Effects of Category Structures on Learning and Communication of the Learned Categories

by

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Authors 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.

Abstract

Communication is an essential part of our life, and is tightly connected to our knowledge. We communicate about what we know, and form our knowledge through communication. This research uses the categorical representation of knowledge and examines how differences in the structure of categories affect the processing of information in category learning and the communication of the learned categories. The structure of categories is defined through the concept of variability; its effects on the efficiency in learning, effectiveness of communication, and the pattern of interactions between people with different categorical knowledge were studied.

Four hypotheses were tested within the context of three experiments. The first hypothesis tested the effects of category structure on the number of features to which the learners pay attention. The second hypothesis investigated the effects of the category structure on the complexity of the theories developed in category learning. The third hypothesis tested how the category structure influences the effectiveness of communication, and the fourth was developed to indicate how the communicators who learned about categories with different structures influence each other in the course of communication.

The participants in this study learned about categories of natural stimulus, flowers from two geographical regions, with either complex or simple structure, and then they communicated the learned categories. The communication process was investigated in two ways: one-way and two-way communication. The

results of the experiments indicated that the structure of the categories influenced the the number of the features that the participants paid attention to. Participants who learned about complex categories developed a more complicated theory, and were less effective in communicating their theory. In addition, the structure of their knowledge influenced the pattern of interaction among them; as a result, the participants who learned the more complex categories were more influential in the course of interaction. The detailed analyses of the communication process, the results and potential contributions are discussed.

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Dedication

For Sepehr, Ali, and my parents.

I love you!

Table of Contents

List of Figures ix

List of Tables iix

Chapter 1 **Introduction** **1**

Chapter 2 **Literature Review** **4**

2.1 Category Learning 4

2.1.1 Supervised vs. Unsupervised Learning *4*

2.1.2 Category Learning Theories *5*

2.1.3 Simple versus Complex Stimulus *8*

2.1.4 Category Structure *11*

2.1.5 Summary of the Literature in Category Learning *14*

2.2 Communication 15

2.2.1 Note on the Connection between Categorization and Communication *15*

2.2.2 Cognitive Structures and Communication *17*

2.2.3 Communication between People with Different Knowledge *20*

2.2.4 Summary of the Literature Review in Communication *22*

Chapter 3 **Theoretical Background** **23**

3.1 Variability: Definition and Measurement 23

3.2 Category Learning and Variability 25

3.3 Communication Effectiveness 29

3.4 Communication between People - Learned Categories with Different Structures 32

Chapter 4 **Methodology** **35**

4.1 Overview of the Experiments 35

4.2 Stimulus Selection and Measurement 35

4.3 Pre-test 36

4.4 Experiment 1 41

4.4.1 Participants and Material 42

4.4.2 Procedure 43

4.4.3 Results and Discussion 44

4.4.4 Summary of the Results and Verification of Hypotheses 1 and 2 62

4.5 Experiment 2 64

4.5.1 Participants and Material 65

4.5.2 Procedure 65

4.5.3 Results and Discussion 66

4.5.4 Verification of hypothesis 3 68

4.6 Experiment 3 69

4.6.1 Participants and Material 70

4.6.2 Procedure 70

4.6.3 Results and Discussion 72

4.6.4 Summary of the Results of Experiment 3 and Verification of Hypothesis 4 89

Chapter 5 **General Discussion and Conclusion** **93**

5.1 The Effects of Category Structure on Learning 93

5.2 The Effects of Category Structure on the Communication of the Learned Categories 94

Chapter 6 **Contribution, Limitations, and Future Work** **101**

6.1 Theoretical and Methodological Contributions 101

6.2 Future Work 103

Appendices 106

Appendix A: The Assignment Probability for the Pictures of Flowers Used in Simple and Complex Set 106

Appendix B: Instructions 109

Appendix C: Questionnaire 114

Appendix D: Participants Comments in Echo-Method 117

Appendix E: Transcribed Conversations in Experiment 3 121

Appendix F: Instructions Provided in Experiment 1 and 3 155

Biliography 172

List of Figures

Figure 2-1 Typical stimulus that might be used in prototype distortion tasks presented in (Ashby & Maddox, 2005) 9

Figure 2-2 Three samples of the sketches used in Pimenta's experiment (Pimenta, 2011) 10

Figure 4-1 Pictures of flowers from region A and region B used for the simple set..... 39

Figure 4-2 Pictures of flowers from region A and region B used for the complex set..... 39

Figure 4-3 Efficiency for the simple and complex groups on the first half of the flowers (identical flowers in both conditions) for trials 1 to 5 47

Figure 4-4 Efficiency for the simple and complex groups on the second half of the flowers (different flowers in two conditions) for trials 1 to 5 49

List of Tables

Table 4-1. The variability within and between the flowers of region A and B for the *simple set* 40

Table 4-2. The variability within and between the flowers of region A and B for the *complex set* 41

Table 4-3 Mean differences in the number of trials across simple and complex conditions 45

Table 4-4 Comparing the mean efficiency between the first and second half of the flowers in the first trial 46

Table 4-5 Difference in the efficiency between complex and simple conditions in trial 1 to 5 for the first half of the flowers 48

Table 4-6 Differences in the efficiency between complex and simple conditions in trials 1 to 5 for the second half of the flowers 50

Table 4-7 Difference in the average number of questions asked per picture in both conditions 52

Table 4-8 Comparing the overall number of features asked per participants 52

Table 4-9 Features and categories to which they belong in the simple condition 54

Table 4-10 Features and categories to which they belong in the complex condition 55

Table 4-11 Examples of instructions with redundancy eliminated 57

Table 4-12 Comparing the number of words in the instructions after redundancy elimination 58
Table 4-13 Comparing the uncertainty score between simple and complex conditions 62
Table 4-14 Variables used for verification of hypothesis 1 63
Table 4-15 Variables used for verification of hypothesis 2 64
Table 4-16 Comparing the performance of the participants in assigning the flowers correctly to their regions 67
Table 4-17 Comparing the performance of the participants in each condition separated for the first and second half of the flowers 68
Table 4-18 Difference in the degree of contribution perceived by the participants of both conditions 73
Table 4-19 Differences in the perception of knowledge in both conditions 74
Table 4-20 Number of words after eliminating the redundancy for individual and group conditions 76
Table 4-21 Comparison among the uncertainty scores of group and individual conditions 78
Table 4-22 Comparing the level of contribution of each participant in providing the instructions 78
Table 4-23 Summary of the comments that the complex condition's participants made 80
Table 4-24 Summary of the comments that the simple condition's participants made 82

Table 4-25 Comparing the simple and complex participants in starting the conversation 85
Table 4-26 Comparing the number of proposed features and percentage of acceptance of simple and complex participants 86
Table 4-27 Variables used to compare the instructions in three conditions 91
Table 4-28 Comparing the percentage of acceptance for simple and complex conditions 92

Chapter 1 Introduction

Categorization is a basic cognitive process, which affects cognitive skills such as learning and communication (Markman & Ross, 2003; Markman & Makin, 1998). We investigated how the complexity of categories affects processing of information during category learning. Further, we examined how the structural differences in categories affect the communication process of the learned categories. As an example of the phenomenon, consider how a Torontonian, in contrast to a citizen of a small town in northwest community, communicates information about "Canadian" people. The latter may categorize and refer to "Canadian" people as "White" ethnic due to less variation in his/her category of "Canadian" people. However, the Torontonian may recognize different types of ethnicities as "Canadian" and talk about multicultural aspects of Canadians. The category of "Canadian" people for the Torontonian has higher variation because it may include diverse ethnicities, which could overlap with the category of "non-Canadian" too.

Previous studies have shown that the structural complexity of categories, in terms of the variation within and between the categories, contributes to learning difficulty (Kloos & Sloutsky, 2008; Minda & Smith, 2001); however, there has been little attention to how the complexity of the category influences the number and type of the features that people focus on during the category learning.

In the field of communication, various studies have reported on the difficulties experienced in the process of communication when communicators are working within different knowledge structures presumably acquired in their learning process (i.e., communication between patients and physicians, or communication between experts and novices); however, these studies have done so without providing much theoretical explanation (Thompson et al., 2011). In this study, I focused on categorical knowledge in order to investigate the difficulties in the process of communication.

The communication process between two communicators is dynamic and constantly affected by the information that both communicators receive from each other. The literature in the fields of communication and social psychology states that a successful communication is connected to the communicators' ability to create a mutual understanding among the communicators (Fussell & Krauss, 1992), and that the communicators try to fill the knowledge gap during the communication process (Isaacs & Clark, 1987). However, there has been less attention on how the communicators judge each other's knowledge (Fussell & Krauss, 1992).

The main purpose of the current study is twofold. First, I demonstrate that the complexity in the strcuture of the categories affects category learning with respect to the number and type of features that people process, as well as the kind of theory they develop to distinguish between the two categories. Second, I investigate the influences of the categorical complexity on the communication of the learned categories and the degree of its effectiveness. In addition, I am

interested in observing how the structural differences in the learned categories influence the pattern of conversation between people with different categorical knowledge. Even though communication and categorization are related cognitive skills, the communication process of the learned categories has not been explored, as far as I can determine.

Chapter 2 Literature Review

The main objective of this research is twofold. First, I would like to investigate the effects of category structure on information processing during category learning, and second, I would like to examine the effects of the structure of the learned categories on the communication of those categories. Therefore, in this chapter, I will review the literature related to category learning and communication that initiates the thoughts on the relationships among category structure, category learning, and communication of the learned categories. Further elaboration on the literature and the connection to the current study will be presented along with the theoretical background and discussions. The fields of category learning and communication are hugely investigated from various approaches. The aim here is not to review all the literature in the two areas. Instead, that part of the literature that could potentially contribute, or be connected, to this research will be reviewed. In the following sections, I will first review the literature related to category learning and second, the communication of the learned categories.

2.1 Category Learning

2.1.1 Supervised vs. Unsupervised Learning

Before reviewing the literature related to category learning, it will be helpful to note two classes of category learning: supervised and unsupervised. Supervised learning means that either the learners receive corrective feedback during the

category learning (Medin & Schaffer, 1978; Nosofsky, 1987; Gluck & Bower, 1988; Nososfsky et al., 1994) or they are told the rule of classification explicitly (Kloos & Sloutsky, 2008). Supervised learning is intentional, and encourages the search for rules and hypotheses testing (Love, 2002). In unsupervised learning, the learners are not provided with feedback. Learners learn about categories through seeing members of the target category and may not be exposed to the non-members.

The existence of the feedback in the process of supervised learning can promote different mechanisms from those in unsupervised learning because learners may experience different psychological situations. The current research is concerned only with learning categories under supervised conditions, and with communicating them.

2.1.2 Category Learning Theories

Category learning has been investigated by many researchers (Medin & Schaffer, 1978; Nosofsky, 1988; Estes, 1986; Kruschke, 1992; Gluck et al., 2002; Love et al, 2004). Various theories have been proposed to predict the performance of people during category learning. (Nosofsky, 1987; Estes, 1986; Maddox & Ashby, 1993). A typical study in this field begins with showing samples of the target category and contrasting category in a certain number of trials. Then the subject is asked to allocate a novel item in one of the categories. The goal of the researchers is to predict the performance of the participants in categorizing the novel items.

Two main category learning theories discussed in the literature are prototype theory and exemplar theory. The prototype theory states that people learn categories by learning the category's prototype. Based on this model, during category learning, people form prototypes of the category and then compare the novel item to the prototypes of the categories. This means that the performance of the learner can be modeled as a function of the similarities between the test items and the prototype, or prototypes (Rosch et al., 1976; Smith & Minda, 1998; Estes, 1986).

Exemplar theory (Medin & Schaffer, 1978) stated that, during category learning, people can learn all the exemplars of the categories, not only the prototypes. Therefore, observing a new item, one compares it to the retrieved exemplars of the category that have been learned previously; the performance of the learner can be modeled as a function of similarities between the test item and all the exemplars (at least those that the learners remember) (Medin & Schaffer, 1978; Nosofsky, 1986; Estes, 1986).

There have been efforts to compare the two models (Minda & Smith, 2001) or to combine them (Estes, 1986). The results of these studies indicated that, depending on the type of the stimulus, one model or another would predict the performance of the subjects better[1]. Nevertheless, there is a consensus among the researchers in this field that, during category learning, people try to find

[1] This study will be explained in details later.

similarities among the members of a category and find the differences between the target category and the contrasting category. Similarity has been defined based on the number of common and distinct features among the items (Tversky, 1977). Under feature-based similarity an item is similar to another item when the two have one or more feature in common.

Followers of the prototype and exemplar theories demonstrated that under various conditions one model might work better than another one. More recent literature has acknowledged different mechanisms underlying category learning (Ashby & Maddox, 2005, Sloutsky, 2010). From current literature in category learning, we know that various cognitive mechanisms underlie category learning, depending on the stimulus (Yamauchi & Markman, 1998; Ashby & Maddox, 2005; Sloutsky, 2010). The neuro-psychological as well as neuro-imaging studies have had essential roles in identidfying the cognitive mechanisms of category learning (Ashby & Maddox, 2005). Ashby and Maddox (2005) classified and reviewed these studies and indicated that the type of the tasks and stimuli used during category learning lead to different cognitive mechanisms (Ashby et al, 1998; Ashby & Maddox, 2005, Sloutsky, 2010). For instance, when categories are easily distinguishable due to simiplicity of their structure, "rule based" tasks (Ashby & Maddox, 2005), hypothesis testing and reasoning are reported as the underlying cognitive mechanisms. The hypothesis testing system involves working memory[2] and attentional processes, and is

[2] Working memory is a short-term ability to maintain and manipulate limited amount of information (Baddeley, 1995). Prefrontal cortex has been associated as the main neural structure supporting working memory (Ashby & Maddox, 2005)

thought to rely on the prefrontal working memory system (Ashby & O'Brien, 2005); however, when the structure is more complex and distinguishing the categories is relatively difficult, "information-integration task" (Ashby & Maddox, 2005), the rules are not immediately obvious, and combination of rules and dimensions is necessary. In addition, the stimulus may be treated as a gestalt. The mechanism of learning is thought to be implicit, procedural learning-based, and dependent on the posterior striatum (Ashby & Maddox, 2005)[3]. The contribution of Ashby and Maddox (2005) is valuable in indicating the differences in learning the stimuli with different structural properties.

2.1.3 Simple versus Complex Stimulus

The theories mentioned above are mostly developed based on a stimulus with a limited number of features (Medin & Schaffer, 1978; Estes, 1986; Kruschke, 1992). This has been claimed as one of the shortcomings in the literature of categorization (Markman & Ross, 2003). An example of the common stimulus used in category learning is the constellation of dots (Figure 2-1) in which a random presentation of 7 to 9 dots is considered as the prototype. The other exemplars of the category are then formed by random distortion of the prototype (e.g., Homa et al. 1979; Posner & Keele, 1970; Shin & Nosofsky 1992). One reason for the popularity of such a stimulus is that the researchers wish to control the effects of the previously learned concepts on the categorization tasks. However, one can argue that there is no guarantee for such a control. In the

[3] Procedural memory is the memory for "how to" (e.g. how to ride a bike). The characteristic feature of procedural memory is that it is acquired gradually through practice and is not easily communicated verbally to others (Ashby & Maddox, 2005).

example of the dot-constellation, it is likely that one perceives the dots similar to certain concepts. For example in Figure 2-1, subjects may perceive the dots similar to letter “C” or “A”. In a series of experiments, Pimenta (2011) indicated that people used similar labels to communicate random sketches. For example, a random sketch shown in Figure 2-2 (a) was communicated by being labelled as “fetus” by 27% of participants, and the one presented in Figure 2-2 (c) was labelled as “tornado” by 30 % of the participants.

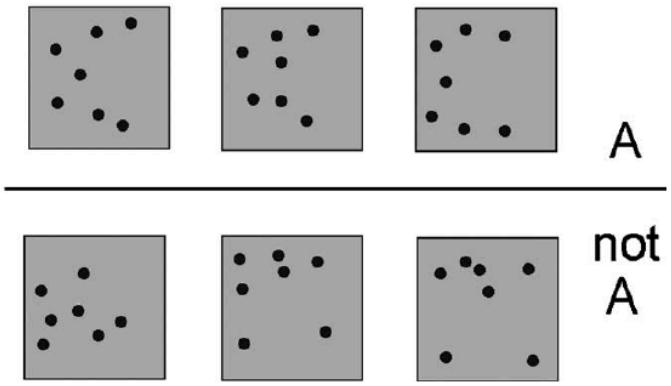
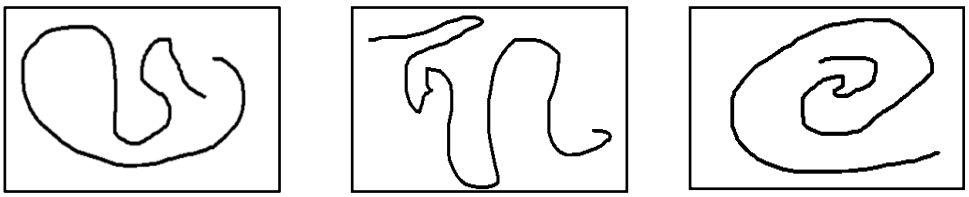


Figure 2-1 Typical stimulus that might be used in prototype distortion tasks presented in (Ashby & Maddox, 2005)



(a) (b) (c)

Figure 2-2 Three samples of the sketches used in Pimenta's experiment (Pimenta, 2011)

In the day-to-day experience of categorization, people are not isolated; their previous knowledge affects the categorization. In such cases, the previously learned concepts may still affect the categorization as well as category learning.

Another type of stimulus used in category learning is a set of imaginary creatures or geometrical shapes with certain numbers of features (dimensions) and values (Kloos & Sloutsky, 2008; Ashby & Ell, 2001; Minda & Smith, 2001; Yamuchi & Markman, 1998). These types of stimulus enable the researchers to measure the similarity and describe the learning process quantitatively. For example, Kloos and Sloutsky (2008) used imaginary creatures with six binary dimensions and calculated statistical variance among the category members as well as the variance between the members and non-members to find the effects of category structure on the category learning process.

In general, there has been less attention to learning the categories of complex stimulus. When the stimulus is complex and consists of many features with potentially various and non-discrete values, it is not clear how individuals perceive similarities to the prototype or other exemplars of a category. For instance, how would we identify facial similarities? In many cases we can judge the similarity between two faces without identifying the similarities between

their components. It is reasonable to study the categorization behaviour of the natural objects in addition to simple laboratory-designed stimuli.

A few studies have focused on learning natural categories. Gonzalez and Madhavan (2011) found that diversity in the training of categories increases the performance in categorizing a novel item. They used categories of dangerous and non-dangerous objects in luggage-screening tasks. Participants of this study were trained in two groups. One group (high diversity) learned about five categories of dangerous items while the other group (low diversity) learned about only one group of dangerous items. The group with high diversity demonstrated a better performance in deciding whether a novel item is dangerous or not. In another study, Goldstone et al. (2001) used pictures of faces to explain the effects of category membership on the similarity judgment. The results indicated that faces labelled under the same categories are judged to be similar not only because they shared the label, but also because when two items are grouped in one category, the shared features are emphasized.

2.1.4 Category Structure

The differences in the category structure affect the categorization and category learning (Kloos & Sloutsky, 2008; Minda & Smith, 2001; Kruschke, 1992; Medin & Schaffer, 1978; Nosofsky, 1988, Canas, 1985). Canas (1985) used the subjective distance as a measure of similarity within and between the categories of proverbs to investigate the structure of the manual categorization of unstructured documents. In the field of category learning, Minda and Smith

(2001) used line-drawn bug-like creatures consisting of four, six, or eight features with binary values. They defined the category structure as the ratio of within similarity over between similarity based on the similarity in features (Tversky, 1977). In addition, they used categories in different sizes such as categories with 5, 7 or 15 members. The results indicated that the bigger the categories, the more likely it is that subjects use prototype rather than the restored exemplars to judge about the membership of a novel item. The same effect was observed when the number of dimensions increased. One reason for such a difference, they claimed, could be that with the increase in the size, a learner may not able to memorize and retrieve all the exemplars, and instead may focus on the prototype. Comparing the poorly-structured categories (low ratio of within/between similarity) to the well-structured categories (high ratio of within/between similarity), there was not a significant difference between the two models in predicting the learners' performance. They concluded that the structure of the category in terms of size and dimensions of the stimuli can affect the mechanism that subjects employ during the category learning.

In another set of experiments, Kloos and Sloutsky (2008), investigated the process of category learning in relation to the structure of categories. They defined the category structure with the help of "statistical density" (Kloos & Sloutsky, 2008), which is defined as "the proportion of category relevant variance to the total variance". Variance is a measure of variability and calculated through entropy (H) (Shannon, 1948). Statistical density is a function of entropy within and between categories.

$$D = 1 - \frac{Hwithin}{Hbetween}$$

High density refers to low variance within the members of the target category and high variance between the target category and the contrasting category. Low density, then, means that there is high variance within the members of the target category and low variance between the target category and contrasting category. The members of high-density categories have multiple inter-correlated features (e.g. animal categories such as dogs, cats, etc.); however, low-density categories have few common features (e.g. high-level concepts: everything that moves). They used six features (binary value) creatures as the stimulus. The subjects learned about the items of the target catgeory in two conditions. The first condition (unsupervised learning), they were only shown the items and then were tested on both target and contrasting items. In the second condition (supervised learning), the subjects were given the rule common among the members of the target category while the items are shown to them. The subjects were tested on both target and contrasting catgeories. The results indicated that categories with high density can be learned easily without any supervision, while learning the categories with low density requires supervision. They define supervision as giving the rules of the category to learners. That study shows that in learning the categories with low density, both adults and toddlers face difficulties in distinguishing the items of the target categories compared to learning the categories with high density.

2.1.5 Summary of the Literature in Category Learning

The literature in the field of category learning has acknowledged the effects of category structures in category learning. The structure was considered as the ratio of similarity within over similarity between the categories (Minda & Smith, 200l; Canas, 1985) or the variance within over the variance between the categories (Kloos & Sloutsky, 2008). Similarity was measured by the number of common features among the stimuli. Since the stimuli, used in most of the studies, are laboratory designed and have few features and related values, finding the similarities between and within the category members as well as statistical variance is possible quantitatively. The results of these studies indicated that learning the categories with complex structures, in which the ratio of within similarity to between similarity is low, is more difficult than learning the categories with simple structure, in which the ratio of similarity within to between is high. I will follow this line of literature in defining the structure of the categories for the current study, and will extend the results of these studies in learning the natural categories. I will use the similarity within and between the categories to approximate the complexity of the natural categories through a different method, which will be discussed in Methodology.

The literature also indicated different neuro-cognitive mechanisms in category learning depending on the types of the stimulus used in the experiments (Ashby & Maddox, 2005), but it does not elaborate on how the learner may process the information about the stimulus differently as a result of different structure. For example, I could not determine from the literature whether the learners who are

learning complex categories pay attention to similar number and types of the features compared to those who are learning simple categories. Part of the current study is aimed at elaborating on this point, and will investigate the effects of the category structure on the ways that the learners pay attention to features and process the related information.

2.2 Communication

2.2.1 Note on the Connection between Categorization and Communication

We learn categories through our social interaction (Rogoff, 1990) and modify our knowledge structure through communication of our knowledge (Freyd, 1983, McGlone & Giles, 2011). Nevertheless, the literature in categorization is criticized for not focusing on the function of categorization in communication (Markman & Ross, 2003), even though communication and categorization are clearly interrelated.

A few interesting studies have focused on the relationships between categorization and communication (Markman & Makin, 1998, Duimering, 1997; Voiklis & Corter, 2012). Duimering (1997) focused on the categorical relationship between events and language by which an event could be communicated from different aspects and in different terms. He showed that the categorical relationship between the event and words allows employees to formally communicate the events in words that are associated with positive

valance (Lewin, 1935) in the organization. This study demonstrated the effects that the categorical properties of language have on the communication process.

In a different type of study, Markman & Makin (1998) studied the relationship between the communication and category acquisition. In a set of experiments, they compared two conditions of sorting Lego pieces to observe the effects of communication on the consistency in categorization. Under one condition, a group of two participants named the Lego pieces and communicated to build Lego models (either a car or spaceship) and then they sorted the pieces separately. Under the second condition, individual participants built a model (either a car or a spaceship) and then sorted the Lego pieces. The results indicated that the communication (naming and building the model together) of a same model creates consistency in sorting the Lego pieces. In another study, Voiklis & Corter (2012) stated that communicating conventions of reference leads to better category learning. They compared two conditions of category learning of a fictitious stimulus: individual condition versus group condition. In the group condition, two participants had to communicate to learn the categories and then were tested individually. However, in the individual condition, both learning and testing were done individually. The experimental setup encouraged the communicators of the group condition to come up with labels as reference points to compelete the learning procedures. They concluded that the communication between the participants in the group condition led them to have more accurate learning than did the individual condition. This means that the participants of the group condition were able to figure out the required features

faster than the participants of the other condition. This difference was attributed to the fact that the communication between the group members influenced the pattern of selective attention, and they were therefore able to pay attention to more features in identifying the category of the simulus.

The studies mentioned above indicated realtionships between the communication process and categorization. The study by Voiklis & Corter (2012), closest to the current study, focused on the effects of communication on category learning and indicated that communication is helpful in learning the complex categories. However, the relation between the category structure and communication could be invesitigated from other directions as well. In the current study, I am interested in how the structure of learned categories affects the communication of the categories, which I could not determine from the literature.

2.2.2 Cognitive Structures and Communication

Literature in the field of interpersonal communication has acknowledged that people's cognitive structure affects their communication process (Berger & Palomares, 2011; Greene & Graves, 2007; Voss, et al., 1980). In this field the relation between cognition and communication has been discussed mostly in the context of message production. An individual's purpose of interaction (goal) and the way the goal is put into a plan are claimed to affect the communication process in terms of the utterance formation (Dillard, 1990; Wilson & Feng, 2007; Berger; 2007). For instance, assuming that communication is a goal-directed action, Berger (2007) stated that communicators understand each other

if they can determine each other's goals and actions. The contextual information and the actions of the communicators facilitate the communication process through providing certain clues to the other communicator's goals (Berger & Palomares, 2011). The successful communication, then, means that the produced message fits to the goals of the listener. This theory, however, does not explain how to ensure that the communicators are correct about each other's intentions and goals, and it assumes that people are clearly aware of their own intentions. The other shortcoming of this theory is that it does not focus on the interaction between the communicators. Focusing on the individual goals does not explain the dynamic nature of the communication processes. For instance, one may initiate a communication for certain purposes, such as being respectful to a colleague, and then may immediately change the goal upon the responses that he/she would receive from the other communicator. As a result, the interaction between the communicators is not explained in this theory, which could be the appropriate unit of analysis in social systems.

The communication process has been compared to planning and problem-solving skills cognitively. In their study, Voss, et al., (1980) asked two groups of individuals with high knowledge in the baseball domain and low knowledge in the same domain to generate domain-related text. People with a higher level of knowledge domain indicated higher ability to generate text with more details about the domain, as well as recalling their generated task after two weeks. They claimed that text generation could be explained through problem-solving frameworks. As a result, they attributed the differences in two groups to

individuals' problem space and ability to monitor solution paths. This study acknowledges the fact that experts' knowledge is more complicated and associated with more details; however, the communication process studied in this work is a one-way communication (written communication) and still does not consider the effects of interaction among the communicators.

Communication is affected by cognitive complexity (O'Keefe & Sypher, 1981), which refers to the higher distinction in cognitive "constructs" (Kelly, 1955) and is connected to the development of the constructs. The more the constructs develop, the more distinct they become. For instance, a young child has limited constructs about people such as "good and bad". However, an older child or adult has more developed and differentiated set of constructs such as "nice versus mean", "friendly versus snobbish", "honest versus liar". The authors reviewed the connection between cognitive complexity and communication by reviewing the communication abilities reported for students from second to ninth grade. The results indicated that the students in higher grades had higher abilities in using persuasive patterns of communication. For instance, in a communication set-up between a student and his/her parent, while a lower-grade student may phrase his request as " I need a puppy", a higher-grade student phrased his request as "if you buy me a puppy I will wash your car everyday".

The above-mentioned studies indicated certain relationships between cognitive differences and communication. The common practice in the field of cognitive communication is to consider one communicator as the level of analysis instead of the interaction between the communicators. Individual level of analysis does

not account for the contextual variables in the communication process, and could not explain the difficulties in the communication process (for instance, why the communicators cannot understand each other's intentions and goals, and how their goals change in the course of the communication). In addition, the categorical representation of knowledge in terms of categories has been rarely considered in the field of interpersonal communication. When it is considered in terms of cognitive constructs the communication is not focused on the communication of those constructs.

