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The Role of Gesture in Spatial and Non-Spatial Learning in Children and Adults

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Abstract

The purpose of this study was to identify whether gesture differentially affects spatial or non-spatial language comprehension and memory in both children and adults. Previous research (i.e. Goldin-Meadow, 1996, 2001; McNeill, 1992, 2005) examines only the role of gesture in learning without addressing development. For this study, participant's baseline gesture rate is recorded and then stories containing either spatial or non-spatial components are read to the participants. Participants then receive factual and convergent comprehension questions. While answering, they either gesture naturally, are required to gesture, or are told not to gesture. A three-term inference problem task (Knauff & Johnson-Laird, 2002) and an operation span task (Deneman & Carpenter, 1980) are used to measure possible covariates. The results show that the gesture condition (natural gesture, no gesture, or forced gesture) and whether the story contained spatial or non-spatial components create two significant main effects but no interaction. This suggests that participant's amount of gesture significantly increases when forced and participant's gesture significantly increases when asked to think spatially, although these two conditions do not interact. The amount of increase in an individual's gesturing during the forced gesture condition did not significantly predict their increase in memory for the stories.

Can gesture be incorporated into teaching to improve student's memory? Existing research on gesturing is limited. The role gesture plays in spatial memory, compared with non-spatial memory, has not yet been connected. Previous research has focused on the different types of gesture, how gesture can be generally beneficial to learning, and how gesture relates to spatial situations. Research on the effects of gesture on memory has not been fully explored. The goal of this research is to explore the role of gesture in spatial and non-spatial learning in both children and adults.

Everyday when people have conversations, they gesture. In fact, it is almost impossible for people to talk naturally without gesturing. There are two ways with which gesture is produced. Gesture is integrated with speech, where it shares the burden of communication and gesture can also be produced on its own, where it assumes the full burden of communication (Goldin-Meadow, 2005). Gesture integrated with speech is not simply hand-waving. Instead it encompasses complex movements which can symbolize many different objects, people and concepts. Additionally gesture can offer unique perspectives on the cognitive state of the speaker, specifically conveying information that is not found in the speaker's verbal repertoire. This is demonstrated when children create a gesture-speech mismatch. Finally, gesture can also predict how speakers learn, solve problems and remember. Gesture can help individuals communicate and understand their world which is why it is so important to study and understand.

Gesture is defined as the hand movements that coincide with speech and have the capacity to beat the tempo of speech, pick out specific reference points in speech and demonstrate imagery to elaborate on speech (Goldin-Meadow, 2003). Gesture does not include hand movements that are considered to be adaptors or emblems. Adaptors are actions that are performed with little to no awareness or with no intent to communicate (Ekman & Friesen,

1969). An example would be smoothing one's hair or pushing up one's glasses. Emblems are gestures that do not depend on speech. They have a constant meaning and do not rely on the context of the conversation (McNeill, 1992). Examples of emblems are the "thumbs up," the "okay," and "shush." The difference between gestures and emblems or adaptors is that gesture is a part of an intentional communicative act (Goldin-Meadow, 2003). However, what makes gesture different from speech is that gesture is not bound to the syntactical or grammatical laws of speech. Gesture is free to reveal meaning that speech cannot accommodate.

There are multiple ways to code or distinguish types of gesture from one another. McNeill wrote the most commonly cited coding scheme in 1992. In this coding scheme there are four types of gestures: iconic, metaphoric, beat, and deictic gestures (McNeill, 2002, p. 78). Iconic gestures demonstrate a close formal relationship to the semantic content of speech. This means that the gesture must incorporate aspects of the same scene that the speech is referring to (McNeill & Levy, 1982). An example of an iconic gesture is when a child does a twisting motion in the air with their hands while saying, "I can't open this jar." In this example, an observer may not be able to tell what the child is motioning without the child's spoken text regarding the situation. Therefore, it is the independent knowledge that the child is attempting to open the jar that makes this gesture iconic (McNeill, 2002). Thus, iconic gestures tend to represent body movements, movements of people or objects in space, and the shapes of objects or people (Goldin-Meadow, 2003).

The second type of gesture is known as metaphoric gesture. Metaphoric gestures are very similar to iconic gestures because they present imagery, however, metaphoric gestures provide an image of an abstract concept such as knowledge, language itself or the genre of a narrative (McNeill, 2002, p. 80). For a gesture to be considered metaphoric, two components must be

present. First, there must be a Base, or concrete action, and second there must be a Referent, or the abstract concept that the Base is presenting. For example, if a person cupped their hands (Base), and asked, “I want to ask you something,” (Referent), this would be an example of metaphoric gesture (McNeill, 2002). This is because the cupped hands are considered to be a concrete action, and the accompanying question is referring to something abstract about the Base.

The third type of gesture is deictic gesture. Deictic gesture refers to pointing motions typically done with the pointer finger, although other body parts may be used such as a person’s head or foot (McNeill, 2002). An example of deictic gesture would be a child pointing at their friend saying, “I gave this to him yesterday.” This represents deictic gesture because there was a pointing motion that indicated an object, person, or location in the world. However, these types of gestures do not always need to indicate people or objects that are visible. They can be quite abstract.

Finally, the last type of gesture is beat gesture, which occurs when hand motions move along the rhythmical pulsation of speech. Beat gestures are typically biphasic, or contain two movement components and do not usually represent discernible meaning (McNeill, 2002). This type of gesture demonstrates the structure of the speech. For example, a low energy flick of the hand that puts stress on a word the speaker believes is important would represent beat gesture.

Each of the four types of gesture, beat, deictic, metaphoric and iconic are coded using the same hierarchical scheme as McNeill (2002):

- a. Hands, which includes handedness, shape of hand, palm and finger orientation, and gesture space.

- b. Motion, which includes shape of trajectory, space where motion is articulated, and direction
- c. Meaning, which is coded for hands, motion, and body separately:
  - i. For the hand, what does it represent, and what viewpoints does it entail?
  - ii. For motion, what does it represent, and what viewpoint does it entail? In addition, are there any marked features, such as manner, direction, or kind of path or locus?
  - iii. For the body, is it representing a different entity from the hand or motion?

Along with coding gesture, an important concept in this research is the dual-coding hypothesis. This theory developed by Allan Paivio (1969, 1971, 1983) states that long-term memory contains two distinct coding systems. The first system, verbal memory, contains information about an item's abstract or linguistic meaning. The second system involves imagery, or mental pictures that can represent what an item looks like. Items that need to be remembered are usually coded in the brain by using verbal labels, visual images, or both. In the dual-coding hypothesis it is believed that pictures and concrete words can produce both verbal labels and visual images or that they have two possible internal codes or mental representations. In contrast, abstract words usually only have one type of representation, which is the verbal label.

To help demonstrate the Dual Coding Theory, Paivio's (1965) study had participants learn one of four lists of noun pairs. The first list, or CC, included pairs of words that referred to concrete objects such as book-table. The second list, or CA included pairs where the first noun was concrete and the second word was abstract, for example chair-justice. The third list or AC was a converse of the second list. A possible pair could be freedom-dress. The final, or AA list contained pairs of abstract nouns, such as beauty-truth. There were a total of sixteen correct

responses on the test. Participant's scores for correct answers averaged around 11.41, 10.01, 7.36, and 6.05 for the CC, CA, AC and AA lists respectively.

Paivio's (1965) results suggest that participants spontaneously formed visual images of the noun pairs whenever possible which demonstrates that formation was easiest with concrete nouns. Paivio believes that visual imagery, increases as a function of concreteness. The more concrete a noun, the richer the image, which translates into a more elaborate internal code. This research also demonstrates why pictures, which are very concrete are often remembered better than words. Additionally, because items can be coded by either verbal labels, visual images, or sometimes both, they have two possible internal codes or mental representations. This could suggest that gesture could help participants better remember the visual images or spatial terms because gesture could better link the verbal labels to the visual images. This is because gesture often aids in the organization of words by helping the flow of speech.

