12-2021

Does Whispering Improve Children's Memory? Comparing Auditory Vigilance and Salience Hypotheses

Christina M. Barnes
University of Arkansas, Fayetteville

Does Whispering Improve Children's Memory? Comparing Auditory Vigilance and Salience Hypotheses

A thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Arts in Psychology

by
Christina M. Barnes
Christopher Newport University
Bachelor of Science in Psychology 2019

December 2021
University of Arkansas

This thesis is approved for recommendation to the Graduate Council

_____
Douglas Behrend, Ph.D.
Thesis Director

_____
Ellen Leen-Feldner, Ph.D.
Committee Member

_____
William Levine, Ph.D.
Committee Member

Abstract

Oral communication is one of the primary tools children use to learn new information and speech registers can deliver additional meaning to the words someone uses. Cirillo's (2004) *vigilance hypothesis* states "Whispering can affect the psychobiological state of recipients, and in particular raise their auditory vigilance" (Cirillo, 2004, p. 76). Building on this theory, the current study investigates the role of whispering and children's memory by examining a whispering vigilance, whispering salience which focused on the changes between normal and whisper registers, and combined vigilance and salience hypotheses to determine if whispering contributes to the recall of information. Using video animations participants were presented normal and whispered a register combination. Characters in these animations carried out a simple conversation in either a whispered or normal base register before the target information was spoken in a whispered or normal register before finishing the conversation in the base register. Participants were then given a cued recall question to assess their memory for the target information. Results demonstrated that whispering does not play a role in the recall of target information of any of the hypotheses. Rather than whispering impacting the informational knowledge, participants in the current study may have used whispering and the register changes to provide details about the speaker's intentions. Future studies should continue to investigate the ways in which children learn to navigate the unique characteristics and communicative function of whispered speech.

Contents

Introduction

Most people recognize that the words we say are important to communicate effectively, but what about the way we say these words? How do our speech registers affect how we receive information and how we respond? A speech register is a phonological change in pitch, intonation, or phonetics of a spoken utterance. Some examples include softness, loudness, high pitch, exaggerated intonation, and grammatical modification (Weeks, 1971). Register is different from speech dialect because dialects provide details about the speaker's origin and linguistic groups whereas registers carry information about what the speaker intends to communicate. Of the registers, one of the more nuanced ones is whispered speech. Whispering is often identified as a decrease in volume with normal register speech presenting at 65 decibels and whispered speech presenting at approximately 50 decibels (Cirillo, 2002). However, whispering differs from normal speech because the folds above the larynx press downwards and restrict the vocal folds from vibrating. Without the vibration provided by the vocal folds air passes through and the resulting turbulent sound is known as a whisper (Cirillo & Todt, 2005). The act of whispering may not be as vocally efficient for the communicator because the efficiency with which the number of syllables per breath is produced decreases. Nevertheless, more often than not the recipient is still able to understand the content of a whispered message just as well as a normal register. Despite having the same communicative abilities as normal intensity speech, whispering is used quite infrequently in day-to-day life, which makes it a communication technique that can play a role in our perception and memory of whispered information. The purpose of this study is to assess the ways in which whispering influences how children remember information. This study will test a vigilance hypothesis, a salience hypothesis, and a combined hypothesis to determine which factors are important for the recall of information.

Characteristics of Whispered Speech

Whispering is multifaceted when it comes to making judgements because whispered speech carries distinct social functions (Cirillo & Todt, 2002; Cirillo & Todt, 2005). For example, whispering can be used to communicate privileged information, to reduce volume, or to be polite. Emotions can also be extracted from whispered speech (Cirillo & Todt, 2002). This can lead to both highly positive experiences regarding whispers but also negative effects when whispering is used in public (Cirillo, 2004). Without changing the content of information, vocal modulation shifts like whispering can be a cue with varying meanings and as a result, different patterns of usage may emerge between whispered speech and normal speech.

To examine adults' judgements of why whispering is used and how it is perceived, Cirillo (2002) surveyed 350 college students and discovered varying explanations, most of them being tied to social perceptions. Most participants noted that while they generally have positive feelings towards whispering, their use of whispering and their perception of whispered information depended on the context surrounding the situation. Few participants, about 38%, said they used whispering in private for partner bonding but 90% said they whispered most often in public. Here, the more nuanced elements of whispering revealed themselves because participants recalled whispering in public for a variety of reasons such as trying not to disturb others, to be playful with others, to share privileged information, or to increase curiosity and draw others in (Cirillo, 2002). The function of whispering is context-based and thus requires a level of understanding between the communicator and the recipient to function properly. When we use whispering to communicate in a different way than we use regular speech it piques curiosity in the listener. However, these uses of whispering become less positive when this

understanding breaks down, most notably when an individual is not privy to a whispered conversation.

Cirillo (2002) found that participants had a desire to pay attention and understand the information being shared when they heard others whispering in public. Approximately 22% of participants stated they used whispering in public in order to communicate privileged information to others and 20% said that when others are whispering in public they often assumed the whispers were about them. Interpretations of the content and function of whispering differ depending upon whether speakers are engaging in whispering themselves or they are the outside party to a whispered conversation simply because whispering is a unique tool for communication. Even when the content itself may be irrelevant or mundane the act of whispering alone seems to increase attention and can be explained with the vigilance hypothesis. Cirillo's (2004) *vigilance hypothesis* states "Whispering can affect the psychobiological state of recipients, and in particular raise their auditory vigilance" (Cirillo, 2004, p. 76). This vigilance hypothesis is the framework for the current study, which seeks to examine if information shared in a whisper register is more likely to be remembered than information spoken in a normal register. If whispering increases auditory vigilance, then it is possible that the additional attention exercised when exposed to whispering could help encode information into long term memory.

However, this is not the only possible explanation for why whispering may increase auditory vigilance. Whispering is more than just lowering the volume of a voice; there is a physical change to the vocal cords when switching from normal intensity speech to whispered speech. Perhaps it is this switch between registers that increases attention, and not just the whisper alone. Thus, this *salience hypothesis* presents the idea that attention increases for any content presented in a register that differs from the original base register. That is, regardless of

whether a person begins by hearing whispered tones first or normal tones, the change in registers is a communicative cue and therefore attention towards that content would increase. The vigilance and salience hypotheses are important starting points to understand how whispering impacts memory, and whether register changes can improve the ability to recall information.

