

EXAMINING THE INFLUENCE OF SEMANTIC KNOWLEDGE ON EPISODIC MEMORY

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Abstract

Memory is a critical capacity for everyday life. Memory is not one process but consists of different systems (Robertson & Köhler, 2007). Semantic memory is memory for general knowledge about the world and episodic memory is memory for a specific event from a particular time and place in the past (Tulving, 1972, 1983). Tulving (1972) referred to these systems as two separated but partially related memory systems. However, relatively little is known about how these two systems relate. Specifically, the influence of semantic memory on episodic memory is not fully understood. This study investigated the influence of semantic memory on memory for events (actions) and their spatial locations. The final sample for this study included 73 participants. Participants were divided into two groups that varied in the delay they experienced between the encoding phase and retrieval phase (immediate group, $n=37$; delay group, $n=36$). During the encoding phase, participants were presented with images of cartoon characters completing an action along with an image of a background scene (i.e., locations) that either matched the action (congruent trial), did not match the action (incongruent trial) or an action that could be performed in any location (neutral trial). During the retrieval phase, participants were presented with actions and asked whether the action was old or new (old/new recognition memory) and, if old, asked to choose the background image that went with that action (spatial location) among a group of distractors. Across delay, participants more accurately identified the locations for the congruent actions compared to the locations for the incongruent actions. Across conditions, participants in the immediate group more accurately identified the actions and spatial locations compared to the delay group. Further, different patterns for the types of errors participants made were observed. This study adds to our knowledge about the influence of semantic memory on episodic memory. Future studies can expand the research to different

settings (e.g., naturalistic environments) and with more variable samples (e.g., different age groups).

Keywords: semantic memory, episodic memory, congruent, incongruent, neutral, congruency effect

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TABLE OF CONTENT

Abstract	ii
Acknowledgments	iv
Table of Contents	v
List of Figures	vii
Chapter One: Introduction	1
Examining the Relation Between Semantic and Episodic Memory During Childhood	6
The Present Study	10
Predictions	13
Chapter Two: Method	14
Participants	14
Stimuli	15
Pilot Testing	16
Procedure	16
Episodic Memory Task	17
Practice Encoding Phase	18
Encoding Phase	18
Practice Retrieval Phase	19
Retrieval Phase	20
Assessment of Standardized Semantic Knowledge: PPVT	21
Note About Delay	22
Scoring	22
Congruent Condition	23

Incongruent Condition	23
Neutral Condition	24
Chapter Three: Results	25
Preliminary Analyses	25
Reaction Time	25
Peabody Picture Vocabulary Test (PPVT)	26
Episodic Memory Task	27
Analysis of Errors	28
Chapter Four: Discussion	30
References	39
Appendices	57
Appendix 1: Experimental Instructions	57
Appendix 2: Counterbalancing Stimuli	62
Appendix 1: Stimuli Sets for Retrieval Phase	67

LIST OF FIGURES

Figure 1: Encoding Phase Trial Samples (10 sample trials)	48
Figure 2: Computer Screenshots for Sample Image for Encoding Training Trial	49
Figure 3: Retrieval Phase: Sample Image for Congruent Condition	50
Figure 4: Retrieval Phase: Sample Image for Incongruent Condition	51
Figure 5: Retrieval Phase: Sample Image for Neutral Condition	52
Figure 6: Accuracy for Locations in All Three Conditions	53
Figure 7: All Types of Errors in Incongruent Condition	54
Figure 8: All Types of Errors in Congruent Condition	55
Figure 9: All Types of Errors in Neutral Condition	56

Examining the influence of semantic knowledge on episodic memory

Chapter One: Introduction

We typically think of memory as one process, though it is, in fact, "several distinct systems" (Robertson & Köhler, 2007, p. 3178). Episodic memory is memory for specific past events that happened at a certain time and in a particular place (Tulving, 1972, 1983). For example, recalling the word *elephant* on the list we studied in a memory experiment setting is facilitated by the episodic memory system (Bauer, 2007). Another memory system, called semantic memory, allows us to retrieve general facts, knowledge, and information about the world (Tulving, 1972, 1983). For example, remembering the fact that an *elephant* is a mammal, or that it has tusks, and a trunk is supported by the semantic memory system. Tulving (1972) referred to episodic and semantic memory as two separated, but partially related, types of memory. However, more research is needed on the collaboration between these two memory systems. Specifically, the influence of semantic memory on episodic memory and its development is not fully investigated.

Past research has found age-related improvements in both types of memory. In term of episodic memory, there are age-related improvements across childhood (Bauer, 1996) in the number of episodic details children provide in their narratives about past events (Bauer, 1996; Bauer & Larkina, 2019; Fivush, 2011). Numerous studies have also found age-related improvements in memory accuracy based on lab-based stimuli (e.g., Geng, Canada & Riggins, 2018; Lloyd, Doydum, & Newcombe, 2009; Mitchell, Johnson, Raye, Mather, & D'Esposito, 2000; Sluzenki, Newcombe, & Kovacs, 2006). For example, Sluzenki and colleagues (2006) examined 4- to 6-year-old children's and adults' ability to remember an event along with its contextual details. Pictures were presented on a computer screen that included an item (animal)

and a background (a specific scene). Participants' memory was tested in three conditions: 1) memory for only the item (animal condition), 2) memory for the background alone (background condition), and 3) memory for the combination of both the item and background together e.g., memory for a bear at a desert; combination condition). Researchers found age-related improvements in memory accuracy for the combined condition, but not for the individual item (animal) or individual background (scene) condition. This suggests that memory for binding an event with contextual features may be especially challenging for children and shows protracted development in childhood. As reviewed by Bauer (2007), several studies have shown that there are improvements in memory for events and context in early to middle childhood when children's ability to encode and recall complicated event representations increases (see also review Ghetti & Bunge, 2012).

Age-related improvements are also reported in childhood for semantic knowledge which has been tested in different ways. For example, several studies have found age-related improvements in children's ability to learn and perceive conceptual hierarchies (e.g., Schaeffer, Lewis, & Decar, 1971; Whitney & Kunen, 1983) in early to middle childhood. In a picture-based study, McCauley, Weil, and Sperber (1976) investigated semantic-priming effects in the development of categorical knowledge in 6 to 8-year-old children. They indicated pairs of images to kindergartners and second graders and asked them to name each image as fast and as accurately as possible. Results were indicative of age-related improvements in children's semantic competence. Examining verbal ability through picture-based tasks (e.g., Peabody Picture Vocabulary Task), Saarnio (1990) investigated 3- and 4-year-old children's knowledge about locations of different objects. Children were asked to place the objects (e.g., chair or tractor) on a given background (e.g., living room or farm). There were age-related improvements

for memory about the locations and schematic knowledge about the objects belonging to a specific location.

Despite the findings of age-related improvements in both episodic and semantic memory, additional research is needed on these systems during development. Further, the relation between these two systems as two components of declarative memory has been a topic of debate (Smith & Lah, 2011), and evidence for how the systems interact is somewhat unclear (Squire, Stark, & Clark, 2004; Tulving, 2005). For example, Squire (1992) assumed episodic memory facilitates semantic retention. On the other hand, Tulving and Markowitsch (1998) suggested the opposite pattern, emphasizing the role of semantic memory on recalling episodic details. Other researchers discuss a bilateral relationship between semantic and episodic memory and conclude that both systems collaborate with each other (Greve, Van Rossum, & Donaldson, 2007; Martin-Ordas, Atance, & Caza, 2014; Menon, Boyett-Anderson, Schatzberg, & Reiss, 2002). Consider memory for a specific visit to an ice-skating rink in the winter. Recollection may include episode details including wearing skates and ice-skating. It also may include remembering some general facts and semantic information. For example, winter is a cold season, and during cold weather, the water freezes. Therefore, episodic details (wearing skates and skating on the ice) and semantic information (during winter water freezes) work together to facilitate remembering a specific visit of an ice rink in winter.

Multiple lines of research show the relations between episodic and semantic memory systems. For example, behavioral studies have indicated that semantic memory can influence episodic memory. Studies have found that an individual's pre-existing knowledge about specific experiences facilitates their memory for the details about the experiences (Bransford & Johnson, 1972; Brod, Werkle-Bergner, & Shing, 2013). Craik and Tulving (1975) showed that words are

better remembered if presented in a congruent sentence (e.g., when a word is presented in a sentence that matches with a participant's semantic knowledge). The "congruency effect" facilitates participants' memory such that items presented within a congruent context (context matched with the prior semantic knowledge about the item) are remembered better than items presented with an incongruent context (context mismatched with their prior semantic knowledge about the item) (Bein, Livneh, Reggev, Gilead, Goshen-Gottstein, & Maril, 2015). For example, Maril, Avital, Reggev, Zuckerman, Sadeh, Sira, and Livneh (2011) found participants better remembered "strawberry" when paired with "red" (congruent), rather than "strawberry" when paired with "blue" (incongruent). In addition, Hoffman (2018) showed that older adults were less successful in ignoring non-related semantic stimuli in task-relevant features of information. Other studies indicated that adults outperformed children in memory tasks due to broader knowledge domains (e.g., Ghatala, Carbonari, & Bobele, 1980; Maril et al., 2011; Schneider, Körkel, & Wienert, 1989).

Neuroimaging studies have identified episodic and semantic memory as two neurologically overlapping systems. Renoult, Irish, Moscovitch, and Rugg (2019) have emphasized that conceptual information relies on the neural activity across the same cortical regions that are activated when recalling specific information. Specifically, the left inferior prefrontal cortex that is activated during semantic control processes is also activated while processing episodic information (Dobbins, Foley, Schacter, & Wanger, 2002; Renoult, et al., 2019; Rugg, Henson, & Robb, 2003). For example, while remembering a concrete concept (e.g., flower), neural activity overlaps with activity when remembering an exemplar of the concept (e.g., a specific rose in our room). An fMRI study by Kesteren, Beul, Takashima, Henson, Ruiters, and Fernandez (2013) examined the effect of congruency on the neural activation. They

indicated that new congruent information relies on the medial prefrontal cortex, whereas the medial temporal lobe plays an important role in encoding new incongruent information. They found that encoding details about the item was related to a pre-existing schema and prior knowledge about the item.

Neuropsychological studies have also examined the relation between semantic and episodic memory in patient populations. Kan, Alexander, and Verfaellie (2009) used visual stimuli to investigate the relation between semantic information on episodic learning in patients with amnesia. Findings indicated that the healthy control group and only a subset of patients with amnesia benefited from the congruency effect while other groups of amnesic patients did not. Kan and colleagues (2009) concluded that patients with faded past knowledge did not benefit from the congruency effect, however, they were still capable of remembering episodic details. In another study, Stampacchia, Pegg, Hallam, Smallwood, Ralph, Thompson, and Jefferies (2019) investigated episodic memory (specifically, spatial location) and semantic retrieval in patients suffering from semantic aphasia following a stroke (Corbett, Jefferies, & Ralph, 2009). Results were indicative of a retrieval discrepancy in semantic cognition as well as weak source recollection for episodic memory for everyday tasks. Thus, remembering episodic memory about the item was under the influence of semantic knowledge about the item. Overall, episodic and semantic memory are two overlapping systems based on behavioral, neuroimaging, and neuropsychological data. However, the influence of semantic information about an event (item) on remembering episodic details about the item (e.g., spatial location of the item), is not fully understood.