To date, there has been little research completed bridging the role of gesture in spatial and non-spatial learning and little to no research completed comparing this topic in children and adults. Virtually, Susan Goldin-Meadow has published all the research in this area. One of her greatest contributions to this area relates to mismatches, or when gesture and speech each encode a different meaning. Goldin-Meadow demonstrated this using Piaget's conservation tasks. Most children in the Preoperational Stage, or between the ages of two and seven do not understand conservation, which is the ability to understand that a certain quantity will remain the same despite manipulation to its container or shape (Piaget, 1968).

In Goldin-Meadow and Singer's study (2003), two rows of checkers were set up in front of a child. Each of the rows contained an equal amount of checkers. However, the top row of checkers was spread out to be twice as long as the bottom row of checkers. Next the child was



asked if there was an equal amount of checkers in each row, and then to explain their answer. In the children who answered there were different amounts of checkers in each row, there were two types of responses. The first type was a gesture-speech match. This is when the child's reasoning of the task matched their gestures. An example would be a spreading out motion with their hands, while saying, "The top row has more checkers because the checkers are more spread out." The second type of response was a gesture-speech mismatch. This would occur when the child points to each individual checker, acknowledging with their hands, that there are an equal amount in row, while stating that the longer row has more checkers.

Goldin-Meadow found that when children produced a mismatch, the child knows to some degree that the information is conveyed in two modalities. However, the child has not developed a framework in which both modalities can be fit together (Goldin-Meadow & Church, 1986). Interestingly, it was found that children who produced more mismatches, or were more inconsistent were found to be more trainable in their explanation of the conservation principle than children who produced fewer mismatches. This could have many implications regarding a child's readiness to learn, and which teaching strategies could be more beneficial (Goldin-Meadow & Church, 1986).

Research by Sauter et al. (2012) attempts to bridge the role of gesture in spatial and non-spatial learning, integrating Goldin-Meadows studies on gesture with Pavio's research on the dual-coding hypothesis. This study examines what children know about space from looking at their hands. Children ages 8-10 and adults walked through a space to learn the locations of six hidden toy animals. After, the individuals needed to explain the space to another person using both speech and gesture. The results indicate the participants often used gesture to communicate spatial information. They did not express much about the spatial layout in speech without also

expressing this information in gesture. Typically when speech and gesture were used together, a higher quality of information was conveyed about the layout than just speech alone.

Possible variables which could confound the results of the study include the amount each participant naturally gestures, the participant's working memory, and whether the participant is a visual learner. According to Frick-Horbury's (2002) research on the effects of hand gestures on verbal recall, there is a possible link between the amount a person gestures and their recall. Due to this link, it is important to gather a baseline of how much each participant gestures naturally. That way this study would be able to test for this link and determine if a person's natural gesture is aiding their recall in the experiment.

Participant's working memory could also act as a confounding variable in this experiment. This is because previous research has demonstrated a link between working memory and memory recall. An experiment by Baddeley and Hitch (1974) had participants temporarily store a number of digits while simultaneously performing another task such as language comprehension. Participants were able to verify the sentences while holding one or two digits in memory. A six-digit memory load did hurt performance. As the sentences took longer to verify meaning, people took longer to reason while rehearsing six digits. This research could suggest that gesture could interfere with the participants recall and working memory.

To test a participant's working memory an experiment by Deneman and Carpenter will be used. In this experiment, participants are given a set of sentences to read aloud. At the same time the participants are asked to remember the last word in each sentence for later recall (Deneman & Carpenter, 1980). For example, the participant may be presented with these three sentences:

The leaves on the trees turn various hues in autumn.

A group of students congregated outside the front entrance of the delicatessen.

Although lying and fabrication are generally not acceptable, they are sometimes necessary.

This task was selected because it will test the participant's phonological loop, which is believed to be responsible for subvocally rehearsing auditory information (Baddeley, 1981, 1986, 1990).

Deneman and Carpenter (1980) have also found that the measure of the participants span, or number of words memorized correlates significantly with other cognitive measures such as reading comprehension and other complex cognitive tasks.

The participants' visual spatial abilities could also act as a confounding variable. It is thought that an individual's nature visual spatial abilities could help their recall of spatial tasks. Previous research by Drew-Abrams (2005) gave participants cutout versions of different buildings on a college campus. The participants were asked to place each building on the map as accurately as possible. Participants who had better visual spatial abilities were able to place the buildings on the campus map more accurately. However, most participants tended to systematically arrange all the cutouts along orthogonal lines to make the campus look neater on the map. The results of this study suggest that participants with better visual spatial abilities will perform better on spatial tasks.

A visual spatial task by Knauff and Johnson-Laird was picked to test this possible confounding variable. In this task participants were shown a three-term series problem (Knauff and Johnson-Laird, 2002). For example:

The eggs are below the butter.

The butter is above the juice.

Which item is the highest?

This task was picked because to solve this problem, mental images must be formed to place the baking goods in the correct order as suggested by the sentences. Therefore, this task will test the participant's visual spatial abilities.

Based on this previous research, looking at how gesture affects spatial and non-spatial reasoning in children and adults would contribute to the field of psychology. Therefore, the purpose of this research is to discover whether gesture helps children and adults to remember spatial or non-spatial stories. This information could be particularly useful in an educational setting, where students are often asked to think in spatial terms. For example, space is often referred to in geometry or math and in stories or literature. By capturing the essence of how children and adults learn about gesture and space could help improve teaching methods, which could then improve a person's academic success or broader, a person's ability to learn. Additionally, by studying two different populations, the development of gesture and spatial, non-spatial awareness can also be monitored.

Therefore, the current research examined relationships between gesture and spatial and non-spatial learning. We hypothesized that gesture will aid in spatial learning in both children and adults. Those who are asked to gesture or gesture naturally will score higher on the subsequent questions asked regarding the stories. This hypothesis is based on the previously mentioned research as well as the assumption that gesture helps humans to place spatial terms and abstract concepts into concrete form. We also hypothesized that those who score high on the covariate tests for memory and visual spatial abilities will also score higher on the story memory questions.

## **Method**

### **Participants**

A total of twenty-three students at the College of St. Benedict/St. John's University participated in this study along with twelve 6th grade students from the St. John's Preparatory School. The college participants were gathered from first year psychology students and from the CSB/SJU Communications Department, while the 6th grade students volunteered at the request of the researchers. No participants received any compensation.

### **Materials**

The materials used in this study were twelve total stories. There were two versions of each story, six involved spatial components and six involved non-spatial components. A series of multiple comprehension questions were designed for each individual story to promote thought and encouraged either spatial or non-spatial thinking. To test for covariate variables, the sentence memory task was used along with the three term inference problems. The stories, sentence memory task, and the three term inference problems were programmed using PsyScope software onto a laptop computer. The experiment also required a video camera to document each participant's session for later coding.

### **Procedure**

The experiment took place in either an empty room at the St. John's Preparatory School or at the College of St. Benedict. The participants were randomly assigned to groups and went through the set of tasks in a counterbalanced order.

To begin, the researcher turned on the video camera and asked the subject to speak about an open-ended subject. This statement was "Describe your favorite family vacation." and/or "Describe your ideal day." This portion will later be used to assess the participants' natural baseline gesture tendencies by coding it according to McNeill (1992) coding scheme.

The majority of the experiment is a 3 x 2, gestural condition (no gesture, natural gesture, forced gesture) by story type (spatial, non spatial) within subjects design. For this section, an oral and visual prerecorded video of a spatial or non-spatial story was read to the participant and they were asked a series of comprehension questions about the story contents (See Addendum 15). The ordering of the type of story and type of gesturing the participant was asked to perform while answering story comprehension questions depended on what group the subject was assigned to. The participant's gesturing was video recorded and later coded. The second story proceeded after the first set of comprehension questions.