Vigilance Hypothesis

First, to understand how the vigilance hypothesis might play a role in memory, it is important to evaluate the social assumptions that develop from whispered speech. Experiencing a conversation as an outsider is called co-listening and people often experience whispering differently when they are a co-listener versus being addressed directly (Cirillo, 2002). The ingroup hypothesis presented by Cirillo explains this distinction and clarifies that whispering can cause individuals to feel a sense of ingroup bonding when they are involved in a whispered information exchange and can make co-listeners feel socially isolated from the conversation when they are not privy to the whispered information. Being a co-listener of a whispered conversation increases the assumption that the information has some unique meaning and cause individuals to feel a strong desire to be a part of the information exchange to feel connected to an ingroup. The reason for this is likely because whispering can be used to communicate privileged information. Privileged information is information that is not easily accessible to a broader audience. Some of the most common examples of privileged information includes secrets, surprises, or intellectual property (Behrend, Girgis, & Stevens, 2018). Behrend et al. presented children three to five years of age and adults with vignettes of either privileged or conventional information. After hearing each vignette, participants indicated whether they believed the protagonist should tell the information, should not tell, or if either option was appropriate. Overall, participants were more selective about sharing privileged information compared to

conventional information; however, a clear developmental difference was found with five-year-old children outperforming three-year-old children in their ability to distinguish between privileged and conventional information but not quite performing at the level of the adults in the study.

Additionally, Behrend et al. (2018) used social judgements based on group alliances to characterize distinctions drawn from privileged or conventional information. In their Study 2, story characters were either information sharers or information withholders who both knew some type of information. In this case, an object was hidden but both the sharer and withholder were aware of the location. To assess social preferences, each actor expressed either that they knew where the object was and would disclose the location or they knew where it was but would not share that information. The children were then asked which character they would want to be friends with. In this between-subjects design, children were assigned either to a conventional information condition or privileged information condition. In the conventional condition, children selected the sharer as a friend more frequently whereas in the privileged information condition, the character who withheld the information was more often selected as the preferred friend. The findings presented here demonstrate how group membership can frame children's perceptions of information and the sharing of that information. When children believe information is conventional and should be freely shared, they prefer those who share that information. Similarly, children preferred others who withheld privileged information. It appears that the ingroup hypothesis may play a role in increasing vigilance and ultimately memory for whispered information. When people are co-listeners they have no idea if the information is valuable and yet they may remain vigilant to avoid becoming a member of an outgroup. It is reasonable to assume that this additional effort to hear whispered information may also mean that

a person is more likely to remember that information because it might hold important information on how to obtain status as an ingroup member or demonstrate loyalty to their ingroups. Group membership has stakes, and therefore remembering and appropriately attending to information can be an essential skill to develop.

The significance of developing a sense of group membership can be seen in early childhood when children are motivated to make connections with their group members. When this need is not met, children often experience negative affect and other consequences to their well-being (Over, 2016). To prevent those consequences, children learn to share privileged information with some people and withhold information from others to demonstrate their group loyalty and remain socially included. Misch, Over, and Carpenter (2016) found that keeping secrets solidifies ingroup alliances and that children ages four and five who were told a secret were much less likely to disclose to an outgroup member than an ingroup member, even when provided with an incentive for sharing. In this study, children ages four and five were divided into a yellow or green group based on the color of a scarf they were given by an experimenter. Puppets operated by the researchers were also given either yellow or green scarves. The child was left alone in the room and two puppets who were secret holders entered to hide a brown book. The puppets told the child that the book is a secret book of the yellow or green group and the child should not tell anyone about it. Next, a new puppet who had no scarf entered looking for what was hidden and asked the child if they knew what the object was and if they would tell. If the child did not immediately disclose, the puppet offered a sticker as an incentive. Each time the child declined to disclose or said nothing the puppet offered another sticker until 5 stickers had been presented to the child. Researchers found that children were more likely to keep a secret for an ingroup than an outgroup member as indicated solely by scarf color and

demonstrated loyalty for no reward and tended to reject the sticker prize to favor their scarf group. The results of this study help to demonstrate the importance of information sharing patterns in group contexts. Children who had a desire to be a part of an ingroup and remain in that group treated that information differently depending on the group status of the puppet who asked for information. Because children recognize and find value in social groups, privileged information like whispered information holds more value as social capital. If whispered speech does carry more social weight than normal speech, the current study aims to investigate whether children are more likely to be vigilant and ultimately have better memory for information presented in a whisper register.

Salience Hypothesis

When focusing on Cirillo's (2003) vigilance hypothesis, value is placed on the characteristics of a whisper register, implying that no matter the context whispering itself is unique. However, this might not be the case. Perhaps, the register itself is not holding meaning, but instead a change between registers is what is increasing attention. Because humans cannot attend to all information at one time effectively, certain cues have a greater attention-grabbing quality and might cause a person to perceive that as stronger than others. According to Gunther, Muller, and Geyer (2016), the distinctiveness of a stimulus in relation to the surrounding stimuli is called salience. Consider a child playing with blocks in a toybox who finds a single blue square among a bunch of yellow squares. A blue square that differs from its surroundings might become a salient square and it draw more frequent or longer lasting attention. The current study uses salience to explain why whispering may stand out when compared to an expected stimulus like normal speech. According to Rácz, Hay, and Pierrehumbert (2017), perception of a salient object can either be because it contrasts with the environment or because the object contrasts

with the observer's background knowledge and experience (Rácz et al., 2017). This definition of salience is one of many that have been used to explain why language affects perception differently in each person. In an attempt to classify the definitions of salience for language research, Schmid and Gunther (2016) argued that there are distinct outcomes that salient stimuli can yield based on the speech context and the individual's expectations and experience. From this, four different definitions for salience in language emerge. First, something can become salient because it exists in long term memory and a particular input would thus be familiar. Consider a new language learner, like a baby. If one of the few words they know is "ball", an adult saying that word would be highly familiar to them and the baby may find it more salient than another word. Second, the context can make something more salient if the cue is particularly relevant or highly expected at that moment. An example of this would be a word like "ball" standing out and having additional salience at a basketball game. If someone expects that to be the topic of conversation the word may have salience to the perceiver. Next, something can be salient because it is completely new to the individual. If you had never heard the word "ball" before and someone said it, you might be more likely to pay attention to that word because it stands out as the sole unfamiliar word among familiar others. Finally, something can become more salient because a person was not expecting it to be present in that context. This would be the case if you were at a swim meet and somebody said the word "ball". At a swim meet there are words that are typically used and it would be unexpected to hear the word. Under the conditions where those language expectations are violated, the word might become more salient (Schmid & Gunther, 2016).

