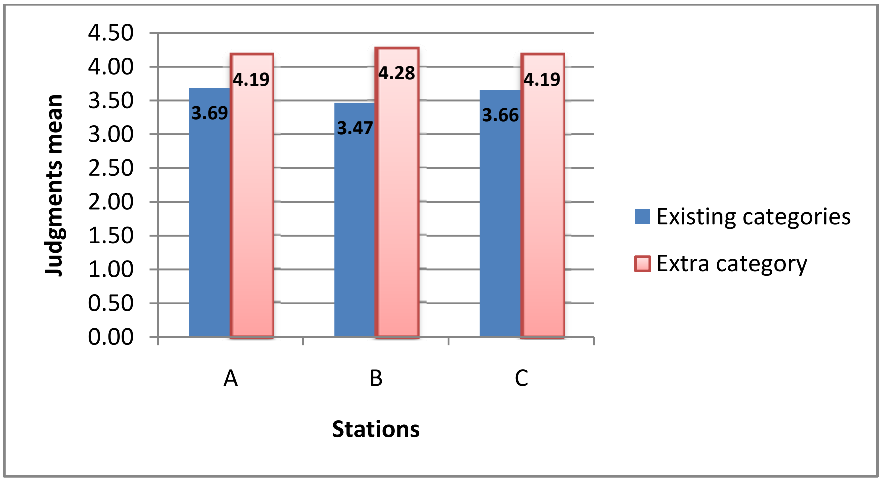

Figure 0-5. Graph representation of mean differences when A ranks all stations (Technical to Abstract)

Under the Technical to Abstract direction, station B did not judge himself as well as others differently before the new category was introduced (X^2= 1.250, p=.535). In the second part, when the group had an extra category, the same behaviour observed in the experiment (X^2=2.438, p=.296) (Appendix F, Table F.13 & F.14). Figure 0-6 shows the mean of judgments when station B rated all the stations.

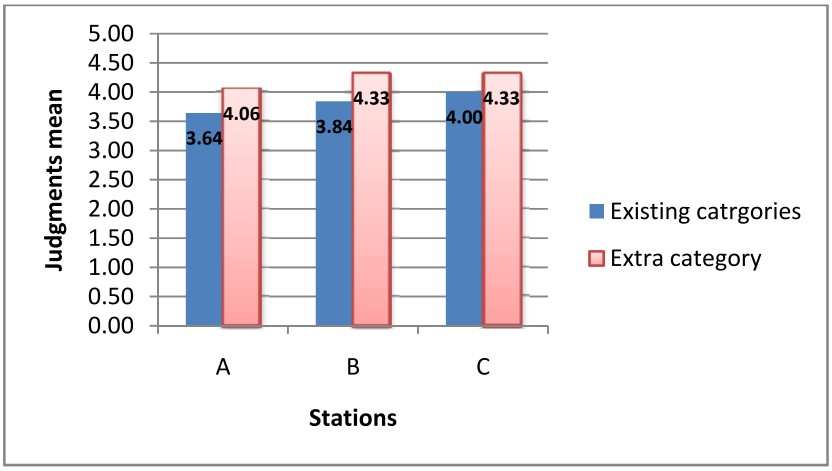

Figure 0-6. Graph representation of mean differences when B ranks all stations (Technical to Abstract)

Station C did not differ among all stations before (X^2=2, p=.368) and after (X^2=3.95, p=.139) the new category was introduced (Appendix F, Table F.15 & F.16). Figure 0-7 shows the means of judgments in both conditions.

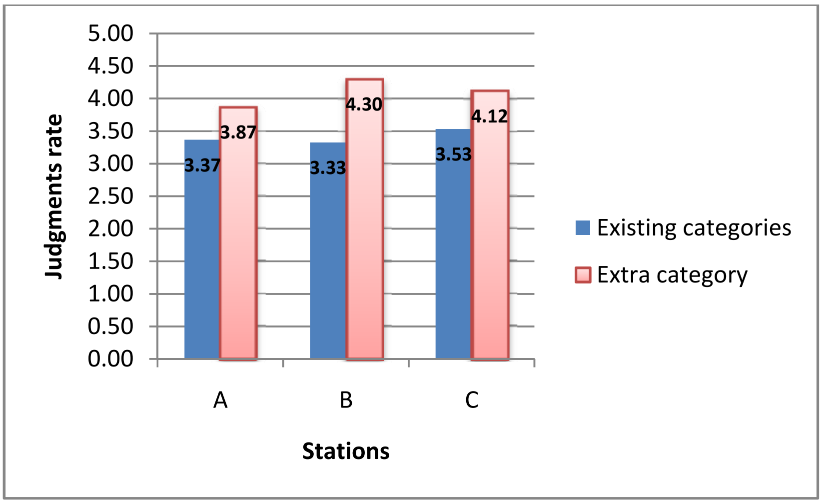

Figure 0-7. Graph representation of mean differences when C ranks all stations (Technical to Abstract)

4.3.2 Different judgments about one station

The communication set up was designed in such a way that station B had all the knowledge that stations A and C had, whereas, A and C did not have enough understanding of things going on in other stations. This lack of knowledge caused individuals judged each other differently; therefore, for a specific station, performance might have been observed differently. The differences were tested in both directions.

4.3.2.1 Direction one: Abstract to Technical

Since data did not follow normal distribution, Kruskal Wallis test was used to test the differences in judgments in each station. The results showed that when the groups used existing categories, station B was rated differently by other stations (X^2= 4.866, P=.088), whereas, is other cases no significant difference was observed in the performance judgments given by all stations. After the new category creation, all the stations were judged almost equally (Appendix F, Table F.17).

Unfortunately, nonparametric tests do not provide the two by two comparisons that post hoc analyses do in parametric tests. Therefore, to determine at which stations B's performance was rated differently, the means of judgment should be reviewed. Figure 4-8 shows the mean differences for station B before the new category was introduced. It shows that station A and B had almost the same opinion about station B's performance; however, C rated station B lower than other stations. Therefore, station C did not have the same opinion about B's performance as A and B did.

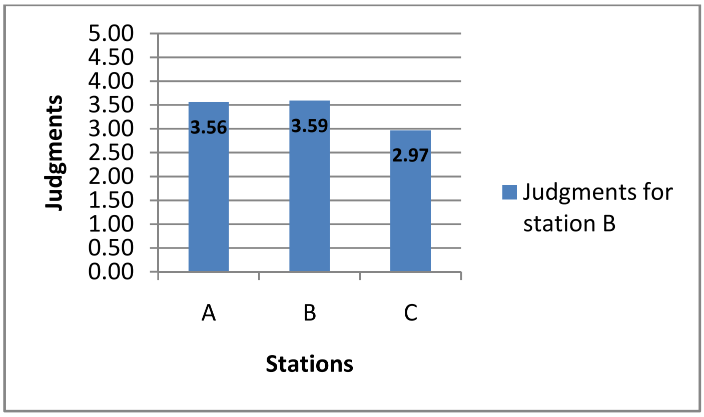

Figure 0-8. Judgments for station B given by different stations (Abstract to Technical)

4.3.2.2 Direction 2: Technical to Abstract

The same procedure was followed in the second direction. When groups are dealing with existing categories, the marginal significant difference was observed in the judgments that are given for station B (X^2=4.756, P=.093); however, none of the stations were given different judgments after the new category was introduced (Appendix F, Table F.18).

In the second direction as well, differences is observed when station B is judged by other stations (X^2=4.756, P=.093). Figure 0-9 shows that there are differences in opinions among A-B and C-B. Station B ranks itself higher than A and C.

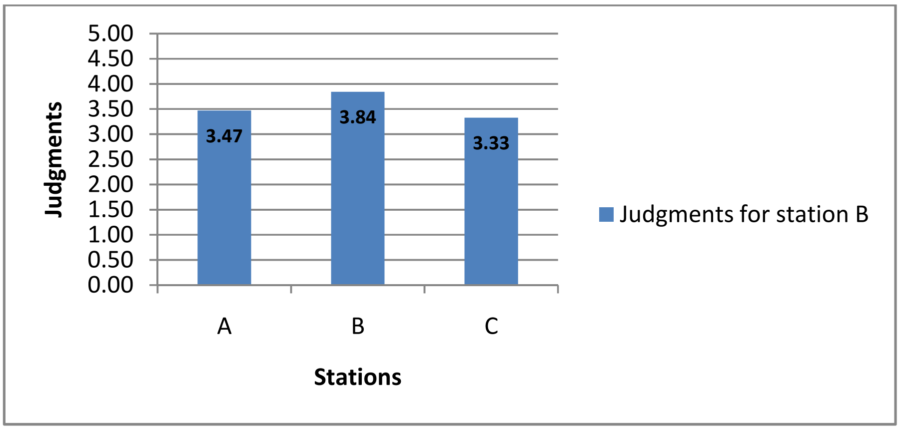

Figure 0-9 . Figure 4.8. Judgments for station B given by different stations (Technical to Abstract)

4.4 Leadership forming

The distribution of knowledge was different in each station, therefore, stations that had more information might have experienced the leadership role in the group. The questionnaire asked participants to mark the leader station if they feel that someone performs a leadership role during the experiment.