2.2.3 Communication between People with Different Knowledge

In the literature of interpersonal communication, there is evidence of difficulties in the communication between people with different knowledge. Many studies have reported difficulties in the communication between patients and physicians (Thompson et al, 2011) and experts and novices (Burger et al, 2010). However, these studies have been criticized because of insubstantial theoretical background (Thompson et al, 2011). As an example, the communication between patients and physicians has been reported to affect health outcomes (Ong et al, 1995; Plat & Keating, 2007). Different researchers have acknowledged the difficulties in information exchange between patients and physicians, and consequently, decision-making problems (Ong at el., 1995; Plat & Keating, 2007; Arora, 2003). Plat & Keating (2007) indicated that perception gaps as well as terminological differences give rise to lower health outcomes as well as dissatisfied communicators. Even though different tools and methodologies such as interviews and observations have been used in these

studies (Arora, 2003), a lack of conceptual work on how the process of communication is working, and a lack of strong theoretical ground have been claimed as the main shortcoming (Thompson et al., 2011).

Successful communication has been discussed in relation to the successful development of shared understanding in the field of social psychology (Fussell & Krauss, 1992). Isaacs & Clark (1987) explained that the communicators try to assess each other's knowledge on the topic of communication and then they adjust their communication accordingly. They designed an experiment in which pairs of communicators, one familiar with New York City and one unfamiliar, communicated to sort pictures of New York landmarks while they couldn't see each other. The results indicated that when the communicators realized that the other person is familiar with New York landmarks, they use labels of the landmark to communicate; however, when they realize that the other communicator is not familiar with the landmarks, they use general attributes shown in the picture to communicate. Fussell & Krauss (1992) found that people use fewer words to explain landmarks that are more identifiable to other people than the ones that are not easily identifiable.

These studies acknowledged the fact that to have a successful communication between people who have different knowledge, one has to "take the perspective" (Mead, 1934) of the other communicators and tune the message to the other communicators' knowledge. However, the elaboration on how a communicator may estimate the other communicators' knowledge is still weak (Fussell & Krauss, 1992).

2.2.4 Summary of the Literature Review in Communication

A few studies in the field of communication investigated the effects of communication on category learning, and indicated that communication can enhance category learning (Voiklis & Corter, 2012) and category acquisition (Markman & Makin, 1998); however, the opposite direction of how communication can be influenced as a result of differences in the categories have not, to my knowledge, been studied. It is possible that people learn about categories differently. For instance, two individuals may learn about the category of "cancer" in different contexts: one from listening to the news and the other from experiencing cancer in the family. The different experiences may result in different cognitive structures of their knowledge about "cancer", which could potentially affect the ways they communicate about "cancer". In the literature, the suggested solution to this problem is to consider the other communicator's knowledge. However, the literature yet has been reporting difficulties in the communication process between people with different knowledge.

Even though the literature has acknowledged the effects of cognitive structures on communication, within this context it is mostly focused on the goals and intentions of the communicators in the process of communication rather than the effects of cognitive category structures on the process of communication. The aim of this study is to explain the effects of category structure on the communication process. I will use the findings in the field of category structure to elaborate on the communication process of learned categories.

Chapter 3 Theoretical Background

The main goal in this chapter is to elaborate on the effects of category structure on category learning and on the communication of learned categories. Literature in the field of category learning indicated that the category structure influences category learning in terms of the learner's performance and accuracy. In the field of communication, the literature acknowledges the connection between cognitive structures and the communication process; however, the communication of learned categories and the effects of category structure on communication have had less attention, if any.

In the following paragraphs, first, I will elaborate on how the structure of the categories influences the ways that the learners process the information during the category learning. Second, I will explain that the complexity in the category structure not only affects the information processing but also influences the communication process of the learned categories.

3.1 Variability: Definition and Measurement

What does variability mean? If we have a category of identical squares with 2 cm sides, all in the same colour and thickness, the variability in this category is zero. Now, if we change a certain feature, we add variability in the category. For example, if the category includes squares with 2 cm sides as well as 3 cm, we

add one more value to the feature of "sides' size". Adding squares with different colours such as red and blue to the same category increases the variability even more. Therefore, the more features and related values there are, the more variability is perceived in the category. Variability is a measure of distinction and could be approximated through statistical variance. In an optimal categorization, items categorized in one category have the least within variability (or the most similarity), while the variability between the category and the contrasting category is in its maximized amount (or the least similarity).

In the literature, the structure of categories have been quantified through the ratio of within to between variability (Canas, 1985), the ratio of within to between similarity (Smith & Minda, 2001), and the ratio of within to between variance (Kloos & Sloutsky, 2008). When the number of the features and their values is limited (e.g. shapes (square, triangle), colour (blue, red), size (small, big)) the similarity can be measured through feature matching mechanism (Tversky, 1977; Smith & Minda, 2001; Nosofsky,1986; Estes, 1986); however, when the stimulus is complex with an unlimited number of features and relative values (e.g. pictures of flowers, faces) the similarity can be approaximated through subjective judgment (Mervis & Rosch, 1981; Shafto & Coley, 2003; Goldstone, 1994). In the same way, distinction can be measured through statistical variance when the stimulus is characterized by limited number of features and values (Kloos & Sloutsky, 2008). For a complex stimulus, the distinction cannot be quantified mathematically but can be judged subjectively.

I use variability as a broader concept than statistical variance by which I try to explain the variation within the members of a category (within variability) and the variation between the members of the target and contrasting categories (between variability). It could be approximated through statistical variance when the stimulus is characterized by limited features or could be subjectively judged when the stimulus is complex. In the natural categorization the number of features increases and their values are not binary, nor limited to few values, any more, making it difficult to use a mathematical formula. For example, it is difficult to measure the variability within the category of "Canadian faces". The variability within the faces of Canadian people could be due to various features such as skin colour, eyes, nose, hair colour, etc. Each of the mentioned features could have various values not necessarily binary, nor even discrete.

3.2 Category Learning and Variability

Learning the categories, we try to find what makes the members of a category similar, and different from, another category. For example, learning about two categories presented in figure 3-1(a), one can notice that the feature "shape" explains the distinction between the categories. Considering the feature based similarity for the sake of the argument, members of each category are similar because they have the same value for the feature "shape" and are different because they have different values for the feature "shape". The learner's theory about how to distinguish the categories could be developed simply according to the feature "shape".

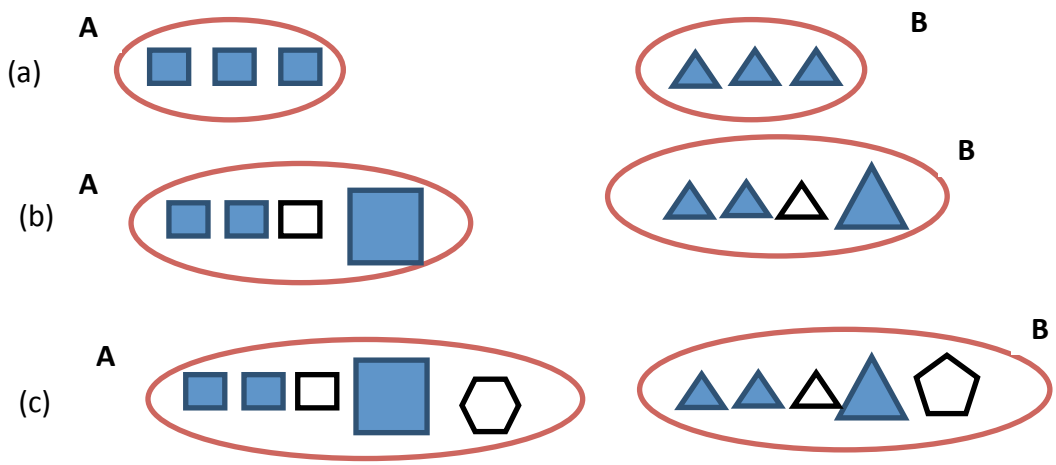


Figure 3-1 Changes in the variability within and between the categories

In figure 3-1(b), the items in category A and B varied with respect to features "colour" and "size". However, the feature "shape" still allows for the distinction perfectly. A potential learner may test the hypothesis that colour and size are definitive features. Upon the rejection, the hypothesis of difference in shape can be formed, which is correct in these cases. As a result, the learner will assign a given square to category A and a given triangle to category B no matter its size and colour. In both sets of categories 3-1(a) and 3-1(b), the learner looks for the features to define the similarity within and differences between the categories.

Figure 3-1(c) shows a case that new items are introduced in both categories A and B. There is higher variation with respect to the feature "shape" because it holds four values of "triangle", "square", "pentagon" and "hexagon". Learning about the two categories in this case, the learner may begin by forming a

hypothesis about the "shape", but realizes that the hypothesis no longer works. In fact, the learner may not even able to form a hypothesis about the shape. If the learner is presented with the two categories presented in Figure 3-1(c) and then asked to categorize an octagon, the person may not be sure to what category the octagon belongs.

The learner realizes that a simple rule that could explain the categories (such as A is a category of triangles) does not work here, and as a result, is forced to develop a more complicated theory such as "A is the category of four squares and one hexagon". In addition, a lack of simple theory will force the learner to look for additional features to justify the categorization. The hexagon and pentagon necessitate attention to extra or hidden features that could explain the categories. In this case, one may change the feature "shape" to the feature "number of sides" and develop a theory of "category A shapes have an even number of sides".

Attention to the extra features is the result of changes in the structure of the categories, which has been addressed through the ratio of within to between variability (or similarity) in the literature (Minda & Smith, 2001; Canas, 1985; Kloos & Sloutsky, 2008). The literature indicated that when the ratio of variability within to variability between is high, the learners experience more difficulty in learning the categories, compared to learning the categories with low ratio of within to between variability. Later, I will explain how I measured the within and between variability for the stimulus used in this study.

The higher ratio could be the result of higher variability within (i.e. different items grouped together) and/or lower variability between (i.e items grouped in two categories are similar) the categories. In such cases, finding the theory that distinguishes between the categories is difficult because items grouped in one category could be very different. At the same time, items grouped in distinct categories can be very similar. Therefore, in this situation, one has to pay attention to more features, test more hypotheses, and develop a more complicated theory for distinguishing the categories. In some cases, the learner may have to focus on features that are not easily perceivable and might have been ignored otherwise.

In Figure 3-1(c), the complexity in the structure of the categories causes the rejection of initial hypotheses about "shape as a definitive feature" and forces the learner to pay attention to the number of sides, which is ignored in learning the categories of Figure 3-1(a) and 3-1(b). In fact, the simple structure of the Figures 3-1(a) and 3-1(b) does not encourage attention to extra features. When the ratio is low, the variability within the members of the categories is low and/or the variability between them is high. As a result, the theory to distinguish between the categories can be found easily. Under this condition, the person needs to pay attention to fewer features, test fewer hypotheses, and as a result develops a simpler theory.

Therefore, the first and second hypotheses state that

Hypothesis 1*: The higher ratio of within to between variability in the categories increases the number of features that the learners pay attention to.*

Hypothesis 2*: The higher ratio of within to between variability in the categories increases the complexity of the theory that the learners develop.*

The literature in this field does acknowledge the variability within and between as a measure of complexity in the structure of the categories and showed the effects of the complexity of the structure on the difficulty in category learning, but it has not elaborated on what happens to the learner in terms of attention to more features when the complexity of the categories increases. The two hypotheses above extend the effects of structure on category learning in terms of the number of features processed and the type of theory developed by the learner during category learning.

3.3 Communication Effectiveness

In real life situations, people have formed cognitive categories with various degrees of variability due to their interests, formal trainings, and experiences. For instance, the words used by the Inuit for snow have been claimed to be far more numerous than is the case in English (Martin, 1986). Due to their special circumstances, there exists high degree of variation in the category of "snow" for the Inuit compared to people who live in areas with less or no snow.

Assuming that the structure of the categories that people learn affects the ways that they pay attention to features, then the next question could be how they communicate their categories. Are there differences in the communication

process when people have different categories? This question can be answered by considering the situations that each learner has experienced during category learning with respect to the number of the features that they pay attention to.

The words that people use to communicate about their categories correspond to the features that they paid attention to and the theory that they developed. As a result, the person who noticed more features uses more words to communicate the learned categories. In addition, the complexity of the category's structure can affect the way that people verbalize their categories. Learning the categories with a high ratio of within variability to between variability, the learner tests and rejects more hypotheses, and experiences difficulties in finding a simple hypothesis that could explain the organization of the categories. However, when the categories have a low ratio of within to between variability the learner develops a simple theory in which fewer features are presented.

For instance, assume two Canadians: one from Toronto and one from a small northwest town in Canada. Their categories about Canadian versus non-Canadian people may differ in terms of the degree of variability. For a Torontonian, the category of Canadian has high within variability because it includes various races and ethnicities. At the same time, the category of Canadian and non-Canadian overlaps significantly and has low between variability. However, for a the person from the northwest community the category of Canadian may have less variation and could be separated from non-Canadian more easily than would be the case with the Torontonian's categories. If these two individuals are asked to communicate and judge whether a third

person is Canadian or not, the communication process will be different for each one because the degree of variability is different in their categories.

The person from the northwest community pays attention to fewer numbers of features and explains that the person is not Canadian with a good chance if he/she has an Asian face; however, the Torontonian could not make such a judgment with high certainty. The Torontonian could say that this person might be either Canadian or not and we have to check other features such as accent to decide about the originality. In fact due to higher variation within and low variation between his/her categories (high ratio), feature white is not enough information to reduce the uncertainty. The uncertainty then is transferred into words in the communication process. For instance, while the theory developed by the person from northwest community could be simply stated as " Canadians are mostly white", the Torontonian's theory could be verbalized as "if the person lives in northern parts of the Canada and is white then he is most likely Canadian". Alternatively, the Torontonian may have to refer to extra or hidden features such as accent or the residential location in his theory. The complexity in the categories is then presented in the structure of the sentences and the type of the words.

When learning categories with high ratio of within to between variability, the learners experience a different situation because they had to test more number of hypotheses, experience more rejections of the hypotheses that they had to test, and has to pay attention to hidden features. Many of the features to which they pay attention may not account for all items in the category. The learner may

even need to consider more exceptions, which could increase the uncertainty about his/her own theories. Learning the categories with high ratio of within to between variability requires more information. The learners need to consider more features and process more information in order to explain the categories. As a result, the learners face more uncertainty during the learning process, which is also reflected in the developed theories.

We expect that the uncertainty experienced by the learner and the complexity of the theories developed for distinguishing the categories with high ratio of within to between variability be transferred in the communication of the categories and decrease the effectiveness of communication because listeners may be confused exposure to more features, more information, and more uncertainty. Therefore, the third hypothesis states that

Hypothesis 3*: Communicating the categories with high ratio of within to between variability is less effective than communicating the categories with low ratio of within to between variability.*

3.4 Communication between People - Learned Categories with Different Structures

As mentioned earlier, individuals who learned categories with high ratio of within to between variability pay attention to more features and developed a more complicated theory. When the two individuals communicate to each other, each refers to his/her own theories developed for distinguishing the categories. People who learned categories with low ratio of within to between variability

develop a simple theory that consists of few numbers of features; however, those who learned categories with high ratio of within to between variability developed theories that include more number of features and are more complicated. The complicated theories may include combination of features and the features may be presented in probabilistic ways. Back to the example of Canadian vs. non-Canadian people, the Torontonian with higher ratio of within to between variability may refer to the feature of accented speech along with facial features. However, the person from the northwest community may only refer to facial features and totally ignore the accent, since the facial feature is enough information to reduce the uncertainty in his categories of Canadian vs. non-Canadian. The communicators, with low ratio of within to between variability, notice that they have ignored some potential features and are impressed by the attention of the other communicators to those hidden features. They feel that the other communicators are more careful and more deliberate. As a result they feel that they have not paid attention to enough features and their theories are not informative enough.

Therefore, we expect to see that people who learned categories with a high ratio of within to between variability influence people who learned categories with a low ratio of within to between variability in the course of interaction. Therefore, hypothesis 4 states that:

Hypothesis 4*: when two individuals who learned categories with different degrees of variability are communicating, the person who learned categories with high ratio of within to between variability is more influential than the person who learned categories with low ratio of within to between variability.*

Hereafter, for the sake of simplicity, the categories with high ratio of within to between variability will be called complex categories and the categories with low ratio of within to between variability will be called simple categories.

Chapter 4 Methodology

4.1 Overview of the Experiments

A set of three experiments was designed to test the effects of structural complexity on the way that people process information in category learning and communication. I expected to see that when learning complex categories[4], people would pay attention to more features and develop a more complicated theory to distinguish between the categories than when learning simple categories. In addition, it was expected that the categorical complexity would affect the communication process and result in less effective communication. Moreover, in the process of communication between two communicators (one learned about complex set of knowledge and the other learned about simple set of knowledge), I expected to see that the person communicating the complex categories is more influential in the course of interaction.

4.2 Stimulus Selection and Measurement

As mentioned in Section 1.1.3, laboratory-designed stimuli with limited numbers of features such as geometric shapes or imaginary creatures have been used extensively in the field of category learning because they provide a good

[4] As a reminder: For the sake of simplicity, the categories with "high within and low between" variability will be called complex categories and the categories with "low within and high between" variability will be called simple categories hereafter.

degree of control for the experimenter and the possibility of quantitative analysis (Kloos & Sloutsky, 2008; Minda & Smith, 2001; Yamuchi & Markman, 1998). At the same time, it has been claimed that such simple stimuli may not indicate the real ways people interact with natural categories on a day-to-day basis (Markman & Ross, 2003). Hence, a few researchers used natural stimuli such as pictures of faces (Goldstone et al, 2001; Gonzalez & Madhavan, 2011).

In this study, I used pictures of flowers randomly selected from the two geographical regions of Alaska and Hawaii. The pictures were selected from specific photographers' websites. Categories of natural stimuli may not have the clear boundaries of the laboratory-designed stimuli. For example, the category of triangles versus the category of squares has a very high between variability. If a triangle is presented to a learner, it will be assigned to the category of triangles with 100% confidence. However, the natural stimuli are not always associated with 100% certainty. For instance, if someone is asked to assign the picture of faces to the categories of sad versus happy faces (or male vs. female faces), such a level of confidence may not be acquired due to some instances that could lie in both categories. The existence of items that can fit in both categories means that the variability within is high (the items in one category are very different) and the variability between is low (the items in one category are similar to the other category).

4.3 Pre-test

A pre-test was run to form two sets of categories to be used in the experiment. For such a natural stimulus, the degree of complexity (i.e., variability within and

between) cannot be directly calculated quantitatively; therefore, I used the subjective judgments of people for quantification. I asked six participants to categorize 76 flowers (38 from each region) in a two-step categorization process. To control the personal biases, I labeled the flowers as flowers of region A (instead of Alaska) and region B (instead of Hawaii). In the first step, I asked a participant to categorize the 70 pictures with the help of three random samples from each region. Therefore, the participant began with three pictures of flowers randomly selected from category A and with three pictures of flowers randomly selected from category B. In order to not overload them with too many pictures, the participants were given small piles of pictures each time (20, 20, 20, 10). Each participant was asked to put the flowers into a category that he/she believed was appropriate. It was emphasized that if he/she was not sure whether the picture belonged to A or B, the picture should be put aside and ignored. Therefore, in the end, there were three categories: A, B, and "not sure." When the participant was done with the first 20 photos, the second pile was given to him/her to continue categorization. The participant was allowed to modify the categories at any stage of the work. In the second step, another participant reviewed and modified the categories that the first participant had prepared. This participant was told how the first participant had created the three categories and was requested to review and modify the categories. The participant was allowed to move the pictures from one pile to another, as he/she wished. This process was repeated by two more groups of two subjects each. In total, I had three

groups of two subjects each (six subjects) who formed three categories of flowers (category “A”, category “B”. and “not sure”)

At the end of the pre-test, each picture of a flower had been categorized as A, B, or “not sure” six times. Pictures that were assigned to one pile more than 80% of the time were considered to have low within and high between variability. For instance, pictures that were assigned to region A by five or six subjects out of six had an 83% or 100% chance belonging to region A respectively. This meant that those flowers were considered to be highly similar to each other and very different from the other region’s flowers. If a picture is assigned to region A 50% of time and to region B 50% time, it means that the flower is similar to both regions.

I formed two sets of categories to be used in the experiment. The simple set of categories was created by randomly choosing six flowers with over 83% probability of being in region A and six flowers with the same probability of being in region B. For the complex set, I took three flowers out from the simple set and substituted them with flowers that had an equal or a close chance of being assigned to either region A or region B. The simple and complex sets of flowers used in the experiment are shown in figures 4-1 and 4-2. (Note: The first six flowers on the left side are identical in both sets.) The assignment probability of the pictures used in the simple and complex set is shown in Appendix A.

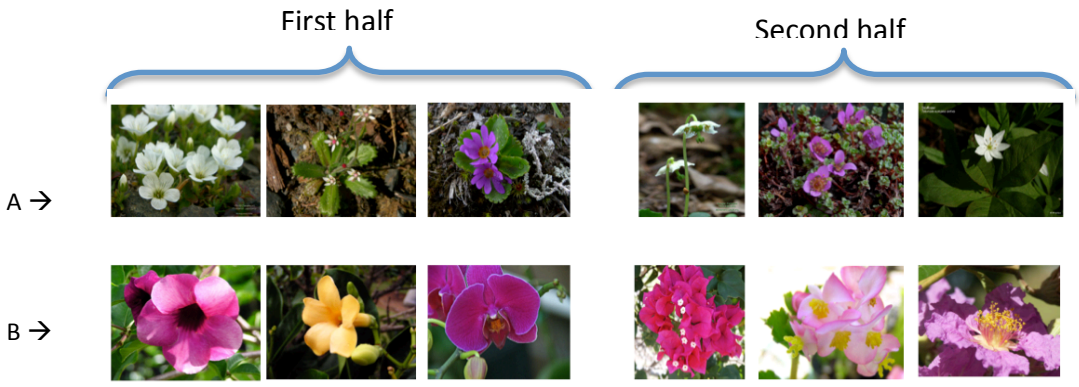


Figure 4-1 Pictures of flowers from region A and region B used for the simple set

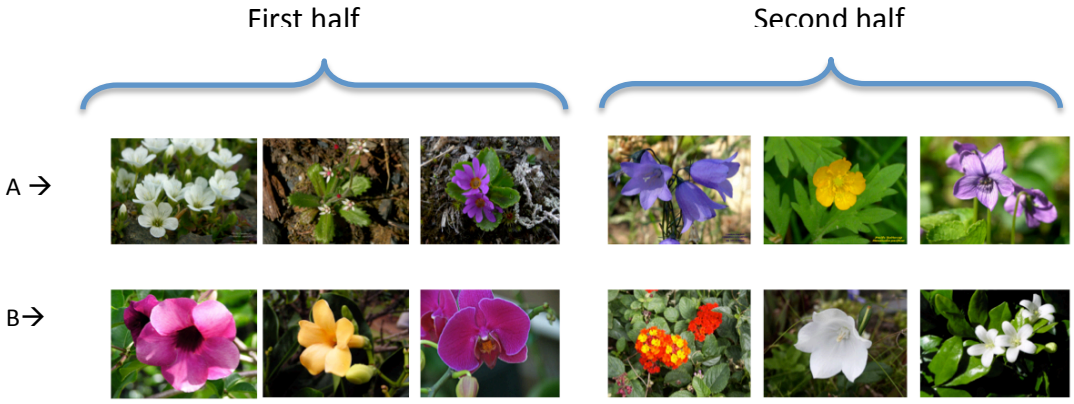


Figure 4-2 Pictures of flowers from region A and region B used for the complex set

The probability of the assignment was used as numeric indicators for each flower, and then the ratio of variability within to between was measured through the variance among the indicators (Table 4-1). For instance, the variability within (V_w) category A of the simple set was calculated by taking the variance ($\boldsymbol{\sigma}^2$) of the probability of assignment to region A (P_A) for the flowers shown in the first row of Figure 4-1. The variability between (V_B) was calculated by

taking the variance ($\boldsymbol{\sigma^2}$) of the probability of assignment to region A for all of the pictures shown in Figure 4-1.

Table 4-1. The variability within and between the flowers of region A and B for the *simple set*

	Region A						Region B					
Flower ID	1	2	3	4	5	6	7	8	9	10	11	12
P_A^*	1	0.83	0.83	1	1	0.83	0.17	0.17	0	0.17	0.17	0.17
V_W	0.008						0.007					
V_B	0.182											
V_w/V_B	0.044						0.038					

Table 4-2 indicated the variability within and between the category A and B for the complex set. Comparing the two tables demonstrates that for the complex set the ratio of variability within to variability between for both categories A and B is higher than the ratio of variability within to between the categories for the simple set; however, the between variability for the complex set is lower than the between variability in the simple set.

Table 4-2. The variability within and between the flowers of region A and B for the *complex set*

	Region A						Region B					
Flower ID	1	2	3	4	5	6	7	8	9	10	11	12
P_A^*	1	0.83	0.83	0.5	0.5	0.5	0.17	0.17	0	0.67	0.67	0.67
V_W	0.04						0.09					
V_B	0.09											
V_W/V_B	0.44						1					

4.4 Experiment 1

The goal of the first experiment was to test the learning and communication process of the categories with different structural categories. The first two hypotheses will be tested in this experiment. I expected to see that participants who learned the complex set of flowers pay attention to more features, demonstrate learning difficulty, and develop a more complicated theory than those who learned the simple set of the flowers.

The experiment had three phases. First, participants learned about the flowers of two different regions in a supervised learning situation. They were divided into two groups randomly. The first group was shown a simple set of categories (i.e., two categories of flowers with low within and high between variability), and will be referred to hereafter as the *simple condition*; the second group was shown a complex set of categories (i.e., categories of flowers with high within

and low between variability), and will be referred to as the *complex condition*. I expected to see differences in the performance of the two groups. In the second phase, the participants were asked to guess the origin of the flowers and to present those features they had paid attention to. I expected to see a significant difference between the number and type of features that each group asked about. In the third phase, they were asked to write instructions on how to distinguish between the flowers of the two regions, so I could observe the theories that they had developed, as well as the degree of the complexity in the theories. The group with the complex set of categories was expected to have developed a more complicated theory.

4.4.1 Participants and Material

Seventy-three undergraduate students from the University of Waterloo participated in the experiment for a partial course credit. Of the 73 students, 35 students performed the simple condition and 38 students performed the complex condition, from which the data of three participants were eliminated because of experimenter error. All 70 participants (35 in each condition) participated in and completed the first two phases of the experiment; however, only 34 participants completed the third phase of the experiment. The other 36 participants completed another task, which is reported in Experiment 3. The instructions for all 70 participants were identical for the first and second phases.

The materials were the two sets of categories provided from the pre-test results. Each set had six flowers from region A and six flowers from region B. For the simple set, pictures were selected in such a way that they formed low within and

high between variability; whereas, for the complex set, pictures were substituted with those that created a higher degree of within and a lower degree of between variability (Figure 4-1 and 4-2). In the simple condition, the participants learned and communicated the simple set of flowers; however, in the complex condition, the participants leanred and communicated about the complex set of flowers. To reduce the differences in two conditions, the order of the flowers was tried to be as similar as possible. Therefore, the participants of both groups first learned about 6 identical flowers from the simple set (the first half of the flowers in both sets were identical). However, the particpants of the complex set had flowers from the complex set in the second half of their sets.

4.4.2 Procedure

All experiments were conducted in the Uncertainty lab at the department of Management Sciences. Participants were told that the experiment had three phases. The experimenter briefly explained all three phases at the beginning of the session and then provided detailed instructions at the beginning of each phase. The instruction set used in the experiment is shown in Appendix B.

Learning phase. In the first phase, called the learning phase, each participant was seated by the monitor and was shown 12 pictures of flowers, one at a time. For each picture, the participant needed to choose whether it belonged to region A or region B. Once the selection was made, the feedback shown on the monitor indicated whether it was the right or wrong response. Then the participant moved on to the next picture. While the participant chose A or B, he/she only saw the current picture and the one immediately before. After performing the

first round of 12 pictures, the participant was told that because he/she was to learn the flowers of the two regions perfectly, he/she was going to perform the same task again. No matter how long it took, the participant was to continue the task until he/she could assign all the flowers correctly, without any errors.

Testing phase. In the second phase, called the testing phase, the participants were seated at another table and were told that they could look over all the pictures before the test began. The same pictures that were shown on the monitor were printed on 10 × 14 cm pieces of paper and separated according to category A and B and placed on the table. The participants were allowed to take notes as well. Then the experimenter took the pictures away and explained the testing procedure. For the test, the participants were supposed to guess the origin of a novel flower (without seeing it) by asking binary questions, to which the experimenter would reply yes or no (e.g., Q: "Is it a flower with five petals?" A: "No.")

Instruction phase. In this phase, called the instruction phase, the participants were asked to provide instructions on how someone who does not have this knowledge could distinguish between the flowers of region A and region B. In this phase, the printed pictures of the flowers were given to them again for their reference.