While each of these definitions have value in different areas of language research, the definition about unexpected content has the most relevance to the current study. To further

explain how expectation violations can cause salience, Schmid and Gunther (2016) wrote, “The incoming cue fails to match expectations that are mainly activated from current linguistic, situational, and/or social context; this could arise from violations of collocational restrictions or preferences, from unfamiliar ways of referring to objects, or from different conceptions of the social significance of words” (Schmid & Gunther, 2016, p. 2). The current study seeks to determine whether information presented in a whisper is more likely to be remembered by children than information presented in a normal register. In addition to an auditory vigilance framework, auditory salience can also be used to address this question. Whispering does have unique social significance (Cirillo, 2002; Cirillo, 2004; Cirillo & Todt, 2005), so if whispering is introduced in a conversational context that is unfamiliar or violates the conceptions of use the content of the whisper might become more salient. For the most part, people are comfortable with the idea that conversations occur in one register because their previous experiences have modeled this. Switching registers from normal to a whisper (or vice versa) would most likely be a violation of the listener’s expectations causing them to attend to the now salient cue. Using the concept of expectation violations, the salience hypothesis can explain that rather than normal or whisper registers carrying some meaning themselves, the change between registers can be surprising and thus will increase salience and memory for the information presented after a change.

An individual’s personal experience with language and the rules for proper use can also cause a cue to become salient. Wildt, Rohlfing, and Scharlau (2019) provide some evidence for the development of salience with a unique focus on word learning in children. In this review paper, the researchers examine the role of salience and the child’s ability to pair a word to the item it is referencing. In addition to the role salience plays in helping children learn words, the

researchers also present the idea of relevance as an essential tool for word learning skill. Relevance relies on engagement and interaction that serves a joint goal for word learning, whereas salience relies more on perception of the cue (Wildt, Rohlfing, & Scharlau, 2019). The researchers present the ideas as distinct, but in reality, the concepts of relevance and joint actions are similar to Schmid and Gunther's (2016) salience concepts. Cues that are relevant come from knowledge and experiences that have developed expectations of how the world is and what should occur. By having children engaged in joint actions to facilitate word learning, researchers are simply building the knowledge and experiences it takes to make the word relevant in the future. Finally, after experience has made a word relevant, children can form definitions and develop rules for proper use of that cue which explains the increase in salience when expectations are violated.

Even though most whispering studies have been done with adult populations, children do have familiarity with whispering and the contexts in which it is used. Barnes (2020) studied children's understanding of whispering and found beginning as young as four years old, children were able to identify and demonstrate whispering. In this same study, children were asked to list reasons a person might whisper and common responses included to communicate privileged information, to reduce the volume of their speaking voice, or to be polite. The rules that children learn about proper usage of whispering have come from their experience, and an instance that breaks one of these rules might be especially surprising to them. By introducing whispering in a context that children are not expecting, memory for that information could improve. In addition to the context rules children learn, switching between normal speech and whispered speech most likely violates the expectation that most information communicated in a single conversation will always be presented in the same register. If children perceive this change as unexpected, the

information spoken following the register change might be a salient cue and the information will be more likely to be remembered by the listener. These factors add to the definitions of salience and present the idea that many changes can become salient if they are unexpected.

Overall, a salience hypothesis for memory may be an important consideration in understanding children's memory for whispered information. Some research provides evidence that attending to salient cues is an ability present at a young age (Bargones & Werner, 1994) whereas vigilance develops later in childhood (Jones, Moore, & Amitay, 2015). Regardless of the uniqueness of the cue, memory depends heavily on whether the cue is salient among other possible extraneous cues and after salience has made a cue stand out from others, it can be stored into memory and later recalled. If register salience plays a greater role in memory, the current study proposes that even when information is presented in a whisper, the shift between registers is more likely to draw the attention of the children and improve memory for that information.

Vigilance and Salience Combined

There is also the possibility that both vigilance and salience could play a role in improving children's memory of whispered information. In many conversations, comprehension relies on the listener's state of mind and characteristics of the spoken information. Both factors can impact in how the message is received, processed, and recalled. This is because vigilance relies on the listener to actively attend to what is being said while salience depends on the characteristics of the stimulus to increase the listener's attention. For information to be properly communicated however, there is a possibility that information is remembered better when the perceiver is being attentive and the information is attention catching. Rather than operating independently, both vigilance and salience could be responsible for increasing memory for information. The potential role that can be played by both vigilance and salience is evident in

studies demonstrating how children learn through overhearing (Akhtar, Jipson, & Callanan, 2001; Akhtar, 2005). Despite the assumption that children learn best when spoken to directly, children can be vigilant and can attend to salient cues even when they are not being addressed directly by a speaker. In one study, children about two years and six months old were split into addressed or overhearing conditions and were exposed to novel vocabulary or actions and were either addressed by the researchers in the interaction or were onlookers to an interaction between the experimenter and an assistant. Children in the overhearing condition correctly identified target objects with the novel vocabulary word or performed the novel action equally as well as children in the addressed conditions (Akhtar et al. 2001). These findings are important for understanding that children do have the capability to retain novel information and demonstrate their learning through recall using both vigilance and salience. Even though they were not being addressed directly in the overhearing condition, the children were vigilant enough to listen to the conversation. At the same time, vigilance relied on salience because children in both conditions likely recalled the novel word or action equally well because the novel word was salient which helped them remember it. Both the listener who was being vigilant, and the stimulus which was salient were factors in this study and instead of them being independent as previously discussed, these two concepts may both help increase memory of information.

So which hypothesis, vigilance or salience, may play a role in recall of whispered speech? Whispering is a cue that may increase auditory vigilance and memory but at the same time, the surprisingness of switching between whisper and normal speech and that may be salient for memory. Both factors might play a role but despite the complex and robust nature and function of whispering, little research has been done about how either is applicable to children's ability to remember information. Therefore, the combined vigilance and salience hypothesis

predicts that children will remember information best when information is presented in a whisper and there is a register change.

The Current Study

The current study aims to assess whether whispering improves children's memory for information. This study will examine Cirillo's (2002) auditory vigilance hypothesis as well as a more general salience hypothesis by combining normal and whispered speech conditions to explore this recall ability in children. If vigilance plays a larger role in remembering target information, then I hypothesize that memory for target information will be best in the conditions where the target is whispered, regardless of the base register. However, if salience plays a larger role in remembering target information, then I hypothesize memory for target information will be best in any condition where the target information is in a different register than the base register. Lastly, it is possible that both vigilance and salience play a role in recall of auditory information. If this is the case, I predict that memory for target information will be best in the condition in which base information is in a normal and the target information is whispered (See Tables 1, 2, and 3).

Method

Participants

A total of 95 participants were recruited for this study. One participant was excluded due to audio issues that impacted the delivery of the stimuli, three participants were excluded due to parental interference, and one participant was excluded for exceeding the age requirement for the study, leaving a total of 90 participants remaining. Of this group, there were 12 three-year-olds, 14 four-year-olds, 13 five-year-old, 10 six-year-olds, 11 seven-year-olds, and 10 eight-year-olds.