When the communication direction was considered to be an independent variable, no significant difference was observed in perceptions of group leadership in the groups when a Chi-Square test was used (X^2=.677, p=.411) (Appendix F, Table F.19). In addition, participants did not indicate any certain stations as a leader in both directions (X^2=2.136, p=.344) (Appendix F, Table F.20).

4.5 Group satisfaction

4.5.1 Working with the same group of people

In the questionnaire, participants were asked to identify whether or not they would like to work with the same group of people to perform another task. This question addresses the group satisfaction. The answers were analyzed through two questions. First, was there any difference in group satisfaction between two directions, and then, in each direction, were there any differences in group satisfaction among stations?

Table 4-8 shows that in Abstract to Technical direction, 66% of participants, and in the other direction, 81% of participants stated that they would work with the same group; therefore, they experienced group satisfaction. However, the difference in group-satisfactions between the two directions was not statistically significant (X^2= 2.650, p=.104) (Appendix F, Table F.21).

Table 4-8 Cross-tabular presentation for number of individuals who preferred to work with the same group of people

Directions	**Would you like to work with the same group?**		**Total**
	Yes	**No**	
Abstract to Technical	32	16	48
Technical to abstract	39	9	48
Total	71	25	96

when the Abstract to Technical direction was considered, group satisfaction did not differed among station (X^2=.750, p=.687). In the same way, under the Technical to Abstract direction no difference was observed in group satisfaction (X^2=3.282, p=.194) (Appendix F, Table F.22 & F.23)

4.5.2 Replacement a station with an expert

To address which station is the source of difficulties in the group during the experiment, participants were asked the following question: If you could replace one of the members with an expert for this task, which member you would select?

As in the previous section, a Chi-Square test was used to test the differences between the two directions and the differences among stations for each direction. Table 0-9 shows the number of times that each station was chosen for replacement with experts in each direction. For example, when a message goes from Abstract to Technical, five participants out of 48 wanted to replace station A with an expert, whereas in the other direction, 14 out of 41 participants wanted to replace A with an expert.

Table 0-9. Cross tabular presentation for suggested replaced station in both directions

Directions	**Which station would you replace?**			**Total**
	A	**B**	**C**	
Abstract to Technical	5	22	21	48
Technical to Abstract	14	19	8	41
Total	19	41	29	89

The results showed that direction made a significant differences when participants were recommending the stations to be replaced (X^2= 9.820, P=.007) (Appendix F, Table F.24).

Table 4-10 shows the number of times that each station was chosen for replacement by each station in the Abstract to Technical direction. For example, among those participants who were is station A (16 in total), eight suggested replacing B with an expert, and eight suggested replacing C with an expert.

Table 4-10. Cross-tabular representation for replacing station suggested by each station in the Abstract to Technical direction

Recommending station	**Recommended station**			**Total**
	A	**B**	**C**	
A	0	8	8	16
B	1	3	11	15
C	3	11	2	16
Total	4	22	21	47

Chi-Square test was used to determine whether differences in recommending the stations to be replaced are different based on the recommending station. The results showed that there were statistical differences among suggested stations by each recommender (X^2= 13.942, P= .007) (Appendix F, Table F.25); However, in the other direction (Table 0-11), there is not a statistically significant difference among each station's recommendation (X^2=6.098, P=.192) (Appendix F, Table F.26).

Table 0-11. Cross-tabular representation for replacing station suggested by each station in the Technical to Abstract direction

Recommending station	Recommended station			Total
	A	B	C	
A	3	8	5	16
B	7	5	4	16
C	4	10	1	15
Total	14	23	10	47

4.6 Stress

Participants were asked to rate the level of stress that they experienced while performing the task. Level of stress shows that the person in charge of doing certain tasks feels that the task is harder or more complicated than what he expected. As in the previous sections, the differences in the stress level the two directions were tested, and then the differences were tested among the stations for each direction.

The results showed that the direction level did not make any difference in the stress level, which is experienced by the group members (X^2=.855, P=.355) (Appendix F, Table F.27). However, under the Abstract to Technical direction there were a significant differences in the stress level that each station has experienced (X^2= 8.6, P= .013) (Appendix F, Table F.28). On the other side (Appendix F, Table F.29), no significant difference is observed in the level of experienced stress in the Technical to Abstract condition (X^2=.516, P= 772).

Chapter 5

Analysis and Discussion

This section discusses the results from the previous section and clarifies the possible reasons for the behaviour observed in the experiment.

5.1 Group performance

Group performance has been approached in two ways in the previous section: first, differences in performance between two communication directions, and second, differences in performance before and after a new category is introduced. Each approach is separately analyzed in this section.

5.1.1 Group performances in different communication directions

5.1.1.1 Task analysis and discussion

In this experiment, group performance was defined as the number of trials needed for a group to find out the given number. Before the new category was introduced, when a message went from the abstract level to the technical level, the group performance was worse than in the other direction. In addition, the group performance in the Abstract to Technical direction was close to random. Although certain information was communicated regarding the selected number, it did not help the person at the end (station C) to find out the number. Therefore, the following two questions arise:

- Why was the performance worse in the first direction?
- How did the communication set up affect performance in this task?

John Corso (1967) shows the schematic representation of different quantities of information in a communication system when there are two source of uncertainty. The uncertainty sources can be "independent" or "non-independent" (Corso, 1967), and "the non-independent sources of information or uncertainty may be considered in terms of a typical psychological situation"(Corso, 1967). Assuming that the system represents a human subject in an experimental situation, a series of stimuli is considered input and a series of response is considered output(Corso, 1967).

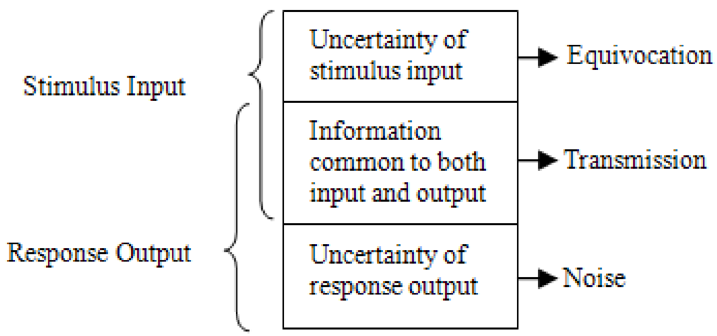

Figure 0-1. Schematic representation of different quantities of information in a communication system (Corso, 1967)

Uncertainty of stimulus input is the information, which is in the input but is not in the output. This information, which is called equivocation, is lost in the communication. “The term may be regarded as the uncertainty associated with the stimulus when the response is known”. The part of the message, which is common in both input and output, is transmitted. Uncertainty of response output is the information, which is sent by output but was not in the input. This information is called “noise” or “ambiguity”(Corso, 1967).

An example can clarify the process better. If number 8 is chosen randomly, and 8 is given to station A, then A has to choose Big to communicate the number. By sending Big, station A reduces the set of 10 numbers (1 to 10) to half. In Shannon’s terminology, station A passes one bit of information to station B. If station B is able to transfer the same message to station C, then the best scenario happens. However, B is not able to follow the best scenario because he is limited to the cards that he has (Odd, Even, Prime, CR, SR). He has to choose one of the categories that are available to him. Station B receives Big, and Big numbers overlaps with all the categories that B has. Since B does not know the given number, he might choose a category from his set that either includes the given number or does not. In this example, the given number is 8; Even and CR includes 8, whereas Odd, Prime and SR does not include 8. If B ends up choosing Even, then he communicates the given number, 8; however the message also contains other numbers (e.g., 2,4,6,10), which are called noise. Otherwise, if he ends up choosing other categories such as Odd, not only does B not communicate the selected number, but B also misleads the next person. Schematic representation introduced by John Corso can clarify the above example.

Figure 0-2 follows the schematic representation and explains how B communicates noise in the Abstract to Technical direction. For example, the given number is 8; station B receives Big and he transfers Even on. The common items in Big and Even are 6, 8, and 10, which are transmitted; however, 2 and 4 are communicated, even though they are not in the Big category, they therefore creates noise and misleads the next person.

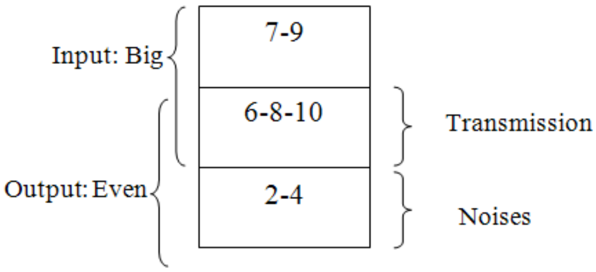

Figure 0-2. Noise created in station B when Even is chosen for the given number 8 (Abstract to Technical)

If person B chooses Odd (i.e., the category that does not include the selected number) the transmission is misleading (Figure 0-3).