4.4.3 Results and Discussion

In this section, I am going to explain the results from all the three phases of the experiment. First, in the learning phase, I will report the efficiency in learning the flower for both conditions. Second, in the testing phase, I will explain the

differences in the number and type of features in each condition. Third, in the instruction phase, the complexity of the theories developed and reported in instructions will be discussed.

Learning phase. Under the complex condition, the participants had to pay attention to more features, since the structure of the categories was characterized as high ratio of within to between variability. However, under the simple condition, the participants investigated fewer numbers of features and tested fewer hypotheses. They were supposed to repeat the test until they could assign the entire flowers correctly. Therefore, I expected to see that the number of trials it took for the participants to learn the origin of the flowers would be significantly higher in the complex group than in the simple group. The results (Table 4-3) indicated that it took the simple group an average of 3.7 trials to learn the flowers perfectly, while it took the complex group an average of 6.8 trials ($t= -4.73$, $\rho<.001$).

Table 4-3 Mean differences in the number of trials across simple and complex conditions

Variable	Condition	N	Mean	St. Deviation	Test	P- Value
Number of trials	Simple	34*	3.7	2.45	Independent Sample Mann-Whitney U Test	0.000
	Complex	35	6.8	2.95		

* The record for the number of trials of one participant was missed

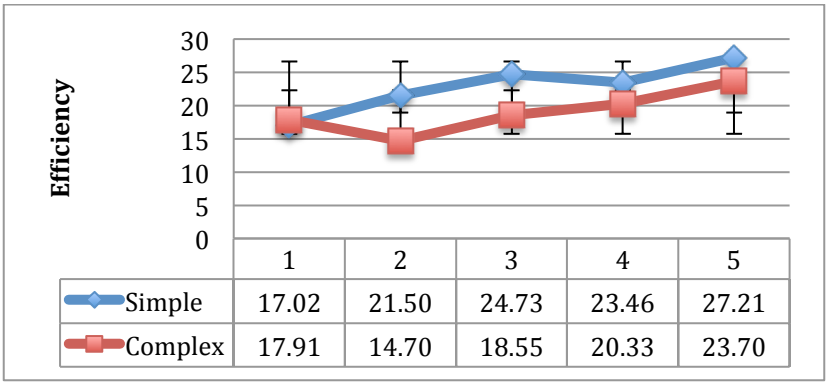
I also tested the efficiency of each group in learning the two categories of flowers. Efficiency was defined as the ratio of the number of correct assignments to the time of the assignment multiplied by 100. Thus, the higher efficiency meant that the participants had more correct answers in a shorter time. It is important to note that 100% efficiency was not possible in this task. The maximum efficiency in this task was potentially 50% in which all 12 pictures were assigned correctly in 24 seconds.

To have a more precise analysis, the results related to efficiency have been reported separately for the first and the second half of the flowers. The first half of the flowers was identical for both groups (i.e., both from the simple set of categories); however, the simple and complex groups had different flowers in the second half (Figures 4-1 & 4-2). For the simple group, the second half of the flowers was from the simple set, while for the complex group, the second half of the flowers was from the complex set.

Table 4-4 Comparing the mean efficiency between the first and second half of the flowers in the first trial

Condition	Variable	N	Mean	St. Deviation	Test	P-value
Simple	Efficiency for the first half	31	17.02	7.30	Wilcoxon Signed Rank Test	0.64
	Efficiency for the second half	31	17.35	7.30		
Complex	Efficiency for the first half	33	17.91	8.74	Wilcoxon Signed Rank Test	0.000
	Efficiency for the second half	33	6.2	6.20		

Since all twelve pictures of the flowers observed by the participants of the simple group are from the simple set, I expect to see no significant difference in their efficiency between the first and second half of the flowers. Table 4-4 confirms the expectation for the very first trial ($M_{firsthalf}$ =17.02 , $M_{secondhalf}$ = 17.35, ρ=0.64). However, the participants of the complex condition first observed six flowers from the simple set, and then they observed six flowers from the complex set. As a result, I expect to see differences in their efficiency for the first and second half of the flowers from the very first trial. For the complex flowers (presented in the second half of the set), they had to pay attention to extra features and test more hypotheses than the participants of the simple condition ($M_{firsthalf}$=17.91, $M_{secondhalf}$=6.2, ρ <0.001)(Table 4-4).



	1	2	3	4	5
Simple	17.02	21.50	24.73	23.46	27.21
Complex	17.91	14.70	18.55	20.33	23.70

Figure 4-3 Efficiency for the simple and complex groups on the first half of the flowers (identical flowers in both conditions) for trials 1 to 5

In addition, I analyzed the efficiency for the participants of both conditions from trial 1 to trial 5 to investigate their differences during category learning. Figure 4-3 indicates the efficiency of the participant for the first half of the flowers across trial 1 to 5 for both conditions. Both groups presented similar efficiency

for the first half of the pictures on the very first trial (Figure 4-3), since they both started the task identically (M_{simple} = 17.02; $M_{complex}$ = 17.91, P<0.86). On the second trial, the efficiency of the complex group decreased to $M_{complex}$=14.7 while the efficiency of the simple group increased to 21.5 (ρ<0.001). This difference was also observed in the third trial, and then disappeared. The difference in the efficiency of the participants for the first half of the flowers in trial 1 to 5, and the associated p-value are reported in table 4-5.

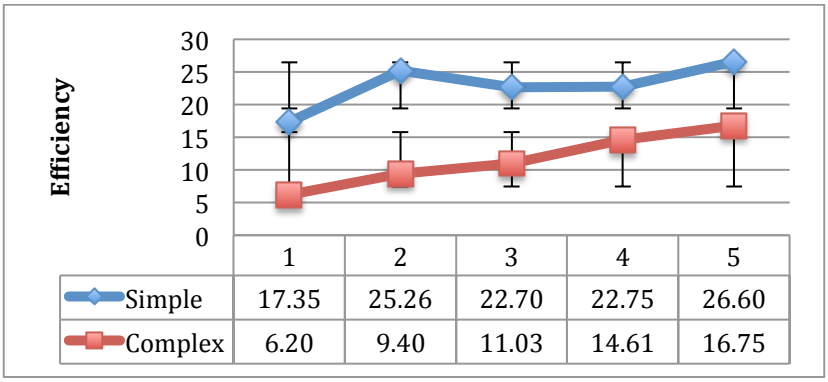
Table 4-5 Difference in the efficiency between complex and simple conditions in trial 1 to 5 for the first half of the flowers

Variable	Condition	N	Missed data+	Number of participants completed in each trial*	Mean	St. Deviation	P-Value
Efficiency in trial #1	Simple	31	4	0	17.02	7.30	0.86
	Complex	33	2	0	17.91	8.74	
Efficiency in trial #2	Simple	33	1	1	21.5	9.96	0.001
	Complex	35	0	0	14.7	8.51	
Efficiency in trial #3	Simple	21	1	13	24.73	10.55	0.037
	Complex	35	0	0	18.55	8.63	
Efficiency in trial #4	Simple	13	1	21	23.46	8.80	0.326
	Complex	30	0	5	20.33	12.27	
Efficiency in trial #5	Simple	9	1	25	27.21	6.99	0.376
	Complex	25	0	10	23.7	12.99	

+ The records of 3 participants in the first trial and 1 participant in all the trials are missed.

*Note that the number of participants may decrease as the number of trials increases. This happens because the learning phase finished as soon as participant learned to assign all the flowers perfectly to region A or B. For example one participant in the simple group assigned all the flowers correctly in the first trial.

To understand the differences in the performance on the first half of the flowers, it is necessary to see what happens during the learning process in the second half of the flowers. Figure 4-4 indicates the efficiency of the participants for the second half of the flowers in both conditions. On the first trial, the efficiency differs between the two conditions (M_{simple} = 17.35, $M_{complex}$ = 6.2, $\rho<0.001$) because the participants of the complex group were learning about flowers of the complex set and had to look for extra features and try various hypotheses, which increased the time and decreased the number of correct assignments.



	1	2	3	4	5
Simple	17.35	25.26	22.70	22.75	26.60
Complex	6.20	9.40	11.03	14.61	16.75

Figure 4-4 Efficiency for the simple and complex groups on the second half of the flowers (different flowers in two conditions) for trials 1 to 5

Even though in both conditions the efficiency increases from trial 1 to trial 5 for the first half of the flowers, the efficiency is lower for the participants of the complex condition for all the trials. The mean for the efficiency and statistical difference between the conditions in trials 1 to 5 have been demonstrated in Table 4-6.

Table 4-6 Differences in the efficiency between complex and simple conditions in trials 1 to 5 for the second half of the flowers

Variable	Condition	N	Missed data+	Number of participants completed in each trial*	Mean	St. Deviation	P-Value
Efficiency in trial #1	Simple	31	4	0	17.35	7.30	0.000
	Complex	33	2	0	6.20	6.20	
Efficiency in trial #2	Simple	33	1	1	25.26	14.30	0.000
	Complex	35	0	0	9.40	4.82	
Efficiency in trial #3	Simple	21	1	13	22.70	12.65	0.000
	Complex	35	0	0	11.03	6.50	
Efficiency in trial #4	Simple	13	1	21	22.75	11.65	0.039
	Complex	30	0	5	14.61	9.80	
Efficiency in trial #5	Simple	9	1	25	26.60	9.76	0.030
	Complex	25	0	10	16.75	11.00	

+ The records of 3 participants in the first trial and 1 participant in all the trials are missed.

*Note that the number of participants may reduce as the number of trials increases. This happens because the learning phase finished as soon as participant learned to assign all the flowers perfectly to region A or B. For example one participant in the simple group assigned all the flowers correctly in the first trial.

To have an overall look at the learning process, and as indicated in these graphs, it is obvious that the existence of six flowers from the complex set affected the learning process that the participants of each group experienced. Both groups began the task equally and indicated similar efficiency for the first six flowers that they observed in the very first trial. The efficiency for the complex group decreases in the second half of the flowers since the participant had to pay

attention to more features and try new hypotheses to distinguish the flowers of the two regions. The attention to extra features then decreased the efficiency of the complex group even on the simple flowers, which they already had learned in the first trial. In fact, they questioned the initial theories that they had, which seemed to work on the first half of the flowers. However, the theories that participants of the simple condition had formed were confirmed in the second half of the flowers, and as a result they were able to figure out the origins of the flowers faster and more precisely. These results indicated that the structure of the categories affects category learning in terms of time and difficulty of learning.

Testing phase. In the testing phase, I measured the differences in the features that participants in each condition had paid attention to. I used different types of variables to investigate the dissimilarities in the two conditions. First, I measured the number of binary (yes or no) questions that were asked for each test. The participants were to ask as many binary questions as they wished in order to guess the origin of an unseen flower. They continued the test until getting two correct guesses. This means that the participants were able to assign two unseen pictures correctly to their original region. These questions corresponded to the features that the participants had paid attention to. The average number of questions (per picture) asked in the complex condition ($M_{complex} = 4.25$) differed significantly from the number of questions asked in the simple condition ($M_{simple} = 3$, $\rho=0.002$) (Table 4-7).

Table 4-7 Difference in the average number of questions asked per picture in both conditions

Variable	Condition	N	Mean	St. Deviation	Test	ρ-value
Average number of questions asked per picture	Simple	34	3.03	1.39	Mann-Whitney U Test	0.002
	Complex	34	4.27	1.89		

I also measured the overall number of features that were asked about in the questions during the testing phase (Table 4-8). These features might be asked for different pictures under the test. If a feature was asked about for more than one picture, I only counted it once. As expected, the number of features asked about in the complex condition was significantly higher than those asked about in the simple condition ($M_{complex} = 4.9$; $M_{simple} = 3.2$, $\rho<.001$).

Table 4-8 Comparing the overall number of features asked per participants

Variable	Condition	N	Mean	St. Deviation	Test	ρ-value
Number of features asked in the testing phase	Simple	34	3.2	1.30	Mann-Whitney U Test	0.000
	Complex	34	4.9	1.77		

In addition to the following variables, the type of the features asked about in the two conditions could be affected by the complexity in the structure of the categories. I was curious to know how the variability could be presented in the features themselves, in addition to their number. The participants of both groups went through hypothesis testing. When one hypothesis (e.g., region A's flowers

were bigger than region B's) was rejected, then the participants actively looked for other features to test. The higher within variation and lower between variations (high ratio) made the participants in the complex group look for features that they would have ignored otherwise.

The high ratio of within to between variability in the categories was represented in the features that were asked about in the testing phase. In the simple condition, participants asked about 14 features overall. These features could be categorized into five groups as presented in Table 4-9; however, the participants in the complex condition asked about 37 features overall. Because of the higher ratio of within to between variability in the complex set, the participants paid attention to extra features in the complex condition. These features could be categorized into four categories; however, there was a higher variability in each category compared to the simple condition (Table 4-10).

Table 4-9 Features and categories to which they belong in the simple condition

Category	Features	Number of times asked (out of 35)
Surrounding area	1. Ground	10
	2. Live or dead area	1
	3. Dry environment	2
	4. Rock/dirt around	4
	5. Sunlight vs. dark background	1
Flower	1. Round edge petals	4
	2. Open petals	1
	3. Stem	5
	4. Stamen	3
	5. Blossom	2
	6. Number of flowers	6
	7. Overlapping petals	2
	8. Centre of the flower	1
	9. Size	20
Leaves	1. White patches on the leaves	3
	2. Leaves around	10
	3. Size of the leaves	3
Colour	1. Colour	29
Picture	1. Close-up shot	1

Table 4-10 Features and categories to which they belong in the complex condition

Category	Features	Number of times asked (out of 35)
Surrounding area	1. Ground	5
	2. Dry environment	1
	3. Rock/dirt	5
	4. Brown vs. green background	5
	5. Water dew	4
Flower	1. Yellow centre	1
	2. Visible centre	1
	3. Round-edged petals	10
	4. Big petals	4
	5. Overlapped petals	2
	6. Number of petals	13
	7. Skinny petals	4
	8. Separated petals	1
	9. Lines on the petals	2
	10. Heart-shaped petals	1
	11. Cup-shaped flower	4
	12. Open/closed flower	2
	13. Tall/short flower	1
	14. Stem	1
	15. Stamen	6
	16. Number of stamens	3
	17. Tall/short/ size of the stamens	3

	18. Blossom/full blossom	1
	19. Bulb in the pic	2
	20. Number of flowers	12
	21. Direction of the flower	1
	22. Size	11
Leaves	1. Leaves around	5
	2. Waxy leaves	3
	3. Pointy leaves	10
	4. Curled in leaves	1
	5. Skinny leaves	1
	6. Size of the leaves	2
	7. Leaves close to each other	1
	8. Colour of the leaves	4
Colour	1. Colour of the flower	29
	2. Multiple vs. single flower	6

Instruction phase. In the third phase, I focused on how the learned categories were communicated and expected that the group that learned categories with high ratio of within to between variability would develop more complex theories to distinguish between the flowers of the two regions. The participants of both conditions were asked to write instructions for another participant on how to distinguish between the flowers of region A and region B. I measured the complexity of their theory through the number of words that they used in the instructions as well as the structure of the instructions.

To make the number of words a reliable variable with which to measure the complexity, I eliminated the redundancy of the instructions. For this purpose, I removed the unnecessary words and formed the sentences using a minimum number of words as though I wanted to send them using telegram technology. In such a case, the sentences may not have had grammatically correct structures, but they did transfer the meaning thoroughly. A few examples of the sentences from the instructions and the redundancy-deducted version of them are presented in Table 4-11. I eliminated the redundancy of all the instructions and then asked an independent reviewer to repeat the process. The number of words after the elimination of the redundancy was in agreement within a margin of 2% of error.

Table 4-11 Examples of instructions with redundancy eliminated

Condition	Original sentence	Redundancy eliminated
Simple	Region B: Size of the flowers are a lot bigger compared to those from region A	B: Flowers bigger than A
	If the flower has a dull colour and is small, then it is in region A	A: Dull colour / small flower
Complex	White flowers from region A usually have more translucent petals compared to those of region B	White flowers from A usually more translucent petals than B
	A: The flowers are smaller in size in most cases	Smaller flowers mostly

The average number of words, after eliminating the redundancy, for the complex group ($M_{complex} = 33.41$) differed from that of the simple group ($M_{simple} = 21.47$, $\rho<0.02$)(Table 4-12).

Table 4-12 Comparing the number of words in the instructions after redundancy elimination

Variable	Condition	N*	Mean	St. Deviation	Test	ρ-value
Number of words after redundancy elimination	Simple	17	21.47	10.81	Mann-Whitney U Test	0.02
	Complex	17	33.41	16.65		

* Note that only 34 out of 70 participants participated in the instruction phase. The rest of them participated in Experiment 3

In addition to the number of words, the written instructions of the two groups were dissimilar with respect to certain factors, such as the type of the words used or the structure of the instructions. Comparison of the instructions indicated certain differences between the two groups. Under the complex condition, the participants paid attention to more features and had more rejections of the hypotheses. In addition, the participants noticed that a simple rule does not account for defining the categories, and they had to talk about various features that might be different in the amount of information that they provide. Three properties were considered to indicate the differences in the provided instructions, which will be explained below.

1) Use of probabilistic expressions

Some of the instructions indicated some degree of uncertainty about the features. In such cases, words such as “usually”, “often”, “some times”, etc. were used along with the features in the instructions. To illustrate this property, three examples are provided below.

Example 1 from complex condition (ID: C4)

> *The flowers [of region A] have numerous petals and come in colours including, but not limited to, while, yellow, and purple.*

The above sentence provides uncertain claim about the colour of the flowers. The reader potentially gives higher probability to the colours mentioned in the statement but at the same time the instruction does not rule out other colours.

Example 2 from the simple condition (ID: S3)

> *[Flowers of region B] usually grown in larger bunches than plants from region A.*

The word "usually" creates some degree of uncertainty for the reader to assign a flower in large bunches to region B. Below is another example which does not convey uncertainty:

Example 3 from simple condition (ID:S2)

> *Flowers [of region A] are planted on the ground, i.e. you can see soil/shrubbery around the flowers.*

2) Combination of rules

In some cases the rules are combined of more than one feature. The combination of rules means that one feature alone is not enough for categorizing the flowers. This corresponds to higher complexity in the theory developed for

distinguishing the two categories (region A and B). For example (complex condition, C10):

> *If [the] flower is not a shade of blue/purple/ pink or red, [then] check the texture of the petals. Flowers from region B tend to have smoother* petals than those of region A.

The above instruction combines the colour and the texture of petals to distinguish between the two categories. Below is another example, which does not present the combination of rules. Even though more than one feature has been considered for distinguishing the flowers of region A, no explicit connection was shown in combining the two features as if each one can explain the difference separately.

Simple condition (ID: S1)

> *If the flower is white it is from region A.*
>
> *If there is dirt/mud in the picture, the flower is from region A.*

3) Prioritizing

In some cases the participants gave priority to some of the features or identified the steps to follow. This means that they think some of the features are more informative in one region. The two examples below show such cases.

Example1 (Complex group, C1)

> *1. Look for yellow centers in the flowers*

2. If the center part of the flower is long and yellow it is in category A

3. If the flowers have sharp petals, they are in category A

Example 2 (Simple condition, S5)

To determine which group the flower belongs to, first see whether the flower is large or small. If it is small, it will likely be in group A. If it is large, it will likely be in group B. In addition, if the flower is of a bright, vibrant colour, it will likely be in group B.

In the second example, the word "first" emphasizes the feature size, as though this feature is more important in identifying the region the flower belonged to.

Instructions were scored based on the number of times the properties were presented. For instance, if one instruction had two probabilistic expressions, one instance of combination of rules, and features are prioritized, then the instruction scored as 4. Comparing the score of the instruction, I expected to see that the participants under complex condition provided instruction with higher uncertainty score. The result of the statistical test indicates that the degree of uncertainty that the complex instructions carry (M_{simple}=1.59, $M_{complex}$=3, ρ=0.049) is higher than the degree of uncertainty that the simple instructions carry (Table 4-13).

Table 4-13 Comparing the uncertainty score between simple and complex conditions

Variable	Condition	N	Mean	St. Deviation	Test	ρ-value
Uncertainty score	Simple	17	1.59	1.37	Mann-Whitney U Test	0.049
	Complex	17	3.00	2.2		

The three properties that I considered may not fully reflect the differences in the level of complication of the instructions. For instance, with respect to number of probabilistic words, no matter what the word was, I scored them equally. However, the degrees of uncertainty that each word transfers are not equal. If the participant wrote "Flowers of region B are usually bigger" or "If the flower is big, it will likely be in region B" were treated equally and both increased the score of the instruction by one unit. However, the levels of uncertainty that each sentence may present are different.

Overall, the participants under complex condition used more words in the instructions. In addition, their instruction differs in terms of word type and rule structure (i.e. combination of rules; prioritizing certain features). The difference has been attributed to the complexity of their theory and to attention to more features during category learning.

4.4.4 Summary of the Results and Verification of Hypotheses 1 and 2

The first experiment was designed to test the effects of the category structure on category learning. More specifically, I was interested to see how the high ratio

of within to between variability affect both the attention to the number of features and the theory developed for distinguishing the theories in the first and second hypotheses. The results supported both hypotheses. The variables tested in this experiment were shown in tables 4-14 and 4-15.

Hypothesis 1*: The higher ratio of within to between variability in the categories increases the number of features that the learners pay attention to.*

Table 4-14 Variables used for verification of hypothesis 1

Variables	Simple	Complex	p-value
Number of trials	3.7	6.8	0.000
Efficiency for the first trial on the second half the set	17.35	6.2	0.000
Overall number of features asked in the testing phase	3.2	4.9	0.000
Average number of features asked per picture	3.03	4.24	0.002

The results indicated that the high ratio of within to between variability in the complex condition delayed learning the two categories of flowers (each consists of six flowers). The participants of the complex condition, learned the 12 pictures after performing average of 6.8 trial while the participants of the simple group learned the categories after performing average of 3.7 trials. In addition, the results indicated that high complexity in the categories reduces efficiency in category learning. This result is aligned with the results of the previous studies in the same domain, in which structural complexity was shown to decrease learning performance (Kloos & Sloutsky, 2008).

The higher ratio of within to between variability also forced the participants to pay attention to more features ($M_{complex}$= 4.9) and ask about more features per

picture ($M_{complex}$=4.24); however, the participant who learned categories with low ratio of within to between variability paid attention to fewer features (M_{simple}= 3.2) and asked about fewer features per picture (M_{simple}= 3.03).

Table 4-15 Variables used for verification of hypothesis 2

Variables	Simple	Complex	p-value
Number of words after redundancy elimination	21.47	33.41	0.02
Uncertainty score	1.59	3	0.049

Hypothesis 2 stated that *the higher ratio of within to between variability in the categories increases the complexity of the theory that the learners develop.*

Variables used to test the hypothesis are shown in Table 4-15. Comparing the instructions provided in two conditions indicated that the differences in the complexity of the learned categories affect the type of theory that they developed to distinguish the categories. The theory developed in the complex condition was more complicated, since more words were used in explaining the theory. In addition, their theory was more complicated since the instruction provided under complex condition had a higher uncertainty score.

4.5 Experiment 2

Experiment 2 was designed to measure the degree of effectiveness of the communication process of learned categories. Hypothesis 3 stated that communicating complex categories is less effective than communicating simple categories. As mentioned in the previous section, the instructions written under

the complex conditions consisted of more words and had a higher uncertainty score. I designed a second experiment in which new participants learned about the flowers of region A and B from the written instructions, provided in Experiment 1, and then were tested to identify the degree of effectiveness of the instructions. I wanted to see how successfully each group communicated their theory about the flowers from region A and region B, and expected to see that the participants who learned the complex set had less effective communication.

4.5.1 Participants and Material

The participants were 34 undergraduate students enrolled in a course offered by the Management Science Department at the University of Waterloo. They participated for half an hour and received a partial course credit in appreciation for their participation. The materials used were the instructions written by the participants in the first experiment. All of the 34 instructions provided in simple and complex conditions (17 in each condition) in the previous experiment were used. Each instruction was typed and printed on A4 paper.

4.5.2 Procedure

Participants were brought to the lab and seated by a table in front of the experimenter. They were told that the goal of the experiment was to investigate the effectiveness of written instructions for identifying two categories of flowers. They were also told that other students provided the instructions. Each participant was given one instruction and was allowed to keep it until the end of the experiment. They were then told that they were going to be shown 12

pictures of flowers and were to assign the flowers to either region A or region B according to the instruction they had been given.

When the participants were given an instruction written for a simple condition, the simple set of flowers was tested. When the instruction provided was for the complex condition, the complex set of flowers was tested. In both conditions, the experimenter showed the pictures by placing them one by one on the table, recording the participant's response until all 12 pictures were shown. The feedback was given at the end of the test, at which point the participants were told how many errors they had and which flowers they had misidentified. Then each participant was interviewed about the quality of the instruction they were following and was asked to improve it in such a way that if the improved instruction was given to another student, that student would perform the same test better.

4.5.3 Results and Discussion

The results of this experiment indicated that the instructions written for the simple set were more effective. The performance of the participants was measured according to the number of correct assignments of the flowers and was used as an indication of the instructions' effectiveness. The participants who read the instructions from the simple set were able to assign all 12 flowers of the simple set correctly to their initial regions 82% of the time; however, the participants who read the instructions provided in the complex condition were able to assign the flowers of the complex sets correctly 72% of the time ($\rho<0.02$) (Table 4-16).

Table 4-16 Comparing the performance of the participants in assigning the flowers correctly to their regions

Variable	Simple			Complex			ρ-value*
	N	Mean	St. D	N	Mean	St. D	
Total number of correct assignments (out of 12)	17	9.94 (82%)	1.71	17	8.7 (72%)	1.65	0.022

* Mann Whitney U Test

In comparing the performances between the simple and complex sets, it is worth remembering that only the second half of the pictures in the complex set were different, which means that in the complex condition, the first six pictures of flowers were from the simple set and the second six pictures of flowers were from the complex set. The performance of the participants separated based on the first and second half of the flowers are presented in table 4-17. The performance of the first half of the flowers in both conditions was similar ($M_{complex} = 4.5$, $M_{simple} = 5$, $\rho=0.47$); however, the performance differs for the second half of the flowers ($M_{complex} = 3.8$, $M_{simple} = 4.9$, $\rho<.02$). As expected, communicating the simple set of flower was easier than communicating the complex set.

Table 4-17 Comparing the performance of the participants in each condition separated for the first and second half of the flowers

Variable	Simple			Complex			ρ-value[+]
	N	Mean	St. D	N	Mean	St. D	
Number of correct assignment on the simple flowers (first half)	17	5	1.06	17	4.5	1.42	0.47
Number of correct assignment on the complex flowers (second half)	17	4.9	1.14	17	3.8	1.4	0.02

[+] Related Samples- Wilcoxon Signed Rank

4.5.4 Verification of hypothesis 3

The third hypothesis stated that

Communicating the categories with high ratio of within to between variability is less effective than communicating the categories with low ratio of within to between variability

I used the performance of participants in terms of the number of correct assignments of the flowers to their regions as the variable for measuring the effectiveness of the instructions. The results indicated that communicating the simple categories was more effective. Instructions provided in both conditions were effective in learning the flowers from the simple set; however, the instructions written for the complex set were not as effective in learning the complex flowers. Therefore, the results supported the third hypothesis by

indicating that the communication of categories with high ratio of within to between variability is less effective than communicating the categories with low ratio of within to between variability.

4.6 Experiment 3

Experiment 3 was designed to observe the communication process between a person who learned a set of simple categories and a person who learned a set of complex categories. More specifically, I would like to see whether there are different patterns in the communication of the two communicators. This experiment will also respond to the fourth hypothesis, in which I expect to see that the person with a complex set of categories is more influential in the course of interaction.

The learning process of this experiment is identical to the first experiment. The first two phases (learning the categories of the flowers and testing the participants about the features that they paid attention) are exactly the same as the first experiment (reported in Section 4.4.2). The third phase is different. While in the first experiment the participants wrote an instruction individually, in this experiment, one participant from the simple condition and one participant from the complex condition were brought together to collaborate and provide an instruction about how to distinguish between the flowers of the two regions for a third party.

4.6.1 Participants and Material

Seventy-three undergraduate students from the University of Waterloo participated in the experiment for a partial course credit. Of the 73 students, 35 students performed the simple condition and 38 students performed the complex condition, from which the data of three participants were eliminated because of an experimenter error. All 70 participants (35 in each condition) participated in and completed the first two phases of the experiment; however, only 36 participants completed Experiment 3. The other 34 participants participated in Experiment 1.

The materials were the same sets of categories provided from the pre-test results and used in the previous experiments (Figure 4-1 and 4-2).

4.6.2 Procedure

All experiments were conducted in the lab. Each session of the experiment started with two participants. When two participants arrived to the lab, they were told that the experiment has three phases. The experimenter explained that the first two steps would be done individually in two separate rooms and for the third phase they would work together. The experimenter briefly explained all the three phases at the beginning of the session and then provided detailed instructions at the beginning of each phase. Then, one of the participants was accompanied to another room to perform the two phases with another experimenter. Both experimenters followed the same procedures.