Examining the relation between semantic and episodic memory during childhood

Tulving (1993) suggested that semantic memory develops prior to episodic memory in early childhood and indicated children are able to acquire knowledge about the world before they remember their past experiences (see also Nelson and Fivush, 2004, in which semantic memory is noted to contribute to the development of autobiographical episodic memory). However, how semantic information may facilitate or support episodic memory during childhood is not fully understood. Studies in which multiple groups of children are tested to examine how semantic knowledge influences episodic memory accuracy across childhood are relatively rare. However, several studies are relevant. A study by Hudson, Shapiro, and Sosa (1995) indicated that children may apply scripts and concepts for planning novel experiences. Other studies suggest that semantic knowledge is transferred into novel experiences. For example, using free recall questions (i.e., “what happens” and “what happened”), Fivush, Hudson, and Nelson (1984) examined 5-year-old children’s knowledge of what generally occurs during a trip to a museum. Specifically, they investigated what precisely occurred during a specific unique trip to a museum and assessed how children’s script knowledge and information may be reflected in their novel experiences. According to Fivush and colleagues, different reports in both structure and content that were provided by for a specific episode compared to general event was indicative of their ability to differentiate unique experience about the event and general knowledge about the event. Robertson and Köhler (2007) examined how 4-6-year-old children’s general knowledge may relate to their episodic memory. They found that a standardized measure of semantic knowledge (based on vocabulary) predicted accuracy on various recognition tasks. Based on old-new recognition (not memory for context), it seemed that in early childhood, individual differences in semantic knowledge predicted individual differences in performance in episodic memory.

Other studies examined how semantic knowledge may influence event memory in the lab in middle to late childhood. Maril et al. (2011) investigated the congruency effect (pairing semantic context with episodic experience) on episodic encoding in 8-11-year-old children and adults. During the encoding phase, they presented noun-color combinations that were either congruent (e.g., 'strawberry' with red) or incongruent (e.g., 'strawberry' with blue), and asked participants to decide if the combination can exist in the real world. During the retrieval phase, participants took part in an old-new recognition task in which they were presented with old (studied) and new (unstudied) nouns and were asked to decide if the noun was studied during the encoding phase. For every noun that the participant said was old, they were presented with colors and asked to indicate the color that was paired with the noun during the encoding phase. The results indicated a congruency effect across both adults and children: accuracy was higher in the congruent compared to incongruent condition. Similarly, Heikkila and Tiippana (2016) studied an audiovisual congruency effect on recognition memory in 8-to-12-year-old children. During the encoding task, they presented auditory or visual stimuli paired with stimuli in other modalities in three conditions, including semantically congruent, semantically incongruent, and non-semantic match, then instructed participants to memorize the stimuli in one modality while ignoring the stimuli in another modality. They found that recognition memory performance was better for visual and auditory stimuli presented with semantically meaningful congruent stimuli in the other modality (e.g., the image of a horse and horse's hee-haw sound) compared to visual and auditory stimulus presented with non-semantic stimuli in the other modality (e.g., image of a wolf and the sound of a violin). Therefore, they suggested semantically congruent experiences during encoding positively relate to memory performance in school-aged children. Both studies

indicated that, in late childhood, semantic knowledge influences memory accuracy of perceptual stimuli.

A recent study examined the effect of semantic memory on episodic memory accuracy in early-middle childhood. Sipe and Pathman (2021) examined how children's semantic memory influenced their episodic memory. Specifically, they tested how semantic knowledge (knowledge about spatial locations) influenced accuracy on a recognition memory paradigm that tested memory for events and their spatial contexts. They examined 5-, 6-, and 7-year-old children's memory at a local museum constructed to resemble a town with exhibits representing 6 locations about the town, including a bookstore, construction zone, "Grandma's house", the market, the medical center, and the post office. During the encoding phase, they participated in various actions classified as congruent (action matched the location, e.g., sorting mail at the post office), incongruent (action did not match the location, e.g., sorting mail at the medical center) or spatially independent (action not tied to any particular location, e.g., tying a shoe). Shortly after this encoding phase, using a laptop computer, children's memory for the events in which they participated (old/new recognition) as well as memory for the event's spatial context were tested (participants selected among pictures of the 6 locations in which the action was completed). In addition to this recognition memory experimental paradigm, the researchers assessed children's general knowledge of the locations of interest through a semantic interview as well as semantic knowledge and language with a standardized measure (Peabody Picture Vocabulary Test; PPVT; Dunn & Dunn, 2007). For the recognition memory paradigm, the researchers found that memory accuracy varied based on the experimental condition. Specifically, across age group, children remembered the locations of the events in the congruent condition better than they remembered the locations of the events in the incongruent condition. Since accuracy for the independent

condition was similar to accuracy for the incongruent condition, the authors suggested that semantic knowledge boosted memory for the congruent condition. Thus, across age groups, children's semantic memory influenced their episodic memory (in this case, episodic memory for the event locations).

In addition, Sipe and Pathman (2021) also examined errors in the incongruent condition. Errors were classified into semantic match errors (when children incorrectly chose the location that was congruent to the event) and semantic nonmatch errors (when children incorrectly selected a location other than the correct location or the congruent location). They found that when children made errors in the incongruent condition, they were more likely than would be expected by chance to select semantic match errors (i.e., to choose the distractor location that was semantically matched to the action even if it was not the location that was paired with that action during the encoding phase). Exploring errors, they concluded that semantic memory for the event can hinder memory for the event location in this incongruent condition. For the interview task, the researchers found age-related improvements in children's knowledge of locations in a town or city (e.g., what happens in a post office) based on the quality of children's narratives about what happens in those locations (e.g., post office, medical center). Further, the researchers found that performance on the PPVT was predictive of aspects of the episodic recognition memory task.

Further studies are needed to build upon these findings. First, Sipe and Pathman (2021) included only children 5-7 years old. They found age-related improvements were only found for the semantic interview task about children's knowledge of locations, however, no age-related differences were found in the main episodic memory task. One reason may be due to the narrow age-range tested in this study. Further, the Sipe and Pathman study cannot speak to how older

participants, including young adults, would perform, and how there may be different patterns for younger and older children, and different patterns for children compared to adults. Second, Sipe and Pathman (2021) suggested that relatively high accuracy and similar performance across age groups may be because this study involved immediate testing (i.e., brief delay between encoding and retrieval). Thus, introducing a longer delay may further expand our understanding of how semantic memory can influence episodic memory.

The Present Study

The primary aim of this program of research is to further learn about the relations between semantic and episodic memory across childhood and into adulthood. Our aim is to investigate how episodic memory for a specific event in a particular location is influenced by spatial semantic knowledge about that location. This research extended work by Sipe and Pathman (2021) by increasing the age span to be tested, introducing a delay condition, and expanding on the error analysis. As a first step in this research program, and for the purposes of this MA thesis, we focused on young adults only. Specifically, we were interested in understanding the contribution of semantic knowledge on memory for actions and locations in young adulthood. We also examined group differences with immediate and delayed testing. Following the methodology of Sipe and Pathman (2021), we investigated this by manipulating the semantic match between actions and locations during the encoding phase. However, instead of children actively doing different actions in different locations in a museum, adults were presented with the images of actions being completed by cartoon characters with different background scenes that represented different locations. Like Sipe and Pathman, we assessed memory accuracy for the congruent condition (actions and scenes that matched, such as going camping with a forest camp in the background) compared to the incongruent condition (actions

and scenes that were mismatched, such as going camping with a cinema in the background). We also included a neutral (independent) condition, like Sipe and Pathman, as a comparison.

In the present adult study, we extended past work in two ways. First, we introduced a manipulation of time delay between the encoding phase and the retrieval phase. With increases in retention interval (delay), we expected weaker episodic memory for the stimuli (actions and their spatial locations). As a result, participants' semantic knowledge about the stimuli might play a larger role in episodic memory accuracy for the actions or their spatial locations. We imposed a delay of one week for half of the participants. Since in the future this research will be expanded to compare young adults to groups of children, a one-week period was the duration we expected children to be able to remember the locations (e.g., Baker-Ward, Gordon, Ornstein, Larus, & Clubb, 1993; Bauer, Doydum, Pathman, Larkina, Guler, & Burch, 2012).

Second, we explored multiple types of errors participants made in both the congruent and incongruent conditions (not just the incongruent condition like Sipe and Pathman) as well as in the neutral condition. Exploring the errors is beneficial for further understanding of the influence of participants' semantic memory on their episodic memory for the spatial location of the actions. Sipe and Pathman (2021) included familiar distractors (all 6 familiar locations) as answer choices in their recognition paradigm. They compared the proportion of match and nonmatch errors to what would be expected by chance ($1/6$ for match and $4/6$ for nonmatch, respectively). They could examine match errors and nonmatch errors only in the incongruent condition and found match errors were significantly different from what would be expected by chance. They did not find a difference in nonmatch errors than would be expected by chance. However, in the current study, we included additional types of distractors by including both familiar and novel distractors in addition to the congruency manipulation. We also examined

errors participants made in all three conditions (congruent, incongruent, and neutral). For the incongruent condition, not only were we able to investigate whether participants made more semantic match errors similar to Sipe and Pathman (2021), but it was also possible to explore the difference between semantic match novel errors and semantic match familiar errors that participants made. In addition to the above, we extended Sipe and Pathman by also examining errors for the other two conditions (congruent and neutral). In exploring errors for the congruent condition, we examined the difference between semantic match novel errors along with semantic mismatch familiar and semantic mismatch novel errors. This allowed us to investigate the effect of semantic match (the importance of semantic knowledge) and also the influence of familiarity. The neutral condition was set as a baseline and, by definition, there was no match or mismatch between action and location in this condition. However, we explored the errors to examine whether there was a semantic match or mismatch to correct answer (the location that was paired with the neutral action). As a result, in this study, we were able to explore errors from three different perspectives, including familiar (reexperienced) and novel (never experienced) stimuli, along with a congruency effect (actions match or mismatch with the location). To be more specific, we were able to explore recollection (remembering the details about the actions or locations that were really experienced) and familiarity (feeling that the actions or locations were experienced previously without recollection) for the recognition task and also a congruency effect for the accuracy for spatial locations for the old actions. Exploring congruency effect errors (match or mismatch) would pave the way to examine the influence of semantic knowledge about the actions on episodic details about the spatial locations for the actions.