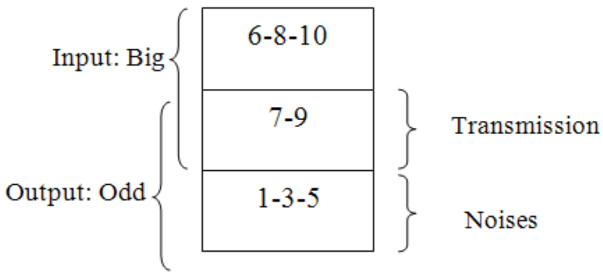

Figure 0-3. Noise created in station B when Odd is chosen for the given number 8 (Abstract to Technical)

Therefore, station B is not able to transfer the information that he has received from A. The best-case scenario for the group is when B can transfer all the information that he receives from A. In this case, station C knows that the given number is either in Small category or in Big category. Therefore, the probability of choosing the right number by person C is 1/5. However, the worst-case scenario is when person B cannot give any useful information to C. Therefore, C has to choose one of the numbers from 1 to 10 randomly. In this case, the probability of choosing a correct number is 1/10.

Moreover, the strategy that B uses to choose a category influences the group's performance. For example, if B thinks the correct number should be 9, whatever his reason is, then he keeps sending Odd. In the worst-case scenario, 9 would come up after all other odd numbers have been tried, and now B understands that 9 is not correct and then he switches to Even; therefore, the performance is much worse than if B had chosen Even to begin with.

One point that should be mentioned is the fact that B does not get to know the number in the Abstract to Technical direction. By communicating wrong categories and noise, station C also loses the chance of helping B figure out the number. For example, if station B assumes the number is 9, while it is 8, and he passes Odd to station C, then C might choose 1, which is not helpful for station B (B knows the number is more than 5); whereas if he chooses 7, then one number is eliminated from the set, and this is helpful behaviour for B.

In the other direction, when a message goes from a technical level to an abstract level, noise is communicated as well, and consequently misleading of participants happen too. Assuming 8 again as the selected number, station A can choose either Even or CR. Let us say that Even is chosen for the sake of similarity to the previous example. When B receives Even, he receives one bit of information; however, he is not able to communicate the same information as he has received; even numbers can be Big and Small. If he chooses Big, for some reason, he sends one bit of information, which is accompanied by noise. Figure 0-4 shows that 7 and 9 is sent through message Big, while they are not Even.

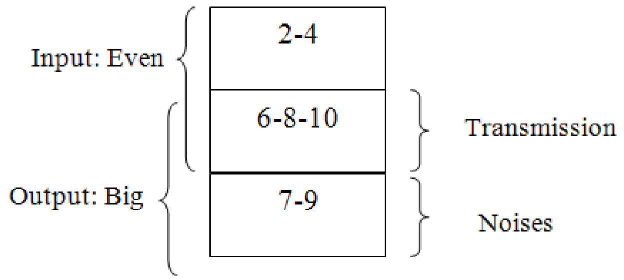

Figure 0-4. Noise created in station B when Big is chosen for the given number 8 (Technical to Abstract)

On the other hand, if B chooses Small, not only does he send noise, but also no correct information is communicated; the message "Small" is misleading.

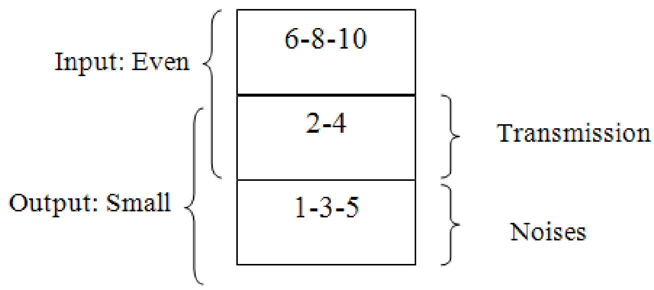

Figure 0-5. Noise created in station B when Small is chosen for the given number 8 (Technical to Abstract)

Under the Technical to Abstract direction, the strategy that B uses to choose either Small or Big affects the performance, and the process of noise creation is similar in both directions; therefore, why is the performance different between two directions? The answer lies in the fact that B gets to know the number faster in the Technical to Abstract direction rather than the other direction. Under the other direction, station B cannot figure out the number, and he keeps sending wrong messages or messages with noise; whereas, in the Technical to Abstract direction, after a few trials, B understands the number. For example, in the Technical to Abstract direction, the selected number is 8, and A sends Even at the first trial; if the correct number is not chosen in the first trial, A sends CR in the next trial. At this time, B intersects CR and Even and notices that the number is 8. In the rest of the trials, he repeats Big; although there are still noise in the message, no misleading happens.

There are two methods to explain why the performance is worse in the Abstract to Technical direction rather than the other direction. (1) The first method is measuring and comparing the amount of information or uncertainty that is transferring in each direction. If more information (or less uncertainty) is passing through the stations in the Technical to Abstract direction, then groups under this direction end up finding the selected number faster than the others. The uncertainty that is created in each station can be calculated using the uncertainty function defined in Information Theory. The uncertainty (entropy) H(x) of a discrete random variable x is defined by (Thomas, 2006)

$$H(X) = -\sum_{x \in \mathcal{X}} p(x) \log p(x) \qquad \text{(5-1)}$$

The above formula is used when there is a single variable in the system, however in this study, the output variable of each station depends on the input variable. For example, at station C, the probability of choosing the correct number depends on the received category from station B, and the probability of choosing a correct category by B depends on the received category from station A. Therefore, the uncertainty of the output variable in each station is conditional on the knowledge of the input variable and can be calculated by

$$H(X|Y) = -\sum p\,(x|y)\; log(x|y) \qquad \text{(5-2)}$$

In this task, the conditional probability function is very complicated. The reason lies in two facts; first, in both directions, the performance of each station depends on the previous station. For example, the performance of station C depends on B, B depends on A, and A depends on the random number that he has been given. Second, the probability function of all stations depends on the strategy that they use. In the Abstract to Technical direction, the output variation at station A is only created by random numbers, which is given to the groups in each round. If the given number is from 1 to 5, he chooses Small, and if it is from 6 to 10 he chooses Big. However, station B and C might use different strategies. Although in the experiment, the strategies that participants used were not asked specifically, different strategies were observed during the experiment. Potentially, station B can follow three strategies:

1) Station B tries to pass the category that has higher chance of including the number (B does not know the number). For example, B receives Big; among all categories (Odd, Even, Prime, Cube Root, Square Root), Even has more big numbers (6-8-10). Therefore, he passes Even to the next station.
2) Station B hypothesizes one number; for example, B has received Big and he hypothesizes 8 as a potential number, he, then, checks all the categories to determine which one has the higher probability for 8 to be happen. In this example, Cube root has the higher possibility. It includes 1 and 8; therefore, 50% of time 8 is chosen.

3) Station B tries to eliminate the possible numbers. For example, if B receives Big, he chooses one of the big numbers randomly, 9, and communicates the number by passing square Root and Odd in two trials following each other. If 9 is selected while the correct number is 8, then 9 is eliminated from the set of big numbers.

In addition, station C can follow two strategies:

1) Station C follows the last category that he has received and he chooses one of the numbers randomly. For example, he receives Odd and he chooses one of the Odd numbers randomly.
2) Station C intersects the category that he receives. For example if he receives Odd at the first trial and Cube Root at the second trial, he intersects two categories and he chooses 1.

Under the Technical to Abstract direction, finding out the probability function is easier. Observation showed that station A always intersected the overlapping categories to communicate the given number in the experiment. For instance, if the given number is 4, he passes Even and Square in the trials following each others. Station B gets to know the number faster than the other direction, and therefore, he communicates either Small or Big accordingly. Station C chooses one of the numbers of the received category randomly. He does not have the opportunity of intersecting the received category because he only receives Small and Big, and there is no overlapping between them.

Talking to conditional probability expert and Information Theory expert, I have noticed that calculating the probability functions of the group in this task is not possible analytically because the strategy that they used is not clear. The strategy that station B followed is not clear, and therefore, it is not possible to calculate the conditional probability, which is needed to be calculated in uncertainty formula (5-2). The solution to this problem is developing a simulation model, by which different possibilities can be considered.

(2) The second method to address the reason of performance differences in two directions is to compare the probability of choosing the correct number in each direction. If the probability rules show that the groups under Technical to Abstract condition has higher chance of choosing the correct number, then I can prove that the performance is better in this condition. However, finding the probability of choosing the correct number in the group is not possible analytically for the same reason that is just explained.

The simulation model can be helpful to address the reason for performance differences in both methods. I am developing a simulation model for the first direction of the experiment; however, completing the model needs more time and effort, which is beyond this research.