Learning phase. In this phase, each participant was seated in front of a monitor in one of two different rooms. One participant was shown flowers from the simple set while the other one was shown flowers from the complex set. The procedure was identical to Experiment 1 reported on Section 4.4.2.

Testing phase. The testing phase was performed identically to the testing phase in Experiment 1 reported in section 4.4.2.

Instruction phase. When both participants completed the first two steps, they were brought together to complete the third phase. After the participant working on the complex categories finished the two phases, the other participant was asked to join him/her in the lab. The two participants were seated by a table in front of the experimenter and were asked to work together and write one instruction on how to distinguish between the flowers of the two regions. They were told that this instruction would be given to another student, from which the student would learn about the flowers of the two regions. After providing the instruction, each participant was asked to fill in a two-part questionnaire. The first part asked the participants to rate (in Likert-type scales) their contribution in providing the instruction, their knowledge about the flower, and their partner's knowledge and contribution. The second part of the questionnaire asked about helpful and non-helpful behaviour of their own, as well as of their partner. The questions were designed according to the echo-method developed by Bavelas (1942). The questionnaire is reported in Appendix C.

4.6.3 Results and Discussion

The results of the learning and testing phases were aggregated to the results of the two phases in Experiment 1 and reported in section 4.4.3. The results indicated that participants under complex condition were less efficient than the participants under simple condition in learning the flowers of the two regions. In addition, under complex condition, the participants paid attention to more features and developed a more complicated theory. The instruction phase in experiment number 3 was different from the instruction phase in experiment number 1. While in the first experiment each participant (either from complex or simple condition) was asked to provide an instruction individually, in the third experiment two participants, one from simple condition and one from complex condition, collaborated to provide one instruction.

In this section of the experiment, I was interested to observe the communication process between two participants who learned about categories with different ratios of variability within to between. To analyze the communication process, I used different methods, which will be elaborated below. Before getting into details of the results, it is worth mentioning that, in general, I was interested to see which participant is more influential during the communication process, how they perceive each other, and how the interaction between the two participants affects the instruction. Different types of data were gathered for this purpose and I will explain them in four sections: (1) results of the rating scales presented in the questionnaires; (2) results from analyzing the instructions; (3) result of the echo-method questions; and (4) results of the conversation analysis.

4.6.3.1 Results of the Rating Scales Questions

A set of rating scales was designed to test the differences in the perception of the communicators about themselves and their partners. The first set of questions asked the participant to rank their contribution as well as their partner's contribution in completing the instruction (Table 4-18).

Table 4-18 Difference in the degree of contribution perceived by the participants of both conditions

Questions	Simple			Complex			ρ-value*
	N	Mean	St. D	N	Mean	St. D	
How much contribution do you think you had in completing the instruction?	18	3.33	0.76	18	3.28	0.82	0.84
How much contribution do you think your partner had in completing the instruction?	18	3.39	0.84	18	3.11	0.83	0.35
ρ-value+		0.78			0.45		

* Mann Whitney U Test for comparison between sample

+ Wilcoxon Signed Rank for comparison within samples

The data from the questionnaires indicated participants of the two conditions rated their own contribution equally (M_{simple}=3.33, $M_{complex}$=3.28, ρ=0.84). In both conditions, the participants rated the contribution of their partner equal as well (M_{simple}=3.39, $M_{complex}$=3.11, ρ=0.35). In addition, within subjects comparison demonstrated that the subjects of simple condition as well as

subjects of complex condition think that both participants contributed equally in providing the instructions (Table 4-18).

The second set of questions asked the participants to rate the knowledge of the other communicators as well as themselves. The data indicated that the participants of the complex group rated their own knowledge about flower lower than what the participants under simple condition rated for their own knowledge about the flowers. (M_{simple}= 3.47, $M_{complex}$= 2.6, ρ= 0.05) (Table 4-19).

Table 4-19 Differences in the perception of knowledge in both conditions

Questions	Simple			Complex			ρ-value*
	N	Mean	St. D	N	Mean	St. D	
How knowledgeable are you about the flowers?	15#	3.47	1.06	15#	2.6	1.05	0.05
How knowledgeable is your partner about the flowers?	18	3.5	1.04	18	3.19	0.85	0.35
ρ-value+		1			0.143		

* Mann Whitney U Test for comparison between sample

+ Wilcoxon Signed Rank for comparison within samples

Responses of three subjects were missed

The difference could be explained in terms of the degree of complexity that the participants of the complex group experienced during the learning phase. Due to the complexity of the categories that they learned, they had to pay attention to more number of features and test more hypotheses. In addition, learning took longer for them, and they required more trials to learn the flowers completely. This experience could cause them to feel uncertain about their knowledge on the flowers and rate their own knowledge lower than the participants under simple

condition. To elaborate on this point further analyses are needed, which will be reported in the following sections.

Rating the other partner's knowledge about the flowers, no difference was observed (M_{simple}= 3.5, $M_{complex}$= 3.19, ρ= 0.35). In addition, within subject comparison showed that subjects of simple condition as well as subjects of complex condition think that there is no significant difference between both participants' knowledge of the flowers (Table 4-19).

4.6.3.2 Analysis of Instructions

The two participants in this experiment collaborated, and provided one instruction about how to distinguish between the flowers of region A and region B. They were told that this instruction would be given to another student and were told how the instruction would be used by the other students. I analyzed the instruction from various aspects. First, I compared the instructions to the instructions provided individually in the first experiment in two conditions of simple and complex. The number of words and the structure of the instructions were compared. Second, the instructions were analyzed to see how much each of the participants contributed in the instructions.

Comparing the number of words: In the same procedure explained in Section 4.4.3, the number of words were counted for each instruction after eliminating the redundancy. Table 4-20 demonstrates the comparison between the number of words between instructions provided in the group condition (experiment 3) and instructions provided in either complex or simple conditions (experiment 1).

Table 4-20 Number of words after eliminating the redundancy for individual and group conditions

Variable	Condition	N	Mean	St. Deviation
Number of words after redundancy elimination	Simple Individual	17	21.47	10.81
	Complex individual	17	33.41	16.65
	Group	18	36.27	20.26

The results of the non-parametric test (Mann-Whitney U Test) indicated a significant difference between group and simple conditions (M_{Simple}= 21.47, M_{Group}=36.27, ρ=0.013); however, the instructions provided under complex and group conditions are not statistically different ($M_{Complex}$= 33.41, $M_{Complex}$=36.27, ρ= 0.78). The discussion between the two participants gave rise to including more details in the instructions for two potential reasons. First, the complex communicators could be more influential and provide more details during the collaboration, and second, the collaboration may create a situation in which the participants in the simple condition feel the need to include more potential features in the instructions.

Uncertainty Scores: Three properties were measured for the uncertainty score of the instructions: (1) number of probabilistic words, (2) combination of rules, and (3) prioritizing. These properties were explained in section 4.4.3 and used similarly in this experiment. However, a slightly different pattern was observed in the instructions provided collaboratively. In some of the instructions, rules are considered along with exceptions.

The number of times that exceptions were mentioned in the instructions was counted under the category of combination of rules, since it resembles the same structure by which a general rule may not always be correct. The communication between the two participants made them talk about different flowers presented during their learning phase. In some cases the flowers may not fit in the general theory presented by one of the participants. To resolve the disagreement, the participants decided to include exceptions in their instruction Such a pattern was not observed in the individual conditions; in group 18 for instance, the instruction provided for considering exception to the rules:

Group condition (ID=G18)

"Flower is high off of the ground or ground not visible in picture = Region B

→ *Exception: flowers that were yellow with a shot of the ground"*

As shown in Table 4-21, the instructions provided in collaboration by two participants were similar to the instructions provided by a single participant under complex condition with respect to uncertainty score ($M_{Complex}$=3, M_{Group}= 3.11, ρ= 0.98); however, the uncertainty in the instructions of the group condition was higher than the instructions provided with single individuals who learned the simple set of flowers (M_{Simple}=1.59, M_{Group}= 3.11, ρ= 0.07). These results indicated that the participants who learned about the complex set contributed significantly to the instructions.

Table 4-21 Comparison among the uncertainty scores of group and individual conditions

Variable	Condition	N	Mean	St. Deviation
Uncertainty score	Simple individual	17	1.59	1.37
	Complex individual	17	3.00	2.2
	Group	18	3.11	2.6

Level of contribution, the level of contribution was measured by checking how many features each participant contributed to the instructions. Table 4-22 demonstrates that both communicators contributed equally in terms of the number of features that they added to the instructions in each group (M_{simple}= 2.6, $M_{Complex}$=2.8, ρ= 0.86).

Table 4-22 Comparing the level of contribution of each participant in providing the instructions

Variable	Condition	Mean	St. D	ρ-value*
Number of features contributed in instructions	Simple communicator	2.6	1.19	0.86
	Complex communicator	2.8	1.6	

* Mann Whitney U Test for comparison between sample

Summarizing the above results about the structure of the instructions indicated that the instructions provided under group condition in experiment number 3 were more similar to the instruction provided in the complex condition (provided individually) in experiment number 1 in terms of the number of words and the uncertainty scores. As a result, the instructions provided by two collaborating communicators with different categorical knowledge has a similar

degree of complication as those instructions provided individually by the participants of the complex condition. This finding suggests that, during the communication process, the communicators who learned about the complex set are more influential; however, the equal level of contribution contradicts this finding. If the complex communicators were more influential and paid attention to more features (as indicated in Section 4.4.3), then why did they not contribute more? It is obvious that the instructions as the final outcome of the tasks do not represent the interaction between the communicators. The results of the echo-method questions and the analyses of the interactions will shed some light on this.

4.6.3.3 Echo-Method

Previous measures in the questionnaire indicated that both participants perceived their contributions equally. Even though the participants under complex condition rated their knowledge about flowers lower than the other participants', the participants under simple condition rated their knowledge about the flowers equal to the other participants' knowledge. In addition, from the instructions provided collaboratively, we know that even though the participants under the complex condition were more influential, both participants contributed equally in writing the instructions.

Each participant was asked to give examples of helpful and non-helpful behaviour of him/herself as well as examples of helpful and non-helpful behaviour of the partner. These questions were asked to elaborate on how the participants perceived their own performance and contribution as well as those

of their partners. Their comments are coded and summarized in table 4-23 and 4-24.

Table 4-23 Summary of the comments that the complex condition's participants made

Complex condition							
Partner's Non-Helpful		Partner's Helpful		Your Non-Helpful		Your Helpful	
Passive communicator/ agreed too much	4	Noticed different feature/challenged my feature	8	Not comfortable speaking/ Uncertain in defining the regions	6	Provided extra or different features/challenge the other features	10
Paid attention to less/simplistic features	6	Elaborating on the instruction	2	Taking control/not considering other features	6	Elaborating on my theory	4
Vague comments	2	Communicative	3	Confusing points/complex words	3	Elaborating on the instruction	2
Taking control/ not considering other features	2	Drawing picture	1			Guide conversation	2
						Drawing picture	2
Total number of comments	14		14		15		20

Table 4-23 demonstrates the summary of the comments provided by the participants of the complex condition. They thought that their partner (from the simple condition) was not providing valuable information since they commented

on the “simplicity of the simple participants’ hypotheses” or “providing vague comments” or “being passive” in the course of interactions. However, they yet appreciated the different features presented by the participants of the simple condition. When they commented about their own helpful and non-helpful behaviour, they commented about “their uncertainty about how to distinguish” the flowers and “not considering the other partners’ features” as their non-helpful behaviour, while they felt they contributed well to the task by “providing features that the other communicator did not pay attention to”. All the comments and respective codes were provided in Appendix D.

Table 4-24 summarized the comments that the participants under the simple condition provided for their own helpful and non-helpful behaviours, as well as those of the other communicators. The results indicated that the simple set participants were not satisfied with the features they paid attention to. They thought that they could have done a better job by paying attention to more details. With respect to the communicators from the complex condition, even though they appreciated the “careful attention of the other participants”, they felt that the complex set participants “had confusing theories” in some cases, and that the other participants did not consider their features. All the comments and respective codes are presented in Appendix D.

Table 4-24 Summary of the comments that the simple condition's participants made

Simple condition							
Partner's Non-Helpful		Partner's Helpful		Your Non-Helpful		Your Helpful	
Confusing theories/ complex words	4	Attention to different feature/challenge my features	5	Too general/not correct features	10	Different perspective/feature	8
Taking Control/not considering my features	3	Attention to details/ good insight	4	Taking control	2	Elaborating on the instruction	4
Uncertain	2	Elaborating on the instruction	2	Passive	1	Open to discussion/ communicative	2
Too much attention to details	2	Taking notes	2				
						Elaborating my theory	1
Passive	1	Elaborating his/her theory	1				
		Picture	1				
Number of participants commented	12		15		13		15

4.6.3.4 Conversation Analysis

Conversation between the simple group participants and the complex group participants were analyzed in each group. The pattern of discussions was coded from different aspects. The main focus in these analyses was on how the communicators influence each other and how they perceive each other's

knowledge about the flowers of region A and B. To do so, different variables were defined, which will be explained below.

Who starts the conversation? I checked all the conversations to see who initiated the conversation. The complex set participants commented about their own uncertainty and confusion as indicated in the previous section. The participants under the simple condition also commented that their partners used complex words and had confused them. In addition, the participants who learned about the complex set developed a more complicated theory, which could be explained in more words and higher uncertainty scores. Their theory was associated with certain degrees of uncertainty because the features included in the theories may not account for all the flowers (or at least most of the flowers) in one region. As a result, it is likely that the participants under the complex condition hesitated in sharing their hypotheses.

The conversations were coded with respect to two possibilities. First whether the participants initiated the conversation and shared the hypotheses and features as self-motivated, or were asked to share the hypotheses and features. For example, the first two instances below indicated the cases in which the complex participants asked the simple participants' opinions. The last example is a case a simple communicator initiated the conversation on his own.

Group 11 (ID: G11)

C: okay how did you determine things of region A?
S: So the flowers petals were typically really smaller than for region B,
C: yeah. Okay.

S: and then does have stem (…) I think,

C: yeah

Group 15 (ID: G15)

C: what did you think?

S: I thought it was just (...) if there was leaves around it like a lot of leaves it would be in A. Did you notice that? What did you notice?

C: is this path the only rule

S: yeah, it worked for me (laughing)

Group 17 (ID: G15)

S: overall in group A flowers were smaller and (..) group B was generally bigger

C: and I realized that for group B there is generally (.) like if it is in a group then it is part of group B

S: okay. Yeah (….) mmm at first I've looked into the colours

Table 4-25 shows the number of times that the communicators under each condition initiated the conversation or were asked to start the conversation. In 13 out of 18 groups, the simple communicator initiated the conversation, which is marginally higher than number of times that the participants under the complex condition started the conversation ($\rho = 0.09$).

Table 4-25 Comparing the simple and complex participants in starting the conversation

Variable	Condition	Self-motivated	Offered	Total	ρ-value*
Who starts the conversation	Simple	4	9	13	0.09
	Complex	1	4	5	
* One Sample Binomial Test					

Rate of acceptance, from analyzing the instructions we found equal contribution in terms of the total number of features that each participant included in the instruction. However, it will be interesting to see the ways that each feature is accepted or rejected in the course of interaction. I checked the number of features that each participant proposed during the conversation, and whether the other participant accepted the feature or not (Table 4-26). The results indicated that the complex group participants proposed slightly fewer features during the conversation compared to the simple participant ($M_{complex}$= 3.7, M_{simple}= 4.5, ρ= 0.22); however, on average, the complex participants received higher acceptance from the other communicator ($M_{complex}$= 81%, M_{simple}= 57%, ρ= 0.02).

Table 4-26 Comparing the number of proposed features and percentage of acceptance of simple and complex participants

Variable	M	ρ-value*
Number of times ***simple*** *communicator* proposed a hypothesis	4.5	0.22
Number of times ***complex*** *communicator* proposed a hypothesis	3.7	
Complex participants accepted features proposed by simple participants	57%	0.02
Simple participants accepted features proposed by complex participants	81%	

*Mann Whitney U Test for comparison between sample

In addition, comparing the number of features that are discussed during the conversation to the features that each communicator asked during the testing phase individually revealed that, during the conversation, the simple communicators talked about all the features that they asked about in the testing phase; however, the complex communicators only discussed 73% of the features that they asked about in the testing phase.

Attention to extra features, I also coded the conversation according to number of times that the complex participants proposed features that their partner did not pay attention to, and was impressed by the proposed features. If one of the participants clearly indicated signs of surprise and being impressed by the features or theories offered by the other participant, then the conversation was coded as attention to extra/hidden features. Examples below demonstrate two instances of such cases.

Group 8 (G8)

S: Did you look at a strategy for figuring out?
C: uh, this is the strategy then. The flower that goes kind of from invert to outward is in B
S: 'aaah' (surprising)
C: and the one goes like a concave (drawing pictures) [are in A]

Group 16 (G16)

C: ..., I thought about the number of petals too sometimes
S: oh. Really? I didn't notice that

Coding the conversations indicated that the complex communicators in 13 cases (out of 18) proposed the features that the simple communicators were impressed by or confessed that they did not pay attention to. However, there was no similar situation for the other communicator.

Lack of attention/being wrong, presenting features that the simple person had not paid attention to along with lower percentage of acceptance by the complex participants made the simple participants doubt their own theories and think that they did not pay enough attention to the flowers during the learning phase. If in the course of interaction, the participants confessed that they missed certain features, the conversation was coded as lack of attention or being wrong. For instance:

Group 3 (G3)

C: … region A flowers had more detailing on it, (…) That was what I noticed. And then they tend to be around four five like less than six petals,

S: uhum

C: whereas this one was like no detailing that's how I distinguished them.

S: Okay and you got them right on the second phase?

C: Yeah, I guess. Whether the colour was bold colour or a brighter colours

S: brighter colours. Okay I think that's something that I am missing here

Group 4 (G4)

S: And I think not in all of region A but in all of region leaves were visible but leaves were never visible in region B

C: The leaves?

S: yes, the leaves of the plant. Like you'd see the flowers from the region B but you wouldn't see the plant in the region B… in the photo,

C: hmm, No I am pretty sure I saw bunch of leaves

S: Really ??? (Very surprised)

C: yeah (laughing)

(Pause) (S thinking)

S: Okay maybe that was my …

C: I am pretty sure I saw leaves, (…) but the flowers were more focused in region B if that's what you meant.

S: yeah, Maybe. That's (…). I may not remember but maybe ..

In Group 3, the simple communicator states that he did not pay attention to the detailing on the flowers. In Group 4, the simple communicator doubts his feature about visibility of the leaves. Coding the conversations of all the groups, 10 groups (out of 18) indicated explicit indication of being wrong or missing something during the learning. However, there is only one instance in which the participant under the complex condition indicated a lack of attention, or being wrong.

4.6.4 Summary of the Results of Experiment 3 and Verification of Hypothesis 4

Various measures were reported for Experiment 3 in the previous sections, and a summary is necessary to make sense of all the data. The results indicated that during the collaboration, participants contributed equally and included equal number of features in the instructions. However, each of them experienced different psychological situations during the learning and collaboration. The complex set participants experienced difficulty in learning the flowers and developed a more complicated theory. Due to the complexity of the set, they felt that they didn't learn about the flowers with high degree of confidence, therefore, they rated their knowledge lower than the other participants in the questionnaire. The conversation analysis indicated that they were also reluctant to begin the conversation. However, the simple set participants felt more confortable about their theory, since it was simple and worked pretty well during the learning and testing phases.

When the conversation began, the simple theories that the simple condition participants provided were rejected 50% of the time. The complex participants paid attention to different types of features that the simple person had missed in most of the cases. as indicated in the conversation analysis. Even though the complex participants shared fewer features during the conversation, the presented features impressed the simple participants. Higher rejection of their theories along with impressive features presented by the complex participants made the simple participants feel uncomfortable about their theories and made them think that they did not pay attention to all of the potential features. As a result, they are more accepting of the comments provided by the complex participant. The complex participants are more influential in providing the instructions as the instructions provided in the third experiment is similar to the instructions provided in the complex condition in Experiment 1 (individual conditions).

The last hypothesis stated that

Hypothesis *4: when two individuals who learned categories with different degrees of variability are communicating, the person who learned categories with high ratio of within to between variability is more influential than the person who learned categories with low ratio of within to between variability.*

Table 4-27 Variables used to compare the instructions in three conditions

Variable	Simple	Complex	Group	ρ-value (Comparing simple and group)	ρ-value (Comparing complex and group)
Number of words after redundancy elimination	21.47	33.41	36.27	0.01	0.78
Uncertainty score	1.59	3	3.11	0.07	0.98

Table 4-28 and 4-29 summarized the variables used to indicate that the participants under complex condition (with high ratio of within to between variability) were more influential during the communication process. The table only reports the variables that were supported statistically. As demonstrated in Table 4-28, the instructions provided in group condition are similar to the instructions provided in the complex condition by individual participants, which indicated that the complex participants were more influential in providing the instructions. In addition, Table 4-29 indicated that the simple participants accepted the features proposed by the complex participant in 81% of times; however, the rate of acceptance is significantly lower when the complex participants accepted the features proposed by the simple communicator ($M_{Simlple}$= 57%). Therefore, the complex communicator was more influential in the course of interaction. The results supported the last hypothesis.

Table 4-28 Comparing the percentage of acceptance for simple and complex conditions

Variable	% of acceptance	ρ-value
Simple participants accepted features proposed by complex participants	81%	0.02
Complex participants accepted features proposed by simple participants	57%	

Chapter 5 General Discussion and Conclusion

5.1 The Effects of Category Structure on Learning

The results of the three experiments point to two important relationships. First, they emphasize how a category structure can affect the ways that the learners process information. Second, they indicate the relationship between the complexities of the learned categories on the communication process. The results of the first experiment were aligned with the results of similar studies that have investigated the effects of category structure in learning (Kloss & Sloutsky, 2008; Minda & Smith, 2001; Nosofsky et al., 1994). The current study is an extension of these previous studies in terms of using a natural stimulus as well as focusing on the number and type of the features affected by the structure of the categories.

The results of the experiments supported our hypothesis about differences in information processing in terms of the number of features. Both the efficiency and number of trials indicated differences in the learning process in the simple and complex conditions. The category with the complex structure was more difficult to learn. Under the complex condition, the participants had to pay attention to more features since the categories were characterized as high ratio of within to between variability. Finding the rules for distinguishing the categories was more difficult and took more time, presumably because the participants had to test more hypotheses. However, under the simple condition, participants

investigated fewer numbers of features and tested fewer hypotheses, which resulted in faster and more efficient learning.

The number of features in both conditions was tested. As expected, more features were asked about under the complex condition than under the simple condition. For instance, one participant of the simple group only tested the differences in the colour and the size of the flower to distinguish between the regions; however, under the complex condition, a participant went through testing features such as colour, size of the petals, size of the leaves, number of petals, existence of single vs. many flowers, and so on. The type of features included in the two conditions was affected by the variability. The higher ratio of within to between variability made the participants of the complex group look for features that they would have ignored otherwise.

5.2 The Effects of Category Structure on the Communication of the Learned Categories

The complexity of the categories also influenced the theories that the learners developed. They were forced to pay attention to more features and experienced more rejection of their hypotheses during the category learning. In addition, it took them longer to learn all 12 pictures compeletly. They found it difficult to develop a theory because the catgeories cannot be explained with just a few features or a simple theory. Even the features that they paid attention to do not explain the categories with a high level of certainty. Comparing the complex and simple categories, more uncertainty exists in the complex categories, and the learner needs more information to define them. Therefore, the theory that they

developed had to present more information. The uncertainty and the difficulty of the theory were presented in their written intructions. The need for a higher amount of information and complexity of theory caused the participants of the complex condition to communicate their theories differently. Their theories were composed of more words and had different structures. The results are aligned with the results of the previous studies in the communicaiton process between people with different degrees of knowledge (Voss, et al, 1980). Voss et al. (1980) noticed that baseball experts exhibited a greater ability to generate text with more details about the half-inning of the game than novices. This corresponds to many instances of communication in a non-laboratory environment. For instance, a mechanic has a more complicated theory about a good car compared to an ordinary person, who has less knowledge about cars. While the ordinary person may refer to the level of comfort in driving, the mechanic may refer to engine power, number of cylindars, and so on.

Communicating the simple categories was more effective than communicating the more complex categories. The large body of literaure on communication between phycisians and patients indicates the difficulties in their communication as a result of differences in knowledge (Arora, 2003; Ong et al., 1995; Plat & Keating, 2007). Part of our knowledge can be represented categorically, such as our knowledge about diseases or animals. The complexity of our knowledge affects the structure of the catgeories that we posesss (Chi et al., 1981; Shafto & Coley, 2003). For example, Chi et al. (1981) found that senior physics students have different categorization schemes than junior students. Shafto and Coley

(2003) indicated that knowledge and expertise impact conceptual structure and reasoning. In the same way, the categories of diseases are more complex for physicians than for ordinary people, and this complexity could be represented in the communcation process when the physicians communicate about the categories of diseases. According to the results of this study, communicating a complex set of categories is less effective, which could potentially explain part of the difficulties experienced in the communication between patients and physicians.

The results of the last experiment indicated that the complexity of the structure of the categories affect the pattern of the conversation between the two communicators. The difficulty in elaborating a theory that could define the categories and the higher amount of information needed under the complex condition made the complex participants feel uncertain about their theory and start the conversation later by asking the other participants to initiate the conversation; however, after being informed about the simple participants' theories, which did not sound correct to the complex participants, they explained their own theories and rejected the theories proposed by the simple participants 80% of the time. Not only were the simple participants' theories rejected, but the complex participants proposed complex theories by which the simple participants were impressed. The complexity of the complex participant's theory and rejection of their own theory made the simple participants assume that their own theory was not comprehensive enough, and made them feel that they did not pay attention to all the potential features. The results indicated that the

complex participants were more influential during the conversation. This conclusion could be considered similar to the conclusion made by O'Keefe & Sypher (1981) in which the higher cognitive complexity resulted in more persuasion; however, their study was not focused on the communication of learned categories; persuasion was measured differently, and not similar to the degrees of influence that I considered in this study.

One important aspect worth mentioning in this study is the effect of interaction on the communication process. As the conversation begins, the communicators influence each other. Their perceptions about the other communicators influence the pattern of communication. For instance, in one of the groups, at the beginning of the conversation the simple participant asked about any strategy used by the other participant. The complex participant proposed a theory of "a concave versus convex flower", which really influenced the simple participant. She gave a big compliment about the smart strategy developed by the complex communicator. In return, the complex communicator acted as being very nice and humbled, and accepted the simple theories that the simple communicator proposed. However, if the simple participant had just started by talking about her theory before the complex communicator, he could have rejected it easily. This interaction and the final instruction provided in the group were shown in Appendix E and F. Each group had its own characteristics with respect to how the two communicators influence each other, which made the analysis difficult; however, the data still indicated that the participants from the complex condition were more influential.

In the literature, the interaction between communicators has been considered in terms of a medium that creates a common ground for the communication. For example, Isaacs and Clark (1987) explained that two communicators with different amount of knowledge (while they didn't have any idea about the other communicator's amount of knowledge on a specific domain) go through three steps to eliminate the discrepancies in their knowledge. First, they "assess" each other's knowledge, then the ones with more knowledge "supply" the needed knowledge and then those with less knowledge "acquire" the knowledge and try to fill the gap. However, their study did not consider the ways that the pattern of conversation may influence the communication process. The pattern of conversation may encourage a different rate of acceptance for the knowledge supplied.

This study has been inspired by the study of Professor Alex Bavelas on cancer cells[5]. In his study, he shows pictures of cancerous and non-cancerous cells to two groups of participants. The participants are separated, and they can neither see each other nor talk. They are told that they should learn to distinguish between cancerous and non-cancerous cells by trial and error. They should indicate whether the pictures show cancerous cells or not, and then they receive feedback of right and wrong on their answers. The first group receives true feedback, meaning that when the participants distinguish a cancerous cell correctly, they receive feedback as being correct; however, the second group

[5] This is an unpublished study. Pual Watzlawich mentioned the study briefly in his book (Watzlawick, 1977). I was informed about the details of this study in my meetings with Professor Frank Safayeni, who received information about the details of the study directly from Professor Alex Bavelas.

participants, called random feedback condition, do not receive feedback according to their responses. Instead, they received the same feedback as the other participants received. This means that no matter what the participants of the "random feedback condition" chose, they receive "correct" if the participants of the true feedback condition's choice is right and receive "incorrect" if their choice is wrong.

Subjects in the first group develop simple and concrete theories to distinguish between two types of cells whereas subjects in the second group are in a difficult situation. They develop a very complex theory because they have to base their theory on contradictory information. The interesting part of this study is when the two subjects of each group are asked to discuss the theories that they have developed. The subjects from the first group with true feedback are impressed by the theory and explanations of the second group's subjects. They are easily convinced by the sophistication and complexity of the theory that the subjects from the second group assert, and are even embarrassed by the simplicity of assumptions that they proposed.