Predictions

We hypothesize that there would be higher accuracy for episodic memory about the spatial location of the actions in the congruent condition compared to the incongruent condition. We also predicted larger differences in remembering episodic locations for the actions between the delay group (i.e., one-week delay) than the immediate group. We expected immediate groups to remember episodic details about the spatial locations for the actions more accurately. Moreover, we predicted an interaction between condition and delay; we expected the size of the difference in accuracy between the congruent condition compared with incongruent condition to be larger in the delay group than in the immediate group. In terms of recognition accuracy, we predicted an interaction between delay and condition; we expected a larger congruency effect (larger difference in spatial memory accuracy for congruent and incongruent conditions for the delay group compared with immediate group). We also predicted participants in both the immediate and delay groups to remember the actions in the congruent condition more accurately compared with the incongruent and neutral conditions.

With regards to error exploration for the incongruent condition, we expected that semantic match familiar errors would be the highest error type, similar to Sipe and Pathman (2021), followed by semantic match novel errors. We predicted that participants would make more semantic match errors because of the influence of participants' semantic memory for the actions on their memory for spatial locations for the actions. Moreover, we predicted semantic match familiar errors to be highest as a result of the influence of both semantic knowledge and a familiarity effect. For the congruent condition, we expected semantic match novel errors to be highest error type due to the influence of participants semantic knowledge about the actions on their episodic memory for spatial locations of the actions. We also predicted that participants

would made more semantic mismatch familiar errors compared with semantic mismatch novel errors as a result of a familiarity effect. For the neutral (baseline) condition, we predicted more errors that were a semantic match to the correct answer (the location that was paired with the neutral action). Overall, we expected participant's semantic memory about the actions influence on their memory for spatial locations for the actions.

Chapter Two: Method

Participants

A total of 83 adults took part in this study. Ten participants were excluded from the analyses due to the following reasons: a) they did not attend the second session ($n = 6$), b) they could not pass the initial phase of the PPVT task ($n = 2$), c) examiner's mistake while conducting the PPVT ($n = 1$), and d) computer software error ($n = 1$). The final sample included 37 participants for the immediate group ($M_{age} = 25.03$ years, $SD = 9.47$; 33 females and 4 males) and 36 participants for the delay group ($M_{age} = 23.94$ years, $SD = 6.99$; 28 females and 8 males). The sample size exceeded previous sample size for Sipe and Pathman (2021).

Demographic information was collected to describe the sample as a whole. The demographic questionnaire completed by participants showed that approximately 23%, 21%, 10%, and 8% of the participants were South Asian, African American or African Canadian, Mixed Race, and White or Caucasian, respectively. Additionally, 5%, 5%, 4%, 4%, 3%, 3%, 3%, and 3% of the participants were Chinese, Filipino, Southeast Asian, Latin American, Caribbean, Arab, Korean, and West Asian, respectively. An additional 8% of the participants reported they were from another ethnicity. The family income reported was <\$20,000, \$20,000-40,000, \$40,000-60,000, and \$60,000-90,000, \$90,000-120,000, and \$120,000-150,000 for 8%, 21%,

22%, 21%, 15%, and 10% of the participants, respectively. An additional 4% of participants reported an income of >\$150,000.

Participants were recruited from York University's Undergraduate Research Participant Pool (URPP) and all participants were tested by the same female experimenter. Participants signed up for the study through the URPP, which was followed up with information relating to the informed consent form provided through an email. Participants were asked to complete the informed consent form through the online platform Qualtrics. Once the informed consent form was signed, participants were asked to contact the researcher to request a secure Zoom link for the first session consisting of the encoding phase. Following the encoding phase, half of the participants were tested for the retrieval task shortly after the encoding phase (15 minutes; referred to as the immediate group), while the other half were tested after an approximately a week-long delay (range: 5 days to 7 days; $M= 5.47$, $SD=.84$; referred to as the delay group). The delay group received a separate link for the test phase of the study (i.e., the second session), which was sent via email, four days after completing the first session. Participants received course credit for their Introduction to Psychology course for their participation in the study. Pilot testing was completed by MDLaB lab members to determine and confirm the length of delay (in order to avoid floor or ceiling effects). MDLaB lab members were not informed of the hypotheses and the purpose of the research prior to test. Data collection occurred from March 3rd to July 19th, 2021. The Research Ethics Board at York University approved the procedure for the study.

Stimuli

For the recognition memory task, stimuli were pictures that were presented to participants online through a Qualtrics survey. Images for the encoding phase were cartoon characters paired

with cartoon backgrounds. Images for the retrieval phase were cartoon characters and backgrounds presented individually (see Procedure section below). Pictures were selected from <https://www.freepik.com>. Four different cartoon characters were selected from <https://www.freepik.com/colorfuelstudio>. Using photoshop and illustrator, images were set up with equal dimensions and put on black margins (see Appendix 1).

Pilot testing

Following Sipe and Pathman (2021), the action and background images were selected based on results from the pilot testing and the actions that best matched a background scene among 91 initial actions and background image collected from <https://www.freepik.com>. To select actions for the congruent and incongruent conditions, from an overall number of 52 actions, they were asked to rate if “This action can only be completed in this location” (background scene). To select the actions for the neutral condition, from an overall number of 39 actions, they were asked to rate if “This action can occur anywhere or in multiple types of locations”. A Likert scale ranging from “strongly agree” to “strongly disagree” was used to measure the degree of agreement for actions and locations and only the actions for which lab members selected “agree” or “strongly agree” were selected for the study.

Procedure

All participants were tested using episodic memory task (seeing actions and locations during encoding phase), recognition memory task (memory about the old/new actions and spatial locations for the old actions during retrieval phase), and Peabody Picture Vocabulary Test (PPVT). In addition, participants had the Semantic Interview task at the beginning of the session (before the encoding phase) and Language and Social Background Questionnaire (LSBQ) (before the retrieval phase), but the results of the semantic interview and LSBQ are not reported

in this thesis. For both groups, the order of tasks was the same except the immediate group was assigned with 3 minutes of math problems before receiving the LSBQ (during the 15-minute break before the encoding and retrieval phases). The delay group was not assigned any math problem. To assess the impact of delay, the retrieval and PPVT task were completed during the second session for this group. Sessions were completed through Zoom, which included audio or video recording. The experimenter was present during the session to provide an additional explanation and training to allow for completion of the task. The encoding and retrieval tasks were programmed in Qualtrics, and participants received the link via the Zoom chat window during the Zoom session. The Qualtrics links included both written instructions and audio recorded instructions so that participants were able to understand the task in case of technical audio related difficulties with their computer or tablet. A female MDLaB research assistant (RA) pre-recorded the audio instructions (this RA was selected among the RAs whose native language is English). The audio recording was programmed to automatically play throughout the Qualtrics survey. See Appendix 1 for the script.

Episodic memory task

The primary goal of this study was to examine whether semantic knowledge (knowledge about about what occurs in different spatial locations) influence episodic memory (memory for actions and context, in this case background scenes and locations) in adults. Prior to beginning the episodic memory task, participants were presented with the image of the cartoon characters doing an action along with an image of a background scene (each at the same time). Episodic memory task included the a) encoding phase (approximately 5 minutes) followed by a delay (15 minutes for immediate group and 5-7 days for delayed group), and b) the retrieval phase (10-15 minutes). During the encoding phase, participants were asked to look at both images (action and

location), listen to the audio describing the action and try to remember both images together.

Participant's memory was examined using an old-new recognition task that included follow-up context (background scene) questions for recalling the location in which an old action that was seen had occurred.

Practice Encoding Phase. Participants were provided with the scripts for encoding instructions and also heard a playback of the audio recording of the instructions. Examiner was present during the session to provide additional explanation and to clarify any questions about the task. The *practice encoding phase* was an exact replication of the *encoding phase*.

Participants were asked to look at a picture of a cartoon character performing an action along with a cartoon background scene presented beside it (See Figure 2). They were asked to pay attention to the character, the action and the scene (see Appendix 1 for precise instructions given to the participant). They also heard a pre-recorded audio stating the name of the character performing the action for both congruent and incongruent conditions (e.g., Anna is brushing her teeth). Also, in each trial they were asked to click on the action and location as well as play the audio (if audio was not played automatically in their system). There were 5 practice trials (two congruent, two incongruent and one neutral) with each slide lasting for 10 seconds. After the 5 practice trials, participants moved on to the encoding phase.

Encoding Phase. The encoding phase followed the practice encoding phase. This phase consisted of 24 trials. Overall, 24 actions were selected for the experimental session (8 actions for each condition: congruent, incongruent, neutral). For each trial, participants saw a cartoon character doing an action (e.g., a girl buying clothes) superimposed on a background scene (e.g., a clothing boutique for congruent condition and flower shop for incongruent condition). For each trial, they also heard a pre-recorded audio stating the name of the character performing the action

for both the congruent and incongruent conditions (e.g., Anna is buying clothes). Images were presented for 10 seconds each with an automatic progression to the next. Eight trials were congruent (semantic match between action and scene), 8 trials were incongruent (semantic mismatch between action and scene), 8 trials were neutral (for this set, we choose actions that were possible to happen in every place; e.g., every possible novel scene selected for “taking selfie” for this set was not from category of the scenes we choose for congruent and incongruent actions). Congruent, incongruent, and neutral trials were presented in a randomized order for each character. Please see Appendix 2 for more information. We counterbalanced congruent and incongruent actions across participants (i.e., for some participants buying clothes action image was in a congruent trial, for other participants buying clothes image was in an incongruent trial). Please see Figure 1 for more information.

Participant’s memory for the old and new actions (recognition task) as well as their memory for identifying the location of the old actions was tested through the Qualtrics link during Zoom session.

Practice Retrieval Phase. After completing the encoding phase, participants saw the scripts for retrieval instructions as well as heard pre-recorded audio instructions. Training trials included two old images of the action (one congruent condition and one incongruent condition) and one new image of the action (each presented one at a time). Participants were presented with image of cartoon characters doing an action (e.g., Anna is dancing). Then they heard a pre-recorded audio asking about the action while also stating the name of the character (e.g., Did Anna dance?). For every old action, participants were presented with an image set of 4 locations at the same time and also heard a pre-recorded audio asking to select the correct background for

the old action (e.g., Where did Anna dance?). Backgrounds included one target and three distractors. See Appendix 1 for instructions.