5.1.1.2 Summary

The above-mentioned explanation clarifies the differences in communication directions when a person with superficial categories of knowledge and a person with detailed and technical categories of knowledge are communicating. Based on analysis of the task, when a person with few broad categories of knowledge, which do not overlap, send a message to a person with several categories, which overlap, the message is understood easier than the other direction. For example, a patient is a person with broad and superficial categories of knowledge; whereas, a doctor has detailed and technical knowledge. The patient gives information about the symptoms that he has experienced, for example, a headache. Headaches can be fitted into different categories that the doctor has, such as colds, tumors, etc. Therefore, the doctor does not know what kind of disease the patient is suffering from. He needs more elaboration on the received message (i.e., the headache) to figure out the disease. On the other hand, if doctor, who has technical knowledge, communicates about a disease, the patient needs less elaboration on the received message to put it in his superficial categories such as curable or non-curable disease.

The above discussion is the result of investigating a specific case in the experiment. In the experiment, the message is sent either from the person with two broad categories without any intersection to the person with five categories with lots of intersections or the other way around. To generalize the findings, different cases must be studied. For example, cases in which broad categories overlap. A simulation model can provide different case scenarios with different number of categories and different degree of overlapping to study different case scenarios.

5.1.2 Group performance before and after a new category is introduced

5.1.2.1 Task analyses and discussion

When station B is allowed to come up with a new category, he tries to create a category that transfers the received message to the next station with minimum alteration. Therefore, noise is reduced, and misleading does not happen. Data from the experiment showed that the new category was helpful in the both directions and improved the group's performance. In addition, Section 4.2 showed that the significant correlation between rounds and performance was the result of participants creating a new category.

Observations from the experiment showed that when the message went from the abstract level to the technical level, 87% of time station B created either Big or Small, which were the categories that he was receiving. Therefore, he was able to transfer the received message to the next stations without noise and misleading.

When the message went from the technical level to the abstract level, station B came up with the category that reduced noise. As was explained in the previous section, B got to know the number quickly in this direction. Therefore, he was not sending the wrong category to C; however, the sent message was accompanied by noise. For example, if he gets to know that the given number is 8, he sends Big; then 6, 7, 9, and10 are noise accompanied by the message Big. Data from the experiment showed that in 50% of the time B created a category such as a mid-range number; therefore, when Big was communicated, C understood that the number was Big but not Mid-range (e.g., 8-9-10). In addition, 30% of the time, B created Odd or Even categories; therefore, when Big (or Small) was followed by Even (or Odd), person C intersected the two categories, and he reduced the noise that occurred with big numbers to occurred only with big and even numbers.

In both directions, station B plays a role of translator; he tries to create a shared meaning by creating a category that is understandable for all stations. For example, under the Abstract to Technical direction, when station B comes up with category “Big”, he creates the shared meaning because now the message, Big, is understandable everyone and includes the same items. Under the Technical to Abstract direction, overlapping is helpful to create a shared meaning. For example, station A uses overlapping categories to communicated an item to station B.

However, the item would be understood easily if the intersection has only one item. Therefore, minimizing the items in the intersections is helpful to create a shared meaning. As a result, the shared meaning can be created when people have the same categories with identical items and least overlapping.

5.1.2.2 Summary

In this experiment, the idea of having the person in the middle of the communication was formed to make the task analyzable. However, the experiment results showed that a middle conceptual level of knowledge was helpful in facilitating the process of communication by translating the received message into the sent message. The person who is familiar with technical and non-technical knowledge can translate the message from one side to the other. This result fits to the study of Bechky (2003), in which she investigated the role of technicians in translating messages between designers and assemblers.

5.2 Performance judgments

In Section 4.3, the results of statistical tests were shown to demonstrate the differences among performance judgments for all stations. The means of all performance judgments are presented in Table 5-1. The highlighted rows and columns show the directions in which statistical significant differences were observed. The results of this section support the reasons mentioned in Section 5.1 for the observed differences in performance (number of trials).

Table 5-1.Means of all performance judgments

Abstract to Technical direction

Existing Categories

Stations	Performance judgments for Station A	Performance judgments for Station B	Performance judgments for Station C
A	3.47	**3.56**	3.41
B	3.38	**3.59**	3.65
C	**3.58**	**2.97**	**3.53**

Extra category

Stations	Performance judgments for Station A	Performance judgments for Station B	Performance judgments for Station C
A	**3.59**	**4.41**	**3.84**
B	3.47	4.28	4.00
C	3.70	3.83	3.83

Technical to Abstract direction

Existing Categories

Stations	Performance judgments for Station A	Performance judgments for Station B	Performance judgments for Station C
A	3.69	**3.47**	3.66
B	3.64	**3.84**	4.00
C	3.37	**3.33**	3.53

Extra category

Stations	Performance judgments for Station A	Performance judgments for Station B	Performance judgments for Station C
A	4.19	4.28	4.19
B	4.06	4.33	4.33
C	3.87	4.30	4.12

5.2.1 Station A judges all stations

In both directions, before a new category was introduced, station A judged every station almost equally (Table 5-1). After the new category creation, station A increased the credit of all stations; however, station B was rated higher than others. In both directions, the difference in the means of performance judgment before and after the new category creation was close to 0.8. However, the significant difference was observed only in the Abstract to Technical direction because stations A and C in this direction were given comparatively less credits (performance judgments increased from 3.47 to 3.59 for station A from 3.41 to 3.84 for station C) rather than the other one.

Station A did not know what kind of categories others were dealing with. When station B introduced a new category, the performance of the groups got better; on average, the performance declined from 5.16 to 3.7 in the Abstract to Technical direction and from 4.58 to 3.45 in the other direction. Data and notes in the questionnaire showed that A gave high credit to B because of the helpful category he had created.

Section 5.1.1.1 explained that, in the Abstract to Technical direction, the performances of the groups were worse than in the other direction because noise and information inaccuracy complicated delivery of the messages. By introducing the new category, B was able to reduce the noise and help the communication process. Therefore, A gave the highest credit to station B for the two directions. However, in the Technical to Abstract direction, A also increased his own credit because he felt that he learned more how to communicate a number to station B, whereas, in the other direction, station A was only able to communicate either Small or Big, and the opportunity of learning was less. Therefore, the significant difference was observed only in the first (Abstract to Technical) direction.

5.2.2 Station C judges all stations before the new category was introduced

In the first direction, before the new category was introduced, station C judged station B's performance as low. Station C needed to follow the categories that B sent him; however, the categories might have been wrong because B did not know the number himself. Although B was doing his best to transfer as much knowledge as he received from A, station C faced noisy and misleading messages.

Comparing judgments given by C in both directions, Table 5-1 shows that when C judged all stations in the second direction (Technical to Abstract), no significant difference was observed. In the second direction, as well as the first one, station C received messages from B, and the messages were accompanied either by noise or by information inaccuracy. What is the difference then? Why was the first one significantly different, whereas the other one was not?

There are two possible reasons for this contrast: (1) as is mentioned in Section 5.1.1.1, when a message went from the abstract level to the technical level, after only a few trials, station B got to know the number and sent the correct message, although it was accompanied by noise. However, in the Abstract to Technical direction, B did not have a chance to find out the number and kept sending wrong messages. Therefore, Station C had to deal with lots of noise and inaccuracy under the Abstract to Technical rather than the other direction. He then attributed these difficulties to station B's inability to perform the task.

(2) In the experiment, I observed that in the Abstract to Technical direction, participants in station C were more frustrated than they were in the other direction because of the subjective probability that they attached to the received messages. For example, when B sent *Even* in the first trial and *Prime* in the second trial, C assumed that the correct number was 2 with 100% subjective probability; however, B did not know the number, and 2 might have been wrong. He might have sent *Prime* because he wanted to communicate 7. Whereas, when a message went from the technical level to the abstract level, C received either Big or Small. If he received Big at the first trial and Small at the second trial, he noticed that the

messages were contradictory, and one of them must have been wrong. In other words, messages with a higher subjective probability of being correct create more dissatisfaction than contradictory messages.

5.2.3 Station B's judgment by others before the new category was introduced

In both directions, before the new category was introduced, station B was rated differently by different stations (Table 5-1). Under the Abstract to Technical direction, the difference happened because station C gave low credit to station B (Section 5.2.3); however, for the other direction, the difference happened because station B gave himself high credit. In this direction, B got to know the number quickly, and he was able to handle the uncertainty that he received through intersecting the received messages. Therefore, he was satisfied with his performance and gave high credit to himself.

After the new category was introduced, all stations rated station B higher than for the previous condition in which the group was dealing with existing categories. The new category helped the group to experience less noise and uncertainty.

5.3 Leadership

The results of statistical tests showed that there were no specific perceptions of leadership in the groups; however, Table 0-2 shows that, during the experiment, half of the group members, in each direction, perceived leadership, and half of them were not able to localize the station that influenced the task.

Table 0-2 Cross-tabular representation for leadership perception in the two directions

Directions	Any one called leader?		Total
	Yes	No	
Abstract to Technical	19	29	48
Technical to Abstract	23	25	48
Total	42	54	96

Table 0-3 Cross-tabular representation of leader station in the two directions

Directions	Which station is leader?			Total
	A	B	C	
Abstract to Technical	7	12	0	19
Technical to Abstract	12	10	1	23
Total	19	22	1	42

Table 0-3 displays that in both directions, leadership was perceived in either station C or station B. In both directions, the number of times that A and B were chosen is very close; however, in the Abstract to Technical direction, B probably indicated that he was the leader, and in the other direction, A assigned leadership to himself.