The results of Alex Bavelas's study can be explained by the amount of variability that one perceives in each condition. The group in the "true feedback" condition categorizes images of cancerous and non-cancerous cells in such a way that the variability within each category is minimized and the variability between the categories is maximized (low ratio of within to between variability). Subjects pay attention to certain features to distinguish between the two categories. However, the group with random feedback receives high within

variability and low between variability (high ratio of within to between variability). The different images of cells have to reside in one category and, the very similar images of cells must be assigned to the different categories of cells due to the random feedback. Therefore, subjects have to focus on different features and combine them to come up with rules and theories to distinguish between cancerous and non-cancerous cells. Therefore, true feedback resembles the case of "low within & high between variability" situation, and random feedback indicates the case of "high within and low between variability". The results of experiment 3 are aligned to the results reported for cancer cell studies where the participants under complex condition (high within low between variability or random feedback condition) developed a more complicated theory, and their theory impressed the participants of the simple condition (low within high between variability or true feedback condition).

Chapter 6 Contribution, Limitations, and Future Work

6.1 Theoretical and Methodological Contributions

This study has contributed to both fields of category learning and communication. The current literature in the field of category learning indicated the relationships between category structure and difficulty of learning. It has also focused on the underlying neuro-cognitive mechanisms that the various structures may activate during category learning. This study extends the literature with respect to the attention to features and information processing in category learning. It has shown that the category structure affects the ways that learners pay attention to the number and type of features.

One of the shortcomings claimed in the field of category learning has been a lack of connection between category learning and other cognitive mechanisms such as communication (Ross & Markman, 2003). In addition, the literature in the field of communication has less attention on the effects of category structure in the communication process. This study specifically contributes to this connection and has focused on the communication of learned categories.

Categorical representation of knowledge is a common practice in formal educations (i.e., categories of mental health disorders; animal calssifications; alants classifications). In many situations, people have to learn, use, and

communicate the categories of knowledge that they have acquired. Considering the potential effects of the structure of the categories on learning and communication can explain the difficulties reported in using the formal categories. For instance, Maclean's magazine (2013) reported about concerns and confusion that many psychiatrics encountered in using the "Diagnostic and Statistical Manual of Mental Disorders (DSM-5)[6]". While many researchers and psychiatrics think there is a need for such a classification to be used as a guide, many others reported difficulty in using such a complex classification and uncertainty in diagnosing the right category of mental disorder that the person in-need belongs to. Identifying the categories that a given person belongs to affects the ways the person will be treated and communicated; however, because of the "complexity and uncertainty" (Maclean's, 2013) in the categories, choosing the right category is not always possible.

In the field of communication, the connection between our thoughts (knowledge) and communication has been considered and emphasized, but the categorical presentation of knowledge has not been recognized. Categorical representation of knowledge can be beneficial specifically in describing the communication process between people who have different levels of knowledge. For instance, communication between patients and physicians and between experts and novices have been reported as being problematic. However, the literature in this area has been claimed as lacking theoretical foundations.

[6] A formal manual initially provided by the Americal Psychiatric Association in collaboration with the National Commission on Mental Hygiene published in 1952. The manual has been reviewed and updated several times. The most-recent version (DSM-5) published in 2013.

Considering how differences in categorical knowledge influence the communicator's process can contribute to theoretical elaboration of the process of communication.

Methodologically, the study contributes to the field of category learning by considering a natural, rather than laboratory design, stimulus. Attention on the natural stimulus will increase the possibility of linking this field to learning various categories in our daily experience with real life categories and can facilitate exploring studies in the connection between category learning and other cognitive actions.

The cancer cell study by Alex Bavelas (reported in Section 5.2) has been reported as a mysterious and interesting study in a few references (Watzlawick, 1977). Since the study never was published, no theoretical background has ever been provided for the study. One of the contributions of the current study is to provide theoretical background and explanation of what happened in the reported study.

6.2 Future Work

One of the interesting paths that this study can shed light on is explaining the difficulties in the communication process between people with different levels of knowledge. This study introduces a new approach to study such communication processes. Specifically, this path will add value if it is accompanied by field studies to test the external validity of the findings.

This study indicated that increases in the ratio of within to between variability of the category structures affect the theory developed by the learners, and the

communication of learned categories. However, the relationship was not examined to investigate the type of the relationship. For instance, the study did not explain whether there is a linear relationship between the ratio of within to between variability and the complexity of the theory or the communication process. Within the current experimental set up, the ratio of variability can gradually increase by substituting one picture from the complex set to the simple set and then studying the effects of variability on the learning communication of learned categories. Along the same line, it will be interesting to see how much variability is necessary for changing our established theories about the categories. For instance, if the ratio of within to between variability increases slightly, one may simply adjust the theory by adding exceptions to the current study; however, higher ratio of within to between variability may cause restructuring of the theories that are already developed.

Another group of studies that could potentially be related to the interaction between people with different categorical knowledge is ”hidden profile”. In group decision making, Stasser and Titus (2003) and the followers (Lu et al., 2012) found that group discussion does not guarantee successful information sharing, since the shared information is more discussed and encouraged compared to the unshared information. Various reasons have been considered for this issue. For instance, Stasser and Titus (2003) explained that shared information has higher chance of being discussed potentially due to the fact that talking about shared information increases mutual enhancement. However, the result of these studies could be affected by the perception that each

communicator has about the other communicator. It will be interesting to see how the manipulation of the rate of acceptance by the group members can encourage disclosure of hidden information.

In conclusion, the use of categories as a representation of our knowledge will be beneficial in opening various windows to study differences in learning and communication in various social settings. It could explain the differences observed in learning various categories, in the field of category learning. In addition, this study suggests that the dynamic of interaction should be considered as one of the important methodological aspects in studying any communication setup. In our communication we constantly form perceptions about the listener and adjust our pattern of communication accordingly.

Appendices

Appendix A: The Assignment Probability for the Pictures of Flowers Used in Simple and Complex Set

	The probability of being assigned in A	The probability of being assigned in B	The probability of being assigned in "Not sure"
	1	0	0
	0.83	0	0.17
	0.83	0.17	0.17
	1	0	0
	1	0	0
	0.83	0.17	0

	0.17	0.83	0
	0.17	0.83	0
	0	1	0
	0.17	0.83	0
	0	0.83	0.17
	0.17	0.83	0

	The probability of being assigned in A	The probability of being assigned in B	The probability of being assigned in “Not sure”
	0.5	0.5	0
	0.5	0.5	0
	0.5	0.5	0
	0.67	0.33	0
	0.67	0.33	0
	0.67	0	0.33

Appendix B: Instructions

Experiment 1

Welcome to my experiment

General Introduction

I am trying to see how people learn about categories of flowers with the help of certain samples as well as how the communicate about the flowers. So I designed this experiment to look at the process more carefully, which has four sections. First, you will learn about flowers from two different geographical regions. Second, your learning about these flowers will be tested. Third, you will provide an instruction that explains how one should distinguish between the two types of the flowers. Forth, your knowledge about the flowers will be tested again in a different way that the first part. Don't worry about all these sections! I will explain them thoroughly as we get into it.

Phase 1 (Learning Phase)

For the first part, I will ask you to sit by the monitor. You will be shown pictures of flowers from two different geographical regions, which I called region A and region B. Each time a picture of a flower will be presented to you and you should choose whether it belongs to region A or region B. You may start by random guessing initially because you haven't seen any of the flowers. However, as it goes on you will receive feedback on your choices and you will get to know how to distinguish between the two types of the flowers. So, in this section you are expected to learn how to distinguish between the flowers of region A and region B.

After the first Trial

Because I want you to learn about at least all the sample of these flowers, we will repeat the first part till you assign all the 12 flowers correctly.

After completing the learning

I think you kind of get an idea of how to distinguish the flowers so far. I will also show all the flowers to you here on the table so you can have an overall look on all of them. Have a look on the pictures, you can also take notes if you want, and let me know when you feel comfortable to move on to the next part, which is a quick test.

Phase 2 (Testing Phase)

For this part, I have pictures of flowers that you cannot see them but you should guess whether they belong to A or B. The way that it works is like this: I will keep a picture of flower in front of me. I can see the picture but you cannot. You can ask me as many questions as you want. I will answer them and based on the responses you should decide whether the picture belongs to A or B. Regarding the questions, I will only answer yes or no (Binary response). For example you cannot ask me what is the colour of the flower. You should ask “is the flower red?”. We will continue this game until you correctly assign two of the pictures to their regions.

Phase 3 (Instruction Phase)

In this part, you are expected to provide an instruction by which another person can distinguish between the flowers of region A and B. This instruction will be given to another person. The way that the experiment works for that person is like this: the person starts reading the instruction without seeing any picture of the flowers ahead of time. Then I will test him/her to see how well that person can distinguish between the flowers. So, After reading the instruction, the person will be shown pictures of flowers one by one and should choose whether the pictures belong to A or B. Whatever the person knows about the flowers of region A and B are from things you put in your instruction. Because the person won't see any picture ahead of time, make sure that your instruction is clear and understandable. Do your best to make it complete and perfect, I will also give you back the flowers so you can use them as kind of reference; however, the person won't see identical pictures as these flowers but from the same regions. You can start writing the instruction any time now.

Experiment 2- Instruction for the Learners

Welcome to the experiment!

I am trying to figure out how people communicate the categories that they learn, and this experiment is designed to test the effectiveness of the instruction prepared by another student about two categories of flowers.

The experiment has two parts. I will explain the second part later when we get into that. I will also record this experiment and everything will be confidential.

For the first part, you are supposed to read an instruction, which is provided by another student, and then distinguish between the flowers of two different geographical regions (called region A and B). The student learned about these flowers by looking into the samples of flowers from each region and then wrote the instruction. Therefore, the instruction shows that how you can distinguish between the flowers of two different geographical regions (called region A and B). Once you read the instruction completely and feel comfortable with it I will show you pictures of the flowers one by one. You should let me know your decision about the origin of the flower. It means that whether you think the flower belongs to region A or B according to the instruction that you have. Once you tell me your decision about the first flower, I will show you the next one. There are 12 flowers in total and I will let you know whether you have been right or wrong at the end when you are all done.

Now, please look carefully to all the pictures here. Read the instruction one more time. And then, improve it in such way that the other person won't make

these many mistakes as you did. The improved instruction will be given to another person following the same procedure as you had.

After doing the interview:

Second part

Now that we are all done with the first part, I am going to test you again about the flowers of these two regions. I will show you 12 pictures of flowers one by one and you tell me whether each picture belongs to A or B.

I will give you feedback in a minute but before that I want you to have a look on the flowers that you assigned to each region and guess how many error you have if any.

Appendix C: Questionnaire

Experiment Date and time ……..

Condition……

Username and student ID (for bonus mark) ……..

Name ……..

Thank you for your participation. Please answer the following questions.

1. How much contribution do you think you and your partner had in completing the instruction? Please rank your contribution as well as your partner?

	0% contribution	25% contribution	50% contribution	75% contribution	100% contribution
Your contribution	O	O	O	O	O
Your partner contribution	O	O	O	O	O

2. How knowledgeable do you think your partner is about the flowers?

O	O	O	O	O
0% knowledge	25% knowledge	50% knowledge	75% knowledge	100% knowledge

3. How knowledgeable do you think you are about the flowers?

O	O	O	O	O
0% knowledge	25% knowledge	50% knowledge	75% knowledge	100% knowledge

4. If you were asked to perform a similar task would you like to work with the same partner?

Yes O No O

5. Give examples of specific things that your partner did, which you think have not been helpful to you while you were providing the instruction.

6. Give examples of specific things that your partner did, which you think have been helpful to you while you were providing the instruction.

7. Give examples of specific things that you did, which you think have not been helpful to your partner while you were providing the instruction.

8. Give examples of specific things that you did, which you think have been helpful to your partner while you were providing the instruction.

Appendix D: Participants Comments in Echo-Method

Comments From the Complex Participants

ID	Complex			
	Partner's NH	Partner's H	Your NH	Your H
G1	Vague comments (VC)	Eye contact/ give suggestion about what he thought	Shyness in speaking/not comfortable in speaking (NCS)	Open to inputs and comments/giving feedback/ eye contact and nodding to express understanding and comprehension (WL)
G2		Stating other perspectives/integrating both views (DF)	Take too much control (TC)	Distinguishing between defining characteristics and general characteristics/integrating both views (GC)
G3		Taking notes on how he distinguished the flowers (TN)	Using confusing words/did not take note (C)	Explaining my theory (ET)
G4	Gave too much info/may be confusing	Providing with the materials he learnt (Com)	Was confused as to which info to write when given too much info at 1 time	Had the main focus of what differentiated the categories to make it more obvious to the reader
G5	Passivity in argument/his opinion was not enforced enough (P)	Challenges my points/he noticed different characteristics (DF)	Not aware the flowers are from two geographical regions	Provided information from asking more questions in the test/challenges his opinion (XF) (CH)
G6	Bringing up features like size of the petals and colour (SF)		I totally guessed (U)	Difference in size and # of pistols (XF)
G7	Agreed too much (P)	Very nice	Writing things down with out asking (TC)	Guiding the conversation (GC)
G8	Talked about other criteria that weren't helpful (SF)	Gave more idea on how to evaluate the flowers and how best to write the instruction (EI) (Com)	Complex wording to explain-confused her (C)	Suggesting to draw the flower (P)
G9	Dismissed some of my ideas if they were not something she notices explicitly (TC/NCF)	Different outlook on flowers/noticed different characteristics that I had not thought about/open to discussion and provided feedback (DF)	Few details which were inconsistent with partner's findings (AD)	Provide clear description of characteristics that I noticed/including picture when necessary (ET) (P)
G10		Areas condition/colours (DF)	Did not think about bright and dull colours (NCF)	Suggestions about leaves (XF)
G11	Agreed with any	He described opposites	I did not observe the	I mentioned colour

	thing I said which probably were not completely correct (p) (U)	helped to distinguished the regions (DF)	stem as closely (NCF)	which helped to distinguished the flowers (XF)
G12	Not explained his categorization (wording was vague)- I had to asked what he meant (VC)	Took a descriptive note- proofreading the instruction (TN) (EI)	Had written and descriptive notes/I used fewer categories (features) to classify A or B (NCF)	I made sure the instruction is clear-explained my reasoning (EI) (ET)
G13	She sort of left it to me to come up with all of the details/make the final decision on what to write down-She was not sure what she saw during the experiment (P)	Different perspectives that either supported or challenged mine-helped narrowing down the characteristics (DF)	I may have been overbearing in stating all my opinion to the point that she was doubting her own (TC)	I pointed specific features-things that she didn't seem to remember/ I explained what I saw in details so she could compare her thoughts to mine (XF) (ET)
G14	Categorizing exclusively on the basis of one particular colour (SF)	Categorizing flowers based on the patterns of the petals (DF)	Categorizing based on relative size (C)	combing colours and sizes to identify the regions (XF)
G15	He provided only one point (SF)	Provided a description of flower A	Didn't provide a clear description of the flowers (U)	Provided more points about the flowers (XF)
G16		Had points written down and ready (TN)		Remembered some of the images-provided analysis for some of the flowers (XF)
G17	Colour of flowers may not be relevant because sometimes there were purple flower in both regions (SF)	Size of the flowers (big or small)- whether the flower was grouped on its own or with other flowers (DF)	Trying to distinguish a particular shape between flowers (hard to find a certain shape)-it is easier to look at other factors such as colour, size (U)	Trying to distinguish locational aspects (soil)- categorizing them into species based on appearance (colour-number of leaves- comes as bunch or single) (XF)
G18	He gave specific trait of region A that I did not agree but we put it in the instruction any ways (SF) (TC)	Drawing picture/legend of the flower-taking it out/communicative (Pic)(Com)	I sat there & hummed a lot instead of brainstorming (NCS)	Suggested how to reword questions/instructions to be clear (EI)

Comments From the Simple Participants

ID	Simple			
	Partner's NH	Partner's H	Your NH	Your H
G1		He shared his hypothesis on the defining characteristics of the flowers (DF)	Forgot my page in the other room with my characteristics for both flowers	Similar understandings about the flowers
G2		Taking note about the features (TN)	Cheating by memorizing the answer without looking deeply into the images (SF)	Focused on certain characteristics (DF)
G3		Bringing up similarities/disagreeing with me and suggesting her own opinion (DF)		Took notes of what was said by myself and my partner/ asked questions to confirm and broaden our understanding of the similarities between group A and B (Open to Discussion)
G4		Opposing opinions/ brought up categories that I didn't think of (DF)		Opposing opinions/brought up knowledge she didn't have (DF)
G5	Not enough time taken to understand my point of view (NCF)	Taking detailed notes/asking relevant questions (TN)	Not enough detailed questions (SF)	Different point of view (DF)
G6	Only one feature (instruction) (U)	At least he had one feature (instruction)		Explaining what I mean by my word choice (ET)
G7	She was in rush so we couldn't make a detailed instruction (NCF)	She cooperated with me and discussed before beginning/accepted all my suggestion (CH)	I didn't write my points myself	Told her what I observed/ told her about region A being close to ground (DF)
G8	Not wanting to include instruction of other characteristics (like leaves) (NCF)	Provided a very specific explanation (concave or convex) (AD)	Offering subjective criterion (like tropical) (SF)	Giving my input about colour to add the initial feature we had written down (DF)
G9	His lack of knowledge of flowers prior to study/he contributed all he could (U)	Paid more attention to the climate and environment and concluded region A is dryer. Also paid attention to the roots of the flowers (DF) (AD)	Not taking notes of roots or overall flower shape	Concluding that we looked at different pictures
G10	Tried to list all of the flowers in each set as opposed to general trends (AD)	She wrote the list down and had a strong knowledge of the two regions (AD)	I gave generic trends which may not help the third person who have not seen the 2 sets (SF)	Tried to be as specific as possible
G11	We saw different	Described the shape of	I thought petals colour	I think the size of the

	flowers so some descriptions did not help me to complete the instruction (C)	the petals well- and number of petals (AD)(DF)	was different by different regions but it was not huge (SF)	petal is the biggest difference and my partner accepted (DF)
G12	Didn't provide significant feedback about what I found just said yea I have what you had (P)	Provide pictures-made the instruction clear (P)(EI)	Did not always provide sufficient time to talk or share (TC)	Providing various opinions and ideas (DF)
G13	Differences in opinions and what we observed made me doubt my own opinion- (C)	She assured me she was no flower expert- spoke out when she was not agreed- she began the conversation- she was willing to listen to all of my points-whether valid or not (DF/CH)	I agreed when I was not sure (P)	I listen to her points-whether valid or not-spoke up when disagreed (DF)
G14	The presentation-layout of notes	Minor observations that I did not catch- like "if flower white & small then A" or "purple and small" (DF) (C)	Large and small feature that I said was very subjective- not a good bit of info (SF)	Setting up a flow-chart strategy-columns separating A and B in my note (EI)
G15	He was ambiguous in some of his reasons for categorizing (C)	Mentioned A region flowers had cactus features and more exotic (DF)	Should have been more detailed in my descriptions (SF)	Provided a third step to help instructions (EI)
G16	Give suggestions for identification methods that were not definitive (AD)	Clarify the clarity of the instructions (EI)	Disregarded the suggestion (TC)	Clarify which methods were definitive and which ones noes not (EI)
G17	When she was explaining the flowers of one group I was a bit confused and had to recall if I saw the same thing (C)	Asked for my opinion for almost every instruction. Form instruction formally even though I presented my thought informally	I was vague describing the flowers (SF)	Took the initiative to communicate-answer her questions (OD)
G18	Request recollection of specific details which I hadn't considered (AD)	Clarifying his instruction/terminology (ET)	Unable to contribute when asked questions about the picture (SF)	Plan out the instruction and clarifying when possible (EI)

Appendix E: Transcribed Conversations in Experiment 3

G1

C: uhm (.) So I guess you wanna start with what you recognized.
S: mmm, I recognized that if you try it the second time it was the same flowers you could just remember what you said true or false and there was only 12 different ones so it was easy to remember.
C: Uh,
S: (Laughing)
C: if they don't get the picture then you can't (…) yeah. Uhm, Okay, So. In region A we have some of the characteristics-
S: white flowers were in region A? (asking in doubt)
C: not all white flowers
S: Okay
C: I think all the purple flowers were in region A
S: Okay. Are they going to see the exact same flowers or other flowers from that set? (asking me)
M: Some flowers from this set some flowers are different
S: Oh so some flower might be part of the set that we had
M: Yes but not all the flowers that the person is going to see.
S: Okay. So we need to find characteristics that are generalizable
C: (overlapping) 'yeah'
S: not just like describing all the flowers that each of us saw
C: Yeah yeah yeah. So (…) its purple color. Uhm, in terms of petals it is more skinny
S: Yeah
C: I think
S: We have like (.) These ones were more like a bunch of flowers kind of together and the other ones like have long stems flower
C: Yeah! (..)I think so because I think one of them had like a lot of flowers like the small one
S: Yeah
C: but that one was in B as well
S: Yeah but it got also long stem, I think (in doubt)
C: Okay, sure. Do you want to write it down?
S: ehhh (…) (mumbling while writing down). Like you never had one big flower that was in A. When it was one big flower it was always in B.
C: Yeah, I think so.
(pause)
C: I think the petals were more flat as well
S: Yeah.(.) I agree
C: yeah. The shape was also more flat (…) (xxx xxx xxx).
(pause)
S: uhm, the petals were flat but the flower had more depth in B I think.
C: What do you mean by depth?
S: like the thickness of the flower seemed bigger in B
C: oh (..)yeah. (…) I think the tip, the petals tip in B is more rounded compare to (.) uhm, petals in A were more pointy
S: Sure. We had, one of the flowers in B you can't see the tip though, it was like a shadow.
C: yeah
S: the big one with and (xxxx) inside
C: yeah
S: So we can't see but that's fine.
(pause)
C: and I think like for A there is this where the petals tip had a double-
S: shape
C: I I don't know how to say it like double layer or

S: yeah shape. Double layer for the tip of , (.)for what?
C: for, some of the petals were like this. For A I think some of them had like something like that
S: like heart shaped petals
C: yeah, something like that
(pause)
S: Are we good?
(pause)
S: Do we get the answer at the end?
M: The answer of ?
S: what are the main characteristics?
M: No. May be later when we are all done with the experiment then I will talk about the whole experiment)
S: Sure. It will be interesting to get a bigger picture.
M: yeah.
C: Yeah, I think that's it.

G2
S: I just wrote some like (.)kind of defining characteristics, when I went through it the first time like (.) I used the first two as trial and after that again so basically I found that in region A flowers are like you see the ground they are typically like grew close to ground. They typically have leaves
C: uhum
S: petals are generally larger.
C: uhum
S: They can be colorful but they are usually like white and not very vibrant
C: (overlapping) 'okay'
S: and they have a longer stem-
C: (overlapping) 'okay'
S: You can see more of the stem than B. whereas (.) the B like the region B flowers are very vibrant usually.
C: uhum,
S: Very colorful. From the pictures I didn't see that they are very close to the ground so they could be elevated or not. They don't seem to have a very evident stem and they don't seem to have those.
C: okay. What I saw is pretty much the same things. With A I noticed that a lot of colors were more of solid colors rather than more gradient or brighter-
S: (overlapping) 'yeah'
C: colors than B had. B also had pointy leaves like like they had leaves that look like pretty pointy, I would say.
S: okay
C: um, Well A is more smooth if I remember correctly.
S: because I remember one picture where the flower was close to ground and had spiky leaves. That was A.
C: Yeah, I remember that one too. I think there are also other plants on top of it or something.
S: Possibly (..) I think the leaves. What do you think about the leaves? Do you think that B usually has less leaves?
C: I think with B, not as much how much leaves they have rather than more of the shape of the leaves.
S: Yes. Because, I guess may be I wasn't looking into the full leaves but I could (.. not clear) generally is the petals, which was like the big petals that actually defined flowers
C: yeah, I think what the pictures when they did show the leaves, the ones that are pointy they are usually B I think.
S: yeah, so I think the main defining factor
C: You mean the color I guess?
S: probably the main defining factors would be the color and the proximity to the ground.

C: uhum
S: I don't know. Did you find that like most of A's was usually you see the ground?
C: yeah yeah
S: Whereas B-
C: is just the flower itself
S: Yeah. Um, So I think that leaves might be a little harder. We shouldn't really include leaves
C: okay
S: We can put it after the defining characteristics and the stem-
C: I don't really know about the stems
S: okay, so we can use it as kind of follow up as well.
C: uhum, I guess A is less colorful more solid colors, B is more colorful, gradience or mixed colors I guess.
(pause)
S: It seemed more vibrant I guess?
C: Yeah
S: (writing) ' typically colorful'. Um, The proximity.
C: yeah, a lot of photos from A grew close to ground too
S: (writing) 'grew close to ground like visible signs of' (…)and then B would usually just be, seemed like higher off the ground
C: (overlapping) 'uhum. Another thing that I noticed was that a lot of pictures from A seemed to be like the pictures of the flowers when they have dew on them so they are wet. (.) Well B (.) I didn't really notice that as much.
S: I cannot say that I saw that personally
C: okay
S: but it could be when it is closer to the ground. Let's use it as the after
C: okay
S: these are kind of defining characteristics, I say, the color and the proximity and then after (follow up characteristics) that it could leaves size
C: hmm and the shapes I guess,
S: yeah. (Writing) typically larger
C: and smooth I guess,
S: smooth, rounded edges.
C: yeah
S: rounded edges (.) where leaves were pointy (..) Less abundant, smaller
C: yeah yeah, smaller.
S: Okay. Possibly, there could be dew, more chances of dew, and dew on leaves. No visible sign of moisture right?
C: yeah. My first though was a dry region for B and then wetter region for A
S: or (..) yeah (…) see(.) I don't know, like dew can be one thing but it doesn't necessarily means moisture. So no visible sign of moisture I guess. Is good.
C: Maybe less visible (xxx)
S: yeah, less. No stem (..) (writing) seems to have smaller shorter stem. Okay. Are you good with this?
C: yeah
S: do you want to start from the scratch for the instruction and say you will be presented by the flowers ..
C: I think we can just copy this here
S: Okay. Sure.
C: Or we can submit this.
S: no I will make it more legitimate (writing)

G 3
S: what did you noticed about the-
C: you took notes
S: I took some but it ended up being wrong. I noticed the pointy petals-

C: Yeah, I noticed that too.
S: and they were thin
C: ehem
S: but then on the second test where I was asked (.) you know ask me a question, I guess these were too subjective or they were wrong. So I couldn't get them based on this.
C: uhm, yeah, I noticed that the ones in region B were more rounded and they tend to be more opened are like bloomed one
S: Okay. I see what you mean. They were sort of (..)they did seemed larger because of that as opposed to these ones they had like sometimes they had gaps between petals.
C; Uhum, and these ones, they had more details on the petals.
S: Uhum
C: I noticed that. And these ones were more like a vibrant color.
S: uhum.
C: Like bright fuchsia, purple (..)Like a one solid color usually (>)
S: uhum
C: and white
S: Uhum
C: and yellow as well. That was what I noticed. And then they tend to be around four five like less than six petals.
S: uhum
C: whereas this one was like no (xxx xxxx xxxx) but that's how I distinguished them.
S: Okay. Did you get it right on the second phase?
C: Yeah, I guess. Like petals whether the color was bold color or a brighter colors
S: brighter colors. Okay. I think that's something that I am missing here. So-
C: yeah the pointy petals was a good one too
S: Okay, I think we should (..) uhum. How should we write this down? Shall we have like a table? A and B
C: I think this is good. We can have A and B. We just write more detailing for the first one
S: detailing you mean other color?
C: mmm (..) I think I call it veins but they are like little lines (.) whereas this one is like a solid concrete color
S: okay
C: the difference between solid color and what about texture, it would be a better word but theses are like more smooth. These are more textured.
S: uhum, Okay.(.) mmm (…) this one I think is wrong the "smaller plants" (a feature he had in his note). So what else we would say? Pointed, thin, textures, and (.) did you notice any thing else?
C: I was gonna say these were more bunches and these were more individually stems but that's not true because there were (xxxx)
S: (overlapping) 'No. uhum'. (…) That's all I noticed
C: trying to think if there was any thing else (..)
S: okay. I can start writing [this]
C: okay. (laughing). (xxx). (….) They were more rounded and like smooth edge on the petals (they started writing for B)
S: right, (writing) 'round petals, smooth edge to petals' . So you mean the other one was pointed edge
C: yeah. And although there was one yellow that wasn't the pointed edge. It had like round edge but the thing is that that flower had detailing on that and was in region A.
S: Are you sure about it? I remember the yellow one was in region B.
C: there were two yellow
S; One of them had like thick petals
C: One had some stuff on it and then there was one like very smooth
S: okay. (mumbling and writing)
C: And then when I did the first test I ended up just distinguishing through texture not other things
S: And you got them true?