Retrieval phase. The retrieval phase started following the practice retrieval phase. This phase consisted of 24 trials (12 old and 12 new actions). For each of the old action, there was an additional task for location judgment. Among the 12 trials for old actions, 4 trials were congruent, 4 incongruent, and 4 were neutral. For each character, three old actions (one action per each condition), and three new actions were assigned. Actions were presented in a random order, one at a time. For each old and new action, participants saw an image of the cartoon character doing an action and heard a pre-recorded audio asking about the action. The audio recording played automatically throughout each question. Participants were asked if they saw the presented action in a previous stage (e.g., Did Anna buy clothes?). For the actions that were old (regardless of whether the participant selected old or new), participants saw the follow up screen with 4 different locations and at the same time, they heard a pre-recorded audio asking about location of the action and to select the background scene that was paired with that action during the encoding phase. Similarly, the audio recording played automatically throughout each question (e.g., Where did Anna buy clothes?). These locations were presented in a randomized order. Participants were asked to select the correct background from 4 different backgrounds (one target and 3 distractors). The background options for each congruent and incongruent trial included: a) semantic match familiar (background that matched the action; background seen during encoding), b) semantic match novel (background that matched the action; background was not seen during encoding), c) semantic mismatch familiar (background that did not match action; background seen during encoding), and d) semantic mismatch novel (background did not match action; background not seen during encoding). Option A was the target for the congruent

condition. Option C was the target for the incongruent condition. Chance was 0.25 (1/4). See Figure 3 for the congruent condition and Figure 4 for the incongruent condition.

The background options for each neutral trial included: a) target (background paired with the action during encoding; e.g., old car factory), b) target category mismatch novel (background did not match the category of target; background not seen during encoding; e.g., a gym), c) target category match novel (background that matched the category of the target; background was not seen during encoding; e.g., another version of car factory), and d) target category mismatch familiar (background that did not match the category of the target; background seen during encoding; e.g., another version of a gym). Chance was 0.25 (1/4). See Figure 5.

All questions, including actions and locations, were set using the forced response function in Qualtrics to ensure all questions were answered. No time limit was assigned for this phase, so participant had the option to spend any amount of time on each question. To measure response time, Qualtrics was programmed to record a) the time of first click, b) the time of last click, c) the number of clicks, and d) the time of page submit. The time of last click was used as the measure of reaction time. Please see Appendix 3 for more details.

Assessment of Standardized Semantic Knowledge: PPVT

Participant's generic knowledge based on language was assessed with the Peabody Picture Vocabulary Test (PPVT) at the end of experimental session (Dunn & Dunn, 2007). In this assessment, participants were presented with a physical PPVT book during the Zoom session. After participants received training on the PPVT, they heard a word spoken by the experimenter and were asked to select the image that most corresponded with that word out of a matrix of four images. Each image in the 4-image matrix was labelled with a number. These

numbers was how participants identified the image that most matched the word repeated by the experimenter. Following the experimental and the PPVT script, the experimenter conducted the PPVT and participant's responses and score were recorded in a confidential response form (each form included the participant's ID and is kept in a locked drawer).

Note About Delay

There was a minor change to the study procedure for the delayed group. At the beginning of the study, some participants ($n = 8$) were tested 7 days after the encoding session and some participants ($n = 8$) participants were tested 5 days after the encoding session. These differing delays were used during data collection to assess the difference between a 5-day and 7-day delay. No statistical difference was found in the performance of both sub-groups $F(1, 14) = 1.22$, $p = .29$, $\eta_p^2 = .08$. Therefore, the remaining participants in delayed group were tested 5 days after the encoding session. One additional participant was tested 6 days after the encoding session due to a technical difficulty on the fifth day. Thus, although we are calling the delay a 1-week delay, the majority of participants were tested after 5 days.

Scoring

We assessed participants' memory for the actions (i.e., old and new actions) as well as their memory for the locations of the old actions. For the old and new recognition episodic memory task, the proportion of the scores from the item (old/new actions) were obtained. Following the standard protocol for tests of old-new recognition, for every participant, the proportion of false alarms (incorrectly identifying a new item as old) was subtracted from the proportion of hits (correctly identifying an old item as old) to obtain the corrected recognition scores. Scoring for participants' spatial memory for location of the actions was obtained by

calculating the proportion of the correct responses for every old action in each of the congruent, incongruent, and neutral conditions.

To explore errors, we focused on each type of error (i.e., each distractor option) in every condition and calculated the proportion of trial that were errors (each type of errors/4 in every condition), as described below.

Congruent condition. To investigate errors for the congruent locations of the actions, we categorized errors as 1) semantic match novel, 2) semantic mismatch familiar, and 3) semantic mismatch novel. Semantic match novel error was when participant incorrectly responded they saw the action in a novel location that was semantically related to the action but in fact participant never saw that location during the encoding phase (e.g., they responded they saw going camping paired with an image of a novel forest camp other than the exact image of the forest camp paired with that action). When participant incorrectly judged they saw the action in a familiar location that was not semantically related to the action, this was identified as a semantic mismatch familiar error. This location was familiar because participants saw it paired with another action (e.g., participant identified they saw going camping on a familiar cinema, however, they saw another action was paired with that familiar cinema). Semantic mismatch novel error was when participant incorrectly responded they saw the action in a novel location that was not semantically related to the action but in reality, participant never saw that location during the encoding phase (e.g., participant responded they saw going camping at a novel cinema). See Figure 3.

Incongruent condition. To investigate errors for the incongruent locations of the actions, we categorized errors as 1) semantic match familiar), 2) semantic match novel, and 3) semantic mismatch novel. Semantic match familiar error was when participant incorrectly responded they

saw the action in a location that was semantically related to the action but in fact participant saw that location during the encoding phase paired with another action (e.g., they responded they saw going camping paired with an image of a familiar forest camp which was in fact paired with another action during encoding). When participant incorrectly judged they saw the action in a novel location that was semantically related to the action, this determined as semantic match novel error. This location was novel because participant never saw it paired with any other action (e.g., participant identified they saw going camping on a novel forest camp). Semantic mismatch novel error was when participant incorrectly responded they saw the action in a novel location that was not semantically related to the action. While in reality, participant never saw that location during the encoding phase (e.g., participant responded they saw going camping at a novel cinema). See Figure 4.

Neutral condition. To investigate errors for neutral locations of the actions, we categorized errors as 1) category match novel), 2) category mismatch familiar, and 3) category mismatch novel. Category match novel error was when participant incorrectly selected a location that was matched with the category of location (e.g., the identified car factory as a location paired with taking selfie during encoding phase, while in fact they saw taking selfie paired with another version of the car factory not the version they selected). Category mismatch novel error was when participant incorrectly selected a location that was not matched with the category of the location participant saw the action (e.g., responding they saw taking selfie in a novel gym) and participant never see that location with another neutral action. Category mismatch familiar error was when participant incorrectly selected a location for an action that was not matched with the category of the location seen with the action. In fact, participant saw that location with

another action (e.g., participants responded they saw taking selfie in a familiar gym other than the exact gym paired with the action during encoding phase). See Figure 5.

To explore errors, the score for each type of error was summed up and the proportion for each type of error in every condition was calculated. For each condition there were 4 options to select a location. Therefore, the chance for each type of error to occur was (1/4).

Chapter Three: Results

Preliminary Analyses

To investigate whether both immediate and delay groups were similar and there were no unexpected differences between two groups, preliminary analyses conducted for both group's reaction time and performance on Peabody Picture Vocabulary Test (PPVT).

Reaction time. To determine whether the immediate group and delayed group varied in the reaction time, preliminary analyses were conducted for both the encoding task and the retrieval task. Each item was designed to be displayed on a separate page on Qualtrics. For example, every action and location displayed in separate page for encoding. Also, for retrieval, every single new and old action each presented on one page and then, four options for the location of the old action were displayed on another single page. As mentioned earlier, Qualtrics was programed to record the time of participants' first click, last click, number of clicks, and page submit. Reaction time was determined as the time that each participant last clicked to select their response. The average of the time of the last click for the encoding phase (click on action and location) and retrieval phase (click on "yes" or "no" for the old and new actions as well as click to select one of the four locations) were computed for every participant.

For the encoding phase reaction time preliminary analysis, the t -test was not significant, $t(71)=-1.88, p=.06, d=-.44$. Participants in the immediate and delay groups did not vary in the time they clicked on the actions and locations.

As a comparison, we also examined click RT for the retrieval phase. Here we would expect the delay to cause a difference between groups. Both the immediate and delayed groups performed different in their reaction time for the retrieval phase. The delay group took longer to respond for the locations ($M=7.36, SD=2.70$), new actions ($M=4.86, SD=1.38$), and old actions ($M=4.78, SD=1.37$) compared with immediate group's responses for the locations ($M=5.09, SD=2.41$), new actions ($M=4.06, SD=1.35$), and old actions ($M=4.08, SD=1.27$). These RT differences between groups were statistically significant for the locations, $t(71)=-3.79, p<.001, d=-.89$, new actions, $t(71)=-2.50, p=.01, d=-.59$, and old actions, $t(71)=-2.26, p=.02, d=-.53$.

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Peabody Picture Vocabulary Test (PPVT). We conducted preliminary analysis to determine whether immediate and delayed group varied in their language competence. To do so, we investigated participant's standard scores for Peabody Picture Vocabulary Test (PPVT) and found no significant difference, $t(71)=.11, p=.91, d=.03$. Thus, the two groups did not differ in their language competence which can be used as a measure of standardized semantic memory (e.g., vocabulary, definitions).

Episodic Memory Task

Two Condition (congruent, incongruent) X Group (immediate, delay) repeated measures analysis of variance (RM ANOVAs) were conducted. The first RM ANOVA assessed old/new recognition: the results for the corrected recognition scores indicated a main effect of Group, $F(1,71)=6.13, p=.01, \eta_p^2=.08$. Across conditions, accuracy was higher for the participants in the immediate group ($M=.62, SD=.37$) compared with participants in the delay group ($M=.46, SD=.37$) ($p<.05$). However, we found no significant main effect of Condition, $F(1,71)=.50, p=.48, \eta_p^2=.007$, and no interaction, $F(1,71)=.13, p=.72, \eta_p^2=.002$.

The second RM ANOVA assessed participant's memory for the location of the actions and found a main effect of Group, $F(1,71)=26.05, p<.001, \eta_p^2=.27$. Across conditions, accuracy was higher for the participants in the immediate group ($M=.77, SD=.26$) compared with participants in the delay group ($M=.54, SD=.26$). We also found a main effect of Condition, $F(1,71)=29.71, p<.001, \eta_p^2=.30$. Across delay, accuracy was higher for the congruent condition ($M=.78, SD=.24$) compared with the incongruent condition ($M=.53, SD=.34$) ($p<.001$). There was no interaction, $F(1,71)=1.09, p=.30, \eta_p^2=.01$. See Figure 6.