In addition, during the experiment, I observed that, in some groups, station B was considered as leader because station B was thinking a lot and spending more time figuring out which category he had to send to station C.

5.4 Group satisfaction

5.4.1 Working with the same group of people

Data from Section 4.5.1 showed that direction did not make any difference in individuals' preference about working with the same group of people. At the first glance, one might expect to see more dissatisfaction in participants working with the same group under the Abstract to Technical direction because more uncertainty and ambiguity is associated with communication. Table 4-8 showed that 32 participants out of 48 wanted to work with the same group in the Abstract to Technical direction, while 39 out of 48 experienced the same feeling for the other direction. Although the numbers do not differ significantly, the satisfaction was higher in the Abstract to Technical direction.

Although group members were separated by cubicles and not allowed to talk, they used body languages to transfer their feelings during the experiment. For example, in some groups, person B moved his head in such a way that showed he did not know what was going on, and the wrong messages that he had sent was not his fault. Therefore, when participants filled out the questionnaire at the end of the experiment, they already knew that the difficulties they experienced occurred because of the communication setup rather than the group members.

5.4.2 Replacement a station with an expert

When participants were asked to replace a member with an expert, communication direction made a significant difference. Table 4.9 demonstrates that in both directions, those stations that were dealing with more noise and uncertainty were recognized as the source of communication problems and, therefore, participants requested that an expert be replaced in those positions. In the Abstract to Technical direction, station A did not need any expertise since he choose only either Big or Small for the given number; whereas B and C worked with overlapping categories that were needed to be intersected. They needed to keep the record of wrong numbers and find the number through messages that were accompanied with noise. In the other direction, station C faced the same situation;

his task did not need any specific expertise since he received only Big or Small, while station A and B were handling noise and uncertainty.

The psychological situation of station A in the abstract to technical direction was different from station C in the Technical to Abstract direction. Both stations were dealing with broad categories (Small, Big); they only had the chance of choosing either Big or Small. However, Table 4-9 shows that in the Abstract to Technical direction A's replacement with an expert was requested 5 times, whereas, in the other direction, station C's was requested only 8 times. Although they had equal knowledge in the two directions, station C was blamed more because he was the one who chose the number in the end.

5.5 Stress

Section 4.6 showed that when a message went from an abstract level to a technical level, participants experienced different levels of stress; however, no significant difference was observed for the other direction. In the Abstract to Technical direction, station B faced a difficult situation in that he had to communicate a category but did not know the number. Therefore, he misled station C and knew that station C would get confused. In the Technical to Abstract direction, B experienced an easier situation; he knew the given number quickly and was supposed to communicate either Big or Small. Therefore, he did not feel stress as much stress as station B did for the Abstract to Technical direction.

Chapter 6

Conclusion

6.1 Summary

This study started by focusing on the communication problems between people with technical and non-technical knowledge. It focused on the fact that people use categories to communicate, and individual knowledge is represented categorically. The categories can be formed for an individual based on the superficial or in-depth knowledge that he or she has. When a person who has superficial categories (abstract level categories) sends a message to a person with in-depth categories (technical level categories), or the other way around, miscommunication often happens. Since the categories are not the same and overlap, a shared meaning cannot be shaped. Therefore, the sent message can be fitted into a receiver's different categories, and the receiver demands more explanation to figure out the message.

An experiment was designed to simulate the process of communication between a technical and a non-technical person. It was run in two communication directions: Abstract to Technical and Technical to Abstract. In both directions, the possibility of achieving shared meaning through creation of shared meaning was considered. The task focused on in this study has the opportunity of presenting a very complicated process of communication in a very simple and analyzable way.

The results of the study explained the process of communication between people with different categorical knowledge and the differences in the communication process in two directions. In addition, they elaborated on the reasons for miscommunication and the conflicts associated with it. The study also suggested that there is a possibility of using Information Theory to analyze the process of communication between people with different categorical knowledge.

6.2 Contribution

One of the main contributions of this study is linking communication and categorical knowledge representation to explain the process of communication. Joining the two areas introduces an opportunity to represent the way that communication works. Categorical representation of communication contributes to the relational approach to communication, which focuses on the way that "people coordinate and communicate to reach a shared perspective satisfactory to all"(Richmond, V. P. & McCroskey, J. C., 2009). This categorical representation clearly demonstrates that when people do not have the same categorical knowledge miscommunication happens, and a shared meaning can only be formed by adjusting the categories in a way understandable to both communication parties.

One of the main challenges in communication fidelity theories is measuring shared cognition. Difficulties come from the fact that easily accessing internal cognition is not possible. Different scoring techniques are used to measure various types of cognition in different communication contexts (Powers, W. G. & Lowry, D. N, 1984). However, this research introduces a simple way of measuring shared cognition through categories of knowledge.

One of the strengths of this study is the task used during the experiment. The task shows the process of communication between people with categorical knowledge through simple and familiar categories of numbers. In addition, the task can demonstrate the difficulties when people with different levels of knowledge are communicating. The task was designed based on a specific definition of communication and cannot be performed without sending and receiving messages.

6.3 Limitation and implication of future studies

This study had some limitations that need to be addressed for future research. First, participants were seated in a room around the table. Dividers were used to separate them, and they were not allowed to talk. The reason was to let them have their own hypotheses about others categories and test the possibility of having conflict in the group because of the difficulties in communication. However, participants used body language, and therefore, they found that the poor performance was not the participants' fault. Therefore, when filling out the questionnaire, the individual judgment on performance was affected by awareness of task difficulties. Performance judgments would have shown stronger differences if participant were separated completely.

Second, participants were not asked explicitly to explain the strategy that they used; however, the strategies affected group performance and clarification of them was needed for task analysis. In addition, it would have been better if an identical set of numbers had been given to the groups. An identical set of random numbers would have enabled a better basis for analysis on the given numbers.

The exploratory study helped me to observe interesting points during the experiments; however, working on all the points was beyond the scope of this research. The first opportunity for future research is using the simulation model to simulate the task and make the process analyzable. In addition, simulation models help the researcher to change the conditions of the experiment. For example, different numbers of categories with different degrees of overlapping can be used.

One of the interesting points observed during the experiment is that the receiver connects messages. Thus, messages are not independent, and the second message is understood as a continuation of the first message. This behaviour was observed in both directions of this study. For example, if person at the end receives *Even* as a first message and then receives *Square root*, he assumes that the messages are following each other. The same process happens in daily communication. If one hear following sentences, “The weather is good. I walk to school”, one connects the two messages in a causal relationship.

Interestingly, I observed that the meaning of the words changed during the experiment. For example, in some cases in the Abstract to technical direction, station A used *Small* or *Big*, which were the only categories available to him, to communicate that the given number was smaller or bigger than the number selected by station C. This observation shows that people change the meaning of words and create a new meaning to facilitate the process of communication.

Finally, I noticed that Station A and C, who did not have enough information about the other stations’ category, developed peculiar theories. For example, A sent

Big and C ended up choosing a Small number; therefore, A assumed that his categories were opposite to those of the others. Thus, the *Big* category, which contained the numbers from 6 to 10, were categorized as *Small* for other stations.

Appendices

Appendix A - Experiment Instructions

Welcome to my experiment!

This experiment is run in groups of three, and as you can see, there are three stations labeled as station A, station B, and station C. Therefore, I call the person sitting in station A person A, in station B person B and in station C person C. The experiment has two parts.

In the first part of the experiment, you are asked to find a number from 1 to 10, which is randomly selected, and I give it to person A. For example, a selected number could be “4”. I give it to person A, and person A communicates it to person B. Person B can only communicate it to person C, and person C chooses a number, shows it to person A. Person A will let everyone know whether the number is correct or incorrect. Therefore, you will work in the team by specific order and limited communication to find the selected number.

Numbers from 1 to 10 can have many different categories. For example, one category could be numbers divisible by 2 which includes (2, 4, 6, 8, 10). Each person will have some categories that include some numbers from 1 to 10. In each station, you can see some big cards (a sample of a big card is shown by experimenter). Each big card shows one category and the numbers, which are included. I will give a random number from 1 to 10 to person A.

Person A communicates the number to person B using one of the categories that are available to him. Each time only one category is communicated.

Person B is supposed to communicate the received category to the third person using his own categories. Person B also has some categories available, which he can pass it to person C. Each time only one category is passed to another person. Person B is not allowed to pass the category, which he received from person A.

Person C will choose a number based on the category he received form person B and will show it to person A. Person A gives feedback to the group whether the selected number is correct or incorrect. If the answer is not correct, the group will continue the game till the correct number is found. So, person A starts the game by communicating a new category or repeating the same category again.