After the first two stories were completed, a working memory task was given to the participants. For this task, we tested the participants' phonological loop capacity. A set of sentences was given to the participant to read aloud. While the participant was reading the sentences, he/she was asked to also remember the last word of each sentence. The participant then repeated the entire sequence of last words back to the researcher as best possible. This test was the same as the Daneman and Carpenter (1980) and the Miyake (2001) studies. See addendum #1 for the text of these sentences. These results were recorded for later coding.

After the memory task, participants will watch and answer questions for stories three, four, five and six. This will follow the same procedure as the first two stories. Finally, the participants completed a visual spatial task. The participants were asked to put the items/subjects discussed in the sentences into the correct order. This was the same as the Knauff and Johnson-Laird experiment, 2002. See addendum #2 for the three term inference problems used. The participants will be evaluated on their speed and accuracy completing the task.

The total length of time for this experiment was about forty-five minutes for each participant. After the participants completed all the tasks, the researchers compiled the data.

## Results

A 3 X 2 analysis of covariance was conducted to determine the effect of gesture (Natural Gesture, No Gesture, Forced Gesture) and story content (Spatial or Non-Spatial) on the amount of gesturing. The interaction between factors was demonstrated using an  $F$  test with a  $p$  value and showed that there was no interaction. ANCOVA results indicate a significant main effect for gesture,  $F(2,68) = 8.768, p = .001$  and a significant main effect for the spatial condition  $F(1,34) = 4.310, p = .046$ . The interaction between gesture and spatial condition was not significant,  $F(2,68) = .330, p = .720$ . This means that recall was better when participants were forced to gesture or could not gesture and that there was better recall in the spatial conditions.

Next, a multiple regression analysis was conducted to determine the extent to which the increase in gesture when forced predicts an increase in memory during forced gesture recall. The results were not statistically significant ( $R^2 = .002$ ). The results indicate that the amount an individual gestures is not linked to better memory.

Due to the ANCOVA results which indicated a main effect for gesturing, paired samples  $t$ -test was conducted to compare adult's memory in natural gesture to their memory in forced gesture, adult's memory in natural gesture to their memory when they were not allowed to gesture and children's memory in nature gesture to their memory in forced gesture. There were significant results between the adult's memory in natural gesture compared to when they were forced to gesture  $t(23) = -3.484, p = .002$ . The adult's memory in natural gesture ( $M = .778, SD = .1226$ ) was significantly different from when they were forced to gesture ( $M = .821, SD = .1209$ ). Additionally there were significant results between the adult's memory in natural gesture compared to when they could not gesture  $t(23) = -3.87, p = .001$ . The adult's memory in natural gesture ( $M = .778, SD = .1226$ ) was significantly lower from when they were not allowed to

gesture ( $M = .8659$ ,  $SD = .0792$ ). However, there were no significant results between children's memory in natural gesture compared to when they were forced to gesture  $t(12) = -2.113$ ,  $p = .058$ . The children's memory in natural gesture ( $M = .7279$ ,  $SD = .1353$ ) was not significantly different from when they were forced to gesture ( $M = .8129$ ,  $SD = .1516$ ).

Finally, three independent sample t-tests were conducted to compare age with the three-predictor variables or covariates, which were working memory, baseline gesture amount and visual spatial capacity. By examining the covariates, the hope was that none of these secondary variables were affecting the relationship between the dependent variable and other independent variables. There were no significant results between children and adults' working memory,  $t(33) = 1.186$ ,  $p = .244$ . The working memory of the children ( $M = .458$ ,  $SD = 1.165$ ) was not significantly different from the adult's working memory ( $M = 4.00$ ,  $SD = 1.477$ ). Additionally, there were no significant results between children and adult's baseline gesture,  $t(33) = -.465$ ,  $p = .654$ . The baseline gesture of the children ( $M = 1.917$ ,  $SD = 3.029$ ) was not significantly different from the adults ( $M = 2.348$ ,  $SD = 2.367$ ). There were also no significant results between children and adult's visual spatial capacities  $t(33) = 1.061$ ,  $p = .296$ . The visual spatial capacity of the children ( $M = 11.75$ ,  $SD = .6216$ ) was not significantly different from the adults ( $M = 11.39$ ,  $SD = 1.076$ ). This suggests that none of the covariates were affecting the relationship between the dependent and independent variables.

## **Discussion**

Our prediction that gesture (both natural and forced) would aid in learning in both children and adults was only partially supported by the data. Overall, the findings suggest that adult participant's comprehension improved when either forced to gesture or told not to gesture. For children, no significant results between comprehension in the natural gesture condition



compared to the forced gesture condition were found. However, the difference between natural and forced gesture conditions were incredibly close to significant for children. These results does not match with the study by Sauter et al. (2012), which found that using both speech and gesture to communicate spatial information produces a higher quality of information than just speech alone. One could assume from this study that natural and forced gesture would create the same effect but this was not the case in this study. We believe that when participants are asked to use or not use their hands, they were forced to pay more attention to their answers. When asked to not use their hands, participants must focused solely on the answers they give, while when participants were forced to gesture they must focus on how their hands can help them communicate by emphasizing the answers to the questions. Natural gesture however, requires limited thought, which could have caused participants not to focus on their answers. The age difference here may have occurred because the children are more easily distracted by a new task or directions. Adults may have used the gesture restrictions to structure their answers whereas children may have been confused or distracted.

Our second main prediction, that gesture would improve the memory scores for spatial stories more than the non-spatial stories in both children and adults, was not supported by the data. No interaction was found between the gesture condition (Natural Gesture, No Gesture, or Forced Gesture) and the story content (Spatial or Non-Spatial). Also, the amount a person gestured was not linked to better memory. No differences were found in the predictor variables between the children and adults. Between children and adult's working memory, baseline gestures, or visual spatial capacity, no significant differences were found.

Though we found few significant results, this experiment helped us look further into the effects gesturing has on memory. We found that a difference exists between the natural gesture

and the forced gesture and no gesture conditions for adult's memory. Close to significant results were found for children's memory between the natural gesture and the forced gesture conditions for children. Therefore, this study supports the notion that gesturing does have an impact on learning. This directly supports Goldin-Meadows's (2003) study that demonstrated the importance of gesture when learning. On the other hand, this research does not entirely support Paivio's (1965) dual-coding hypothesis. The dual-coding hypothesis implies that any type of gesture would help to encode the information two-times over for participants. However, distraction by one's own gestures appears to play a larger role in this study. Altogether, work on this subject has continued to show varying effects on memory.

Many null results occurred in this experiment. However, the insignificant results can also have meaning. For instance, the lack of a significant between the spatial and non-spatial story comprehension may be evidence of mutual effects of gesturing. This may show that gesturing equally affects both spatial and non-spatial material, meaning gesture could potentially be used to improve both types of comprehension. Also, the lack of difference between adult and children's baseline gesture could show that gesture style is established at a young age and is consistent throughout one's life. Gesture amount and story comprehension not having a significant interaction is also important. Future studies should focus on gesture type instead of amount of gesture. This study did not give many opportunities for participants to do more than beat gesture. Studies looking at how metaphoric, deictic, or iconic gesture affect memory or learning in a different situation could be beneficial.