It was not possible to counterbalance the neutral condition with the two main experimental conditions (congruent and incongruent). Therefore, like Sipe and Pathman (2021), neutral condition accuracy is not included in analyses directly comparing the congruent and incongruent conditions. However, it was used as a baseline condition to compare the effect of semantic knowledge about the actions on episodic memory for spatial locations of the actions in both congruent and incongruent conditions. We found that the two groups differed significantly in their corrected recognition scores for the neutral actions, $t(71)=3.71, p<.001, d=.87$. The immediate group ($M=.66, SD=.29$) performed were more accurate than the delay group ($M=.39,$

$SD=.33$) on corrected recognition for the neutral actions. Investigating spatial accuracy for the neutral actions, $t(71)=2.96, p=.004, d=.69$, the immediate group ($M=.70, SD=.26$) more accurately remembered the spatial location that was paired with that action during the encoding phase compared to the delay group ($M=.52, SD=.26$).

Neutral condition mean accuracy is represented in Figure 6 with dashed horizontal lines. Visual inspection of Figure 6 suggests that for both groups, accuracy in the congruent condition was higher than accuracy in the neutral condition. However different patterns seem to emerge based on visual comparison of the neutral and incongruent conditions between groups. For the immediate group, mean accuracy in the neutral condition was similar to that for the incongruent condition. Meanwhile, for the delay group, mean accuracy for the locations was higher for the neutral condition than incongruent condition.

Analysis of Errors

We investigated errors participants made in all three conditions. To explore errors, separate repeated measures analysis of variance (RM ANOVAs) were conducted for each condition: 1) Error Type (category match novel, category mismatch novel, category mismatch familiar) X Group (immediate, delay) for the neutral condition, 2) Error Type (semantic match novel, semantic mismatch novel, semantic mismatch familiar) X Group (immediate, delay) for the congruent condition, and 3) Error Type (semantic match familiar, semantic mismatch novel, semantic mismatch familiar) X Group (immediate, delay) for the incongruent condition.

Examining the type of errors for the incongruent condition, the results indicated the main effect of delay, $F(1,71)=8.70, p=.004, \eta_p^2=.11$. Across conditions, participants in the delay group made more errors ($M=.21, SD=.14$) compared with participants in immediate group ($M=.14, SD=.14$) ($p<.05$). We also found a main effect of error type, $F(2,142)=65.37, p<.001$,

$\eta_p^2 = .48$. Pairwise comparison revealed across delay, participants made more semantic match familiar errors ($M = .39$, $SD = .27$) than semantic match novel errors ($M = .08$, $SD = .15$) and semantic mismatch novel errors ($M = .06$, $SD = .12$) ($p < .05$). Semantic match novel errors and semantic mismatch novel errors did not differ ($p = .42$). We found no interaction between the delay and the type of errors participants made, $F(2, 142) = 1.29$, $p = .27$, $\eta_p^2 = .02$. See Figure 7.

Exploring the type of errors for the congruent condition, the results indicated a main effect of delay, $F(1, 71) = 11.32$, $p = .001$, $\eta_p^2 = .14$. Across conditions, participants in delay group made more errors ($M = .10$, $SD = .11$) compared with participants in immediate group ($M = .04$, $SD = .10$) ($p < .05$). We also found a main effect of error type, $F(2, 142) = 5.83$, $p = .004$, $\eta_p^2 = .08$. Pairwise comparison revealed that across delay, participants made more semantic match novel errors ($M = .11$, $SD = .19$) and semantic mismatch familiar errors ($M = .09$, $SD = .18$) compared to semantic mismatch novel errors ($M = .02$, $SD = .08$) ($p < .05$). Semantic match novel and semantic mismatch familiar error types did not differ ($p = .46$). Further, we found no interaction between the delay and the type of errors participants made, $F(2, 142) = .90$, $p = .41$, $\eta_p^2 = .01$. See Figure 8.

For the neutral condition, the results indicated a main effect of delay, $F(1, 71) = 11.38$, $p = .001$, $\eta_p^2 = .14$, a main effect of error type, $F(2, 142) = 24.00$, $p < .001$, $\eta_p^2 = .25$, and also an interaction between the type of errors participants made and the delay $F(2, 142) = 5.50$, $p = .005$, $\eta_p^2 = .07$. To follow up this, we conducted separate RM ANOVA for each of the immediate and delay groups. The results for RM ANOVA was significant for both immediate group, $F(2, 72) = 4.07$, $p = .02$, $\eta_p^2 = .10$ and delay group, $F(2, 70) = 22.04$, $p < .001$, $\eta_p^2 = .39$. Pairwise comparison revealed participants in immediate group made more category mismatch familiar errors ($M = .15$, $SD = .21$) than both category match novel errors ($M = .06$, $SD = .11$) and category mismatch novel errors ($M = .06$, $SD = .11$) ($p < .05$). Participants in immediate group did not differ

in category match novel and category mismatch novel errors ($p=1.00$). Participants in delay group made more category mismatch familiar errors ($M=.32, SD=.24$) compared with both category match novel ($M=.10, SD=.15$) and category mismatch novel errors ($M=.06, SD=.11$) ($p<.001$). Participants in delayed group did not differ in category match novel and category mismatch novel errors ($p=.08$). We followed up the interaction the other way and it was the case that participants in the delayed group made more category mismatch familiar errors than the immediate group, $t(71)=-3.28, p<.002, d=-.77$. However, both groups did not differ in category match novel errors, $t(71)=-1.19, p=.24, d=-.28$, and category mismatch novel errors, $t(71)=.21, p=.83, d=.05$. See Figure 9.

Chapter Four: Discussion

The primary purpose of the current study was to investigate how semantic knowledge about actions influences episodic memory for the actions and their spatial locations. We presented participants with images of a cartoon character doing an action along with an image of the location for the action. Later (with or without delay), we tested their memory for the actions and their spatial locations. To investigate whether participants' semantic knowledge about the actions influence on their episodic memory for the location of the actions, we manipulated the actions to the extent that they matched, mismatched, or were not related to the location paired with them. We assessed both accuracy scores for episodic memory for the actions (recognition task) and episodic memory for the actions' spatial locations. We also explored the errors made. Our preliminary analysis of the PPVT indicated that participants in each of immediate and delay group were similar in terms of their English language competence and semantic knowledge (as assessed via vocabulary).

When we investigated the results for participants' spatial memory for the locations of the actions, we found that participants more accurately identified the locations for the congruent actions compared with locations for the incongruent actions. For example, when participants were asked where they saw the specific action (e.g., making salad), they identified the location more accurately if they saw this action paired with a congruent location (e.g., kitchen) than when they saw this action paired with an incongruent location (e.g., basketball court) during the encoding phase. Perhaps participant's existing semantic knowledge about the actions boosted their episodic memory performance for the location of the actions in the congruent condition due to the "feature correlation" in semantic memory (McRae, Cree, Westmacott, & Sa, 1999). Apparently, participant's semantic knowledge about the relationship between the concepts of actions and their features (hear, between "making salad" and having "knife to cut the vegetables"; The knife is a kitchen accessory not a basketball court's equipment, or vegetables is kept in the fridge and fridge is located in the kitchen not in the basketball court) influenced episodic memory for the spatial locations of the actions. This result was similar to Sipe and Pathman (2021), where they explored the influence of children's semantic memory on episodic memory performances for the congruent and incongruent events. Remembering more episodic details about the actions in the congruent condition was indicated that "congruency" facilitate memory process through semantic attribution and the relational binding performance (Staresina, Gray, & Davachi, 2009). For example, perception of additional semantic details "matching" between the action and location (e.g., "flower shop" or "boutique") could facilitate the identification of the correct location and reject the incorrect location for the actions (e.g., "buying clothes") at the retrieval phase. This interpretation is similar to that proposed by Sipe and Pathman (2021) and falls in line with the work of Robertson and Köhler (2007) when they

concluded that children's semantic knowledge contributed to their episodic memory. Our findings are also consistent with the findings of Staresina and colleagues (2009) that superior memory for additional details about the source of congruent items in memory including subjective schema which is defined as how new information about the concept of an item fit to mental rules and scripts about the item (McVee, Dunsmore, & Gavelek, 2005), facilitates processing the item in memory. These findings support the idea that semantic memory plays a role in recalling episodic details (Irish & Piguet, 2013).

In the present study participants were explicitly told to "try to remember both actions and locations together later on" by both audio recorder and the experimenter as they would be tested on this later on (intentional/effortful learning; Hasher & Zacks, 1979). In Sipe and Pathman (2021) however, participants were not explicitly told they had to remember the actions, or their spatial locations (incidental/automatic learning; Hasher & Zacks, 1979). In Sipe and Pathman (2021), participants were not expecting the retrieval phase, while in our study they were expecting the retrieval phase. The similarity in the result patterns suggests that whether or not participants were explicitly told they have to remember the actions and locations together, they still remember the episodic spatial locations for the actions with the support of their memory for semantic knowledge about the actions. According to Hasher and Zacks (1979), participants were able to remember the locations when they learn them "intentionally" and also when they learn them "incidentally".

Investigating the type of errors participants made in each condition, different patterns were observed. First, we discuss the exploration of the errors in incongruent condition which was the focus of error analysis in Sipe and Pathman (2021). We assigned three distractors (semantic match familiar, semantic match novel and semantic mismatch novel) for the incongruent

condition. Similar to Sipe and Pathman (2021), participants made more semantic match familiar errors than any other type of error for this condition which is indicative of the influence of participant's semantic memory for the actions on their episodic memory for spatial locations for the actions. As indicated by Lloyd et al. (2009), memory for an experience does not include a single item, but is formed through combination processes and connections between items (linkage between the item and its context). For example, when participants remembered a specific action (e.g., playing on the seesaw), semantic knowledge about the mentioned action interfered with remembering of the location that participants saw the action, and led them identify familiar "playground" as a correct location in incongruent condition. According to Fivush et al. (1984), if there were no intrusions of the general events (here, general knowledge about the actions) on the specific events (here, episodic memory for the spatial locations of the actions), we would not expect the high rate for the match errors. Our results showing that semantic match errors were more likely than other types of errors would be evidence that participant's semantic memory about the actions played an important role on their identification for the spatial location for the actions. Another finding for error exploration in the incongruent condition was that participants made more semantic match familiar errors compared with semantic match novel errors. This might be because of the influence of both semantic knowledge and familiarity effect (incorrectly feeling to reexperience the event without conscious retrieval of an event). According to Diana, Yonelinas, and Ranganath (2008), sources of items remembered based on their contextual recollection; However, familiarity can influence on recognizing the source of item specially when participants were not successful on recollection.