During the game, group members are not allowed to talk; except at the end of each trial in which person C announces the number he has chosen and person A gives feedback. In other cases the only way to communicate is by using the small cards (small card is shown). Each time only one card is communicated. Person A passes one category to person B. Person B passes one of his own categories (not the person A's category) to person C and then person A gives the feedback.

At the beginning of each round I will give you a paper (The sample of the paper is shown). At the end of the each trial, I ask you to write some information on the papers in front of you about the trial. For example, person A and B and C are asked to write the category that they have passed or received and their estimation about the chance of getting the number in the next trial. For example, if at the end of the third trial you are sure that in next trial you will get the number, then you will write 100% in the third row in the specific column.

This task will repeat in 6 rounds and then the first part of the experiment is finished.

In the second part of the game, person B will have the opportunity to create a new category of numbers to help the group perform the game better. At the beginning of the second part, I will give person B two big blank cards and Person B should define a new category and specify the numbers in the new category, write them down, and he can pass one of the big cards to person C. That is the only time that one big card is communicated. The game will be continued for 6 more rounds in the same way. There fore, I will give a randomly selected number to person A, person A communicates it to person B by using one of the available categories. Person B communicates the received category using his own categories, which include the new one. Person C chooses a number based on the received category and will announce the number and person A will give a feed back to the group. The game will be continued for 6 more rounds.

I will ask you to fill a questionnaire at the end of the session.

Appendix B - Questionnaire

Station ………………

Name:……………………… Date:………………

Gender: Male… Female … Program: …………………………………..

1. In terms of finding the number, were you satisfied with your group's effort (doing its best) in the **first part** of the game?

1 2 3 4 5

Low Satisfied Medium Satisfied High Satisfied

Please explain: ..………………………………………………………………

2. In terms of finding the number, were you satisfied with your group's effort (doing its best) in the **second part** of the game?

1 2 3 4 5

Low Satisfied Medium Satisfied High Satisfied

Please explain: ..………………………………………………………………

3. Please judge yourself as well as two other people in the group in terms of **individual effort** in the **first part** of the game:

A: 1 2 3 4 5

Low effort — Medium effort — High effort

Please explain: ....

B: 1 2 3 4 5

Low effort — Medium effort — High effort

Please explain: ....

C: 1 2 3 4 5

Low effort — Medium effort — High effort

Please explain: ....

4. Please judge yourself as well as two other people in the group in term of **individual effort** in the **second part** of the game:

A: 1 2 3 4 5

Low effort — Medium effort — High effort

Please explain: ....

B: 1 2 3 4 5

Low effort | Medium effort | High effort

Please explain: ..………………………………………………………

C: 1 2 3 4 5

Low effort | Medium effort | High effort

Please explain: ..………………………………………………………

5. Please judge yourself as well as two other people in the group in term of **individual's capability in communication** in the **first part** of the game:

A: 1 2 3 4 5

Low Capability | Medium Capability | High Capability

Please explain: ..………………………………………………………

B: 1 2 3 4 5

Low Capability | Medium Capability | High Capability

Please explain: ..………………………………………………………

C: 1 2 3 4 5

Low Medium High

Capability Capability Capability

Please explain: ..…………………………………………………………

6. Please judge yourself as well as two other people in the group in term of **individual's capability in communication** in the **second part** of the game:

A: 1 2 3 4 5

Low Medium High

Capability Capability Capability

Please explain: ..…………………………………………………..

B: 1 2 3 4 5

Low Medium High
Capability Capability Capability

Please explain: ..……………………………………………………………

C: 1 2 3 4 5

Low Medium High
Capability Capability Capability

Please explain: ..………………………………………………………

7. Did you feel stress while you were performing the task?

1 2 3 4 5

Low Medium High

Stress Stress Stress

8. Is there anyone in the group who you would call “leader” in your group?
   Yes___ No____

If yes, please circle the person: A B C

9. Would you like to work with the same group of people doing another similar task?
   Yes _____ No ______

10. If you can replace one of the members with an expert for this task, which member you would select?

Person A ----------- Person B ---------------- Person C ------------

11. Please describe your understanding of the difficulties in this communication set up.

……………………………………………………………………………………
……………………………………………………………………………………
……………………………………………………………………………………
……………………………………………………………………………………
……………………………………

12. Do you have any suggestion so your group can perform better?

……………………………………………………………………………………
……………………………………………………………………………………
……………………………………………………………………………………
……………………………………………………………………………………
……………………………………………………………………………………
…………………………

Appendix C – Station's note

Station A

Round: …………….   Selected Number: ………..

Trial	Category passed	Answer (given by C)	Chance of getting the number in next trial (%)	Comments
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Station B

Round: …………….

Trial	Category received	Category passed	Chance of getting the number in next trial (%)	Comments
1				
2				
3				
4				
5				
6				
7				
8				
9				

10				

Station C

Round: …………….

Trial	Category received	Number you have chosen	Chance of getting the number in next trial (%)	Comments
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Appendix D –The result of the questionnaire in detail

The questions of the questionnaire is presented in Appendix B. The answers to the questions are coded as follows

Direction 1 = Abstract to Technical, Direction 2 = Technical to Abstract

Yes = 1, No =2 (Questions 8 & 9)

1 = Station A, 2 = Station B, 3 = Station C

Table D.1. 1. Summary of results of the questionnaire filled by participants

Group No.	Direction	Station	Performance		Questions																		
			P1	P2	1	2	3 A	3 B	3 C	4 A	4 B	4 C	5 A	5 B	5 C	6 A	6 B	6 C	7	8	8 ID	9	10
1	1	A	4	4.33	3	3	4	5	5	5	5	5	5	5	5	5	5	5	3	2		1	3
1	1	B	4	4.33	3	3	1	5	4	1	3	4	1	1	3	1	3	4	3	1	2	2	3
1	1	C	4	4.33	3	3		3	4	3		4	3	2	5	3	2	5	3	2		2	2
2	1	A	4.33	3.33	2	4	3	3	3	4	4	4	3	3	3	4	4	4	1	2		2	2
2	1	B	4.33	3.33	4	5	5	4	5	5	5	5	5	5	5	5	5	5	2	1	2	1	2
2	1	C	4.33	3.33	3	4	3	3	3	4.5	4.5	4.5	4.5	3	5	5	5	5	3	2		1	3
3	2	A	4.17	2.83	3	4	3	4	4	4	5	4	3	3	4	4	4	4	4	2		1	3
3	2	B	4.17	2.83	5	5	5	5	5	5	5	4	3	3	5	3	4	5	5	2		1	3
3	2	C	4.17	2.83	3	4	4	4	4	4	4	4	3	2	3	3	4	4	2	1	1	1	23
4	2	A	4.5	2.17	5	5	5	5	5	5	5	5	5	1	1	5	5	5	1	2		1	3
4	2	B	4.5	2.17	5	5	5	5	5	5	5	5	4	3	2	4	4	3	3	2		1	2