Several confounds may have factored into this experiment. The results of this study may not be an entirely accurate representation of a spatial and non-spatial comparison. Each story did have a spatial and non-spatial version but three stories were written by each researcher. This

may have created differences in the amount of spatial material included within the stories. Also, while running several of the children participant's sessions, noise from other students in the hallway could be heard. This may have been distracting to the participants being tested. Another confound that may have occurred took place within the predictor variable tests. Almost all adult and student participants scored nearly perfect on both the visual spatial task and the working memory task. This could be evidence of a ceiling effect. Using more difficult tasks could have fixed this problem. Also, the comprehension questions for each story differed slightly. Some of the questions drew upon more spatial criteria from the stories than others. This could have led to some students not engaging in spatial reasoning.

Overall, this experiment showed no significant effect of spatial or non-spatial content on memory. However, adults who were told to gesture or not to gesture significantly improved comprehension in both spatial and non-spatial stories. Using more regulated spatial and non-spatial stories and questions could help explain if there really is a significant difference between the two. Also, by controlling the other confounds we faced it may be possible to find more significant interactions. Using a large sample and having more difficult predictor variable tests will help as well. Goldin-Meadows (2003) and Sauter (2012) have shown a significant interaction between gesturing and learning which could be beneficial to students and teachers. Studying gesture further could help improve teaching techniques and inevitably aid in student's learning.

## References

- Baddeley, A.D. (1986). *Working memory*. New York, NY: Clarendon Press.
- Baddeley, A.D., & Hitch, G.J. (1974). Working memory. In G.A. Bower (Ed.), *The psychology of learning and motivation* (Vol. 8, pp. 47-90). New York Academy Press.
- Church, R. B. & Goldin-Meadow, S. (1986). The mismatch between gesture and speech as an index of transitional knowledge. *Cognition*, 43-71.
- Daneman, M., & Carpenter, P.A. (1980). Individual differences in working memory and reading. *Journal of Verbal Learning and Verbal Behavior*, 19, 450-466.
- Dara-Abrams, D. (2005). *Architecture of mind and world: How urban form influences spatial cognition*. Carleton College, Northfield, MN.
- Ekman, P., & Friesen, W. (1969). The repertoire of nonverbal behavior: Categories, origins, usage, and coding. *Semiotica*, 1(1), 49-98.
- Frick-Horbury, D. (2002). The effects of hand gesture on verbal recall as a function of high and low verbal skill levels. *The Journal of General Psychology*, 129(2), 137-147.
- Goldin-Meadow, S. (2005). The two faces of gesture. *Gesture*, 241-257.
- Goldin-Meadow, S., McNeill, D., & Singleton, J., (1996). Silence is liberating: Removing the handcuff on grammatical expression in the manual modality. *Psychological Review*, 103, 34-55

- Goldin-Meadow, S., Nusbaum, H., Kelly, S., & Wagner, S. (2001). Explaining math: Gesture lightens the load. *Psychological Science, 12*(6), 516-522.
- Goldin-Meadow, S., & Singer, M. (2003). From children's hands to adult's ears: Gesture's role in the learning process. *Developmental Psychology, 39*(3), 509-520.
- Knauff, M., & Johnson-Laird, P. N. (2002). Visual imagery can impede reasoning. *Memory & Cognition 30*, 363-371
- McNeill, D. (1992). *Hand and mind: What gesture reveals about thought*. Chicago: University of Chicago Press
- McNeill, D. (2005). *Gesture and thought*. Chicago: University of Chicago Press
- Paivio, A. (1983). The empirical case for dual coding. In J.C. Yuille (ed). *Imagery, memory and cognition* (p.307-332). Hillsdale, NJ: Erlbaum.
- Sauter, M., Uttal, D., Alman, A., Goldin-Meadow, S., & Levine, S. (2011). Learning what children know about space from looking at their hands: The added value of gesture in spatial communication. *Journal of Experimental Child Psychology, 587-606*.

## **Appendix**

### Addendum 1

#### Memory Task

- 1) When at last his eyes opened, there was no gleam of triumph, no shade of anger.
- 2) The taxi turned up Michigan Avenue where they had a clear view of the lake.
- 3) After a long day at work, Jim drove home thinking about a hot cup of coffee.
- 4) The clouded sky looked ominous to the athletes about to compete in Memphis.
- 5) Scorching sunlight peaked through the crack under the blinds, keeping Jane awake.
- 6) Several students in the classroom winced as the TV emitted a high pitch frequency.
- 7) Shannon looked longingly at her bed as she sat at her desk working on job applications.

### Addendum 2

#### Three Term-Inference Problems

--Visual Memory

Josh is taller than Drew.

Samuel is shorter than Drew.

Who is the tallest?

Is Josh the tallest? (Yes)

The dog is cleaner than the parrot.

The parrot is dirtier than the cat.

Which animal is the dirtiest?

The parrot the cleanest? (No)

--Control

Sandy is better than Joey.

Joey is worse than Rachel.

Who is the best?

Is Joey the best? (No)

Jason is smarter than Mark.

Mark is dumber than Kathy.

Who is the dumbest?

Is Mark the dumbest? (Yes)

--Visuospatial Memory

The bush is in front of the tree.

The tree is in back of the flower.

Which plant is in front?

Is the flower in front? (No)

The eggs are below the butter.

The butter is above the juice.

Which item is the highest?

Is the butter the highest? (Yes)

Addendum 3

Non-spatial Stories

#1

I knocked on the door. Inside the house I heard a radio go quiet, then shuffling sounds. I had a good feeling about this place.

She opened the door partway. “Yes?” Her voice was thin and croaky from lack of use.

“Good morning, Ma’am,” I chirped. “My name is Jared Righetti and I’m looking for summer work. Painting, lawn mowing, odd jobs?” One good thing about being an undersized sixteen-year-old is that I can pass for thirteen. I tried to see beyond her, into the house.

“No, nothing for you,” she said and stepped back from the door. I couldn’t see much but it smelled like an old person’s house – stale, fruity, soggy tea bags, flowers, cats, all of it mixed together like the odor of old carpet.

“Okay, ma’am,” I said. I flashed her my winning smile (learned from my old man).

“Sorry to bother you.” I headed off – except that I went only a short way before turning back.

“What is it now?” She said. She was still at the door. “I told you I have no work for you.”

“I understand, ma’am,” I said. “But I’m in the Boy Scouts, and we get pins for doing volunteer work. I’m wondering if you’d mind if I mowed your lawn for free? It won’t take me long. It’s part of the Boy Scout oath – to do volunteer work.”

She was silent, then cleared her throat with a raspy sound. “Okay. But just that front part.”

“Thank you, ma’am!” I said and saluted.

I had spotted this place when my family first came to this small town. It was one of those little towns that the real world hadn’t caught up to yet – a petty thief’s dream. My dad says stealing runs in our family.

When I finished mowing, the woman had left me a glass of iced tea. “I wouldn’t feel right without giving you something for your trouble,” she said from behind the screen.

“Whew! It’s hot – thank you so much, Mrs. Anderson,” I exclaimed.

“How’d you know my name?” she said suspiciously.

“The mailbox?” I answered.

She was silent.

I took my time with the iced tea, but finally finished the last, long, cold swallow.

“Just set it on the porch,” she said.

“Thank you. Bye, Mrs. Anderson,” I called cheerfully over my shoulder.

A few days later you could still see me doing odd jobs in her house. I was growing on her.

“Today I think I’ll start in on the paint in the garage, Mrs. Anderson.” I told her as I arrived one day.

Inside the garage, I found a little old car hidden under an old tarp. The car had to be worth twenty or thirty grand.

By the end of the day I was cruising the streets right out of Oakville, before Mrs. Anderson could even come to check on me.

I told you stealing is in my blood.

#2



A bicycle pulled up alongside me as I walked to the store one day last summer. A girl jumped off the bike. “Hey!” she said.

“Hi.” I wondered if she thought I was somebody else.

“I saw you going into the library a few days ago, with Mr. McCrory, didn’t I?”

I nodded. “Yeah, Jim’s my uncle. Do you know him?”