The remaining 20 participants were adults between the ages of 18 and 21 and were recruited to serve as an adult comparison sample. Of the sample, 50 participants were identified as female and 40 were male. The racial and ethnic breakdown of the sample was 81.1% White, 11.1% mixed or multiple races, 5.5% Asian, 3.3% Black or African American with 7.7% of participants identifying as ethnically Hispanic or Latino. A total of 94.4% participated virtually while at their homes while 5.5% participants participated virtually while at their after-school center. Parents were offered a $15 gift card per child for their participation while adults were recruited from the University of Arkansas undergraduate population were given 0.5 credits towards their general psychology research credit requirement.

Participants were sorted by age into categories: younger, middle, older, and adult. The younger group (3–4-year-olds) had a mean age of 4.0 years, children in the middle group (5–6-year-olds) had a mean age of 5.89 years, and children in the older group (7–8-year-olds) had a mean age of 8 years. Adults were undergraduate students and their average age was 19.95 years. There were 50 females and 40 males, and the racial makeup of the sample was 81.1% White, 5.6% Asian, 5.6% biracial White and Asian, 4.4% biracial White and Black or African American, and 3.3% Black or African American. About 7.8% of participants indicated that their ethnicity was Hispanic or Latino. A total of 94.4 % of participants were delivered stimuli during an individualized call at home while 5.6% of participants were given a virtual on-site option and were delivered stimuli by a researcher virtually while the child was on-site at their after-school care facility.

Materials and Procedure

Due to the current COVID-19 pandemic, the stimuli were presented by the experimenter virtually. Parents filled out a virtual consent form allowing their child to participate in research

and selected a day and time to have their child participate in a video conference with a researcher. All participants were required to have access to an internet connection and a desktop, laptop, or tablet at the time of their participation in the study. In order to receive participant assent from the children, the researcher asked if the child wanted to play a game, and after the child agreed the researcher shared their screen and audio for a PowerPoint slideshow that contained video animations produced with Vyond software (Vyond Studio, 2020).

During the testing, children viewed a total of six video animations, two practice trials and four test trials, in which two characters spoke to one another in a simple dialogue with multiple conversational turns for each partner. Each animation had a key piece of information that was used to assess the memorability of information. This information is referred to as target information. The practice trials had one scenario in which characters use normal speech throughout the entire animation and all whispered speech in the other video. For example, two characters appeared on screen and each said their name. The experimenter then asked the child to respond verbally what the name of the second child was. This target information was intentionally simple to get the child accustomed to the video animation format and become comfortable with the experimenter asking recall questions.

The test trials were longer in length than the practice trials, approximately five to six lines of dialogue. Each scenario had two characters engaged in a casual conversation until the target information was presented near the end of the scenario. Each animation presented a unique combination of base register and target register. The first condition is base speech normal-target whispered (BN-TW), and scenarios in this condition had both characters speaking in a normal register throughout the video until one character switched to say only the target information in a whisper register and then returned to normal speech. The second condition is whispered base

speech whispered-target normal (BW-TN). Here, the conversation began with both characters whispering until one character switched and said the target information in a normal register and finished off in a whisper register. Next is base speech whispered-target whispered (BW-TW), which is an all-whispering condition where both characters spoke in a whisper register the entire time, including the target information. Lastly, base speech normal-target normal (BN-TN) is where both characters said all information, including the target information, in a normal register without ever changing.

After viewing each animation and before continuing to the next, the researcher used a cued recall question to ask the child if they remember the target information. For example, in one animation, one character says "I might look at the flowers in the garden. The purple flowers are my favorite!" with the color of the flowers serving as the target information. The researcher waited for the animation to finish playing and then asked, "Which flowers did Lola say were her favorite?" to assess whether children remembered the information (See Appendix A for the full scripts to the scenarios). All responses of purple were considered correct, and any other response was counted as an incorrect response. There were two presentation orders with the second order being the reverse order of the first. These orders were randomly assigned to participants. Scenarios were also counterbalanced for speaker location on the video (left vs. right) and gender to minimize any confounding factors. The speaker who said the target information will be on the right side of the screen for two of the presentations and on the left side of the screen for the other two scenarios. Additionally, two scenarios were two girls holding a conversation and the other two were two boys holding a conversation (See Appendix B). Responses were recorded, and the researcher made comparisons of the number of correct responses and the register in which the target was presented. In order to fully understand any developmental trends that emerge, an adult

comparison sample using the University of Arkansas undergraduate population was also collected following the same data collection procedures.

Results

All analyses were carried out using R Statistical Software (R Core Team, 2021). The first of the planned analyses looked at overall memory performance. Across all trials and age groups, the target information was correctly recalled on 65% of trials. When broken down by register combinations, information was recalled 68% of the time in the BW-TW condition, 64% of the time in the BN-TW condition, 68% of the time in the BW-TN condition, and 62% in the BN-TN condition with each of these being different than chance performance (see Figure 1). Next, overall memory performance by age was investigated. On average, younger children recalled target information 48% of the time, middle children averaged 73% recall across conditions, older children averaged 64% recall across conditions, and adults who averaged 84% recall across conditions. Younger children remembered less target information than middle children ($t(242.99) = -4.190$, $p < .001$), older children ($t(227.83) = -3.135$, $p = .002$) and adults ($t(227.17) = -5.211$, $p < .001$). These findings are relatively consistent with general trends of memory development with younger children remembering less information compared to all groups and middle and older children remembering less than adults.

Next, in order to test each of the hypotheses, data from certain register conditions were put into categories and analyzed together. Responses from the BW-TW and BN-TW condition were analyzed together to assess overall vigilance for whispered speech and responses from the BW-TN and BN-TW were analyzed together to assess overall salience for whispered speech. Combined vigilance and salience for whispered speech included responses from the BN-TW condition. In order to accommodate the binary data, a logistic regression was used to test the

main effects of any hypothesis as well as any interactions with age. There were no main effects for any of the hypotheses nor were there any interactions present. As a result, these data suggest the original vigilance, salience, and combined hypotheses are not supported. Supplementary paired-samples t-tests revealed overall performance in the vigilance and salience conditions were identical (M = 0.661) indicating that there was not a difference in the average information remembered based on vigilance or salience. There were also no differences between the combined measure (M = 0.664) and the vigilance condition (t(175.9) = 0.269, p =.788) nor between the combined and the salience condition (t(175.9) = 0.269, p =.788).