4	2	C	4.5	2.17	2	4	4	3	4	3	4	4	2	3	2	4	5	4	3	2		1	2
5	2	A	2.67	3	5	3	3	4	3	4	4	3	4	4	4	4	4	3	1	2		1	2
5	2	B	2.67	3	5	5	5	5	5	5	5	5	5	5	5	5	5	5	2	2		1	1
5	2	C	2.67	3	4	4	4	4	4	4	4	3.5	4	3.5	4	4	4	4	3	2		1	2
6	2	A	4.83	3.67	3	3	4	3	4	4	3	4	3	3	5	3	3	5	2	2		1	2
6	2	B	4.83	3.67	5	5	5	5	5	5	5	5	3	3	3	4	4	4	2	2		1	2
6	2	C	4.83	3.67	2	4	2	2	2	4	4	4	2	2	3	4	4	4	2	2		1	2
7	1	A	5.67	3.17	2	3	4	4	4	4	5	4	2	3	2	4	4	3	2	2		2	3
7	1	B	5.67	3.17	3	5	4	4	3	3	4	4	2	3	2	3	3	3	3	2		2	3
7	1	C	5.67	3.17	2	1	4	4	3	4	2	2	5	4	4	3	4	4	4	2		2	2
8	1	A	5.67	5.5	5	5	5	5	5	5	5	5	2	2	2	2	2	2	3	2		1	2
8	1	B	5.67	5.5	2	2	4	5	3	4	5	3	1	4	3	1	4	3	2	2		2	1
8	1	C	5.67	5.5	3	3	5	3	3	5	3	3	3	3	3	3	3	3	1	2		2	2
9	1	A	5.83	4	5	3	5	4	4	5	4	4	3	3	3	3	4	3	2	2		1	2
9	1	B	5.83	4	3	4	3	3	3	5	5	4	2	2	2	5	3	4	2	1	2	1	3
9	1	C	5.83	4	2	3	3	2	3	3	2.5	3	3	2	3	3	3	3	3	2		1	2
10	1	A	5	2.83	5	4	4	4	5	4	5	4	4	4	4	4	4	4	2	1	1	1	3
10	1	B	5	2.83	3	5	3	5	5	3	5	5	3	3	3	3	5	5	3	2		1	3
10	1	C	5	2.83	4	4	5	5	5	5	5	5	4	4	5	4	3	5	2	1	1	1	2
11	1	A	3.67	2.5	4	4	4	5	4	5	5	4	5	3	4	5	4	4	2	1	1	1	3
11	1	B	3.67	2.5	3	5	5	5	4	5	5	4	5	3	4	5	4	4	1	2		1	3
11	1	C	3.67	2.5	2	4	4	2	5	3	5	4	2	3	3	2	4	3	4	1	2	2	1
12	1	A	4.83	4.17	3	4	2	3	2	3	5	4	2	3	3	2	5	4	1	1	2	1	3
12	1	B	4.83	4.17	3	4	2	4	4	2	4	4	1	4	5	1	5	5	1	2		1	3
12	1	C	4.83	4.17	4	5	3	4	4	3	5	4	5	3	2	5	4	2	2	1	2	1	2
13	2	A	3.67	3.5	4	5	5	5	5	5	5	5	3	3	5	3	5	5	1	2		1	
13	2	B	3.67	3.5	4	4	4	4	5	5	3	5	4	5	5	4	5	5	3	1	3	1	2
13	2	C	3.67	3.5	5	5	5	4	5	5	5	4	5	5	5	4	4	4	2	1	1	1	2
14	2	A	4.17	2.5	3	5	5	4	4	5	5	5	4	4	4	4	5	5	3	1	2	1	2
14	2	B	4.17	2.5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	1	2		1	
14	2	C	4.17	2.5	3	4	4	2	3	5	4	4	4	4	4	5	4	4	2	2		2	2
15	2	A	4.83	2.33	2	3	4	3	3	4	4	4	3	4	2	4	5	5	4	1	2	1	1
15	2	B	4.83	2.33	2	5	3	4	3	5	5	5	2	3	5	4	5	5	4	1	1	1	1
15	2	C	4.83	2.33	5	5	4	4	4	4	4	4	5	3	3	4	4	3	2	1	2	1	1
16	2	A	3.5	3.67	3	4	4	3	4	4	4	4	4	3	1	4	4	1	1	2		1	3
16	2	B	3.5	3.67	5	5	5	5	5	5	5	5	5	5	5	5	5	5	1	2		1	1
16	2	C	3.5	3.67	4	5		4	4		5	5	3	4	4	5	5	5	3	2		1	1

17	2	A	4.33	2	3	5	4	4	3	5	5	5	4	3	3	5	5	5	4	1	2	1	2
17	2	B	4.33	2	4.5	4.5	5	4	4	5	4.5	4.5	4.5	4	4	5	5	5		1	2	1	
17	2	C	4.33	2	3	5	4	4	4	4	5	5	1	3	1	3	5	1	4	2		1	
18	2	A	4.33	3.67	3	5	3	3	3	5	5	5	2	1	5	5	5	5	5	1	1	1	3
18	2	B	4.33	3.67	3	3	3	3	3	3	3	4	4	3	2	4	4	3	5	1	2	1	3
18	2	C	4.33	3.67	3	5	5	3	4	5	5	5	4	3	4	5	5	4	1	2		2	2
19	2	A	6.17	4.83	4	5	3	5	5	4	5	5	3	4	5	3	4	5	3	1	1	1	1
19	2	B	6.17	4.83	2	2	3	3	3	2	3	3	2	3	3	2	3	3	2	2		2	1
19	2	C	6.17	4.83	2	3	3	2	3	3	3	3	2	2		3			3	1	1	2	1
20	2	A	4.83	5.67	4	3	4	4	4	4	4	4	4	4	4	4	4	4	1	2		1	2
20	2	B	4.83	5.67	4	4	3	3	3	4	4	4	3	3	3	4	4	4	1	2		1	1
20	2	C	4.83	5.67	1	1	3	5	5	3	5	5	3	1	5	3	3	5	4	2		2	2
21	1	A	5.17	3.33	3	4	3	4	3	1	4	3	2	3	2	1	5	2	1	2		2	3
21	1	B	5.17	3.33	2	4	4	4	5	4	4	5	3	2		3	4		4	2		1	2
21	1	C	5.17	3.33	2	3	3	2	2	3	3	4	3	3	3	3	4	4	5	2		1	2
22	1	A	5.33	3.83	4	4	5	5	5	4	5	5	5	4	4	5	5	5	1	2		1	3
22	1	B	5.33	3.83	3	5	5	2	3.5	5	4	4	5	5	5	4	5	5	2	2		1	3
22	1	C	5.33	3.83	3	4	4	5	5	4	5	5	4	3	3	4	4	5	2	1	2	1	2
23	1	A	4.5	3.67	3	4	4	5	4	4	5	4	4	4	4	4	5	4	3	1	2	1	2
23	1	B	4.5	3.67	5	3	5	5	3	5	5	3	5	3	3	5	4	2	4	2		2	3
23	1	C	4.5	3.67	3	4	5	5	5	5	5	5	4	4	4	4	5	5	5	2		1	3
24	1	A	7.17	2.83	4	5	3	4	4	4	5	5	3	3	3	3	4	3	1	2		1	2
24	1	B	7.17	2.83	1	4	2	4	3	2	5	4	2	4	4	2	5	4	3	1	2	2	3
24	1	C	7.17	2.83	1	5	2	1	1	5	5	5	3	2	2	5	5	5	5	1	1	1	1
25	1	A	4.5	4.5	3	2	4	2	3	5	1	3	3	1	3	4	3	4	5	1	1	2	2
25	1	B	4.5	4.5	2	4	4	2	3	4	4	3	4	2	3	4	4	3	3	2		1	
25	1	C	4.5	4.5	3	4	3	2	3	4	4	4	2	2	4	3	3	3	3	2		2	2
26	1	A	6.5	3.33	1	5	1	1	4	1	5	4	3	2	3	3	4	2	1	2		1	2
26	1	B	6.5	3.33	1	5	4	3	5	3	4	5	3	3	3	3	4	5	2	1	2	1	3
26	1	C	6.5	3.33	1	1	5	5	5	3	2	1	3	1	1	3	1	1	3	2		2	2
27	1	A	6	4.17	3	5	4	4	4	5	5	5	3	3	3	5	5	5	3	1	1	1	2
27	1	B	6	4.17	3	4	4	4	2	4	4	3	2	3	5	3	4	5	2	2		2	3
27	1	C	6	4.17	2	3	4	3	2	3	4	3	3	3	3	3	4	4	5	2		1	1
28	2	A	5	2.67	4	4	4	4	4	3	4	5	3	4	4	4	5	4	2	1	2	1	1
28	2	B	5	2.67	4	5	3	4	5	5	5	5	3	4	5	4	5	5	3	2		1	1
28	2	C	5	2.67	3	4	2	5	1	3	4	4	4	2	4	3	4	4	2	1	1	2	3
29	2	A	4.5	4.83	4	4	4	3	4	4	3	4	4	3	1	5	3	1	1	1	1	1	2

29	2	B	4.5	4.83	4	4	5	5	5	5	5	5	4	3	2	4	4	2	2	1	1	1	2
29	2	C	4.5	4.83	4	4	1	4	3	2	5	5	1	3	1	3	1	3	4	1	2	1	2
30	2	A	6.67	4.33	2	3	4	3	3	4	3	3	4	3	3	4	3	3	1	1	2	2	2
30	2	B	6.67	4.33	1	2	1	2	2	1	3	2	1	1	1	4	3	3	2	1	1	2	3
30	2	C	6.67	4.33	3	4	4	4	4	5	5	5	3	3	3	4	4	3	2	1	1	1	1
31	2	A	5.17	3.67	4	4	4	4	5	4	4	4	2	3	3	5	5	5	3	1	1	1	
31	2	B	5.17	3.67	2	4	2	4	5	2	4	5	2	4	5	2	4	5	1	2		2	1
31	2	C	5.17	3.67	3	4	5	5	5	5	5	5	4	4	4	5	5	5	1	1	2	1	
32	1	A	4.5	3.83	1	5		5	1	1	5	3	1	5	1	1	5	3	3	1	2	1	3
32	1	B	4.5	3.83	5	5	5	5	5	3	4		4	4	4	5	5	5	2	1	1	1	2
32	1	C	4.5	3.83	2	4	3	2	5	3	4	4	3	2	5	5	4	5	4	1	2	1	2

Appendix E – SPSS Normality tests for performance scores

- Performance scores for the first part (existing categories)

One-Sample Kolmogorov-Smirnov Test

		Performance First part
N		32
Normal Parameters[a]	Mean	4.8750
	Std. Deviation	.97826
Most Extreme Differences	Absolute	.118
	Positive	.118
	Negative	-.078
Kolmogorov-Smirnov Z		.668
Asymp. Sig. (2-tailed)		.764

a. Test distribution is Normal.