“He’s your uncle? He was my freshman biology teacher. He’s such a doll! Are you staying with them for the summer?”

“Yeah, for six weeks or so. I’m Helene.”

“I’m Poppy. Do you have a bike?” she asked.

I shook my head. “No. I thought they’d let me drive one of their cars, since my aunt is kind of laid-up anyway, but they’re being very paranoid.”

“You can drive? Oh, God, you’re so lucky. I have another year until I can get a license. You mind if I walk along with you? What’s wrong with your aunt? I never met her. What’s her name? Is she pretty?”

Poppy was one of those girls who you weren’t sure if she was actually speaking to you or just liked to hear her own voice.

“Her name is Lucy, and, yes, she’s pretty. Although she doesn’t look so great these days. She’s pregnant and has to lie around in bed all day, so she doesn’t usually bother to fix her hair or change out of her pajamas.

Poppy made a face. “Gross! Poor Mr. McCrory!”

I had to laugh. “Jim’s too busy to mind. He’s working and taking care of their three-year-old.”

She babbled on for awhile and finally said, “Listen, if they ever let you have the car, give me a call – Poppy Malone – and I’ll show you around to all the cool places.”

“Thanks,” I said. “That would be great.”

After dinner that night I told Jim about Poppy. His eyes rolled back in his head.

“Poppy Malone! Of all the people you could meet!”

“Is that the one who was always stopping by to chat after school last year?” My aunt Lucy asked.

“That’s her.”

Lucy laughed. “Sounds like she’s got a big old crush on you, Jim.”

“That’s what I thought too!” I said.

“Oh, please. Don’t say it.” Jim sank back into the couch.

#3

#### Addendum 5

The people in my family aren’t the kind who ever go anywhere. So when my letter came in the mail that fall, I knew it didn’t make any sense to go getting my hopes up.

Dear Ms. Haven,

Congratulations! As the top scorer in your region on the state aptitude test, you are cordially invited to participate in the College for High Schoolers at Mercer University, July 12-19. Join in college-level seminars with the best and brightest in the state. Learn from Mercer’s world-class faculty and experience the finest in Mercer’s state-of-the-art facilities!

With my palms sweating, I hid that letter for weeks in my dresser. No one in my family had ever gone to college and Mercer University was hours away from home. All my parents would have said about the letter would be “Well, that’s real nice, honey.”

If I had shown my teachers they would have been proud and told the whole school. “Look, you all, and see what Lindsey went and did! See what you can accomplish with a little studying and hard work?”

But then there was Granny... Granny always understood me. “I always knew you were smart,” she said when I showed her.

“I’m good at taking tests,” I said. “Daddy’ll tell you that’s not the same thing.”

“The state thinks you’re smart,” Granny said, like that settled the question. “So you gonna frame this letter and hang it on the wall, or are you gonna do something about it?”

“Well, I want to,” I said. “I’d give anything to go to College for High Schoolers. I reckon it’d be like – like heaven. But how am I going to get there? How am I going to pay for it? I mean, I don’t even own a sleeping bag!”

“I think one of my cousins has a sleeping bag,” Granny said. “Now, if I could just remember which one... And you’ve got nine months to raise the money. If God can make a baby in that amount of time, you ought to be able to make enough money for college. As for getting you there – why, I’ll take you. I always did want to see a little bit more of the world before I die.”

I stared at Granny. “But, but –” I sputtered.

“Now, don’t you worry,” Granny said. “I can drive fine. Just never had a reason to do much of it before. What do you say?”

What I wanted to say was, “But I didn’t tell you about the biggest obstacle of all. How can I go to that big fancy university? How can I pull up a chair beside all those really smart kids?”

Instead I took a deep breath. “New territory,” I breathed, thinking of the university.

“I believe in you,” Granny added.

I hesitated to respond. A few days won’t kill me I decided. “Alright... No use worrying, right? I’ll give it a shot!” I finally answered.

#4

#### Addendum 6

“Did you know that tiger’s can’t climb trees?” whispered a soft voice from above.

“Rick, leave me alone,” growled the tiger. “I can do anything I put my mind to.”

Behind him a boa constrictor slithered down from a nearby tree.

“I bet you can’t Bob. Only John, the panther and Mary, the jaguar can climb trees. You’d just make a fool out of yourself. You’re nothing but an orange striped kitty.”

In annoyance, Bob bared his white, sharp teeth as Rick, the boa slithered away.

“It’s not fair that tigers can’t climb trees. I mean we are just as qualified as panthers. What makes a panther so special? Is it because their fur coats are black? Are their claws sharper? Maybe it’s because they are skinnier. I know from experience that tigers love to eat meat.”

“So, I heard from Rick that you can’t climb trees,” taunted another voice from high in the air.

Looking up Bob saw John, the panther.

“So what’s your secret? How are you able to climb that high?” pleaded Bob desperately.

“Like I’m going to tell you...” smirked the black cat. “Only animals who are worthy can climb to such...great heights!”

With exasperation, Bob continued walking.

“Only panthers can climb that high,” hissed Bob in a mocking manner. “Well, I don’t care! I will find a way to climb a tree!”

“Well you look determined young tiger,” came a voice from above.

Loudly Bob sighed.

“Why is everyone in a tree? Why am I the only one left on the ground?” cried Bob as he crumpled to the forest floor.

“It’s because other animals aren’t as special as you are!” replied Matt, the chameleon in a cheerful manner.

“What do you mean?” sniffled Bob, attempting to hide his stray tears.

“You don’t need to climb trees to survive. You, unlike John and Rick have everything you need to survive on the forest floor.”

“But still... I want to climb a tree. Will you help me Matt?”

“I guess,” Matt softly sighed. “Let’s find a tree with many branches coming out from the bottom.”

After a quick search, Bob quickly located one.

“Here! This one looks all right!”

“Perfect!” encouraged Matt. “Now just put your front paws on the first branch. Then put your back legs on the same branch. Next reach up with your front paws for the next highest branch. After, using your front paws, pull your back legs up as well!”

“Look at me Matt! I’m climbing! I’m climbing! Can you believe it? I did it!”

“Congratulations Bob! You conquered your goal!” cheered Matt. “See tigers can climb trees too!”

#5

#### Addendum 7

“Well it seems like such a lovely day to explore in the backyard woods,” thought Sophie to herself as she ventured towards the trees.

She couldn’t help but notice small purple flowers lining the forest floor. Picking one up she began to pull off the pedals.

“He loves me, he loves me not,” sang Sophie as she skipped through the woods.

Soon Sophie realized she was lost. Panic began to inch across her body as her eyes threatened to release a waterfall of tears.

“Oh no!” Sophie frantically thought as she continued walking. “My mother is going to be worried sick about me. What if I can’t find my way home? Do you think they will have to send tracker dogs after me? What if they can’t find my scent? This was such a bad idea. Why did I have to be so silly? I should always have parental supervision when I wander into unknown places.”

Sighing Sophie decided to sit on a small rock outside of a large grey stone structure. It looked like a cave for some sort of giant animal.

“ROOAAARRR!” came a deep growl from inside the cave. Stepping out into the sunlight was a huge grizzly bear! Carefully, the bear stood on his hind legs and opened his mouth revealing his pointy white teeth.

Once again, panic set in as Sophie began to sprint. Out of the corner of her eye she noticed a stream. Maybe the bear wouldn't follow her across the water. Sophie would have to take that chance as her feet splashed and fought against the light current. Soon she made it to the other side. Luckily, the bear did not follow her.

Not knowing what else to do, Sophie sat down on the bank of the stream. The water calmed her as she watched the small fish swim past.

"One fish, two fish, three fish," whispered Sophie to herself.

Soon the calming presence of the water and fish put Sophie to sleep.

Hours past before Sophie opened her eyes again.