Although the logistic regression revealed no interactions between age and condition, exploratory analyses were carried out to investigate the data further by condition and age. First, for the BW-TW condition, differences in memory were present between younger (M = .5) children and adults (M =.9) (t(41.918) = -3.295, p = .002) as well as between older children (M= .619) and adults, (t(33.59) = -2.185, p = .04). However, the difference between middle children (M = .73) and adults was not significant. Next, in the BN-TN condition the only difference in memory was between younger children (M =.42) and adults (M = .8) (t(43.825) = -2.795, p = .008), and there were no other differences between age groups. In the BW-TN condition, adults' memory for target information M=.95) was significantly greater than for younger (M = .5) (t(36.094) = -4.0249, p < .001), middle (M = .70) (t(32.384) = -2.31, p = .03), and older children (M = .62) (t(28.052) = -2.768, p = .01). Lastly, in the BN-TW condition there was only one difference in memory performance between the younger children (M = .46) and the middle children (M = .74) (t(47) = -2.030, p = .048). Younger children did not perform significantly differently from older children or adults. In fact, overall performance of adults in the BN-TW

condition was the lowest across conditions for adults (M = .70), which was non-significantly lower than both middle (M =.74) and older children (M = .71) (See Figure 2).

Finally, because the pattern of responses varied for children and adults, the two presentation orders were also compared. Order 1 and Order 2 were counterbalanced for speaker location on the video (left vs. right) and gender to minimize any confounding factors. The data indicated a marginal difference in memory performance between order 1 (M = .62) and order 2 (M = .70), t(445.79) = -1.976, p = .049), This difference was a function of the performance of only the adult portion of the sample. As a whole adults in order 1 (M =.70) remembered less information than adults in order 2 (M = .88) and this difference was significant (t(88.334) = -2.243, p =.027). No order differences were found for the other age groups. It is unclear why this order effect is present but further investigation revealed some variability among the questions themselves that appears to be systematic in nature. Two of the four items had poorer memory performance in both orders. These were the questions where the correct cued recall response was riding a bicycle and using a broom to clean the floor (See Appendix A). Because the stimuli were counterbalanced these scripts appeared in BW-TW, BN-TN, BN-TW, and BW-TN across both orders and overall memory performance for the questions that used these scripts (M = .44) was significantly worse than for the questions that did not use these scripts (M = .87). These data suggest that participants may have had difficulty understanding or remembering certain questions or perhaps found some questions to be too easy which may have impacted the findings in a way that was unintended. No other differences in memory performance were found based on the gender, race, or ethnicity of participants.

Discussion

There were three primary hypotheses for this study about speech registers and memory. First, if auditory vigilance plays a role in remembering information, it was hypothesized that memory for target information would be best in the conditions where the target information was whispered, regardless of the base register. Next, if salience plays a larger role in remembering information, it was hypothesized that memory for target information would be best in any condition where the target information is in a different register than the base register. Lastly, if both vigilance and salience play a role in recall of auditory information, the combined hypothesis suggested memory for target information would be best in the condition in which base information is in a normal register and the target information is whispered. Unfortunately, the data did not support any of these hypotheses. While there was a general developmental trend with middle and older children remembering more information than younger children, this pattern was not related to any of the register hypotheses and is more likely due to the typical ways in which memory develops across childhood.

One interesting finding comes from the memory performance in each of the age groups. Unsurprisingly, the younger children remembered the least amount of information. This finding suggests that the task was either challenging for this group or that whispering is too subtle a cue to play a role in memory. However, middle children performed better than older children and this difference was statistically significant. The difference between adults and middle children was unusual because even though adults did recall a greater percentage of target information remember this difference between memory in middle children and memory in adults was not statistically significant. This contrasts with the general developmental expectation that memory improves gradually and consistently across development. One explanation for this finding is that

middle children are not yet adept at recognizing the nuances of whispered speech and were not using whispering as a cue as originally hypothesized. Instead, it is possible that they treated all information uniformly regardless of register which may explain why overall performance was strong for this group but did not follow a vigilance or salience pattern. Older children and adults in this study provide some evidence that these nuances may reveal themselves later in childhood and into adulthood as both of these groups become familiar with the variety of uses for whispering and utilize difference strategies to understand, interpret, and draw meaning from whispered speech. As a result, adults and older children in this study may have been more sensitive to the register changes which improved their ability to remember target information on some trials and not in others. This study was the first of its kind to explore the relationship between speech registers and memory which has led to some potential limitations but also positive directions for future work on these topics.

Limitations of the Vigilance Hypothesis

One important consideration about the results of the current study is the foundational work through which each of the hypotheses was developed. Cirillo's (2004) vigilance hypothesis states "Whispering can affect the psychobiological state of recipients, and in particular raise their auditory vigilance" (Cirillo, 2004, p. 76). This concept guided the current study's goal to test this hypothesis with children and extend the findings by predicting that memory would be best for any condition where the target information was whispered. One explanation for the null results is the developmental differences that exist between children and adults. Cirillo's (2004) work involved surveying whispering behaviors in adult populations only. There are numerous cognitive differences between children and adults that would impact memory and there may also be some important social components that might help explain what

knowledge children have about whispering and why it was difficult to find effects in children in the present study. Whispering has multiple meanings and functions, so a whisper might not carry identical meaning for each person. For example, some adults in the Cirillo (2004) study indicated their usage and understanding of whispered speech was based on courtship and mate bonding in private settings and to address a close friend or partner in public. Children would not understand whispering in this way. Similarly, while whispering can be a communication tool, in some circumstances whispering can also be taboo. Many participants noted that in addition to using whispering to communicate privileged information they occasionally avoided whispering because it induced curiosity of others and often felt impolite (Cirillo, 2004). It is possible that parents teach their children that they should not keep secrets and that whispering is impolite. If this is the case, the children in the current study may have been taught to treat all information as conventional and therefore whispered information would have no impact on their auditory vigilance or subsequent memory for information.

Limitations of the Salience Hypothesis

The salience hypothesis places emphasis on the change between whispered and normal registers. One of the key features of a salient stimulus is that it grabs attention. However, by having memory for target information as the only dependent variable we may have limited the scope of attention in the current study. To clarify, it may be true that register changes are salient but perhaps there is another mechanism beyond attention and memory that this study was unable to capture. One possibility is that target information presented during a register change is not as relevant as the features of the information sharer. Whispering and register changes might be more related to the communicative intent of the information sharer and not the information itself. A register change might be salient enough to catch your attention but that does not necessarily

mean the whispered information will be encoded. Instead, the information obtained from the salient register change might be a cue for characteristics about the speaker (e.g., trustworthiness) or details about the intentions of the speaker.

Support for this idea can also be found in Cirillo's (2004) original whispering study. Whispering can be a cue for ingroup bonding and it can also be a cue for exclusion if one is a co-listener who is experiencing or overhearing a conversation as an outsider (Cirillo, 2004). Participants in the current study may have used whispering to provide details about whether the speaker intends to include or isolate others with the way they speak. Perhaps children might be more likely to remember in-group speakers based on speakers' use of registers and register changes. If the current study had examined memory for information sharers and not information alone, we may have been able to identify whether register changes play a role in how children make social judgements about various speakers. However, with memory for target information being the dependent variable it was not possible to parse out these factors and may explain why there was no clear evidence that register changes impacted memory for target information.