Exploration of participant's errors for the congruent condition also revealed some interesting results. For the congruent condition we imposed three distractors including semantic

match novel, semantic mismatch familiar, and semantic mismatch novel locations. As we predicted, participants made more semantic match novel errors followed by semantic mismatch familiar errors. More match errors can be interpreted as another indication for the influence of semantic memory on remembering episodic details. When participants made more errors from the semantic match novel category (e.g., incorrectly selecting a novel location that was semantically matched with the action), that might be the influence of integration of semantic knowledge about the actions and semantic information about the location of the action as determined by Bein et al. (2015). Another finding for error exploration in congruent condition was that participants made more semantic mismatch familiar errors compared with semantic mismatch novel errors as a result of familiarity effect as discussed above and indicated by Diana et al. (2008). Errors that were semantic mismatch familiar in congruent, might be indicative of participant's semantic knowledge about the actual location that seen with the action. For example, when they saw "going camping" paired with the "cinema" during encoding trial, semantic knowledge about the "cinema" might have guided them to incorrectly select the other version of the "cinema" instead of the exact "cinema" that was paired with the action. This result was consistent with the findings of Atienza, Crespo-Garcia, and Cantero, (2011) that new episodic details forms in memory with the support of semantic congruency and memory for episodic locations were more accurate when the context was semantically congruent to the items. The result for the error analysis in both incongruent and congruent conditions were indicative of less semantic mismatch novel errors in both conditions. Evidently, the reason would be due to both characteristics of this type of error (being mismatch and being new). Being mismatched prevented participant's semantic knowledge about the actions to influence and interference on their episodic spatial memory for the locations of the actions. According to Prior and Bentin

(2008) formation for new semantic details in memory improved and facilitated by memory semantic processing operation.

For the neutral condition we included three distractors including category match familiar, category mismatch familiar and category mismatch novel. Unlike for the congruent or incongruent condition in which there was a match or mismatch between the action and location, for the neutral condition distractors were defined by the category of the target location. It was related to the category of the location that was paired with the action during the encoding phase (e.g., participants saw “looking at a tablet” in a “subway station”). Thus a category match novel location would be another version of a “subway station” not the exact “subway station” seen during the encoding phase. Examining errors in the neutral condition as we expected, participants made more errors that were a semantic match to the target (i.e., correct answer). For example, when they saw “taking selfie” at a “gym” and later they were asked where they saw that action they selected another version of the “gym” in error. This was evidence for the influence of participant’s semantic knowledge on their episodic memory for the spatial location. Possibly they selected the novel “gym” instead of the target “gym” because they remembered it was a gym, but were not able to accurately remember the exact “gym” they saw during encoding phase. Interestingly, for this condition participants also made more mismatch familiar errors. For example, they saw “taking selfie” at a “gym” but they incorrectly identified a familiar “car factory” as a location for this action. The reason would be due the nature of the action (being neutral) participant’s semantic memory for the action could not support them in remembering the episodic memory for the location of the action. As a result, they relied on familiarity and incorrectly selected this type of error.

With respect to the old/new recognition for the action (i.e., corrected recognition scores), similar to Sipe and Pathman (2021) we did not find any difference between conditions.

According to Sipe and Pathman (2021), children were able to identify the event they took part in (old) and reject the event that they never took part in (new) due to the fact that children actively took part in the actions and thus all actions were self-relevant which has been shown to improve memory (e.g., Pathman, Samson, Dugas, Cabeza, & Bauer, 2011). Thus Sipe and Pathman stated that they did not find a condition effect for the actions because the memory representation of the actions was strong enough and not influenced by other factors like congruency between action and location. Sipe and Pathman's explanation of why there was no congruency effect for memory for the actions themselves (old/new recognition) cannot be used to explain our findings because our task did not involve active participation or self-relevance. However, we could use the same line of logic. The reason that we did not find a congruency effect for memory for the actions could be because adult's memory for the actions themselves were strong enough and so the condition manipulation did not affect accuracy. However, the condition manipulation did affect the more challenging task in which participants had to remember and bind action with a location. This finding was consistent with Sievers, Smith, Saasa, Simons and Renoult (2019), when they indicated participant's memory for the source of item were weaker. However, they were still less likely to forget the item itself.

Contrary to our predictions, there was no interaction between condition and delay: there was not a larger difference in accuracy between the congruent and incongruent conditions for the delay group compared to the immediate group. Perhaps a 5 to 7 day delay is not long enough to weaken the memory representation and make the delay group rely on semantic knowledge more than the immediate group. Thus, it is possible that we did not find an interaction because our

manipulation about delay was not strong enough. On the other hand, it is possible there was a difference between groups, but we did not detect this difference based on our primary analysis. Consideration of the neutral condition could give us more insight. Similar to Sipe and Pathman (2021), our results indicated accuracy for the locations was similar for the incongruent and neutral conditions for the immediate group. However, for the delay group the accuracy for locations was noticeably lower for the incongruent condition compared with the neutral condition (at least based on visual inspection of Figure 6). Thus it is possible that the delay group differed in their accuracy than the immediate group and were more negatively impacted by the incongruent condition even though we did not find this difference through our analyses. Future analyses of this data would explore that possibility.

We observed the influence of both delay and our experimental manipulation across both groups. Specifically, the effect of the delay was not only apparent in our preliminary analysis for the retrieval reaction time, but also observed in corrected recognition scores for actions, old/new recognition for the actions, spatial accuracy for the actions in all conditions, and the type of errors participants made in both groups. Participant's performance in all tasks were higher in immediate group and participants in delayed group were still able to remember the actions and their spatial locations in different conditions. Though, after a delay (5 to 7 days), it was participant's semantic knowledge about the actions that influenced their memory for the spatial locations and the type of errors they made when identifying the locations for the actions.

This research expanded the work of Sipe and Pathman (2021) to investigate the influence of semantic knowledge on episodic memory. Specifically, we examined the influence of participant's semantic memory about the actions on their episodic memory about the spatial locations for the actions in younger adults. To our knowledge, studies directly investigated the

influence of semantic knowledge on memory for binding actions and locations among adult age groups are rare, but several studies have examined the influence of semantic knowledge on other aspects of episodic memory in both typical adults and in patient population (e.g., Kan et al., 2009; Stampacchia et al., 2019). We expanded past findings by including a manipulation of delay and the various experimental conditions allowed us to explore the relation between semantic memory and episodic memory for the spatial locations of the actions. We also examined different type of errors in all conditions by including various distractors to discover the relation between semantic and episodic memory. However, this research was a lab-based research (e.g., participants saw visual stimuli on a computer screen). Although this study benefits the higher control validity, further studies need to investigate the influence of semantic memory on episodic memory for spatial locations among adults in naturalistic settings with the higher ecological validity and with stimuli that would not be limited to visual images and where adults can actively experience the events. Moreover, participants were selected from an undergraduate participant pool. Future studies can include participants other than undergraduate students, particularly children from different age groups to examine how semantic memory may influence episodic memory accuracy across development.

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Figure 1

Encoding Phase Trial Samples (10 sample trials)

Congruent condition
(semantic match)

Incongruent condition
(semantic mismatch)

Neutral Condition

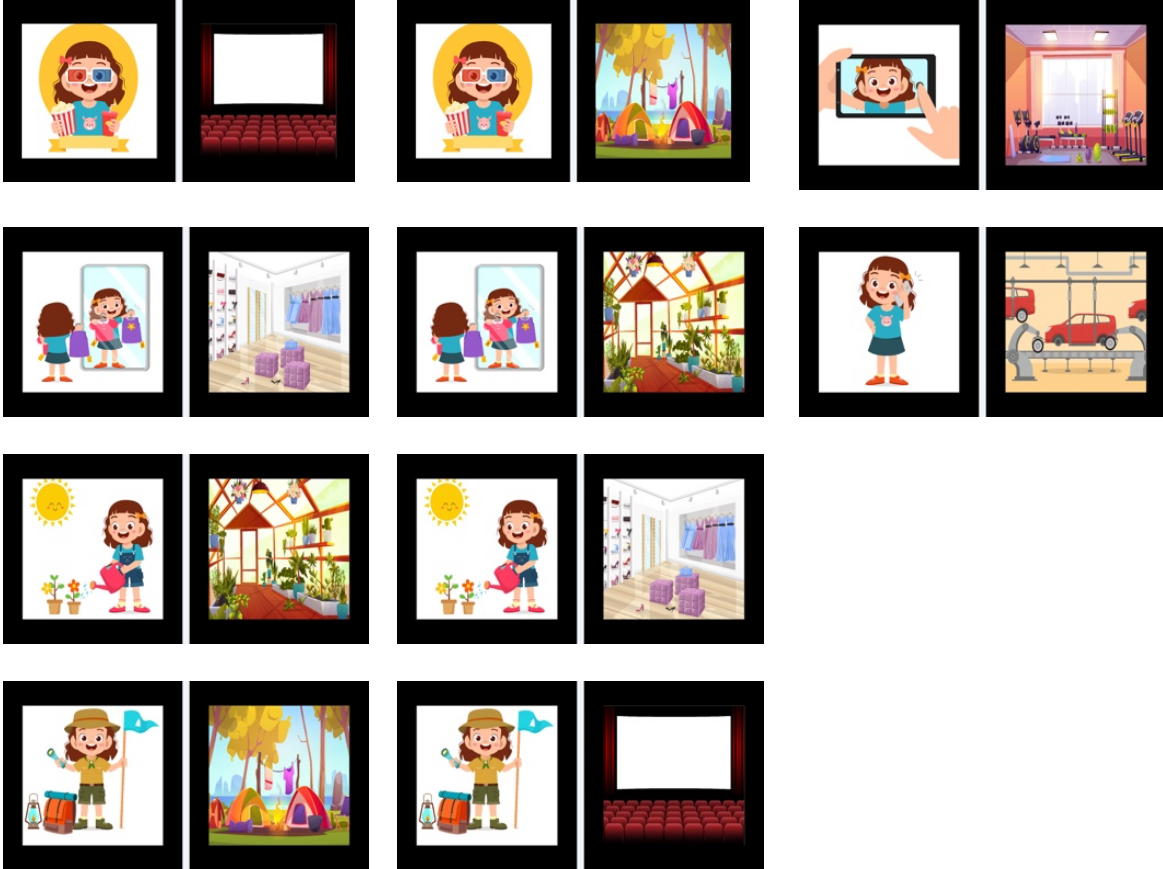
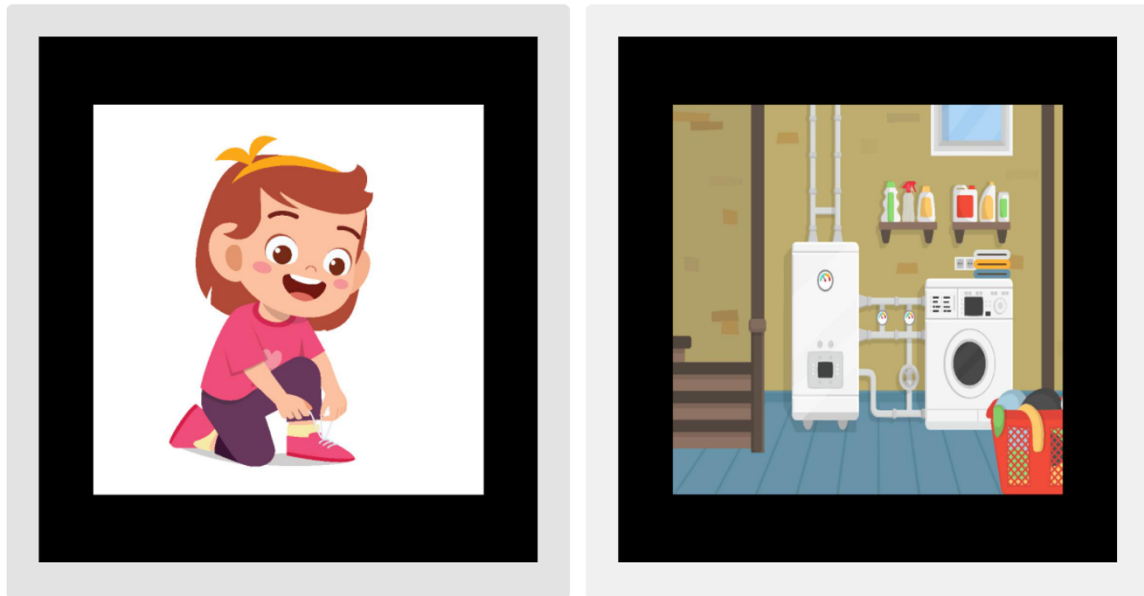