C: yeah I got them true using texture
S: Oh' Okay. So this one we said solid color
C: yeah. (.) Solid smooth color. Solid color right.
S: solid color
C: This one has solid color too but then it has texture on it.
S: Okay so this is the best way to write it down. Details on the petals (…) I guess.
C: Details/ texture. I think the texture is a better word. An orchid has details on that I guess. Texture is a better word.
S: And what a bout the white one.
C: The small one right?
S: right. The small white one.
C: that one would be in pointy petals because there was another purple with pointy petals too and it was detailed.
S: And it was in group A?
C: yeah. I think it the pointy edge and it was more than 6 petals
S: So I am writing it down, details on the petal, texture
C: texture is better than details
S: okay. Texture. (writing) (..)How do you spell petals?
C: That's how it is. Not that one.
S: haha, that's why I am an engineer (….)Okay. Mmm (writing) if a flower has one or more of this characteristics here it's either in group A or B. Right?
C: (..) yeah
S: (mumbling and writing)
(writing)
C:(….) Listed under A?
S: Yeah. If it is listed under A is A and vise versa. (…) Is this making sense? I am thinking if you are reading this how would you think.
C: Right
S: Okay do you want to go though it?
C: I think solid bold color?
S: Do you mean like vibrant?
C: yeah. (…) But like A wasn't that vibrant
S: was there a flower with vibrant white?
C: there was the vibrant white, there was an orchid the fuchsia color, there like hot pink color. There was like the small ones, orange and red and yellow one
S: uhum. I think that would be confusing
C: I know (laughing) because there were white in group A and white ones in group B
S: yeah. And it was (xxx)
C: I think this is good
S: Okay. Good

G4
S: So we write separate instructions?
M: No together.
S: Okay. How did you do this?
C: Basically, uhm, I noticed that the A region is all on the ground-
S: yeah. Ground you can see
C: And then B was growing no on the ground like on branches.
S: right. I noticed that you can see the ground also
C: is this how we categorize?
S: How about you make (?) the writing?
C: Okay
S: So I agree with the warmer places. Right? Like B looks like coming from the warmer place A looks like-
C: I have no idea. I was just like ..

S: oh. Yeah? Because A looked like tempered(?) flower because it looks smaller the leaves were more obvious
C: okay. So we can write
S: B looked like more orchids, which I associated with the more tropical climate
C: Okay. It doesn't matter how we write? Like in point forms.
M: yeah. Point form is fine
S: we can also do like a table, a matrix
C: How
S: Oh, no no. what I mean is just (…) this is like A and
C: oh, okay
S: And then put qualities like ground, visible not visible. See what I am saying
C: yeah. (xxx) I am just writing the quality
(pause)
S: Okay. The flowers also tended to be brighter in region A and they tended to be reder and more vibrant in region B. DO you agree?
C: I don't know (laughing).
S: that's-
C:Okay. Yeah I remember region B was more brighter.
S: right region B was brighter. I also though region B was like more as I side like orchid style. Kind of very intricate, elaborate
C: Okay , so (mumbling and writing) (…) Okay the color in region A was -
S: whiter, less vibrant or paler.
C: And then region B was ..
S: bright vibrant. What else would you say?
C: okay. I don't know if the color was a big differentiation because I was kind of confused with color
S: Well, yeah. Wasn't a clear cut. It is just that ones in A tend to be not as red as vibrant but it's not a perfect thing
C: yeah.
S: I guess we can put like in general (laughing), you know what I mean? Just so they know it is not like a hard and fast rule so they are like oh wait this one …
C: it starts with this one because it seems the most obvious
S: yeah, mmm, the petals were different too right? …
C right region A was more, it was like more like (…) thick, I don't know if that's the word to describe it
S: yeah, thicker is right but also like stars and small like petals is region A were like this while they would be like this is regions B. Do you agree?
C: I remember region B green leafing
S: yeah exactly. Yeah yeah yeah
C: So what would you call that? The petals?
S: yes. The petals we can even draw those two shapes
C: do you wanna draw? (laughing)
S: Yes. Yes. I will draw, (.) they probably look at it and say what is it? (…) leaf shape (..) in general. Okay
C: All right. what was the two flowers name that can distinguish? Orchid?
S: Orchids? I don't know with the other ones. Anu (xxx)?
C:I don't know
S: but just orchid we can call this one orchid-like..
C: I don't know. But I though region A was more weed. You know like randomly grown
S: yeah
C: and region B was more garden (.) I don't know (laughing)
S: No. That's good I didn't think about it that way. I agree. That make sense. I didn't think about it that way (..) but yeah. it also just felt, as you said, it was a much like mushy ecosystem with B. DO you know what I mean?
C: No

S: like A seemed like you could see the ground and the ground wasn't covered with plants. Seemed like things you'd expect in northern Canada or even here just it's a bit scarcely (?) in the ground. Right?
C: yeah, yeah yeah
S: but region B looked like you'd expect it in Costa Rico or something
C: So I can write it here (..) and it is grown above ground on branch
S: And I think in the, not in all of region A but in all of region leaves were visible but leaves were never visible in region B
C: The leaves?
S: yes, the leaves of the plant. Like you'd see the flowers from the region B but you wouldn't see the plant in the region B (…) in the photo-
C: mmmm, No I am pretty sure I saw bunch of leaves
S: Really ???
C: yeah (laughing)
S: Okay maybe that was my (…)
C: I am pretty sure! I saw leaves(…..) but the flowers were more focused in region B if that's what you meant.
S: yeah, Maybe. That's . I know what I meant but but maybe
(pause)
C: (laughing). I wont write that just in case. Is that enough?
S: I think so. I mean what else you would put. The only differences , the only think I would say too is like the texture of the leaves of the flowers were different. Right?
C: yeah. Yeah. The texture of the flowers? I just realized the texture for region A leaves was more like hard-
S: hard- thick right
(pause)
C: And this was, I don't know , regular.
S: Did you notice the pollination? Like the pollination center? It seemed to be a little different but I don't know if held all the time. Because Sometime it was like this for region A like you had the flower and this is it and then for region B it was much more intricate. It was one going like that (drawing) and it had the orchid style.
C: I don't know
S: Okay. I am not sure either just checking.
C: (mumbling and writing)
S: And then I think the texture of the flower was thin.
C: Okay.
S: would you agree?
C: yeah. That's true.
S: I think that's enough to give them 6 items to go. Actually we might be giving them too much information because at some point they will be overloaded and they like
C: (overlapping) 'yeah'. I just start this with this one which is the big differentiation.
S: right
C: legend! (laughing).this means more obvious. Okay.
S: Okay. I think we are done

G5
C: Okay. What you got?
S: I think the main thing was B was like closer shot flower while A .. B was like closer shot on one flower while A was like bunch of different small flowers scattered together.
C: B wasn't closer shot flower there was one flower that was really far. The one that was orange, red and yellow had little bunch of small flowers and it wasn't big shot
S: oh really?
C: yeah. I don't know if you can base it completely off of the shot
S: yeah yeah
C: What I found based on the photos, right, and I think most of these are statistically insignificant but in group B five or six of them were in a tree or bush

S: yeah yeah, I had that too.
C: but it was opposite here. There was no pink flower in group A. There was no purple flower in group B from the photos but then after the testing and stuff that didn't seem to matter. Seemed like the majority of flowers in group B had five petals whereas the number of petals in group A varies more but some still have five so basically it is …
S: yeah
C: I am not sure if there is a certain way to say it, but actually it is based on probabilities
S: yeah, well, I asked two questions for each one. And I got them. it was pretty much I asked like if the ground was visible and whether it was one flower or a bunch of flowers like a bunch of bulbs
C: uhum
S: And also whether it was white or not but just because I had A more white. And for the second one I asked if it was white and it wasn't but it was still in A I think. So yeah, I don't think the color really matters but
C: I found that, did you find that the ones in B, some of them had more than one color on the flower whereas in B most of them had where single color?
S: B as a group seemed more colorful in general which seemed more bland but I don't think we can based off of colors
C: It seemed like B was from a warmer climate, tropical, and A was more like
S: I don't have any idea (laughing)
C: I don't know. We can ask that. So what would you see to figure this out? Because I found that the ground thing did not work.
S: really?
C: how many ..
S: was a bit low (?)
C: how many trials did you do before you got two?
S: before I got what?
C: before you got two right answers. How many?
S: just 1 (smiling)
C: what do you mean?
S: what do you mean? The last one? We had to guess?
C: We had to guess what the flower was? From A and B?
S: like asking questions right?
C: right. How many trials you try before you got them?
S: in a row?
C: not in a row
S: there were two flowers right
C: two flowers? Did you do different test than me?
S: yeah. I did. I just had a two flowers. Like I did the 12 thing on the computer. Right. I did that. And then I made my observations (laughing) and had a asking questions about the flowers and whether it was right or wrong. I had to say whether it was A or B.
C: yes or no questions.
S: yeah asking questions. Yes or no questions about the flowers and I did determine whether it was a or B
C: yeah. How many time did you try before you get them right.
S: like two right. Just once.
C: you tried once?
S: I got them right on the first time.
C: You got two right.
S: right
C: okay so you did two tests. … . because what I ended up thinking was I should get two right in a row. So then I did a bunch of test to try to see which of these are right first before I get right two in a row. So I asked for six to 8 flowers.
S: o really?
C: yeah and I found that like… you see I asked you see the ground or on the ground?
S: yeah

C: And you see there was no pink, but there was a pink and still in group A.
S: yeah yeah. It Is not the color
C: number of petals. I don't know at all.
S: the clos-up shot. The ones in B where all close-up shot
C: wasn't all close-up though
S: okay then it was one flower in B, one bulb in B.
C: how does that distinguish the flowers' regions though? What did you thought? (??)
S: See which one is in B (laughing)
C: excuse me?
M: yes.
C: He supposed to know that there are from two different regions right?
M: yes you both had flowers from two different regions
C: yes. They are two different region I mean physically
M. yes.
S: oh are they?
C: yes. They are not just categories.
M: yes A is one geographical region B is another geographical region
C: Oh he was under impression that
S: oh I see I see
M: So you were under impression of what? Sorry?
S: no no nothing
M: you though both of them are from the same region?
S: no. I just though they are divided into A and B
C: he just though there are bunch of flowers ..
M: okay you though I divided them based on some features or may be randomly
S: yeah yeah. Okay that's okay. (laughing). Okay.
C: did that change any thing? Close up shot? (both laughing)
S: let's go for what you have.
C: petal? Leaves?
S: the ones in A I found they had like more leaves and stuff
C: yeah. Because that kind of goes with the fact that B grows on something rather than from the ground
S: yeah. So the one in B area grow on trees
C: there is also. Do you remember those look very dry. The ones like weeds
S: yeah yeah
C: So those where like something more north American whereas the others were more tropical
S: yeah
C: So based off of that how you can tell though? I wanted to say moisture is more effective. But in some of the photos were obviously with water on them
S: yeah
C: so what do you wanna say?
C: can we write the instruction is nay format
M: yes
C: wanna do a table?
S: sure ….
C: okay what do you want to say
S: okay . Start off. So we said that A was from the ground B was on tree
C: I don't think that was really indicative but
S: what else? What would you think?
C: to be honest at the end of it I was very confused because I only had so many point that I could ask. On the last flower the one I got right on Was the first time I asked about the number of petals
S: yeah
C: So I cant say if that is a good indication. Because I was pretty sure that ..
S: no I counted the petals too and it was kind of random. Isn't it?
C: because every single flower in the B had the same number of petals

S: really? A wasn't like this.
C: A wasn't like this. Did you count the ones in A?
S: No. I checked A's and then ..
C: okay.
Both laughing
S: well.
C: our apologies to any one who get this set of instruction (both laughing).
S: Okay I think the flowers in B were up higher than the flowers in A. Do you agree with that?
C: let's go with it. Let give them enough points so they can use in their discussions. (both laughing)
S: tell them to ask the questions that I asked (joking). Then as a result they get more sun and are more colorful.
C: they get to see the picture? Right?
M: for the test.
C: this is a big one they get to see the picture
S: yeah. I like the word generally generally. Because at first you may
C: there was a white one in B ..
S: no and there was a purple one in A. So that would pop up
C: mmm, majority …..,, it was random … the last one had five petals
S: yeah, I think,,,,, we had petals … (mumbling something about the regions)
C: no it is the fact that they are form two different regions
S: yeah. I know but …
C: it is not like that they are from tow different groups and from every where in the world
S: yeah yeah
C: wasn't like one had more zoom than the other one. (both laughing)
S: distinguish between the two groups ….. (mumbling and laughing) but A had like a bunch of bulbs B had like one bulb
C: I swore . There was one in B
S: No,no, I asked that question. Was like Is there one flower or is there many flowers?
C: okay
S: We have to write these questions base on yes or no responses or just things to look for?
M: no. The test is different than yours.
C: okay then … typically.
S: A had many bulbs
C: A were typically was on the ground
S: I asked whether the ground is visible or not and if there is like sort of connection visible between the bulb and the ground.
C: generally less colorful
S: generally. There was an exception. The one purple one in B
C: that was a pale purple. How about saying vibrant
S: yeah. But one pale to someone may not be pale to someone else
C: that's true
Mumbling and writing
C: more colorful. Appears to be in dryer. What's that called. the kind of word?. …
S: oh grade 6 geography. I don't know
C: I just say dryer … (mumbling-laughing and writing) different types of trees.
S: the trees are reflective of the climate types
C: typically more one flower
S: yeah. That for sure. Laughing. So vague
C: oh wait. Did you notice the ones in group A had linger stems in some cases.
S: No I didn't notice that. B had more stems too. Actually not really big. You wouldn't see much of the stem because it was a closer shot of B (laughing).
C: what else?
S: That's pretty much what I had
C: okay. Yeah
M: all done?

C: yes. I think so.

G6
C: Okay. (laughing). I totally guessed. What did you find out?
S: A and B. (pause), ah, (..) I found B to be more colorful (..) and A more pale-
C: yeah that's what I found-
S: (overlapping) 'okay'.
C: but there was white flower in B as well.
S: yeah but more colorful doesn't necess- like, the- (…) the colors are more bright in B -
C: (overlapping) 'uhum'
S: as opposed in A they were more pale. Like (..) there was some pinks in A but there are pink like pale pink not flashy pink-
C: (overlapping) 'yeah'. Right
S: ,I would say, that B is more flashy more colorful (.) and it's more (writing) 'more colorful than A and more-more plain colors' and then B (writing) 'the petals are bigger or voluminous I would say and A are smaller petals'. What else? (…) That was how I distinguished them.
C: one thing that I found was that the flowers from region A (.) had like (..) most of them had many pistols like 6 I count from the middle
S: what? Sorry?
C: you know the pistols? Those sticks coming out from the middle of the center
S: Okay. from A? oh yeah, I saw that from B
C: but B usually had one single or (…) yeah they usually had one single or they didn't even (.) have (.) any
S: oh yeah. Okay. Sure. Write it down.
C: (writing it down and a bit of laughing for the spelling from both of them). P-i-stol. I don't know
S; I don't know what it is
C: (laughing)
S: You got any thing else?
C: no (laughing)
S: Okay. Cool. That's it then.

G7
C: do you mind writing?
S: sorry?
C: do you mind writing?
S: I think, oh-
C: no my writing is messy. That's why I ask. It is not readable
S: okay.
C: (laughing) It is not readable
S: What did you think about it?
C: I thought the B flowers had fatter petals-
S: exactly
C: and I thought they were more colorful but they are not -
S: yeah ..
C: uhm, and then I also thought (.) these flowers were smaller
S: yeah. I think uhm for region A (.)I thought that they were, that most of them were like very dry close to ground-
C: yeah (confirming)
S: They looked cactusy
C: (overlapping) ' uhum, looked cactusy'
S: but then during the questions I came across one flower which was not like that.
C: uhum, the yellow one?
S: exactly. The yellow one.
C: So it was like an exception
S: I don't think there was yellow flower in region A but it showed up. I don't know (laughing)

C: yeah (laughing)
S: yeah, there was another one which was vibrant color. It also had a lot of leaves around it but all others for region A didn't have a lot of leaves around them
C: mmm
S: But still I think there are exceptions.
C: uhum
S: for region B I think every one of them was bright and big petals-
C: except one. There was one exception, they were orange and like all orange and little small ones. Looked like this (..)Do you remember? They were like every where.
S: oh the small one!
C: yeah, the smallest
S: what (laughing) what should we say then (laughing)
C: we should say(….) Mmm(…) uhm for the majority have like big white petals
S: yeah big white petals and leaves
(pause)
C: mmm (.) smaller to medium (…) more cactus like?
S: yeah (.) I think so
C: mmm (…) mmm
S: Maybe closer, look closer to the ground (..) except one of them. One of them had a long stem (…)
(pause)
S: I (...) I guess we are not allowed to mention something specific right?
C: we can. We mention whatever I guess
S: So then we could write here that one of them had longer stem (..)except one of them has long stem
(pause)
C: mmm (….) Was that really an exception (…) I don't know
S: (reading the instruction)
C: Oh I tried to look at how pointy the leaves are? These are more generally pointy. Like tips of the layers. I mean the petals I think
(pause)
C: closer to camera (laughing) (..). Was like (xxx)-
S: oh yeah, and that's why it may be looked great right?
C: yeah. that's it.

G8
S: Did you look at a strategy for figuring out?
C: uhh, This is the strategy then. The flower that goes kind of goes from invert to outward is in B
S: (overlapping) 'aaah' (surprising)
C: and the one goes like a concave (showing pictures)
S: that's a good strategy. Okay. I, Okay, how did you think about that
C: I actually didn't think until I saw the picture in front of me and like okay (laughing)
S: that was really good like .. okay
C: I guess that was the only thing I saw.
S: mine was like it does look like tropical
C: right
S: and it seemed to work. So (.) I like your explanation better. Probably it is easier to understand (laughing)
S: (overlapping) 'Okay'
C: Did you have any thing else (x)?
S: okay. The colors of ones in region B kind of took me off because the ones were more like dull and plain and white were like region A ones and the one which where more vibrant tended to region B. So that may be another factor to write in the instruction
C: (overlapping) 'right, yeah'

S: mmm(.) other than that (..) region A also had like more leaves and stuff.
C: (overlapping) 'yeah, I'
S: did you notice that
C: Actually, I noticed that it has more background stuff
S: overlapping 'yeah', it was like mossy
C: exactly
S: and I didn't notice it in region B but the flowers (xxxxxxxxxxx), it kind of makes sense
C: (overlapping) 'yeah exactly). Do you want me to write it?
S: sure. Yeah. If you wanna write would be great.
C: okay so-
S: should we write like what to look for or?
M: pardon me?
C: do we write the instruction like what to look for in the flowers?
M: It's up to you what kind of format you gonna use. Just make sure the other person understands
S: okay.
(pause)
C: I don't know how to word it I'm just gonna say flowing from inward to outward (laughing)
S: like (.) if it comes like up to the center. Is that make sense?
C: yeah
S: okay (laughing)
C: flowing from, flowing up to the center. Okay
S: does that make sense?
C: mmm
S: no (laughing)
C: I can draw the picture
S: yeah. That is really good.
C: uh
S: Can you draw flowers?
C: I'm just gonna write a vague explanation before I show [the picture] (writing)
(pause)
S: Is it kind of like the petals are concave or convex
C: yeah. Exactly. because
S: okay(laughing)
C: uh, Flowing , that would be -
S: convex would be like tropical B and then
C: (mumbling while writing). Like that?
S: (laughing). Good enough
C: and then (writing) (xxxxx)
S: it's like if the flower petals are flowing (..) I don't know how explain it.
C: uh (.) in a concave manner? (laughing)
S: sure. (laughing)
C: like that. (…) So bad in drawing
S: (laughing). no it's fine.
(pause)
S: Okay. Uhum , do-
C: do you want write down the color? So you can explain
S: sure. (writing).
C: the colors are more vibrant
S: (writing) Typically goes belong to B? it's like there is (xxx)-
C: yeah this is the second criterion. If one thing goes vague here then-
S: yeah
C: typically belong to region B
S: I don't need to explain both in region A
C: yeah, otherwise it's region A, or you can say that this can be used as the second criterion (writing)

S: Okay. And then do you want to talk about the leaves and then
C: you mean the background stuff?
S: yeah
C: overlapping 'yeah'.
S: mmm,
C: the woody color background (laughing)
S: uhhh,
C: I don't know how to explain?
S: if there's more like small leaves and binds on the base of the flower? does that make sense?
C: small leaves, yeah
S: because the other flowers had like leaves they all looked like dead. was that?
C: they were kind of, the pictures were kind of taken more like zoomed in. they were some flowers that were vibrant but still had bushes and still belong to (x)
S: yes.
C: so I think we should leave it out
S: leave it out? Okay. I feel bad for anyone trying (xxxx) figure out (xxx) (laughing)
C: (laughing)

G9

S: Hi (laughing)
C: I am pretty sure like everything I wrote is wrong (laughing)
S: laughing. Okay so basically I noticed that region B had like more vibrant color
C: hmm
S: so, oh they had overlap. because I found that they are usually like bright pink and bright yellow while region A was like softer shares of purple and white. Kind of? Yes?
C: right. Except that one yellow. But I think that's an exception not a rule
S: overlapping 'okay' and then region B had like larger petals that was bigger than its leaves
C: I don't' know
(both laughing)
S: I didn't noticed the leaves though. Did you think about the leaves
C: well, every single time that I (.) would be like okay here they are waxy and then I was like oh carp it is not this (laughing)
S: no. I found that in region A there were some flowers that had like a leafy thing underneath it was like that and then the flower was like that (drawing)
C: okay
S: I don't know that was just the picture or that was a trend (?)
C: hmm. (.) I (.) think the only thing that was pretty definitive on was the things that was coming out of the center of the flowers, the pistols, I think
S: so .. I have no idea
C: So it is like a flower and then like the little pollinated stem thing
S: (overlapping) 'yeah I know. so you found that
C: so the ones in A had and the ones in B did not.
S: (overlapping)' like'
C: The ones in A were very noticeable like large
S: We did the same thing? Right? (both laughing)
M: the process were the same but I am not sure you may have seen different flowers
S: okay. Because I found that for B that wasn't sure because I had some flowers that also
C: laughing
S: huh, yeah, I don't think I'd apply
C: flowers are met for my case (xxx xxxx) I stared to these pictures for quite a while and tried to come up with some sort of a rule. Uhum, yeah, (xxx, xxxx) All of these were like meet to the majority but definitely not a rule
S: okay. I don't think that it'd work, because the majority of my flowers (laughing) had the things in the middle
C: that's unfortunate.

S: yes that is.
C: Okay.
S: mmm,
C: Start writing something at least
S: sure (.) probably take a- you said you had a flower that was yellow for region A
C: yes
S: is that like bright yellow? How was its petals?
C: uh (..) rounded- like rounded 5 petals (.) I don't really know
S: (overlapping) 'okay'. So small rounded flower
C: I would say it's like a typical flower but I guess that's pretty ..
S: (laughing and writing) So like a (xxx) shape
C: yeah.
S: okay. Instructions! may be number 1, I think petals shape would be the easiest (…) So region A has smaller compare to leaves (writing)
C: don't know it stays true for mine. A lot of mine. Didn't (..). I had one that looked like tray down and then had like purple pointed petals and the leaves on that was kind of like rosemary (laughing)
S: okay (..) Smaller rounded?
C: the petals were pointed. The leaves looked like little (.) like as pine tree kind of thing.
S: (overlapping) 'the leaves'. I see (xxxx)
C: (laughing)
S: because like from my region B part, they are all super big petals that were kind of flowy and kind of overlapped for the majority of them
C: I did have(.) uhm, Region B had more (..) I guess I describe it as rounded petals I guess (.) because I had a lot of flowers that they were pointy. They would actually, the petals get to a point at the end (?)
S: like is that a flower you call pointy? Or like?
C: okay. I gonna draw it.
S: (laughing)
C: uhm, Like it was come out and then rounded like this as opposed to some of the other flowers which were like that
S: oh I see. Okay. So was that a region A or B?
C: So this is more in region A and this is more in region B (..) Once again my flowers also seemed like kind of random. None of these guessing worked (xxxxx)
S: what do you think?
C: (mumbling not clear)
S: maybe (mumbling and laughing).
(both laughing)
S: so I was like, I think, I didn't noticed (xxx) actually. I noticed that a lot of these tend to overlap
C: I even tried like counting the petals to see if maybe like region B would have like more, but some of them actually the flowers were pretty identical and then for this pointed flowers was like this and then whatever flower
S: (overlapping) yeah I had that too.
C: and then B's were like big petals but here like they were very-
S: tiny
C: thin like-
S: can I say in general smaller
C: go for it
S: and region A (.) my flowers petals didn't overlap as much.(.) Is that true for yours? Like they overlap a bit (xxx) but I had region B flowers which was like folds of petals
C: like a lot of petals? like numerically? and the overlap. Or they were tighter so they overlap
S: (overlapping) 'xxxx' .No they were bigger and like had surface area overlapped (laughing)
C: okay
S: does it make sense?
C: I agree with that

S: okay. So (writing) Smaller petals (..) which did not overlap that much?
C: uh (.) you'd just need to say underneath that B had more overlapped or some thing
S: Okay (writing). Okay. (…) Not really sure about the shape. (…)I think some of my region A were more rounded as well. Some of them with seven leaves (??)
C: oh yeah, I definitely had some (xxxx) one it wasn't intended to B
S; (overlapping) 'okay'
C: uhm, I just would say if they were pointy one then they were all in A
S: oh, I see. Do you want (xxx)
C: (overlapping) 'uhm' I don't think so
S: okay. Color next maybe?
C: sure.
S: uhh (…) (mumbling and writing),
C: maybe just get them (…) yeah
C: like purple? though I am pretty sure during my test the flower that was in region A had pink petals
S: I had a couple of them
C: I didn't actually see it. This is like a-
S: oh yeah the test. Like pink. Just write in general .. maybe … (writing). We can make a note just saying that that region A tended to have petals that were more pointy
C: petals are what sorry?
S: pointy?
C: yeah
S: uh, others! (laughing)
C: one of the things that I looked at was kind of like the background of the picture where the flower is. And for lot of region A were like
S: dry
C: rocks and cold looking dirt (not necessarily?) dryer climate
S: (overlapping) 'yeah', I was thinking about that because I noticed that lots of region A's flower are close to the ground like
C: I was thinking that they might be shorter kind of thing
S: uhum, (writing) : pointy shape petals (laughing) (…)maybe its climate (…) region A (..)had (…)close to the ground and generally growing out of rocks and dirt
C: in brackets write seems like a dryer climate because I don't know rock and dirt (…)like we know what we are talking but not -
S: right. (spell checking and laughing). Yes!
C: yes!
S: Okay. Is this all about it?
C: it's for me
S: I think we are good

G10
S: okay
C: umm, alright (.) so. I guess there was (.) one distinguishing goal for white flower. There was just one flower. So one white flower was in region 2. So I can write it
S: yeah please.
C: So they were 12 flowers in total.
A: are they gonna see the same picture as us or same regions?
M: same regions
C: so the picture gonna be different
M: could be. Some flowers may overlap with your set or be different
C: okay. So we may wanna talk about which feature are in which region
S: yes. I thought region A was kind of was dry -
C: (overlapping) yeah,
S: some of them
C: I noticed that too

S: and the colors were kind of dull
C: uhum
(pause)
C: mmm, it seemed like region A had like more shrubby leaves-
S: yeah
C: like green leaves
S: yeah
(pause)
C: may be we should put dryer area compare to B because some of them in A were still kind of (…) I thought region A was also could be white flowers
C: okay
S: There were not white flowers in B so it is (…)more likely
C: so this is (…) less dry region?. Should I just say less dry?
S: I'd say tropical as I wrote in my notes as it appeared to be (…) and then I had a lot of pink flower in region B
(pause)
C: (overlapping) 'uhum' (…) the leaves were like pretty green
S: yeah (…) I would say all the colors were pretty bright in region B. (……)Is there any thing else
C: No. I don't think so
S: yeah

G11
C: okay how did you determine things of region A?
S: So the flowers petals were typically really smaller than for region B
C: yeah. okay
S: and then does have stem … I think
C: yeah
S: and mostly white color but B does have pink
C: oh yeah, I had the majority. A had more purple right? And the pink ones were fuchsia color were B
S: I think so yeah
C: (writing the colors down). I think there was, both of them had two whites
S: really? I didn't see white-
C: like the tiny ones for the region A and for region B was the big ones
S: oh yeah yeah
C: and region A had pointier petals I got
S: yeah yeah, right
C: (writing down) and uh
S: And region A has leaves that are bigger than petals
C: okay. (……) I found (..)yeah(..) region B (.) trying to remember pictures (..) noticed one with bunch of little ones that were from B the red and yellow ones-
S: red and yellow ones?
C: (overlapping) 'notice any feature about those?' The very tiny ones
S: uhhh,?
C yeah, there is like small little ones that grouped together in region B, it was very different than the rest, so I was not sure how to describe that
S: did we see the same pictures of flowers?
C: yes I think. Did we see the same pictures? (asking from me)
S: 12 same picture?
M: no, not all of them were the same. Some of them are the same
S: (overlapping) 'yeah'. I didn't see the red one
C: (overlapping) 'Okay'. Uhum. What else? (…)
S: uhhh
C:I think region B also had less petals

S: yes. Less petals. .. and more petals
C: yeah.
(pause)
S: that's it?
C: yeah I think so.
S write it the big petals for B.
C: Big petals?
S: There was to use difference?
C: that's true.