General Limitations and Future Directions

Since this study was the first of its kind there are some practical factors that may have impacted the data. First, due to COVID-19 restrictions the stimuli in this study had to be delivered virtually through Zoom. At this point, it is difficult to know if this delivery mechanism, compared to traditional laboratory studies, plays a role in children's memory performance but it cannot be ruled out. Controlling for extraneous factors is also difficult with online research with children. Training trials served as a failsafe to detect any sound or video issues at the beginning of each session but interference could have impacted participant's ability to accurately hear all target information. Participants were in their homes which also may have created some

distractions. Many of the children had siblings who were nearby which meant that most external sounds could not be eliminated. In the future, a study like this could benefit from a face-to-face delivery option not only to help control for technological issues but also to provide an opportunity for children to be more engaged with the stimuli. One reason children may have been less engaged is because the study materials were presented in a way that made participants third party observers to a conversation rather than taking a more active role in the exchange. This level of engagement may also explain why performance on the questions with certain scripts differed. If the scripts were too difficult or too easy we may have seen variation in attention that could have impacted memory performance on certain questions. While research from Akhtar et al. (2001) demonstrates that children can recall information learned through overhearing perhaps the role of memory for whispering depends on how involved the person is in a conversation. If this is the case this remote presentation of stimuli may not have been sufficient to activate memory processes and future studies could address this by incorporating a first-person perspective. Lastly, it is also possible that the scripts themselves were flawed so future studies should examine the stimuli and make adjustments that take strike the balance between assessing learning and memory abilities and not exceeding the cognitive load of participants.

Conclusion

This study is one of few to explore the psychological understanding of whispered speech and one of the only to examine its usage patterns with children. Although the possible conclusions that can be drawn from the results were not entirely obvious here, there do appear to be some patterns that are more complex than initially predicted. We have yet to discover the exact ways speech registers affect how children receive and respond to information however, it is

clear that whispering is a unique cue with multiple functions and communicative abilities and this study has laid the foundation for future studies to explore these relationships

References

Akhtar, N. (2005). The robustness of learning through overhearing. *Developmental Science*, *8*(2), 199-209. https://doi.org/10.1111/j.1467-7687.2005.00406.x

Akhtar, N., Jipson, J., & Callanan, M. (2001). Learning words through overhearing. Child Development, 72, 416–430. https://doi.org/10.1111/1467-8624.00287

Bargones, J. Y., & Werner, L. A. (1994). Adults listen selectively; infants do not. Psychological Science, 5,170–174. https://doi.org/10.1111/j.1467-9280.1994.tb00655.x

Barnes C. M. (2020). Children's understanding of whispering as a cue for privileged information. Unpublished Raw Data.

Behrend, D., Girgis, H., Stevens, R., (2018). On a need-to-know basis: Young children's friendship choices as a function of information sharing behavior. Unpublished Manuscript.

Cirillo, J. (2004). Whispering: communication by unvoiced speech. - Ann. Braz. Acad. Sciences 76: 413-423. https://doi.org/10.1590/s0001-37652004000200034

Cirillo, J., & Todt, D. (2002). Decoding whispered vocalizations: relationships between social and emotional variables. In *Proceedings of the 9th International Conference on Neural Information Processing,* Singapore. (pp. 1559-1563).

Cirillo, J., & Todt, D. (2005). Perception and judgement of whispered vocalizations. *Behaviour*, 113-128.

Günther, F., Müller, H. J., & Geyer, T. (2017). *Salience, attention, and perception.* In H.-J. Schmid (Ed.), *Language and the human lifespan series. Entrenchment and the psychology of language learning: How we reorganize and adapt linguistic knowledge* (p. 289–312). American Psychological Association; De Gruyter Mouton. https://doi.org/10.1037/15969-014

Hedrick, A. M., Haden, C. A., & Ornstein, P. A. (2009). Elaborative talk during and after an event: Conversational style influences children's memory reports. *Journal of Cognition and Development*, *10*(3), 188-209. https://doi.org/10.1080/15248370903155841

Jones, P. R., Moore, D. R., & Amitay, S. (2015). Development of auditory selective attention: why children struggle to hear in noisy environments. *Developmental psychology*, *51*(3), 353–369. https://doi.org/10.1037/a0038570

Lai, W., Rácz, P., & Roberts, G. (2019). Unexpectedness makes a sociolinguistic variant easier to learn: An alien-language-learning experiment. [Proceedings of the 41st annual conference of the Cognitive Science Society] (pp. 604-610). Montreal, QB

Misch, A., Over, H., & Carpenter, M. (2016). I won't tell: Young children show loyalty to their group by keeping group secrets. *Journal of Experimental Child Psychology*, *142*, 96-106. https://doi.org/10.1016/j.jecp.2015.09.016

Over, H. (2016). The origins of belonging: social motivation in infants and young children. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *371*(1686), https://doi.org/10.1098/rstb.2015.0072

Parr, T., & Friston, K. J. (2017). Working memory, attention, and salience in active inference. *Scientific reports*, *7*(1), 1-21. https://doig.org/10.1038/s41598-017-15249-0

R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Rácz, P., Hay. J., B. & Pierrehumbert, J., B. (2017). Social salience discriminates learnability of contextual cues in an artificial language. *Front. Psychol.* 8(51). https://doi.org/10.3389/fpsyg.2017.00051

Schmid, H., & Günther, F. (2016). Toward a unified socio-cognitive framework for salience in language. *Front. Psychol*.*7*:1110. https://doi.org0.3389/fpsyg.2016.01110

Vyond Studio [Computer software], 2020. Retrieved from https://www.vyond.com/

Weeks, T. E. (1971). Speech registers in young children. *Child development*, *42*(4) 1119-1131. https://doi.org/10.2307/1127797

Wildt, E., and Rohlfing, K. J. (2018). "What type of interactional presentation helps 10-month-olds to overcome the saliency-effect during referent selection?" in Poster Session Presented at the International Congress of Infant Studies (ICIS), Philadelphia, PA.

Wildt E, Rohlfing KJ and Scharlau I (2019) The role of saliency in learning first words. *Frontiers in Psychology.* 10:1150. https://doi.org/10.3389/fpsyg.2019.01150

Tables and Figures

Table 1
Vigilance Hypothesis

	Base Normal	Base Whisper
Target Normal	BN-TN	BW-TN
Target Whisper	BN-TW ✓	BW-TW ✓

Note. These check marks are representing a vigilance only hypothesis where it is predicted that target information will be remembered best in conditions where target information is whispered. A main effect for target language is expected here.