"The sun is close to setting. My parents must be worried sick about me. I better figure out a way to get home. I wouldn't want to be stranded here in the dark. That bear might get hungry and cross the stream to eat me!"

Staggering to her feet, Sophie began to retrace her steps. This would involve crossing the stream again. The water would be cold. With big, brave steps, Sophie crossed the stream, and fought the current. Tiptoeing past the bear cave, Sophie began walking until she found her long trail of purple flower pedals. Smiling Sophie knew she could find her way home.

#6

#### Addendum 8

Joey and Ellie were two siblings on an adventure. After randomly wandering through a forest, they found a beautiful swirling portal.

"I heard that if we jump through this portal, we will be taken to a mystical land!" shouted Joey, a tall boy with reddish, orange hair.

"A mystical land?" asked Ellie.

"Yes! A land with things we could never imagine!"

"Like unicorns?" pondered Ellie. "I've always wanted to see a live unicorn!"

"I'm sure there are many!"

Holding hands, Ellie and Joey jumped through the magical portal. Seconds later they arrived.

Taking a path, they began to walk towards a giant castle. Soon they were lost.

"Who goes there?" shouted a loud, booming voice.

"Why, it's Joey and my sister Ellie. Who are you?"

Out of the shadows emerged a large figure. The figure looked like a giant goat, except it stood on two legs. The horns on his head sparkled in the sunlight.

"I am Govotte. The King's keeper."

"There's a king here? Could we meet him? Ellie and I need to find a way home!" exclaimed Joey.

"The king only meets with special visitors."

"Well what if we are from a place far from here?"

"Such as?" growled the goat.

"Minnesota! The land of four seasons!"

"Why I've never heard of that place... I guess, that is a good enough reason to meet with the king. You could talk to him about foreign lands such as... Minnesota..."

With the king's keeper guiding them, the children started north toward the castle again. They were just about to walk onto the castle's drawbridge when a large creature flopped in their way.

“I’m Kyran, the mermaid who lives under this bridge. You must barter to get across or pay with your lives!”

When the children turned to ask Govotte for advice, they realized he had vanished

“What if we don’t have anything to barter with?” whimpered Ellie.

“Then you pay with your lives! Surely you must have something of value?” responded the mermaid.

“My necklace?” asked Ellie.

“Let me inspect it dear!”

Carefully Ellie threw her necklace into the hands of the creature who carefully looked at every detail.

“I guess this will suffice. Now you boy!”

Joey, not having anything of value took off his running shoes.

“These are a popular brand from back home,” defended Joey as he tossed his item.

“Very well, you two may pass. I guess these things will fit with my collection under the sea.”

With a flick of her tail, the mermaid took the necklace and shoe before darting back into the water under the bridge.

Sighing with relief, the siblings pushed open the door to the castle. Immediately they were greeted with another swirling portal. Holding hands, the siblings jumped into the vortex. They were returning home.

## Addendum 9

### Spatial Stories

#### #1

I came up to the door of a rickety old house and knocked. Inside the house I heard the radio go quiet, then shuffling sounds. I had a good feeling about this place. The woman opened the door only enough for her face to show through the crack. “Yes?” She asked. Her voice was crackly from lack of use.

“Good morning, Ma’am!” I chirped, excitedly hopping from one foot to the other. “My name is Jared and I’m looking for summer work.” One good thing about being as short and skinny as I am is that I can pass for thirteen. I can’t grow a beard, not to mention peach fuzz. I’m sure this helped my cause too.

“I have no jobs for you,” she said and stepped back from the door. Inside I noticed expensive leather furniture, polished vases, and elaborate paintings hanging from the wall. This woman definitely had some money. I knew I had picked the right house.

“Ok, Ma’am,” I said. I flashed her my winning white smile. “But you see, I//m in the Boy Scouts. We get pins for doing volunteer work. Could I mow your lawn for free?”

The woman’s face dropped slightly in disappointment. “Yes, ok. Go ahead,” she answered.

Immediately I found her mower in the garage and began mowing. For having such a fancy home inside I was surprised how poor the outside was kept. Some sections of the grass were so tall the seeds on the ends were blowing slowly back and forth in the wind. I strained to mow the lawn; I was sweating hard by the time I finished.

After mowing, the woman had left me a glass of ice tea. The glass had already begun to sweat from the shock of the iced drink and the hot sun. I watched for a second as slow beads of water pooled and dripped onto the ledge of the porch.

I returned the next few weeks to continue mowing the woman's lawn. I slowly gained her trust.

The last time I ever went to her house, I did my best work. Inside the garage I discovered a dark but large bump. I gently pulled at the edge of the dark brown tarp. Underneath I discovered a bright red Corvette. I slipped behind the wheel into the drivers seat. My hand fell immediately to the stick shift; the car fit me like a glove. In the glove box were some faded papers and a key. I took no mind of the papers but instead put the key into the ignition. I drove off.

I knew I had picked the right house.

#2

## Addendum 10

As I walked down the dusty dirt road one day to the store, a shiny teal blue bicycle pulled up alongside me. A girl jumped off the bike. "Hi!" she exclaimed.

Surprised by the pure glee showing on her face I responded with a tentative "Hello..."

"I saw you outside the old brick library a few days ago, with Mr. McCrory, didn't I?"

I slowly nodded in response. "That's my uncle, you know him?"

She started walking her bike forward along the dirt road and motioned for me to continue walking. The movement of her bike's wheels sent a steady cloud of orange dust into the wind behind us as we walked.

"He was my biology teacher. He's such a doll!" she responded. She brushed her hair back off her forehead to reveal two rings in her eyebrow that matched the one in her nose. The silver jewelry shined bright in the sunlight. I inspected the rest of her. She was wearing an average pair of jeans and a baggy band t-shirt. Nothing too out of the ordinary, well besides the hunks of metal in her face.

"Is he married? I've never seen him with a woman?" she asked. At the first sign of my nod she continued, "What's wrong with her then? I never see her. Is she pretty?"

Puzzled by her questions, I pictured my aunt Lucy instead. Her hair was strawberry blonde and her face was speckled with just a few stray freckles. She is beautiful, though recently she had let herself go a little. She spent most of the day lying in her saggy old couch in her frumpy pajamas because of her pregnancy. She was also taking care of their son but the pajamas reminded me of something you find in a second-hand store. They were plaid and faded enough to make you believe they were older than she was herself.

"She's fine, she's just pregnant," I finally responded.

"Poor Mr. McCrory! Well, if you ever want to hang out call me! My name's Poppy Malone!" She hopped back on her bike and sped off down the long road.

As I watched her slowly disappear down the road, I thought about her interest in my uncle. Why would someone as young as Poppy be asking about my uncle? His hair was slowly thinning. It was also turning gray. I don't think he liked to be reminded of that though.

When I returned home that night I asked my uncle about Poppy. The second I mentioned her name his nose crinkled in slight disgust.

"Oh that's the girl that has a crush on your uncle," my aunt answered for him, winking at me. I immediately burst into a fit of laughter. The idea of this loud teenage girl on a bicycle liking my uncle was too much for me. My aunt and uncle stared at me, amusement in their eyes.

#3

## Addendum 11

The people in my family aren't really the kind who ever go anywhere. The only travelling you could say I had ever done in my life was to go two towns down the road away for a school field trip. My parents hadn't even travelled out of the state as far as I knew. So when my letter came in the mail, I knew I shouldn't get my hopes up.

Dear Ms. Haven,

Congratulations! As the top scorer in your region on the state aptitude test, you are cordially invited to participate in the College for High Schoolers program at Mercer University...