Figure 2

Computer Screenshot for Sample Image for Encoding Training Trial



Sara is tying her shoes

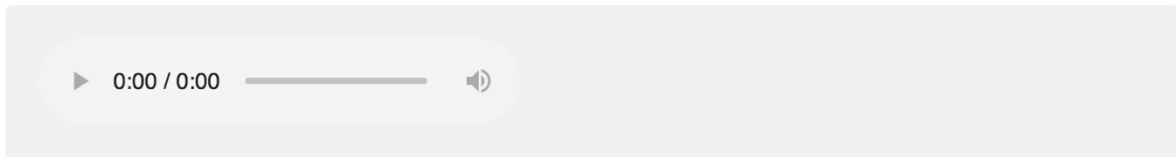


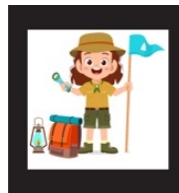
Figure 3

Retrieval Phase: Sample Image for Congruent Condition

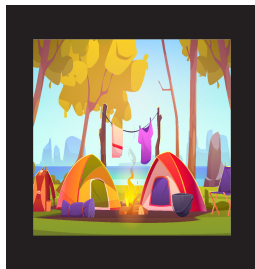
New action



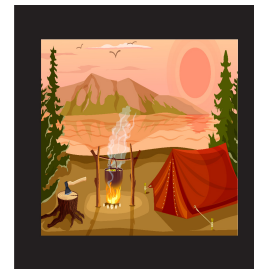
Old action



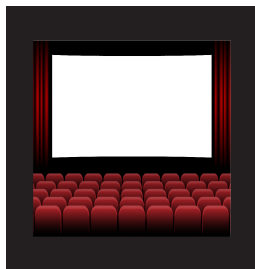
a) Semantic match familiar: Participants saw this location paired with the action during encoding phase (Target)



b) Semantic match novel: This location was semantic match with the action. However, it was not paired with any other action during encoding phase



c) Semantic mismatch familiar: Participants saw this location paired with another action during encoding phase



d) Semantic mismatch novel: This location was not paired with any action during encoding phase

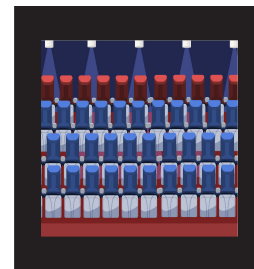


Figure 4

Retrieval Phase: Sample Image for Incongruent Condition

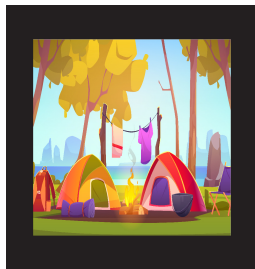
New action



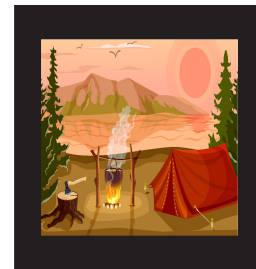
Old action



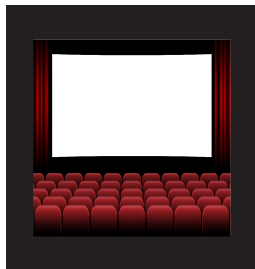
a) Semantic match familiar: Participants saw this location paired with another action during encoding phase



b) Semantic match novel: This location was semantic match with the action. However, it was not paired with any action during encoding phase



c) Semantic mismatch familiar: Participants saw this location paired with the action during encoding phase (Target)



d) Semantic mismatch novel: Semantic mismatch novel: This location was not paired with any action during encoding phase

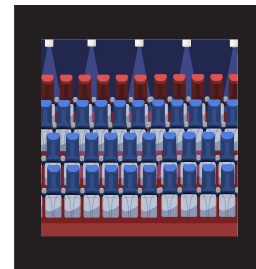


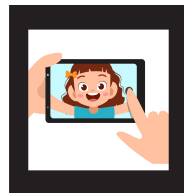
Figure 5

Retrieval Phase: Sample Image for Neutral Condition

New action

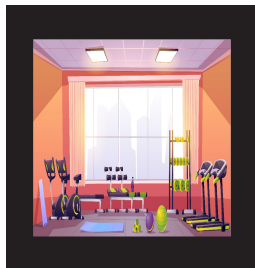


Old action



a) Category match familiar: This location is the target; Participants saw this location paired with the action during encoding phase

(Target)

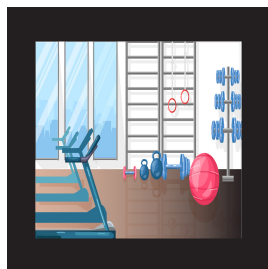


b) Category mismatch novel: This location was not matched with the category of the target and was not paired with any action during encoding phase

during encoding phase



c) Category match novel: This location was matched with the category of the target. However, it was not paired with any action during encoding phase



d) Category mismatch familiar: This location was not matched with the category of the neutral condition target; Participants saw this location paired with another action during encoding phase

encoding phase

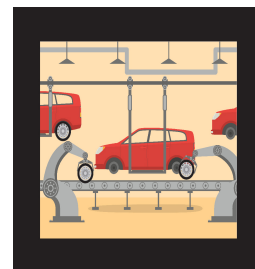
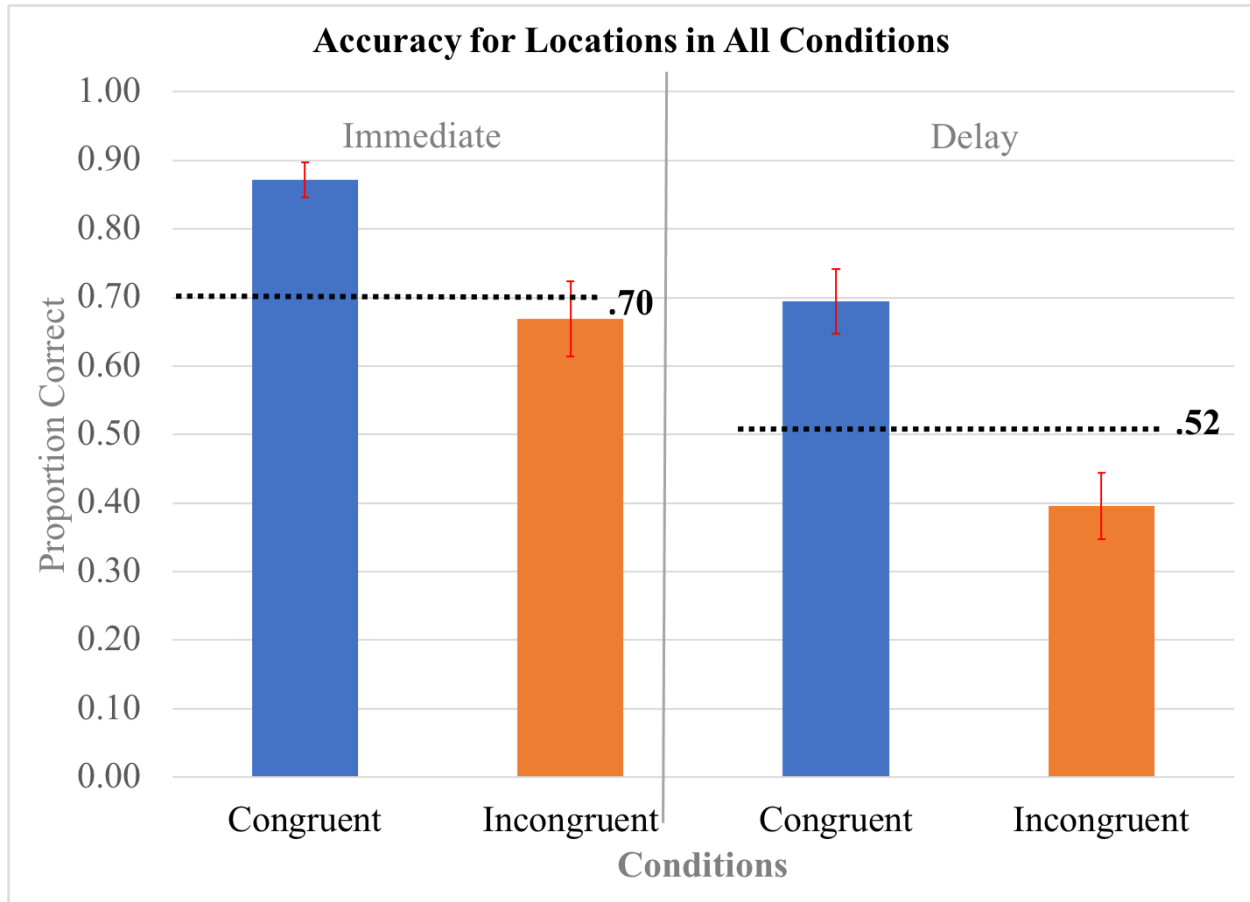


Figure 6

Accuracy for Locations in All Three Conditions



Note. The dash horizontal line represents mean accuracy for the neutral condition. Error bars are $\pm SEM$