Table 2
Salience Hypothesis

	Base Normal	Base Whisper
Target Normal	BN-TN	BW-TN ✓
Target Whisper	BN-TW ✓	BW-TW

Note. These check marks are representing a salience only hypothesis where it is predicted that target information will be remembered more often in conditions where base register differs from the target register. A base language by target interaction is expected here.

Table 3
Combined Vigilance and Salience Hypothesis

	Base Normal	Base Whisper
Target Normal	BN-TN	BW-TN
Target Whisper	BN-TW ✓	BW-TW

Note. This check mark represents a combined vigilance and salience hypothesis where it is predicted that target information will be remembered best in the condition where base information is presented in a normal register and then switches so that target information is whispered.

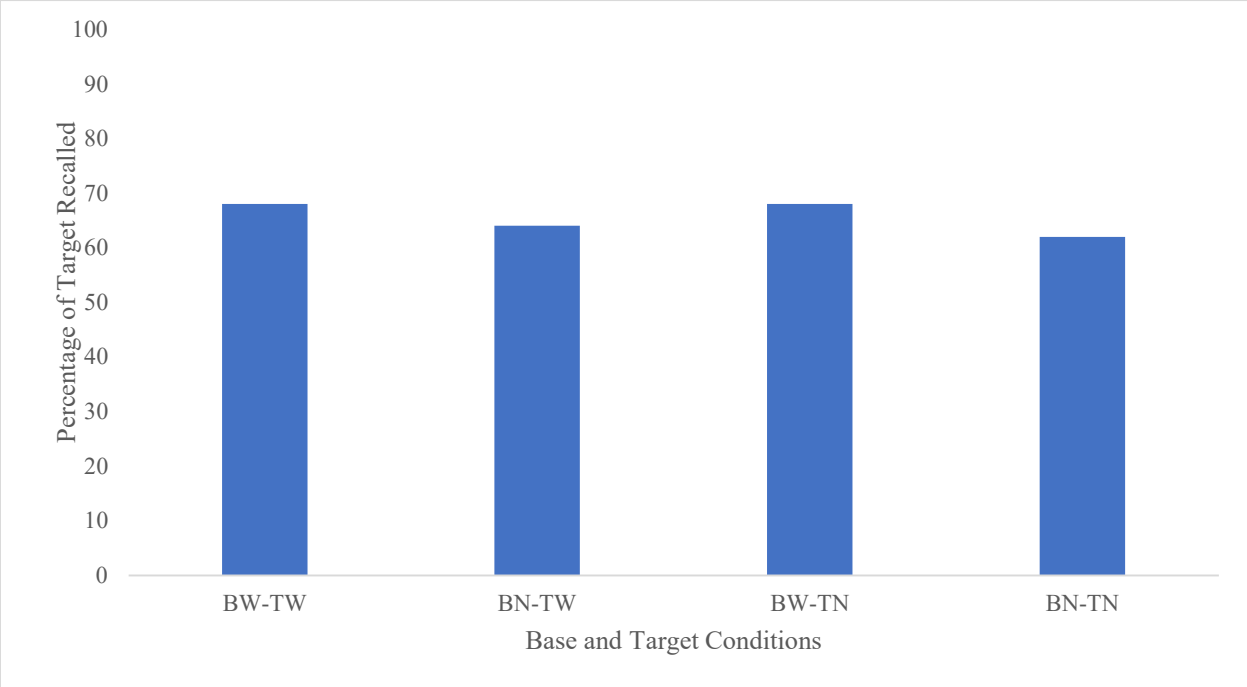

Figure 1
Percentage of Target Information Recalled

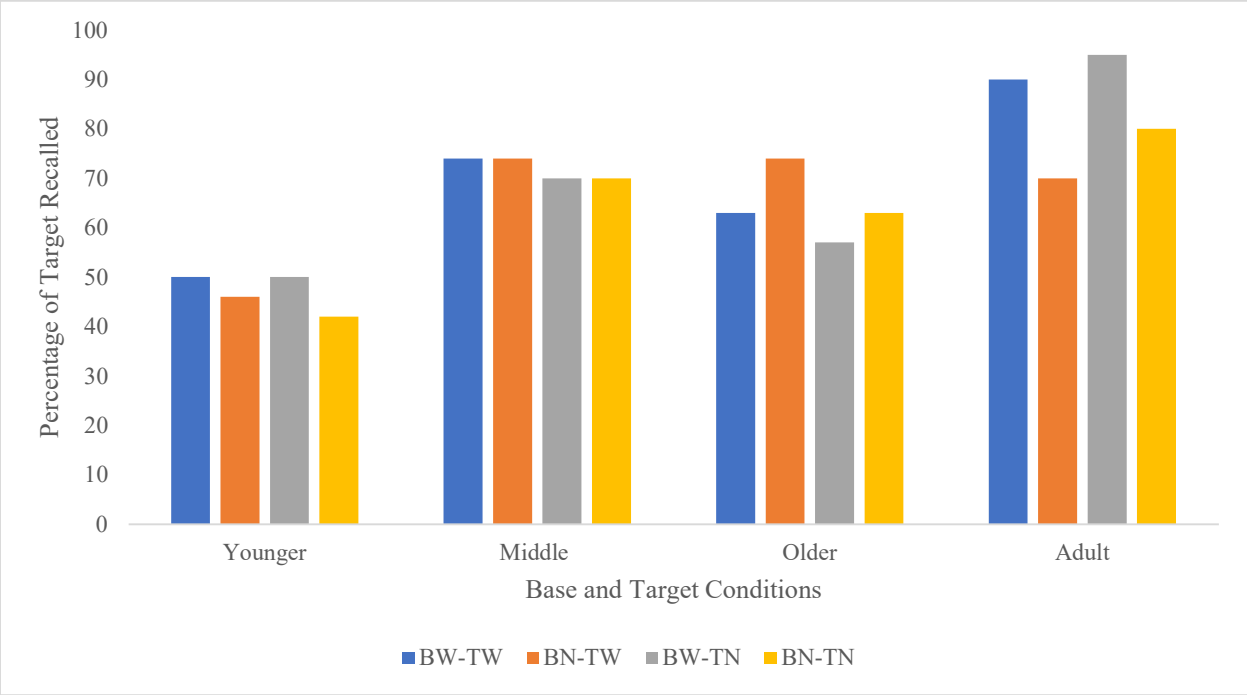

Figure 2
Percentage of Target Information Recalled by Age

Appendices

Appendix A

Order 1

Training Trials

Training Trial A

Person A: Hi my name is Holly.

Person B: Hi, my name is Tom.