G12
C: So what are your notes?
S: This was I saw, it said, some of the flowers in region A had a center-
Yeah
S: and there was some lines (?) actually pointing out
C: yeah stuff coming out
S: (overlapping) 'exactly'. So that's one think I noticed a lot of.
C: (overlapping) 'yeah'
S: Then I noticed the petals (.)
C: (overlapping) 'yeah'
S: were not necessarily overlapping one another as much as B would. That was another thing. Pretty light in color (xxx)
C; (overlapping) 'yeah'. Dull. Not as vibrant
S: exactly. one thing that I also noticed was a kind of bowl shaped. Most of the petals that I saw were like that.
C: (overlapping) 'yeah' whereas B came up like a cone
S: exactly. They were like a bell-like shape. Then I'd also say the petals were smaller in comparison. Much much smaller.
C: Yeah.
S: Much much smaller.
C: Much smaller yeah
S: and they didn't seem to ba a lot of plants growing near that one in region A.
C: (overlapping) 'yeah'
S: whereas in B you can see other buds or same species of same plant growing the same area. So once again region B not necessarily all the plants for the flower had the center posturing out .
C: yeah
S: parts (not clear)
C: yeah. Most of them had empty center
S: exactly. The petals were overlapping. That was pretty distinct
C: (overlapping) 'yeah'
S: uhm, dark in color
C: darker yeah. More vibrant
S: exactly. And (.) like I said before the petals tend to form a bell-like shape
C: yeah
S: and petals were quite large. That was the other thing.
C: (overlapping) 'yeah'
S: And they clustered together. I noticed two or three pictures, they were actually same species of plans together
C. yeah, now, are we allow to draw like a picture? Or should be completely text
M: no its okay. You can have pictures.
C: okay
S: so was there any thing else you found of
C: no. I pretty much said that they are more vibrant in color and I sort of looked at the edges of the petals and for region B they sort of seemed to be like crisp straight lines (.) whereas for region A some of tem were curled a little bit

S: oh!. Okay. okay. one of them in region B was kind of shriveled or something (..) not (xxx)
C: (overlapping0 'yeah' I don't know, I do not remember exactly if that was from region A . There was like a wild one right?
S: yeah. (laughing) okay
C: but yeah (.) I agree with pretty much everything's down here. So we gotta (.) write instructions.
S: alright
C: You wanna write?
S: yeah it doesn't matter (laughing). (xxx)
C: Are they explained the experiment or not. They are just given this
M: I will explain it. You don't need to explain the instruction and the experiment
C: okay. So
S: I guess you wanna say region A has this characteristics region B has these characteristics
C: we should. Yeah
S: I think that's a (?)
C: yeah, separate it like this and sort of make instruction on how to select from it
S: so (writing)
C: characteristics of region A
(writing)
C: So I would say like to start by color like pale muted color
S: what do you mean pale muted because I wouldn't know what pale muted mean.
C: like a pale color, it's not a vibrant, it is dull. We should use probably more than one descriptive word
S: I notice some of them were blue
C: yeah
S: yeah, blue, most of them were white
C: yeah, white and pale, like white we should say typically white and pale. But if we say white
S: they might think all of them are white
C: yes.
S: so
C: pale, dull
S: the petals right?
C: the petals color
S: the petals color
C: …. is pale
S: can we use different word other than pale
C: we would get through three words, like pale dull. I don't know what else we can call it
S: what I said was most of them were typically white
C: yeah. Typically white
S. typically white, (..) dull (.) not sure if this is the right word to use. I remember some from region B that were dull
C: no. region B was typically vibrant like very dark vibrant color. Whereas, like region was like washed-out. For region A, they had color but they were washed out. They were faded
S: uhhh, because in region B, I remember there was one plant in a combination. There was a fade white and a fade I think it was violet or something (..) blue (..) it was a combination of two
C: yeah
S: I think it might get mixed up
C: but I don't think really
S: typically white, we say slightly faded
C: it is not the only characteristic that they compare on it
S: slightly faded (writing)
C: slightly faded colors
S: most of them were white except one of them was slightly purple color
C: we should say white with slight hue of a color or something like that
S: because for white and faded color we have some in B similar to that

C: okay, lets do another one for region B below so we can do color-color compare them and they can do step by step… and then essentially they can pick the one that matches to most characteristics in total
S: okay. In region B, petal colors ..
C: darker
S: darker, you said they were vibrant
C: yes. Vibrant like
S: darker, vibrant. And you also said they were crisp
C: yeah, that's edges not colors
S: oh okay. Darker, vibrant
C: and that's good enough for color we go to the next
S: exactly
C: right. Let's go down the list
S: overlapping
C: yeah overlapping. We should do size. Right. Size first. Like color, size
S: sure.
C: that's gonna be easier to pick up
S: petal sizes were smaller can we say relative to something
C: relative to something I said a Looney
S: hahaha. Okay. Because I asked a similar question and she was like relative to what?
C: I said Looney, everyone what the Looney is
S: petal size were this much
C: yeah, but there were petals larger than a Looney in region B
S: in region B.
C: in region they were typically larger than a Looney
S: so they were smaller, relative to a Looney
C: a dollar, Looney, then no one mixes up with us dollar
S: petal size here,
C: yes they are typically larger, like larger petals
S: and here with respect to a Looney. So now talking about overlapping
C: yeah. Do the overlapping
S: just one thing, there is one thing. I noticed that two flowers in region A they actually don't overlap
C: yeah
S: I didn't see in on the computer but when I saw the pictures afterwards they didn't seem to overlap just touch. Whereas theses ones in region B they had overlap
C: overlap like a quarter to the half
S: exactly
C: so, non overlapping or slightly overlapping
S: so petals are slightly overlapping
C: overlapping less than 25% or something like that
S: has little or no overlaps
C: yes. Little or no overlap…. Lets say like a percentage of overlap or something like that
S: mumbling and writing …. Can we draw it out?
C: no I would just … would … well
S: for example , that's a horrible drawing
C: I would quantify that, 10 to 20 % of that
S: 10 to 20 percent of the petals
C: I wouldn't say 10 to 20, I would say 0 to 20 in case that they don't overlap
S: okay. Yeah … 0 to 20% overlap; whereas here petals tend to
C: tend to overlap by like significantly more, I would say 25 to 30 or 25 to 50
S: typically 25 to 50
C: yeah.. I don't know I would say 25 and greater (laughing) what if it is greater 50 and then they are like oh what am doing now?
S: (laughing) significantly more than the other. So we talked about color size, overlapping

C: size …. The center, the center, that's the easy to pick up. We should at least give like 7 traits because if it leaves at 6, then fifty-fifty split and then I guess
(both laughing)
S: uhum
C: the center, for A, there is typically something sticking out of the center of the flower
S: uhhh, is there another way to say something sticking out
C: I don't know the technical term but then I don't if everyone knows the technical words
S: okay . fine. Something sticking out so (writing) something generally .. would you draw a picture its making it (?)
C: I cant draw the picture (laughing
S: it's okay. Something generally sticking out of the center …. Mumbling and writing
C: I don't know if I can draw… okay …
S: mumbling …. Okay … and here
C: typically nothing,, they are gonna read this first so I don't think we need to do comparison for each one of the claims to make the number more (?) …
S: typically nothing sticking out of the center … it's like empty
C: it's empty, yeah
S: I don't want to use the word empty but hull
C: yeah because it deeply goes down and (?)
S: darker vibrant, slight combination of color
C: yeah, for part A they were all typically one color
S: yeah
C: I think we should mention that underneath the color
S: and a single .. color ,,, generally sticking out, typically nothing sticking out but they have a hull in center. I think one or two of them did actually had something sticking out but I think differentiation between petal size and color
C: well, there's gonna be some that don't match each one, which is fine
S: okay. What we got, overlapping, center, how about talking about the shape
C: the shape, and that's pretty much of it
S: and also
C; and the clusters… the shape.. there no uniform shape for region A.
S: I found them like a bowl
C: oh, yeah, they are small, sort of curved out, they all curved out a bit
S: petals tend to form an upright or downwards
C: yeah
S: like a bowl like shape, whereas here
C: they formed like bell, inverted down
S: writing …
C: typically inverted down
S: inverse
C: inverted
S: yeah, inverted just in case we get math person ,, an upright (inverted)
C: lets draw a cross section
S: yeah. This person have to forgive me. It's bad drawings …. And clusters….so flowers generally didn't have I wanna use through my slang (?) it wont be right.. generally did not have flowers around them of the same species
C: yeah:
S: okay. I have an idea we can say doesn't have any species or buds
C: typically it's a single flower
S: except some of them , yeah, what I say is. Some A's have buds whereas in B you know they show a single picture of the flower they don't show buds
C: it depend of the pictures
S: they gonna see the same pictures
C: are they going to see the same pictures
M: not necessarily

C: because other than that it's either 6 from region A and 6 from region B. because they were 6 flowers from region A and 6 flowers from region B.
S: so just leave it like this. I think here we can say they have large cluster
C: yeah typically large clusters, yeah.. and then we can make the instruction of how to choose based on these characteristics
S: so typically large clusters of flowers or similar neighboring species (writing) beside the flower (mumbling)
C: okay, looks good
reading and writing again,,, fixing words
C: petals overlapping no just add with each other, because overlapping what?
S: okay ..
C: okay we should mention how they gonna choose, they should pick the flower
S: do you wanna write this one
C: yeah. Sure.
S: alright
C: steps.. 1 read
S: instruction characteristics
C: are they given all the flowers at once or one at the time
M: no. one by one
C: classify the flower according to ..
S: do they still have this when you give them the pictures
M: yes.
C: characteristics, 3, select …..based on which one …. Matches …. We should say, note: the most important characteristics start at the top and go to the bottom because these are the most important ones and these are the .. do we classify them or should we (?) these number of importance
S: no number of importance. They just look at the colors and then just say oh okay it's a combination it might be B, might be A
C: yeah. Okay. .. I don't really wanna say that we had 6 and 6 but that would be (both laughing)
S: is there is thing else we did, when we ere doing at computer and
C: no , on the computer we had access to the previous picture and they don't have it
S: when you were looking at them was there any steps that you followed. The only steps that I was following was looking at overlapping that was one of the things I was looking at the most, overlapping and the size
C: actually I did mined based off the color and size and I did the first round. And then I did it again because I had to do it perfect obviously an then I was more concentrating on the remembering what I had so I had the order of the first 5 already in my head and then was classifying the rest and in the third round I had already got all
S: laughing
C: you can game the system
S: reading, wait a second here
C: what?
S: color, here it says must be single color, here it says combination of colors
C: we should say but this does not rule out single,, I thing we should cross the mixture of color, just say possibly mixture of color instead of combination of color, just cross that out
S: should I keeps the mixture
C: I wouldn't say slightly mixture. I would say may contain more than one color right. Or might have a mixture. When you say might that
Writing and mumbling
C: alright because that might means that … because we said this one is single and this one is okay more vibrant, it could be single and it might have the combination of color
S: okay. That's it?
C: that's it. Let's put a note and then our
S: carefully, read over at the instruction, that would be my note
C: had 6 from A 6 from B
S: not necessarily true for you.

C: right
S read through the characteristics is important
C: yeah, … star… okay. I would put that first.

G13
S: do you wanna write?
C: my writing is not the best but
S: that's okay. You can go a head
C: okay. So I guess to distinguish A flowers first.
(pause)
S: I don't know if you found this too (.) but every flower that had the main color as white, white petals, I found to be in A
C: ummm, that's not true though
S: no? (laughing)
C: because there was one white flower in B as well
S: was there?
C: did we get different flowers? (laughing)
S: maybe we did.
C: but I noticed that the flowers in B were greater and the foliage like the leaves and stems were very green and um the ones in A were more like there were sometime rocky like dirt and ..like
S: okay. Sure (laughing)
C: (overlapping) 'I don't know' (laughing)
S: I found it very difficult to find a pattern
C: and there was like spikey leaves a lot in A the one in B were like more I don't know
S: That's right. We can put that it
C: (laughing) Okay. at first I thought it was like about the number of petals but then (..) sometimes it …
S: you had a lot, I considered that too,
C: that was obviously false
S: we can talk about the foliage of it (..) I think
C: (writing) (…….) flowers were either ..
S: I just found one of the ones in category B, I don't know if we had them in the same order, but there was one that was **really** big and pink. It came with the test, I passed the test with it. Because I asked are the petals big and pink and she said yes it is B (laughing) I guessed that's B because all the pink flowers were in B (laughing) that's what I said but
C: interesting.
(pause)
S: For the most part yes though? (laughing) I also tried to look at what was kind of inside the flower like they had pollenated
C; yeah yeah
S: and
(pause)
C: ummm, okay I leave the space
(pause)
S: It also kind of seemed in terms of the shape of the petals for A category the one we saw on the screen, were very like, I don't know how to explain it but they look like a flower you would draw do you know what I mean? Like a regular petals. Whereas in B I think there were two of them like them…
C: we had different flowers
S: do you think so? (laughing)
C: (overlapping) I think so
S: I mean the difference shape of the flowers one one very generic the other one was more almost abstract

C: umm, not actually, because I remember I had two flowers where one of them was like (.) it was lavender and it had (.) it looked like (xxxx) but it had pointy ends and I had a white one very similar shape in B that had
S: oh white one in B? (overlapping) 'I didn't had white in B'. okay
C: (laughing). Okay I see . this is interesting.. Uhhm
S: could be that we have just different visions of
C: (laughing). That's possible too.
S: no it's totally true
C: umm, that changes things. Any thing you wanna add to this one..
S: (overlapping) 'mmm', laughing.
Do this one then. mmm, (..) Do you want me to talk about (xxxx)
S: yeah. You may as well
C: I don't know what you noticed compare to what I noticed (laughing). Okay.
S: I kind of doubting (.) everything I saw
C: (laughing) okay
(pause)
S: shall we like a full set of leaves?
C: not always, some of the flowers were like they wouldn't have leaves and you would see just the stem of the flower and whatever was in the background(..), But I know both of them had flowers with leaves
S: I don't know, just the general (info?) that I got from them was like that A's flower like the picture itself was more bare I don't know how to say that but just in B the picture itself was full
C: yeah. (overlapping) 'I agree with it' (..) (writing) so flowers in picture A were more were bare
S: uhum, (xxxx) (laughing) don't know how to explain that
C: (writing) I don't know how to say (…) flowers were bright (..)but then your flowers were not bright
S: well, most of them were bright it was just one or two of them but then again I don't know if that's descriptive enough, How do you describe bright as (..) I don't know
C: (writing)
S: It s kind of like the way you made me feel is more emotionally, like these ones are more happy you know
(both laughing)
C: I kind of categorized them as tropical and kind of (.) more like coniferous, what you would see
S: oh yeah
C: do you want me to write that
S: yes
C: I am not a nature traveller but
S: what's the opposite of coniferous? Deciduous
C: tropical (both laughing)
S: okay
C: and the last point was (..) oh this one
S: the entire picture was more full (xxx), I don't know plump
C: (laughing) (writing)
(pause)
S: (xxxx) That's what I remember
C: I remember al the flowers I just
S: I doubt myself because of what you said
C: like wise (laughing). Okay . I think we are good (doubting) hopefully

G14
C: so I noticed that the flowers are small is size
S: yeah
C: those flowers were white in color in region A. pink and yellow is they are small

C: so it is like pink, purple yellow color, because these one were in both the list if they are relatively large they were going to region A the vice versa goes to B
S: generally I thought all the whites (.) were in A
C: okay
S: but there was one purple in A as well
C: there was one a white 10^{th} or 11^{th} picture, it was in region B-
S: that was the other white kind of yellowish. If it was whitest thing otherwise if it was with shades of pink or purple-
C: (overlapping) 'oh okay okay'.
S: if it was fully white it was in A
S: okay okay
S: so I was like (.) the first question would be is it white?
C: (overlapping) 'right'
S: this is the first question and then if it is yes then it's
C: goes to region A, okay
S: if it is no then we have to ask something else. When you said (.)Next question can be is it pink or purple? But
C: yeah(.) but (…) uhm
S: next we can ask would-
C: about the size. right?
S: the size-
C: yeah. Because you are saying that ..
S: if it is not white then it could be pink purple we don't have to ask for each individual flower
C: (overlapping) yeah . exactly, so we can go on with the size
S: so is it small?
C: yeah, then that's the thing-
S: (overlapping) 'it is extremely subjective'
C: it is extremely subjective. I would consider something small, you would consider it big-
S: (overlapping) 'so we can say' whether is comparatively small?
C: yeah, comparatively small-
S: oh the other thing I noticed is (.) these ones had thinner petals
C: (overlapping) 'thinner petals right'
S: but these ones more like way bigger.
C: yeah yeah yeah
S: so that could also be a question (.) (xxx) small and thin
C: (overlapping) 'right', yeah (..) because (..) generally the B ones had (.) larger petals (..) so yeah, that could be (.) the next question I would say. Because then that (..) covers the pink yellow purple category as well
S: which one?
C: like all of them (.) mmm, because the yellow pink purple etc which were in region B also had large petals
S: large petal. okay so (Writing) Did the petals have large wavy petals?
C: if this one is yes then it should be in region B
S: if it is no then region A (laughing) right? because it says if it is non white and has large thin petal is in A right
C: (overlapping) 'right' right exactly because if it is not white and does not have big petals it is in A. right.
S: (mumbling) (xxx). okay. I can put one more question like does it have thin petals and you say yes then
C: (mumbling) 'then xxx xxxx) no! because if this one is not in the B and then you put that it has the thin petals, right? yes goes to B no goes to what?
S: yeah but if think from the perspective of that person he doesn't know what - he has to have some information about thin petals too right?
C; yeah
S; so if I put this question they know what kind of difference they will be looking for?
C: yeah, yeah right.

S: so when they see the thin petals they say oh I don't think this is thin and then they answer the question
C: yeah yeah yeah right
S: here I can say did it have (writing) thin petals (..) and then yes goes to
C: A
S: and then no .. do you have nay other questions
C: mine was entirely based on color, color and size, pretty much, because the way we think covers uh this …
S: so we didn't cover size at all in this but large petals
C: yeah large petal goes to this, uhhhh, yeah because for the white color ones it is all A, right. So it doesn't' matter.
S: yeah.
C: I think we are all done.

G15
C: what did you think?
S: I thought it was just (..) if there was leaves around it like a lot of leaves it would be in A. Did you notice that? what did you notice?
C: is this path the only rule
S: yeah, it worked for me (laughing)
C: okay (…) mmm, I noticed that if the flower had like cactus like characteristics it was A, like sharp or uhm, the leaves were sharp and you know mmm I mean (drawing).
S: yeah
C: Also most of the A ones were white. Uhhm. that's mainly what I noticed
S: yeah. I just know the leaves thing just worked for me I got them in the first try. So maybe we go with that then and yours. Let's put them together because I think the leaves and the cactus kind of go toghether I guess
C: yeah. There was a purple flower that didn't have any leaves
S: was it ehhhh …
C: It was in A
S: there was a white one (,,,) which had stem right is it that one? (..) yeah (…) but had cactus leaves?
C: yeah, uh the things like uhh there was little bit of sharp edge like around things
S: okay. We can go with it, cactus-like features.
C: do we get to see the pictures now?
M: which pictures? The ones that you have already seen?
C: yes.
M:no
(pause)
C: how do you spell categorize?
S: (spelling)
(pause)
C: okay. So if it has a lot of leaves -
S: yeah, this goes with the cactus like features I guess
(pause)
C: okay
S: were all of them also white or was is like 5 or 6 of them?
C: all of them? (…) there was like (…) For A?
S: yeah
C: no there was few color ones
S: B didn't have any white ones
C: B had white ones
S: oh. Okay, so we cant say that
C: but the majority was white. Like more than half. (..) I don't think that helps a lot
S: yeah

C: actually we say most
S: saying most though wouldn't help the next person categorizing because still we are guessing
S: (overlapping) 'yeah'
C: what was your point.
S: I think if you say if the flower is surrounded by lots of leaves it would be in A
C: A?
S: yeah. It was also A
C: there was like , I think there was one or two white flowers that had a lot of leaves around them and it was B
S: really?
C: yeah (….) The leaves were kind of shiny. I don't know (.) if you remember them
S: yeah. I cant remember that one.
(pause)
C: (witting) A or B? (.) A? right
S: yeah.
C: okay
S:I guess we can have a third thing and say if neither of them contains the part A, 1 or 2 then it is B
C: uhum, you don't want to add anything else?
S: yeah, because I don't know how (..) I know how to separate A but I don't know how to describe B. So I mean if it is not A then it's gonna be B
(pause)
C: yeah. I thought also B was more colorful
S: yeah. I guess we can add that
(pause)
S: good enough?
C: if I read this I wouldn't be able to get (.) all the correct answers
S: I don't know what else we can say
C: I will add that B are more colorful. No. yeah. I don't know. Sure.

G16
C: okay what did you think?
S: uh (..) actually, I already have something.
C: (overlapping) 'oh you took notes'
S: It's just like that. I got it right first time
C: I think you are right. I think you are right on this. I thought about the number of petals too sometimes
S: oh. Really? (Overlapping) 'I didn't notice that' .
C: For B I noticed-
S: I guess with would have less, right?
C: yes. I am not (xxx) 100& sure of that
S: (overlapping) ' xxx side effect' .wouldn't be the side effect of how the petals are larger and then they are less
C: yeah. I don't know
S: but there was also a bigger gap between the petals in region A right
C: yeah
S: so they were smaller
C: and B's color was more like (…) more colorful
S: yeah, but I couldn't get it right just by going through the colors. That's what I noticed though.
C: I know I know. (overlapping) 'I was going by the color first'
S: It was like is red or pink or what ever
C: but it wasn't B
S: yes. I was supposed to be in B but it actually turned out to be A so I think (.) we can can't just go by the color

S: there was leaves and the background too. In region A, I noticed that not all the time but most of the time there are leaves in the back ground. It was kind of (.)The region A flowers were kind of like (..) uglier in way. They are not the ones you would go the flower store, buying and give it as valentine gift
C: I think you are right
S: that's what I noticed that they are not as appealing
C: uh, I think you are right. I don't remember the size of the petals honestly. But I do know that something about the petals was off. It was like there was some difference between them
S: I think honestly it's about the size. And I guess it is also relative to like the leaves and stuff or what ever that are around the flower. They are almost either the same size or only a little bit bigger for region As and for region B it was a big difference
C: I think you are right now how do we formalize that (laughing)
S:I guess first thing I checked to see if it's region A , this is the true and false when I was asking the questions
C: yeah asking the questions
S: I first asked if there are leaves in the background and then (laughing)
C: I kind of went with the intuitions to be honest, I kind of went into the intuition like I just comparatively would I kind of had a feeling. I don't know how to say the feeling
S: yeah, that's the thing. But I mean maybe it's not just the leaves and the (?) it is also the fact the whether you can the background in the first place
C: really? Well … You could see the background to me (xxx)
S: (not clear)
C: you can see the backgrounds things, wasn't sky or any thing like that
S: okay.
C: I don't know. I don't fully remember
S: because sometimes in A I think you either see (xxxx) sometimes you see couple of rocks or something on the ground. Did you ever notice that for region B?
C: no. I don't remember noticing any rocks maybe I was focused on the flowers (both laughing)
S: because sometimes it was like (…)that's how I noticed the weeds in the back. Oh, yeah, there is something like doesn't look as good in region A flowers as supposed to region B flowers.
C: There was also one picture in region A were they were like very very tiny hundreds of flowers
S: hundreds flowers?
C: not hundreds but like bunch of flowers but very small ones
S: yeah, it was like bunch of small ones, (,,) hmmm, could be that. Let's start writing
C: okay. I would say you have it more nailed than me
S: (laughing)
C: oh yeah. Is weeds in the background a very definitive thing though? Do you remember?
S: It wasn't always. You can't go with just weeds in the background because sometimes they are not no weeds in the background and
C: is still in A?
S: there is no weed in the background and still in A yeah
C: No but if is only A
S: yeah seeing it is definitely in A
C: so do it as definitive thing
S: yeah
C: then write it down if weeds in the background then it's region A for sure
(writing)
C: now how do we say the colors or attractiveness here
S: (overlapping) I' don't know'. Yeah that one is hard to describe that's just the region A flowers have something like really you wouldn't say this is beautiful or something as opposed to region B ones
C: as opposed to region B ones
S: but not that they all are bad. There were some that look pretty okay
C: like the A ones had couple of purple ones that were good

S: yeah
C: and there was that yellow one in A that kind of
S: Do you remember one in region A that was kind of upside down, (.) was kind of like(…)it wasn't very (..) they are like(…)I don't know (laughing)
C: yeah, like they were (.) yeah that's kind of like what I was indicating at one point. They were facing in different ways but I couldn't find anything definitive out of it.
S: I definitely don't think in region B I saw any that like I don't know like shrub
C: B was more grouping. There was more grouping. They were like kind of groupie down abit on the side
S: but not like this
C: yeah not like this but like less than horizontal, kid of like that … but A ones were more straight
S: every time I saw I don't know I was like (laughing) .(non-clear) was like upside down. That's why it was kind of uglier that why I say that its like doesn't look like appealing because of the way..
C: it looks. right?
S: yeah
C: or how it is photographed.
S: yeah. But I think, I just went with the petal size and weeds in the background for the most part and it was like almost I was always right.
C: Okay then how do you define petal size?
S: see, it needs to be relative to something that's one
C: what a bout
S: these are more rounded in region B
C: Yeah, I did-
S: just because they are bigger they end up being rounder
C: do you mean round? Or do you mean pointy?
S: region A ones were more pointy I guess
C: region A was more pointy? Because I remember that up side down I though A was more roundy and B was more pointy
S: hmm because the A's ones start to look like this just because they were sort of smaller and this is definitely region A one when start seeing something like this (..) and then I started seeing something more like this. Yes. This gonna be like region B. then how do you (..)I guess it is just more round they are larger petals sizes and rounded
C: okay. How do you communicate that?
S: if (….) I think if the (…)but sometimes I think there are also some other stuff on the stark or what ever you call it they are like this tiny thing over her and then you get the same thing and then its like that and then the size of this is pretty similar to the size of that (drawing)
C: (xxxx)
S: yeah
C: oh you mean comparative to the leaves
S: leaves yeah (..) I think it should be the next thing. If it's a lot bigger than leaves then it's region B
C: mmmm.
S: or may be the shape. Maybe just from the shape of the petals or whatever we can (..)that covers most of it
C: do you remember A were pointy. Are you 99% sure
S: yeah
C: Okay. Let's go with that. Because I remember seeing the pointiness difference like the pointiness at the end
S: I didn't really look at the pointiness. It's more like the shape of it. It's more like elongated
C: elongated, tend elongated
S: if it's A elongated(…) if the petals
C: if the petals elongated then ….
(pause)
C: then how would you define the color?