I read the letter over twice. My palms were twitching from my nerves. If anyone had been there to see me I'm sure my face would have been every imaginable shade of red. The idea of such a far off opportunity being offered to me was too much to handle. After I finished reading the second time, I carefully folded the letter in half and then in half again. I opened the bottom drawer of my dresser. I picked this drawer because it was the hardest to open. The angle of the drawer combined with the leg of my bed right next to it made it impossible to open if you didn't get it just right.

A few weeks later, I was with my grandma in her small apartment. I looked at the wall and skimmed her pictures. There was a picture of me when I was 6, graduating from kindergarten. Close next to it, in a shiny gold frame, was her high school diploma. My grandmother was an avid supporter of education. She had always told me how sad she was that she was not able to attend college herself.

"Grandma, I received a letter from a university the other day," I started. I filled her in on the opportunity the school was offering me.

In the softest, soothing grandmother voice she began to tell me how I could make it work. "First, you'll need to fundraise for the next few months. We can borrow a sleeping bag from that cousin of yours so that you'll be warm. I'll get my car tuned up and take you." She had a way to make it work for every nervous excuse to not go I could think of.

As my grandma talked my nerves slowly relaxed. The tension in my shoulders eased and I could feel them lower. With my whole chest filling and releasing an impossibly large gasp of air, I gave a deep sigh of relief. I could make this work. I could go on an adventure and travel away from home. I finally became excited and a small grin spread across my face.

#4

## Addendum 12

Bob, a young tiger happened to be wandering through the jungle when he heard a soft voice from above.

"Did you know that tiger's can't climb trees?" the voice whispered.

Turning around Bob saw a small clearing with a small tree in the middle. Slithering down from that single tree was a long, black boa constrictor.

Out of disgust, Bob began to walk away, towards a large pool of water in front of him, while the boa slithered after him.

“Haven’t you heard? Only John, the panther and Mary, the jaguar can climb trees. You’d just make a fool out of yourself. You’re nothing but an orange striped kitty.”

In annoyance, Bob bared his white, sharp teeth as Rick, the boa constrictor slithered away.

After Rick left, Bob continued walking straight past the cluster of trees and towards the clear drinking pool in front of him. After circling the small pond multiple times to scare off the other animals, he finally settled down in the grass near the water’s edge.

“So I heard from Rick that you can’t climb trees,” taunted a voice from across the pond, high in the trees.

Squinting in the distance, Bob could make out John, the panther.

“So what’s your secret? How are you able to climb that high?” pleaded Bob desperately.

“Only animals who are worthy can climb to such...great heights!”

With exasperation, Bob lifted his body off the ground and continued walking straight past the pond and past the tree where John was hiding. He continued to walk straight past the beautiful macaws nesting in the trees, past the orangutans swinging by and past the purple fluttering butterflies.

“Well you look determined!” shouted a voice from above.

Loudly Bob sighed.

“Why is everyone in a tree? Why am I the only one left on the ground?” cried Bob as he crumpled to the forest floor.

“Well, I will help you learn how to climb a tree! Let’s find a tree with many branches sprouting from the bottom,” answered the voice, which belonged to Matt, the chameleon.

Nodding Bob began to search for a bushy tree. Instead of continuing forward, Bob decided to backtrack. Turning around, Bob walked past the macaws, orangutans, and butterflies towards the drinking pool. Once he arrived at the drinking pool, he spotted the perfect tree. The tree was rather short and stubby. There were many branches coming out from the bottom. It looked like the perfect tree for a tiger to climb.

“This tree looks perfect,” encouraged Matt. “Now just put your front paws on the first branch. Then put your back legs on the same branch. Next reach up with your front paws for the next highest branch. After, using your front paws, pull your back legs up as well!”

“Look at me Matt! I’m climbing! I’m climbing! Can you believe it? I did it!”

“Congratulations Bob! You conquered your goal!” cheered Matt. “See tigers can climb trees too!”

#5

### Addendum 13

It was a beautiful, sunny day in the backyard woods. The forest was filled with tall pine trees that almost touched the sky, while the ground was filled with small blooming flowers. The flowers were a lovely shade of deep violet and its petals were shaped like oval teardrops.

“He loves me, he loves me not,” sang Sophie, a young girl as she skipped through the woods pulling the petals off the violet flowers.

Soon there was a long violet trail behind Sophie as she continued her way deeper and deeper into the forest. Not much time past before Sophie realized she was lost.

Panic began to inch across her body as her eyes threatened to release a waterfall of tears. In front of her, Sophie could see an increasing number of tall trees. They were densely clustered



together, almost forming a thick wooden wall. To Sophie's right, there was a small stream about ten steps away. She could hear sound of the water rushing by, which calmed her nervous nerves. If she squinted she could see the sun's rays reflect off of the water's shiny surface. Turning to her left, she was greeted by a large grey stone structure. It almost looked like a cave for some giant animal.

"ROOAAARRR!" came a deep growl from inside the cave. Stepping out into the sunlight was a huge grizzly bear! Carefully, the bear stood on his hind legs and opened his mouth revealing his pointy white teeth.

Once again, panic set in, as Sophie began to sprint to her right towards the stream. Her feet splashed and fought against the light water current. Soon she made it to the other side. Luckily, the bear did not follow her.

Sophie continued to follow the stream which sloped downward. After walking roughly two hundred steps, Sophie sat down in the sand next to the stream. This adventure was exhausting!

"I should have never wandered into the forest by myself," muttered Sophie as she watched the water. The calming presence of the clear liquid quickly put Sophie to sleep.

Hours past before Sophie opened her eyes again. The sun that used to be high in the sky was now close to setting. It barely hung above the forest tree tops. Sophie needed to return home before dusk. So, she began to retrace her steps back up the stream.

After walking some time, Sophie squinted left to look across the stream. She could barely make out the large cave structure where the bear lived. Very quietly, Sophie crossed the stream, careful not to splash. She found this very difficult. After reaching the stream's edge, she quietly tiptoed by the bear cave, and away from the dense cluster of trees. It wasn't long before she found a trail of dark purple flower petals. Smiling, Sophie knew she could find her way home.

#6

#### Addendum 14

Joey and Ellie were two siblings on an adventure. After wandering through a forest, the children found a crevice, indented in the side of a rock. Walking inside they found a beautiful purple swirling portal.

"I heard that if we jump through this portal, we will be taken to a mystical land!" shouted Joey, a tall boy with reddish, orange hair.

"A mystical land?" asked Ellie.

"Yes! A land with things we could never imagine!"

Holding hands, Ellie and Joey jumped through the magical portal. They were sucked into the giant vortex. Their bodies tingled as they were pulled in multiple directions. The ride ended with the children thudding on the ground.

Staggering to their feet, they began to look around. They were located on a large hill that could see for miles around. To the north was a giant castle with red flags billowing in the wind. To the east, was the endless sparkling sea. To the west, was a tight cluster of forest. And finally to the south was a desert with grey, unappealing sand.

Not knowing what to do, the children followed the path heading towards the castle. Soon they were lost.

"Who goes there?"

"Why, it's Joey and my sister Ellie. Who are you?"

Out of the shadows emerged a large figure. The figure looked like a giant goat, except it stood on two legs. The horns on his head sparkled in the sunlight.

“I am Govotte. The King’s keeper.”

“There’s a king here? Could we meet him? Ellie and I need to find a way home!” exclaimed Joey.

“Yes, follow me children!”

With the king’s keeper guiding them, the children started north toward the castle again. After passing the forest, they began to walk onto the drawbridge. But suddenly a large creature flopped in their way. It was a woman, with green scaly legs that merged into a large fin.

“I’m Kyran, the mermaid who lives under this bridge. You must barter to get across or pay with your lives!”

Turning towards each other, Joey and Ellie realized they had nothing to give to this mysterious creature. When they turned to ask Govotte, they realized he had vanished.

“How about my necklace?”

“Let me inspect it dear!”