- Performance scores for the second part (Extra category)

One-Sample Kolmogorov-Smirnov Test

		Performance Second part
N		32
Normal Parameters[a]	Mean	3.5833
	Std. Deviation	.91189
Most Extreme Differences	Absolute	.089
	Positive	.089
	Negative	-.068
Kolmogorov-Smirnov Z		.501
Asymp. Sig. (2-tailed)		.963

a. Test distribution is Normal.

Appendix F – SPSS statistical tables

Table F. 1. 2*2 factorial analysis for comparing the performances of all conditions

Tests of Between-Subjects Effects

Dependent Variable:performance

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	29.931[a]	3	9.977	11.458	.000
Intercept	1144.723	1	1144.723	1.315E3	.000
Direction	2.768	1	2.768	3.179	.080
Category	26.716	1	26.716	30.681	.000
Direction * Category	.447	1	.447	.514	.476
Error	52.247	60	.871		
Total	1226.900	64			
Corrected Total	82.178	63			

a. R Squared = .364 (Adjusted R Squared = .332)

Table F. 2 Correlation between the performance and rounds when all 12 rounds were considered

Correlations

		Round	Performance
Round	Pearson Correlation	1	-.855**
	Sig. (2-tailed)		.000
	N	12	12
Performance	Pearson Correlation	-.855**	1
	Sig. (2-tailed)	.000	
	N	12	12

**. Correlation is significant at the 0.01 level (2-tailed).

Table F. 3. Correlation between the performance and round before the new category in introduced

Correlations

		Round (1-6)	Performance
Round (1-6)	Pearson Correlation	1	-.212
	Sig. (2-tailed)		.687
	N	6	6
Performance	Pearson Correlation	-.212	1
	Sig. (2-tailed)	.687	
	N	6	6

Table F. 4. Correlation between the performance and rounds after the new category was introduced

Correlations

		ID	Avetrial
ID	Pearson Correlation	1	-.390
	Sig. (2-tailed)		.444
	N	6	6
Avetrial	Pearson Correlation	-.390	1
	Sig. (2-tailed)	.444	
	N	6	6

Table F. 5 Freidman test for comparing performance judgments when A rated all stations with existing categories (Abstract to Technical)

Test Statistics[a]

N	15
Chi-Square	.205
df	2
Asymp. Sig.	.903

a. Friedman Test

Table F. 6 Freidman test for comparing performance judgments when A rated all stations with an extra category (Abstract to Technical)

Test Statistics[a]

N	16
Chi-Square	8.773
df	2
Asymp. Sig.	.012

a. Friedman Test

Table F. 7 Freidman test for comparing performance judgments when B rated all stations with existing categories (Abstract to Technical)

Test Statistics[a]

N	15
Chi-Square	.542
df	2
Asymp. Sig.	.763

a. Friedman Test

Table F. 8 Freidman test for comparing performance judgments when B rated all stations with an extra category (Abstract to Technical)

Test Statistics[a]

N	14
Chi-Square	3.476
df	2
Asymp. Sig.	.176

a. Friedman Test

Table F. 9 Freidman test for comparing performance judgments when C rated all stations with existing categories (Abstract to Technical)

Test Statistics[a]

N	15
Chi-Square	9.174
df	2
Asymp. Sig.	.010

a. Friedman Test

Table F. 10 Freidman test for comparing performance judgments when C rated all stations with an extra category (Abstract to Technical)

Test Statistics[a]

N	15
Chi-Square	.744
df	2
Asymp. Sig.	.689

a. Friedman Test

Table F. 11 Freidman test for comparing performance judgments when A rated all stations with existing categories (Technical to Abstract)

Test Statistics[a]

N	16
Chi-Square	.491
df	2
Asymp. Sig.	.782

a. Friedman Test

Table F. 12 Freidman test for comparing performance judgments when A rated all stations with an extra category (Technical to Abstract)

Test Statistics[a]

N	16
Chi-Square	1.389
df	2
Asymp. Sig.	.499

a. Friedman Test

Table F. 13 Freidman test for comparing performance judgments when B rated all stations with existing categories (Technical to Abstract)

Test Statistics[a]

N	16
Chi-Square	1.250
df	2
Asymp. Sig.	.535

a. Friedman Test

Table F. 14 Freidman test for comparing performance judgments when B rated all stations with an extra category (Technical to Abstract)

Test Statistics[a]

N	16
Chi-Square	2.438
df	2
Asymp. Sig.	.296

a. Friedman Test

Table F. 15 Freidman test for comparing performance judgments when C rated all stations with existing categories (Technical to Abstract)

Test Statistics[a]

N	14
Chi-Square	2.000
df	2
Asymp. Sig.	.368

a. Friedman Test

Table F. 16 Freidman test for comparing performance judgments when C rated all stations with an extra category (Technical to Abstract)

Test Statistics[a]

N	14
Chi-Square	3.950
df	2
Asymp. Sig.	.139

a. Friedman Test

Table F. 17 Kruskal Wallis test for comparing the differences of judgments given by all stations (Abstract to Technical)

Test Statistics[a,b]

	Existing category			Extra category		
	Station A's performance	Station B's performance	Station C's performance	Station A's performance	Station B's performance	Station C's performance
Chi-Square	.187	4.866	.366	.224	4.428	.354
df	2	2	2	2	2	2
Asymp. Sig.	.911	.088	.833	.894	.109	.838

a. Kruskal Wallis Test

b. Grouping Variable: Stations

Table F. 18 Kruskal Wallis test for comparing the differences of judgments given by all stations (Technical to Abstract)

Test Statistics[a,b]

	Existing category			Existing category		
	Station A's performance	Station B's performance	Station C's performance	Station A's performance	Station B's performance	Station C's performance
Chi-Square	.815	4.756	2.404	1.572	.179	1.459
df	2	2	2	2	2	2
Asymp. Sig.	.665	.093	.301	.456	.914	.482

a. Kruskal Wallis Test

b. Grouping Variable: Stations

Table F. 19 Chi-square test for comparing the differences in the perception of group leadership between the two direction

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.677[a]	1	.411		
Continuity Correction[b]	.381	1	.537		
Likelihood Ratio	.678	1	.410		
Fisher's Exact Test				.537	.269
Linear-by-Linear Association	.670	1	.413		

b. Computed only for a 2x2 table

Table F. 20 Chi- square test for comparing the dofferences in indicating the leader station

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.136[a]	2	.344
Likelihood Ratio	2.518	2	.284
Linear-by-Linear Association	.419	1	.517
N of Valid Cases	42		

a. 2 cells (33.3%) have expected count less than 5. The minimum expected count is .45.

Table F. 21 Chi-square test for comparing group satisfaction between the two directions

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	2.650[a]	1	.104		
Continuity Correction[b]	1.947	1	.163		
Likelihood Ratio	2.678	1	.102		
Fisher's Exact Test				.162	.081
Linear-by-Linear Association	2.623	1	.105		

b. Computed only for a 2x2 table

Table F. 22 Chi-square test for comparing group satisfaction among stations in the Abstract to Technical direction

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	.750[a]	2	.687
Likelihood Ratio	.771	2	.680
N of Valid Cases	48		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 5.33.

Table F. 23 Chi-square test for comparing group satisfaction among stations in the Technical to Abstract direction

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.282[a]	2	.194
Likelihood Ratio	3.529	2	.171
N of Valid Cases	48		

a. 3 cells (50.0%) have expected count less than 5. The minimum expected count is 3.00.

Table F. 24 Chi-square test for comparing the differences in recommended replacement in the two direction

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	9.820[a]	2	.007
Likelihood Ratio	10.148	2	.006
Linear-by-Linear Association	9.551	1	.002
N of Valid Cases	89		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 8.75.

Table F. 25 Chi-square test to check the differences in suggested replaced stations among recommenders in the Abstract to Technical direction

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	13.942[a]	4	.007
Likelihood Ratio	16.266	4	.003
N of Valid Cases	47		

a. 3 cells (33.3%) have expected count less than 5. The minimum expected count is 1.28.

Table F. 26 Chi-square test to check the differences in suggested replaced stations among recommenders in the Technical to Abstract

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	6.098[a]	4	.192
Likelihood Ratio	6.575	4	.160
N of Valid Cases	47		

a. 6 cells (66.7%) have expected count less than 5. The minimum expected count is 3.19.

Table F. 27 Kruskal Wallis test to check the differences in the stress level between the two direction

Test Statistics[a,b]

	Rate of stress
Chi-Square	.855
df	1
Asymp. Sig.	.355

a. Kruskal Wallis Test

b. Grouping Variable: Type

Table F. 28 Kruskall Wallis test to check the differences in the stress level among stations in the Abstract to Technical direction

Test Statistics[a,b]

	Rate of stress
Chi-Square	8.650
df	2
Asymp. Sig.	.013

a. Kruskal Wallis Test

b. Grouping Variable: NumStation

Table F. 29 Kruskall Wallis test to check the differenced in the stress level among stations in the Technical to Abstract direction

Test Statistics[a,b]

	Rate of stress
Chi-Square	8.650
df	2
Asymp. Sig.	.013

a. Kruskal Wallis Test

b. Grouping Variable: NumStation

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