S: I really don't think the color is a good way of differentiating them
C: yeah?
S: like I saw white ones and I saw the red ones and
C: it could be the last resource (?)
S: yeah, could be the last resource(?). But I'm pretty sure even these, if we have the size ones like the size of the petals is like to say the petals are more round
C: How are you gonna define round?
S: just round (…) more circular kind of (laughing). (..) go with circular?
C: circular? (laughing) okay. I don't know if there is a better scientific term for this
S: I don't know
(pause)
C: uhh, we need to also say that (.) like the first is not a definitive test. Like it only goes one way it doesn't go the other way(…) because hopefully-
S: because if not is not necessarily region B I guess.
C: yeah
S: I can (xxxx)
C: yeah, I don't know we can put something at top. Hold on. Let's say uhm (…)
S: otherwise not necessarily in region B
C: no I think that's (xxx) hold on (…)do not assume otherwise
S: otherwise, do not assume region B
C: oh yeah, that works. (….) Do you want me to do this for all of them. We can do it later or right now
S: if you feel look nice then region B (laughing)
C: uh, okay
S: but is still subjective, I think something we can
C: yeah, the last resource I think
S: is just the color
C: how do you define it
S: if it's like redish, but you'd get it wrong sometimes. But in most of the times you get it right
C: (overlapping) it would be 50-50'. what a bout counting the petals. Do you remember the count of the petals
S: I think there were more petals in region A ones. But I didn't count them so I cant say for sure
C: okay. Either we put color as a last resource or count of the petals. I think the count petals actually be a very definitive describing
S:I think we could you with counting petals first like but then what's the good number?
C: I think 5 was mine If it's more than or equal to five then it belongs to
S: A
C: B (laughing0
S: really?
C: (laughing). Are you share we didn't get swap regions
S: well, the red ones were what for you region A or region B?
C: the red ones?
S: they weren't red, like pinkish
C: oh, pinkish, B
S: yeah, they were region B. the yellow one was also region B. right?
C: there was one in region B. One yellow in A and one yellow in B
S: I didn't notice yellow one in A
C: the one in A had like no change. It was like monotone. You know how sometimes in B there were like different colors across the same flower (…) A was like monotone for me. Like they were not indifferent shades
S: uhum, they were white most of the times in A (..)The petals were mostly white (..) as opposed to B
C: but do you remember in B seeing different shaded petals?
S: I didn't go by the shades or these things . there is (..) I literally went with these two. I would be probably done by these two
C: okay. (overlapping) (xxx) you know

S: as long as you go by this and this you are always right (laughing)
C: okay, let's just put that petal thing at the end
S: maybe this should not be the last. Maybe it is the first thing, if the petal size is large. It's subjective but I think they get the idea. Or petal size is large compare to like the size of the leaves as the second one
C: okay. We can change that then.
S: then we can go down there ..
C: oh, we can write down that later.
S: yeah.
C: do you wanna put (..) you think we are done with this?
S: I think we should explain only if, I don't know, if any of these (,,,) okay, if any of the criteria is met it's gonna be region A or it's gonna be this region and then (..) how would you say that it is not distinct (?)
C: well, mathematically you would say A applies B but B doesn't apply A (laughing). I don't know how to put it
S: yeah.
C: oh we can say it is region A if this and this, number points otherwise it is region B if this or this
S; okay
(writing)
C: and then do a number points. Like number 1
S: even in some pictures you can't see the background it's purely because the petals, like in B, just because the petals were so big. It's (xxxx). And I think we should-
C: you wanna hold that?
S: (mumbling and writing). I think we should go with the large petal size compare to leaves or something
C; okay. Then just say that ..
S: (mumbling)
C: petals are larger
S: How'd you say. Smaller petal sizes.(..) They are not that much bigger than leaves.
C: petals' size is almost equal to the leaf size. (xxx) somrthing
S: okay. (writing)
C: okay leave three lines if you want to put the color later
S: yeah. I don't know about the color . (writing) Elongated petal, petals shape is like elongated
C: uhum. Okay.
S: (mumbling and writing) … petal shapes are more circular
(pause-writing)
C: bracket go like non elongated (…) what are you gonna do for the last thing? (…) I'd say we put the colors , I don't know, bright color in B
S: bright colors (..)white is pretty bright
C: bright and non white
S: actually all the ones that were in B were not white. There was no white in B
C: no! no! I tried that. Apparently there was one white in B. I tried that.
S: I don't think we should go with the color honestly
C: no at the end
S: it's seriously misleading
C: no we like a fall back ,the person would know nothing about that, so if like there is something that even gives them 50/50 right at the end (…) if all else fails
S: hmm
C: (laughing) flip a coin
S: how do you say that (reluctant)?
C: no, what do you mean, do you want me to do the color
S: yeah. I mean saying the last resource. If
C: color is brighter compare to the background something like that
S: so if non of these have been met
C: yeah, just at the end, if non of these have been met

(pause)
S: and
C: choose A if (..) the flower, the color of the flower is dull as compared to the background
S: (laughing) is white really dull compare to the background of ..
C: of like green stuff
S: yeah
C: I don't know
S: region A if it is A and region B if redish (laughing)
C: that was true for me 80% of the time
S: yeah true right (….)That was pretty much (writing) if like non white
C: okay there was a yellow in A and there were
S: that yellow was in B
C: no there was a yellow in B and there was a yellow in A
S: (xxxx) !
C: and there was a white in B too
S: but then you get it write most of the time. Mostly non0white. I am pretty sure maybe there is one which is not white in A and there is one (laughing)
C: okay I'd say then.
S: okay. non white. They gonna get it right most of the time.
C: (laughing)

G17
S: overall in group A flowers were smaller and (..) group B was generally bigger
C: and I realized that for group B there is generally (.) like if it is in a group then it is part of group B
S: okay. Yeah (….) mmm at first I've looked into the colors
C: yeah, me too.
S: group A has more white flowers
C: despite more colorful
S: more purple pink, pinkish purple flowers
C: I think yellow too
S: yes yellow and then for that side white and purple in group A
C: okay.
S: so
C: because at first I was looking at the leaves too but then I realized that both have leaves
S: group B has less leaves showing
C: okay.
(pause)
S: we have to put them in sentences I guess
C: yeah. That's true.
(pause)
C: I guess first look at the size
S: uhum
C: if it is bigger, if it looks (writing)
S: yeah
C: (mumbling and writing together). If not then part of group A
S: yeah,
C: and then next
S: color?
C: (writing) next look at the flower color if mmm more colorful
S: yeah
C: (writing) example yellow pink and sometimes purple?
S: uh (..) like fuchsia
C: oh yeah yeah I think that's a better word
S: yeah

C: then part of group B if don't have (mumbling and writing) not any … example…white or purple
S: light purple
C: the part of group A?
S: yeah
C: And then
S: look at the leaves I guess
C: okay. (writing) Then look to see if leaves are present in the picture if yes then
S: most likely to be in group B
C: if not then (mumbling and writing)
S: yeah
C: that's it? Do you wanna talk about the
S: oh no
C: I guess that's pretty it
S: yeah, you can talk about this and then just like can be used as a reference
C: (writing) whether. (mumbling and writing) …. It's likely to be in group B … likely in B
S: okay.
C: okay

G18

C: I didn't write any notes down
S: should we write down generally what we have here and then compel (?)
C: I would like to see what you got first
S: most importantly was whether it's-
C: on the ground or not
S: on the ground or not. Right. There was like one exception. I am sure it's fine to make general statements based on our assumptions. And after that, this was kind of tricky, but
C: more single color short contrast
S: that was kind of tricky but not sure. What did you have?
C: oh sorry. What did I have, let's see (…..) I'm not sure you'd agree with this but in general I saw that most of the ones in region A had usually one or more pistols in the middle whereas in region B usually have nothing but just one large sticking out, not sure if you noticed that
S: I…
C: I noticed two exceptions or one exceptions
S: okay. So generally A had more?
C: yeah like a lot branching out in the middle
S: how do you spell it?
C: not sure. (…)okay. What was the exception for that (thinking)…
S: (xxxx)
C: And region B was either (.) one or none in the middle. I think the exception was the three white flowers or something in which they had two but I cant remember for sure.
S: okay
C: ah, let's see. I guess that was the only really conclusive one that I could come up with
S: okay.
C: I'm not sure what you mean by this. What do you mean by color is (xxx)
S: so if there was like whitish part and purplish part
C: yeah
S: it between would be like light purple and the first one would be like white and the middle might be yellow or something but they'd seem more distinct
C: they'd blend more in region B, right?
S: yes, it is pretty qualitative though
(pause)
C: okay. Yeah
S: I don't know these were pretty consistent?

C: that's the only one with one or two exceptions that I noticed for all of them. That high thing (?) I was not sure about that one (…) what else
S: I think this was fine except that yellow one. it was kind of hard to make decision about whether the background was on the ground or not
C: did you notice any thing with the shape of the petals or anything?
S: I think they were pretty(,,,) like there was no difference (xxxx) in both of them
C: kind of the same, yeah
(pause)
S: That's all, probably works
C: yeah, that's pretty much.
S: okay. Does that mean like three separate flowers?
C: that's the picture, this one is just stuck out of my mind
S: so the flower had three petals
C: no no there were three flowers which had multiple pistols but still in region B. so I don't know (.) about that one
S: okay, so how should we prioritize this?
C: (laughing) I don't know. I guess the high goes the first one
S: then pistols and then colors and then I not sure how legend is this
C: (laughing)let's put this claim on them (?)
S: at this point you're basically you are (xxx)
C: (laughing)
S: I don't if you want to write or I should writ it
C: okay . sure. What shall we say for the first one
S: can you see the ground on the background, does it seem like the flower is coming from the ground
C: so if the flower is higher is in region B I think you said?
S: yeah
C: higher, okay. (writing) So flower is high off ground
S: or may be the ground is not visible or something
C: then what?
S: then it's probably region B
C: okay. (mumbling and writing) (…) with the exception of that yellow flower (…) what if they have 2 or 3 flowers
S: I think if you consider ground that was A except there's that has yellow petal (…)
C: Also you could see the ground if that picture as well?
S: I think so.
C: okay . (mumbling and writing), exception
(..) then it's region B definitively (…) mumbling(…)close to the ground region A right (…)then more pistols (…)many pistols (….) Region A (….). (writing and mumbling) …. And color ,, could we say transition from one color to another is smoother
S: sure
C: that's for petals right?
S: right
C: writing and mumbling.. okay. …
S: okay.

Appendix F: Instructions Provided in Experiment 1 and 3

Experiment 1: Simple Group Instructions

S1:

If the flower is white it is from region A.
If there is dirt/mud in the picture, the flower is from region A.
Flowers with bright/vibrant colours are from region B.

S2:

To distinguish between flowers from region A vs. B:

Region A:
Flowers are planted on the ground, i.e. you can see soil/shrubbery around the flowers.
Flowers are smalls and not very vibrantly coloured.
Flowers are growing apart from each other, i.e. not in clusters.
Region B:
Flowers are growing on trees/elevated above the ground, i.e. you cannot see the surface of the ground in the picture.
Colours are tropical in nature, i.e bright, vibrant.
If more than one flower is visible, these flowers are growing in tightly packed bunches.

S3

Region A
This region has plants that are mostly found growing outdoors.
These plants are short in heights, perhaps less than 5 inches.
These plants require little maintenance and can often be found in wild.
These plants are nothing extravagant and probably cannot buy in a flower shop but rather picked at the park or streets

Region B
These plants are more extravagant.
Likely something you buy in a flower shop. Can be grown in flower pot or used in bouquets.
Usually grown indoors, but some can survive outdoors.
Usually grown in larger bunches than plants from region A.
Taller plants than region A, perhaps 10 inches to even human height (5 feet)
Colourful.

S4

Flowers in region A usually have many leaves around them. And they have many pulps which are symmetric in shape. They also grow either on ground or near mountains.
Flowers in region B have a few features. First is that they are more colourful. Secondly, they grow on a tree with a long branches, but they have less leaves and less symmetric pulps.

S5

To determine which group the flower belongs to, first see whether the flower is large or small. If it is small, it will likely be in group A. If it is large, it will likely be in group B. In addition, if the flower is of a bright, vibrant colour, it will likely be in group B. If it is white or of a pale shade, it will likely be in group A.

S6

If the flower colour is white it belongs to region A.
Region B flowers size tends to be much larger compared to the background.
Region A background flower/leaves are generally shorter in size.
Yellow flowers are found in region B only.

S7
The petals in group A are generally larger than those in group B.
The petals in group A often come to appoint instead of rounding off.
The leaves of the flowers in group A are usually larger and curved inward to gather water
The ground in group A is a bit rocky and does not have much grass growing around it.

The flowers of group B are bright and have much “warmer” colors than the flowers of group A
Group B flowers have few or no leaves
The petals of group B are curved downwards

S8

If the flowers appear to be growing from the ground then it is most likely from region A.
Flowers of region A also tend to be white and appears a lot smaller than the size of a rose.
Flowers from region B appears to be growing on trees and has brighter colours than A. Flowers from B appears to be the size of the a rose and have a light shade of pink.

S9

Flowers in category A are a mixture of white and pink, meaning that most of them are white and few are pink.
Flowers in category B are larger in size, with bigger petals. They are also pink. 90% of region B flowers are pink.

S10

Region A

White
Open petals
Surrounded by leaves

Region B
Closely packed petals
Flowers (multiple) are in close proximity to each other (bunched together)

S11

If the flowers has a bright colour (catches your eyes) and is large, then it is in region B.

If the flower has a dull colour (does not catch your eyes) and is small, then it is in region A.

S12

Choose the category which best describes the image of the flower:

A	B
Is the flower white? Is the stamen short with little to no bud? Does the flower grow on the ground?	Is the flower colourful (i.e. pink, yellow) Does the flower have long, visible stamen? Do the stamen have buds on them? Does the flower grow on a tree?

S13

If the flower looks like it grown in a dry region, it belongs to A.
If the flowers look something like you would grow in your own garden, it belongs to B.
If the flower blossoms really well, it belongs to A.

S14

Region A:

White
Light color
Small size flowers

Region B
Bigger size flowers

S15

Region B:

Brighter colour (bright pink, pink, yellow)
Seems like warmer temperature

Region A:

Cooler temperature and dryer (leaves look prickly)
Lighter colour (white and pink)

S16

Distinguishing flowers (region A and B)
Noticeable features of flowers for each region

Region A
Flowers are relatively small
Not so fancy in appearance
You can see lots of leaves around the flowers
Petals are small in width and length

Region B
Size of the flowers are a lot bigger compared to those from region A.
Colourful, usually pink/red, some others like yellow.
Fancy in appearance

S17

Group A
Flowers are usually small
The tree is small and does not grow much higher above the ground (less than one feet)

Group B
Flowers are usually big
The tree is grow higher (bigger than 1 feet)

Experiment 1: Complex Group Instructions

C1

1. Look for yellow centers in the flowers

2. If the center part of the flower is long and yellow it is in category A

3. If the flowers have sharp petals, they are in category A

4. If the petals have lines through them they are in category A.

5. Category B flowers have round, thicker petals

C3

Region A

Region A appears to be more arid than region B. The flowers from region A can still be colorful, but appear to grow in dry rocky ground. Some flowers stay close to the ground, while the ones that grow tall droop such that they are almost facing the ground with an upside down "U" shape in their stem. In cases where the flowers are large, they tend to grow on individual, thin stems to support their weight.

Region B

In contrast, the flowers from region B appear to be more luscious and from a well watered environment. Multiple flowers can be supported by a thick stem. The plants have many leaves to capture large amounts of sun since they don't risk drying out as much. The flowers appear to be very large and colorful. When the flowers are small, many of them can grow close together from the same spot of the plant.

C4

Instructions:

Flowers from region A are small flowers found low to the ground. The flowers have numerous petals and come in colours including, but not limited to, while, yellow, and purple. The region appears to be wet, as the area surrounding the flowers often looks to be dead and mossy. Region A contains flowers you might expect to find a forest.

Flowers from region B are larger flowers, higher off of the ground. The flowers are exotic-looking with few petals. They come in colours including, but not limited to, yellow, white, red, and pink. Region B appears to have flowers you might expect to find in an exotic place like a rainforest.

C5

First, establish whether, it is a single flower or many smaller flowers. If the image is of many smaller flowers growing in a semi-spherical manner from a bush or shrub (i.e. surrounded by leaves), the flowers belong to region B. If the group of flowers are uniform (identical) and growing in small groups (with low density, e.g. 3-4 flowers), it is likely they are from A, but continue analyzing to make sure.

For individual flowers' characteristics, first look at the petals. If the petals are thick (e.g. like a lily or tropical plant leaves), the flower likely belongs to region B. Conversely, flowers with thing petals, often narrower (e.g. like a daisy) are likely from region A.

Next, check the pistels (sp?). Flowers from region B will either have one large pestel or will not have a visible pistel and deep narrow centre. Flowers from region A usually have 4-10 (or more) visible pistels, or will have a clearly-visible centre with no pistel.

Finally, if the flower appears to be growing from the ground, it is likely from region A. Flowers from region B usually grow from vines, shrubs, or trees.

C7

If there are rocks/ice in the background ----------→ Region A
If the area looks "wet" ---------→ region A
Otherwise --------→ region B

C8

Flower Instructions

Type A
Background of picture more arid
A lot of the times, the flowers is closer to the ground (shorter stem)
In the center of the flower there are usually multiple stem things
** The colour of the flower is more pale and not very saturated
The way the flower grows is a more concave (bowl) shape

Type B
The flower may have multiple stems in the middle, but usually has one.
** Flower is usually much more saturated/bright.
The flower typicall is farther from the ground (i.e. longer stem)
The background of the picture is usually green/ more leafy
The flower opening is wider

Use the chart to compare the characteristics
Pick the type based on which characteristics meet more often (A vs.B)
Flower colour saturation is an important point to consider
Typically A has more stems in the center, more of the closed opening appearance, and a slightly brown background
Typically, B doesn't have so many stems (i.e. usually) in the flower center, more open widely and greener background

C9

Flowers of Region A vs Region B

Region A:

- Small to medium sized flowers
- White, purple or yellow petals
- Waxy and thick leaves
- Grow close to ground
- Grow in mossy/rocky area

Region B:
Pink, white, yellow, red petals

- Tall (grow further from ground)
- Small, thin leaves
- Most have large petals
- Flowers with smaller petals grow in clusters

C10

1. Note the color of the flowers. If it is a shade of red/pink, it is from B. If it is in a shade of blue/purple, it is from A.
2. If flower is not a shade of blue/purple/ pink or red, check the texture of the petals. Flowers from region B tend to have smoother petals than those of region A.
3. White flowers from region A usually have more translucent petals compared to those of region B.

C11

To distinguish flowers from region A and B

Most distinguishing feature of flowers from region B is presence of closed bulbs in the picture. This does not describe all flowers from region B however.
Most distinguishing feature of A are dark fiels in behind the flowers and jagged edges of leaves or lack of leaves.

B	A
Closed bulbs of flowers	
	Serrated edges of leaves
	Lack of leaves
	Poor soil background
Many blooms together	

The above chart shows the priority of features.

C12

Region A flowers can be any colour, they should have stems (stamen) in the middle of the flower. The petals should not curl back. If the flower is pink, it is not in region A.

Region B flowers can be any colour. They may or may not have clearly visible petals. The petals should curl back beyond the distant they stick .

C13

Flowers of region A
Includes all purple flowers
Closer to the ground
Surrounding appears “wild”
Small and pointy petals
Little buds sticking out from the center of the flowers
Stems are separated

Flowers of region B
Petals are not sharp but rounded
Appears to be in “cone” shape.
Bud-like branches.

C14

The flowers should be distinguished by region A if they have several petals, several stamen from the middle of the flowers and soft colours (such as light purple). Whereas region B does not have stamen or have very few extracting from the center, and they are brighter coloured flowers (Such as pink)

C15

Region A flowers

1. These flowers seem to be from a warmer climate.
2. The leaves of these flowers are sometimes thicker or cactus-like.
3. They consist of many shades of purple.
4. The petals are thinner than the other flowers.

Region B flowers

1. These flowers have leaves in the normal leaf shape.
2. A few of the flowers look like they are from rainforest due to their abnormal shape.
3. These flowers consist of a lot of pinks.
4. Some of these flowers are in bunches with 2-3 colours and are really small.

C16

Region A:
Colder environment.
The ground has a lot of rocks. It is rough, it has permafrost in some cases.
Flowers sometime have water on top of them.
The flowers have darker colours such as purple but with exceptions they could be yellow or white.
Smaller leaves and also fewer leaves can be seen.
Also the flowers are smaller in size in most cases

Region B
Warmer environment.
More colourful flower.
Bright yellow, red, white colours.
No visible signs of water.
The flowers are bigger in size compared to region A
Bright green coloured leaves.
The ground is smooth.
The flowers have round edges.
Greater amount of the leaves can be seen.

C17

Region A:
Flowers leaves open outwards
Seeds (stamens) are separate from each other
Leaves are separates from each other
When it first grow, it looks like small fruit (such as blueberry)
Region B:
Flowers leaves do not open outwards
Flowers are clustered together
Seeds (Stamens) are staggered
It looks like there is deep whole inside the flower

C18

1. Is the flower purple?
   Yes → A No→ proceed

2. Does the flower have 5 rounded petals and is the flower white or yellow and does the petals have striations?
   Yes → A No → Proceed

3. Does the flower have very small petals, and are the flowers not clustered?
   Yes → A No → B

C19

Flowers of region A

In general, category A flowers have:

- Pointy petals
- Bloom outwards with visible petals
- Often light coloured

Flowers of region B

In general, category B flowers have:

- Round petals
- Bloom in a "cone-shaped" fashion with pistols in side the "cone"
- Often have dark, solid colouring

C20

Some key questions to ask. Follow the sequence:

a) Are there leaves?
Yes, are the leaves defined by jagged edges? Yes →Go to c) No → go to b)

b) Are the stems like twigs or branches?
Yes. Does the flower look like it's on an orchard? Yes → go to d
No. Does the flower look like it's on the ground? (i.e. there is dirt, rocks, brown, etc) yes → go to c

c) Category A

d) Category B

Experiment 3: Group Condition Instructions

G1

Region A
If purple colour, then most likely in A
Petals are skinnier
Pointy tip for petals
Hearth shaped petals
Pointy leaves

Region B
If only one big flower, it goes to B
Petals were more flat
Thickness of the flower more than A
Tip for petals were more rounded
If pink colour then most likely in B

G2

Region A
Defining characteristics:
Sad colors, typically less colorful
Proximity of the flower. It is closer to the ground. And there are visible signs of rocks & sail

Sub-characteristics:
Typically larger leaves, smooth rounded edges
More visible moisture (dew)
Generally larger stems (perceived)

Region B
Defining characteristics
Gradient color, vibrant, typically more colorful (brighter colors)
Flower is typically higher off the ground, visible sky

Sub characteristics:
Typically smaller leaves
Less visible moisture
Generally shorter stems (perceived)

G3

Region A	Region B
Pointed edge to petals Thin petals Texture on petals	Round smooth edge to petals Wide petals Less than 6 petals Solid color

If a flower has one or more of the characteristics listed under A then it is group A, and if under B then group B.

G4

Quality	Region A	Region B
* On ground	Yes	No
Temperature	Cooler	Warmer
Color (in general)	Less Vibrant Pale	Brighter Vibrant
Leaf Shape		
Flowers	More weed-like	More garden-like
* Grown above ground on branches	No	Yes
Leaves	Hard-thick	Regular (?)
		Orchid flower-like

Legend
*More obvious differentiation indication

G5
The following table should provide you with the general differences between flowers from group A and group B. The following characteristics are based off of a very finite sample size, and may not be truly indicate of which group a particular flower belongs to.

Group A	Group B
Flowers typically close to/ or on the ground *Very generally less vibrant Appears to be from a drier climate, relative to group B Typically more than one flower present	Flowers are typically elevated from the ground (they grow on trees/bushes) *Generally more vibrant and colorful Appears to be from a typical climate Typically only one flowers

* CAREFUL!

G6

Region A

- More pale
- Smaller petals
- Many tin pistols

Region B
- More colorful/bright
- Bigger petals/more volumes
- One big pistol or none

G7

Region A	Region B
• Small to Medium sized petals • More cactus like • Looked closer to ground • ** Has a long stem • Generally pointy tips of petals	For the majority, have big wide petals **Has very small orange petals Closer to camera

** There are exceptions in both

G8
1. Look whether the petals of the flowers are flowing
convex →
If it is, it belongs to B

If the flower petals are flowing in a concave manner →
it belongs to region A.

2. The colours that are more vibrant typically belong to region B. (This can be used as secondary criterion)

G9

1. Look at petal size:
Region A has smaller petals
Region B has larger petals that are overlapped

2. Look at colours of petals:
Region A has softer colours, e.g. White, light purple, light pink
Region B has vibrant colours, e.g. Bright pink, bright yellow, red

Others: Flowers with pointy petals ( ) were generally from region A.

3. Look at climate
Flowers in region A grew closer to the ground and were generating out of rocks and dirt (dryer climate)

G10

Region A

1. Dry area compared to region B
2. Flowers had dull colors
3. Leaves are like shrubs
4. More likely to be white

Region B

1. Tropical region
2. Lots of pink flowers
3. Leaves were green
4. Bright colors

G11
Region A

- Small petals
- Stems
- Purple flowers
- Leaves that are larger than the petal
- More petals

Region B

- Pink flower
- Pointier petals
- Less petals
- Big petals

G12
Steps:

1. Read through the characteristics (**This step is important**)
2. Classify the flowers according to the characteristics
3. Select region based on the category with the most matches

Characteristics of Region A:

- Petal colours are typically white, slightly faded, or white with a slight hue of a color(a single color)
- Petal sizes are smaller relative to a dollar (looney)
- Petals have little or no overlapping with 0-20% petal overlapped ( )
- Something generally sticking out from center of the flower. i.e.

- The petals tend to form an upright or downwards bowl-like shape

Characteristics of region B:

- Petal colors are darker, vibrant, might have combination of colors
- Petal is larger overall, with respect to a looney
- Petals significantly overlap with one another (typically 25-50%)
- Typically nothing sticking out of center, but hollow center.
- Petals tend to form an upright (inverted) bell like shape. i.e.

- Typically large clusters of flowers or similar neighboring species beside the flower

G13

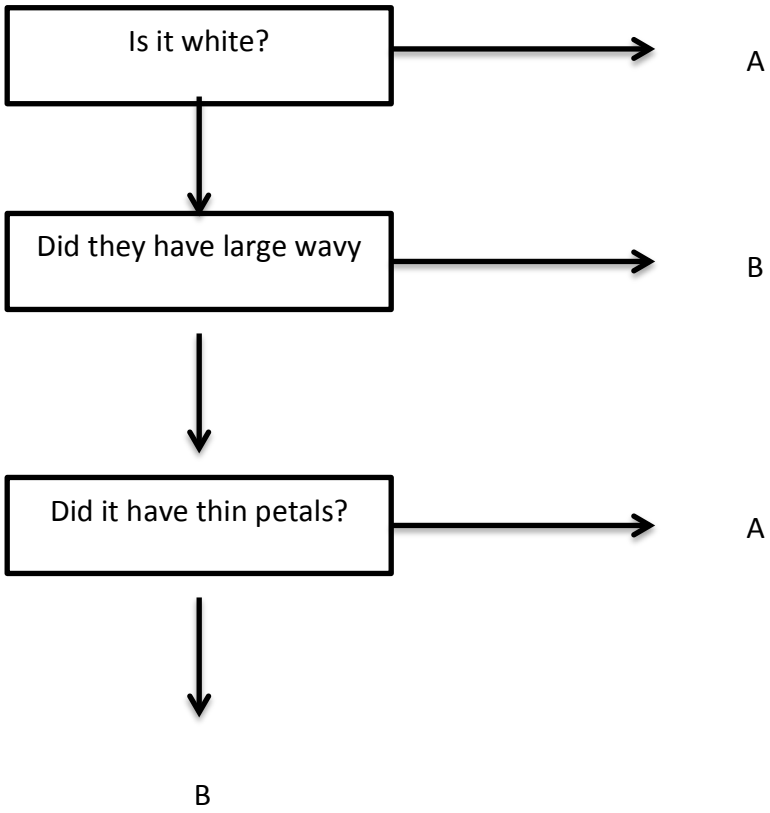
To distinguish flowers of region A:

1. Examine foliage. If leaves are spiky, not bright green, or you see the presence of dirt, rocks or moss, then it is A.
2. Flowers were either white or muted colors.
3. Flowers pictures are bare in appearance (not a lot pictured), plain.
4. More coniferous

To distinguish flowers from region B:

1. Examine foliage: if leaves are bright, waxy in appearance, not spiky, smooth, then it is B.
2. Flowers are bright (solid colors)
3. More tropical
4. Picture was more full. Entire space taken up by flowers, background leaves, etc.

G14



G15

Instruction for categorizing the flowers:

1. If the flowers has cactus like features, then it is “A”
2. If there are many leaves around the flower then it is “A”
3. If non of the above is true, and the flowers are colorful, then it is “B”

G16

Region A if

1. Weeds in background or
2. Petal size almost equal to leaf size or
3. Petal shape is elongated

Region B if

1. Petal size larger than leaf size or
2. Petal shape is circular (not elongated)

If non of the above criteria are met:
Region A if white
Region B if non-white

G17

1. First, look at the size of the flower. If it looks big, it is generally part of group B. If not, then part of group A.
2. Next, look at the flowers color. If more colorful (e.g. yellow, pink, fuchsia) then part of group B. If not any of these colors (e.g. white or light purple) then part of group A.
3. Then, look to see if leaves are present in picture. If yes, then must likely to be in group A. If not, then likely to be in group B.
4. Lastly, whether the flowers are grouped together or on its own can be used as a final categorization. If on its own, likely to be in group A. If grouped together, likely in group B.

G18

Sorted in order of decreasing importance

1. Flower is high off of the ground or ground not visible in picture = Region B
   → Exception: flowers that were yellow with a shot of the ground

2. Flower is located close to the ground = Region A
3. Many pistols (small) in the middle = Region A
4. No pistol or only one in the middle = Region B
   → Exception: the white petal flowers with many petals=Region B
5. For the petals, transition from one color to another is smoother
   (i.e. white → grey → black) vs. (i.e. white→black)

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