Carefully Ellie threw her necklace into the hands of the creature who carefully looked at every detail.

“I guess this will suffice. Now you boy!”

Joey, not having anything of value took off his blue mesh running shoes.

“These are a popular brand from back home,” defended Joey as he tossed his item.

With a flick of her tail, the mermaid took the necklace and shoe before darting back into the water under the bridge.

Sighing with relief, the siblings pushed open the door to the castle. Immediately they were greeted with another purple swirling portal. Holding hands, the siblings jumped into the vortex. They were returning home.

## Addendum 15

### Non-Spatial Story Questions

#### Non-Spatial Story #1

- 1) What was the main character’s name?
- 2) How old did the main character say he looked?
- 3) What group was the main character doing volunteer work for?
- 4) What was hidden under the tarp in the garage?
- 5) What city did the main character “cruise the streets” in?
- 6) What did the main character’s dad say ran in the family?
- 7) Why did the main character first approach the house and woman?
- 8) What did the smell of the house say about the woman?
- 9) Why did the main character continue to do favors for the woman?
- 10) Why do you think the main character picked this house?
- 11) Why do you think the woman stood behind the door talking to the main character and never let him into her house?
- 12) Create a title for the story you heard.

#### Non-Spatial Story #2

- 1) Where had Poppy seen the main character before?

- 2) How did Poppy know Mr. McCrory?
- 3) In the beginning of the story, where was the main character walking?
- 4) Why had Mr. McCrory's wife been staying home?
- 5) What item did Poppy jump off of when she met the main character?
- 6) Who did the main character's aunt take care of at home?
- 7) What did Poppy think of Mr. McCrory?
- 8) What did the main character and her aunt think of Poppy's feelings?
- 9) How did the main character feel when Poppy first talked to her?
- 10) Why did Poppy say "Poor Mr. McCrory"?
- 11) Why does Mrs. McCrory (the main characters aunt) have to stay at home all day?
- 12) Create a title for the story you heard.

#### Non-Spatial Story #3

- 1) What was the name of the University inviting the main character?
- 2) Where was the letter hidden?
- 3) Who is going to borrow the main character a sleeping bag?
- 4) About how much time elapsed before the main character shared the letter with her grandma?
- 5) Who is going to take the main character to the college for high schoolers event?
- 6) How will the main character pay for the event?
- 7) How did the main character feel after she talked with her grandma?
- 8) Why was the main character so uncomfortable with the idea of travel?
- 9) About how old was the main character?
- 10) How did the main character feel when she received the letter?
- 11) About how far off is the college for high schoolers event?
- 12) Create a title for the story you heard.

#### Non-Spatial Story #4

1. What was the name of the jaguar in the story?
2. According to Bob, what makes panthers so special?
3. Who is the first character Bob meets in the jungle?
4. What animal is Matt?
5. Does John reveal his secret to climbing trees?
6. Which animal does Bob mock?
7. What was Bob's main goal in the story?
8. What does the panther mean when he says, "Only animals who are worthy can climb to such...great heights!"
9. Why does every character in the story interact with Bob from a tree?
10. How would you describe the main character?
11. Describe the jungle where Bob and the other animals live.
12. Create a title for the story you heard.

#### Non-Spatial Story #5

1. How many fish did Sophie count?
2. What type of bear was in the cave?
3. What animal does Sophie think her parents will send to look for her?
4. What temperature was the water?

5. What size were the flowers in the story?
6. What color were the bears teeth?
7. Why should Sophie always have parental supervision in the forest?
8. According to this story, are bears afraid of water? How do you know?
9. What do the flower pedals symbolize in this story?
10. Describe Sophie, the main character.
11. Describe the path Sophie took throughout the forest.
12. Create a title for the story you heard.

#### Non-Spatial Story #6

1. What was the name of the mermaid under the bridge?
2. What does Joey give to the mermaid?
3. What does Ellie want to see in the mystical land?
4. What type of animal is Govotte?
5. Where are Joey and Ellie from?
6. What do the children use to cross between lands?
7. Describe the journey Joey and Ellie took from beginning to end.
8. How would you describe Kyran?
9. What does the magical land look like?
10. Is Govotte a bad character?
11. Why do the children seem to trust Govotte?
12. Create a title for the story you heard.

#### Addendum 16

#### Spatial Story Questions

##### Spatial Story #1

- 1) What was the main character's name?
- 2) How old did the main character say he looked?
- 3) What group was the main character doing volunteer work for?
- 4) What was hidden under the tarp in the garage?
- 5) What city did the main character "cruise the streets" in?
- 6) What did the main character's dad say ran in the family?
- 7) Why did the main character first approach the house and woman?
- 8) What did the smell of the house say about the woman?
- 9) Why did the main character continue to do favors for the woman?
- 10) Why do you think the main character picked this house?
- 11) Why do you think the woman stood behind the door talking to the main character and never let him into her house?
- 12) Create a title for the story you heard.

##### Spatial Story #2

- 1) Where had Poppy seen the main character before?
- 2) How did Poppy know Mr. McCrory?
- 3) In the beginning of the story, where was the main character walking?
- 4) Why had Mr. McCrory's wife been staying home?

- 5) What item did Poppy jump off of when she met the main character?
- 6) Who did the main character's aunt take care of at home?
- 7) What did Poppy think of Mr. McCrory?
- 8) What did the main character and her aunt think of Poppy's feelings?
- 9) How did the main character feel when Poppy first talked to her?
- 10) Why did Poppy say "Poor Mr. McCrory"?
- 11) Why does Mrs. McCrory (the main characters aunt) have to stay at home all day?
- 12) Create a title for the story you heard.

#### Spatial Story #3

- 1) What was the name of the University inviting the main character?
- 2) Where was the letter hidden?
- 3) Who is going to borrow the main character a sleeping bag?
- 4) About how much time elapsed before the main character shared the letter with her grandma?
- 5) Who is going to take the main character to the college for high schoolers event?
- 6) How will the main character pay for the event?
- 7) How did the main character feel after she talked with her grandma?
- 8) Why was the main character so uncomfortable with the idea of travel?
- 9) About how old was the main character?
- 10) How did the main character feel when she received the letter?
- 11) About how far off is the college for high schoolers event?
- 12) Create a title for the story you heard.

#### Spatial Story #4

1. What color was Rick?
2. What color are the butterflies in the story?
3. What does John call Bob?
4. Why did Bob circle the drinking pond multiple times?
5. Where does Bob find the perfect tree?
6. Who helps Bob?
7. What was Bob's main goal in the story?
8. What does the panther mean when he says, "Only animals who are worthy can climb to such...great heights!"
9. Why does every character in the story interact with Bob from a tree?
10. How would you describe the main character?
11. Describe the jungle where Bob and the other animals live.
12. Create a title for the story you heard.

#### Spatial Story #5

1. What animal was in the cave?
2. What color were the flowers Sophie had?
3. How did Sophie know she would be able to find her way home?
4. What put Sophie to sleep?
5. What caused Sophie to cry?
6. What color was the cave?
7. Why should Sophie always have parental supervision in the forest?

8. According to this story, are bears afraid of water? How do you know?
9. What do the flower pedals symbolize in this story?
10. Describe Sophie, the main character.
11. Describe the path Sophie took throughout the forest.
12. Create a title for the story you heard.

#### Spatial Story #6

1. What color was the portal?
2. When the children landed in the mystical land, what was to their west?
3. What physical feature on Govotte sparkled?
4. What type of animal is Govotte?
5. What does Joey use to barter with Kyran?
6. What is Ellie's relationship to Joey?
7. Describe the journey Joey and Ellie took from beginning to end.
8. How would you describe Kyran?
9. What does the magical land look like?
10. Is Govotte a bad character?
11. Why do the children seem to trust Govotte?
12. Create a title for the story you heard.