Cued Recall Question: “This girl’s name is Holly, what was that boy’s name?”

Training Trial B

Person A: My favorite food is hamburgers

Person B: My favorite food is pizza.

Cued Recall Question: This boy’s favorite food is pizza. What was that girl’s favorite food?

Test Trials

Scenario 1

Person A: Hi James! What are you doing out here?

Person B: Oh, Hi Richard! I am just standing out here looking at the clouds and enjoying the sunlight.

Person A: What will you do after that is done?

Person B: After that I might look at the flowers in the garden. <u>The purple flowers are my favorite!*</u>

Person A: Wow, sounds fun I hope you enjoy your day outside!

Person B: Thanks!

Cued Recall Question: Which flowers did James say were his favorite?

Scenario 2

Person A: Hi Sam, did you have fun at recess?

Person B: Hi Tommy! I did have fun especially playing on the swings.

Person A: That sounds like fun! I think they have swings at the park too. Have you ever been there?

Person B: Yes, I have! My parents took me there once. I learned to ride my bike at the park.

Person A: That's so fun! I have to go now but I'll see you later.

Person B: Great! See you later.

Cued Recall Question: What did Sam do at the park?

Scenario 3

Person A: Hi Lola

Person B: Hi Molly, what are you going to do today?

Person A: Well because it's Friday, my mom is going to let me play with all of my toys!

Person B: That's really cool! Do you have a favorite toy?

Person A: Yes! My favorite one is the toy car. I put the toy car in the box.

Person B: That sounds fun! I hope you have a fun time playing.

Person A: Thank you. See you later!

Cued Recall Question: What does Molly put in the box?

Scenario 4

Person A: Anna Hey! What are you doing today?

Person B: Hi Sally, today I am going to tidy up my house and make it look nice.

Person A: That's awesome Anna! How do you plan to do that?

Person B: Well, I will wash the windows first, then I will take out the trash, and because the floor is dirty I'll clean that too. I'll use a broom to clean my floors.

Person A: Wow, well best of luck with your cleaning!

Person B: Thanks!

Cued Recall Question: What did Anna say she was going to use to clean her floors?

Order 2

Training Trials

Training Trial A

Person A: Hi my name is Chad.

Person B: Hi, my name is Taylor.

Cued Recall Question: “This boy’s name is Chad, what was that girl’s name?”

Training Trial B

Person A: My favorite food is chicken nuggets

Person B: My favorite food is French Fries.

Cued Recall Question: This girl’s favorite food is pizza. What was that boy’s favorite food?

Test Trials

Scenario 1

Person A: Sam Hey! What are you doing today?

Person B: Hi Tommy, today I am going to tidy up my house and make it look nice.

Person A: That’s awesome Sam! How do you plan to do that?

Person B: Well, I will wash the windows first, then I will take out the trash, and because the floor is dirty I’ll clean that too. I’ll use a broom to clean my floors.

Person A: Wow, well best of luck with your cleaning!

Person B: Thanks!

Cued Recall Question: What did Sam say he was going to use to clean his floors?

Scenario 2

Person A: Hi Lola! Where are you doing out here?

Person B: Oh, Hi Molly! I am just standing out here looking at the clouds and enjoying the sunlight.

Person A: What will you do after that is done?

Person B: After that I might look at the flowers in the garden. The purple flowers are my favorite!

Person A: Wow, sounds fun I hope you enjoy your day outside!

Person B: Thanks!

Cued Recall Question: Which flowers did Lola say were her favorite?

Scenario 3

Person A: Hi Anna, did you have fun at recess?

Person B: Hi Sally! I did have fun especially playing on the swings.

Person A: That sounds like fun! I think they have swings at the park too. Have you ever been there?

Person B: Yes, I have! My parents took me there once. I learned to ride my bike at the park.

Person A: That's so fun! I have to go now but I'll see you later.

Person B: Great! See you later.

Cued Recall Question: What did Anna do at the park?

Scenario 4

Person A: Hi James

Person B: Hi Richard, what are you going to do today?

Person A: Well because it's Friday, my mom is going to let me play with all of my toys!

Person B: That's really cool! Do you have a favorite toy?

Person A: Yes! My favorite one is the toy car. I put the toy car in the box.

Person B: That sounds fun! I hope you have a fun time playing.

Person A: Thank you. See you later!

Cued Recall Question: What does Richard put in the box?

*Underlined sentences represent the target register sentence

Appendix B

Order 1

A. Training Trials
   - BW-TW – Holly and Tom
   - BN-TN – Hamburger and Pizza
B. Test Trials
   - BW-TW -Boys. Target info: Purple flowers
   - BN-TN - Boys. Target info: Learned to ride bike
   - BW-TN – Girls. Target info: Toy car in box
   - BN-TW – Girls. Target info: Broom to clean

Order 2

A. Training Trials
   - BN-TN – Chad and Taylor
   - BW-TW – Chicken Nuggets and French Fries
B. Test Trials
   - BW-TN – Boys. Target info: Broom to clean
   - BN-TW- Girls. Target info: Purple Flowers
   - BW-TW- Girls. Target info: Learned to ride bike
   - BN-TN – Boys. Target info: Toy car in box

Appendix C

UNIVERSITY OF ARKANSAS

To:	Christina M Barnes BELL 4188
From:	Douglas J Adams, Chair IRB Expedited Review
Date:	12/16/2020
Action:	**Expedited Approval**
Action Date:	12/16/2020
Protocol #:	2010293742
Study Title:	Children's Memory for Whispered Information
Expiration Date:	11/15/2021
Last Approval Date:	

The above-referenced protocol has been approved following expedited review by the IRB Committee that oversees research with human subjects.

If the research involves collaboration with another institution then the research cannot commence until the Committee receives written notification of approval from the collaborating institution's IRB.

It is the Principal Investigator's responsibility to obtain review and continued approval before the expiration date.

Protocols are approved for a maximum period of one year. You may not continue any research activity beyond the expiration date without Committee approval. Please submit continuation requests early enough to allow sufficient time for review. Failure to receive approval for continuation before the expiration date will result in the automatic suspension of the approval of this protocol. Information collected following suspension is unapproved research and cannot be reported or published as research data. If you do not wish continued approval, please notify the Committee of the study closure.

Adverse Events: Any serious or unexpected adverse event must be reported to the IRB Committee within 48 hours. All other adverse events should be reported within 10 working days.

Amendments: If you wish to change any aspect of this study, such as the procedures, the consent forms, study personnel, or number of participants, please submit an amendment to the IRB. All changes must be approved by the IRB Committee before they can be initiated.

You must maintain a research file for at least 3 years after completion of the study. This file should include all correspondence with the IRB Committee, original signed consent forms, and study data.

cc: Douglas A Behrend, Investigator