Figure 7

All Types of Errors in Incongruent Condition

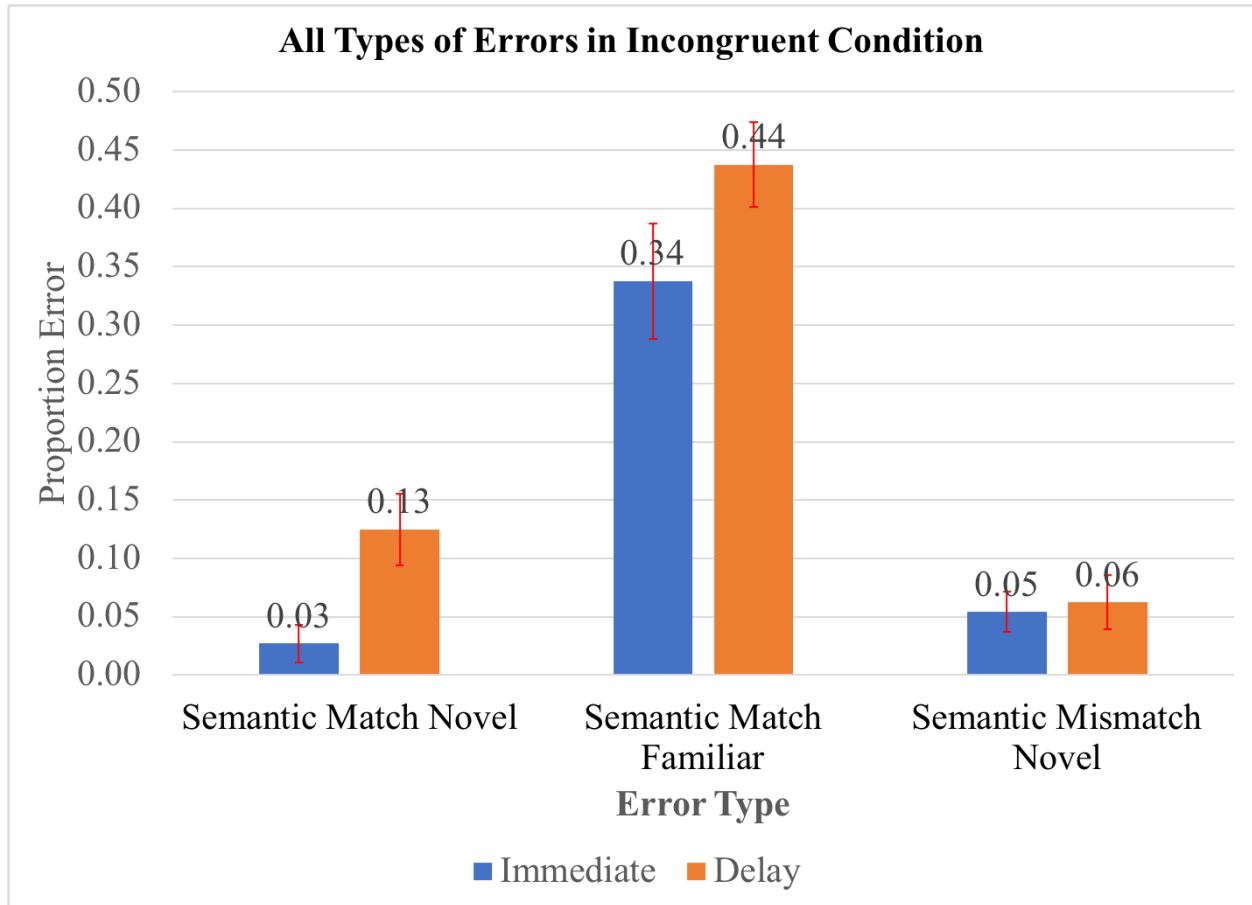
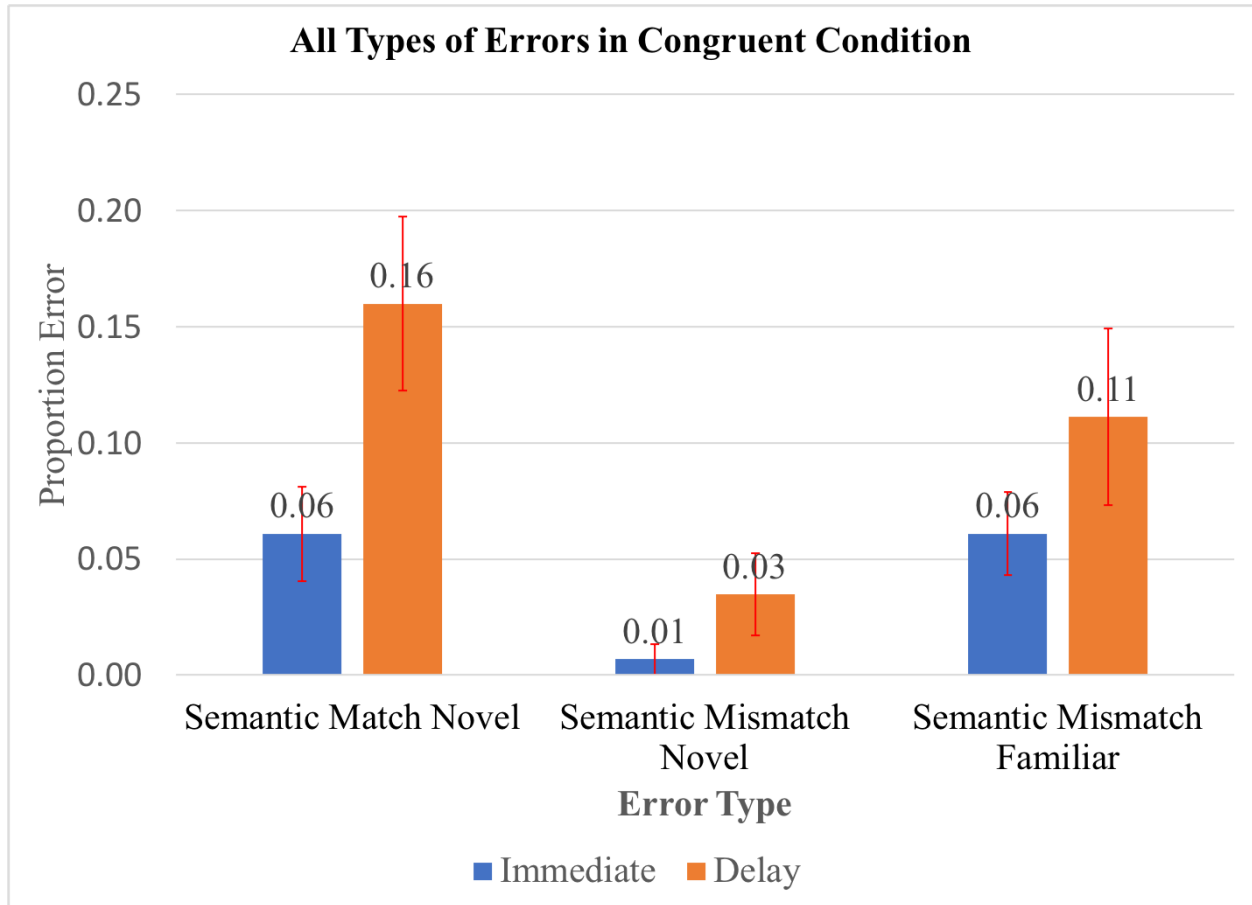
*Note.* Error bars are $\pm SEM$

Figure 8

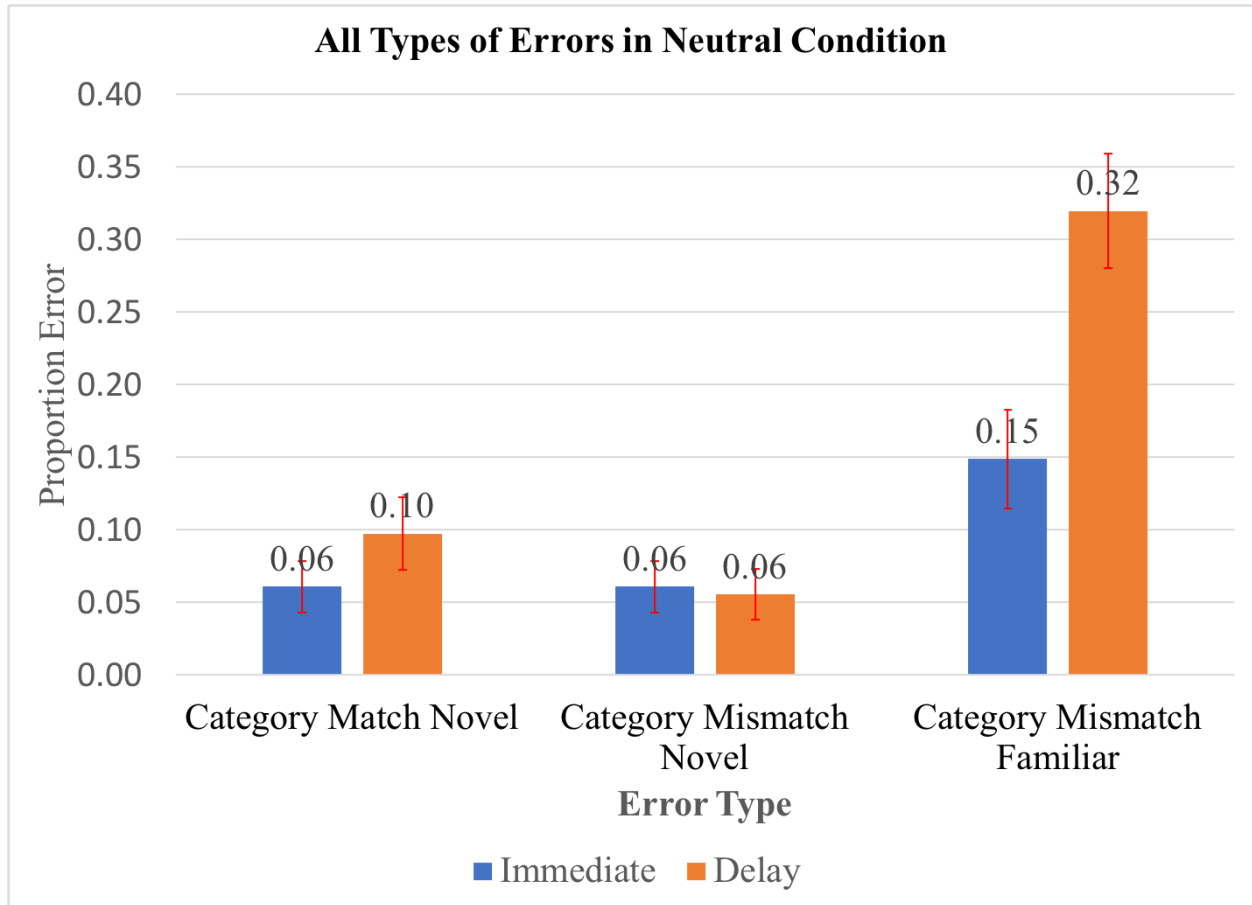
All Types of Errors in Congruent Condition



Note. Error bars are \pm SEM

Figure 9

All Types of Errors in Neutral Condition



Note. Error bars are \pm SEM

Appendix 1.**Experimental Instructions*****Encoding Phase***

For this part of the study, you will see two pictures together on each page. One picture will be a cartoon character doing an action. Next to that picture, you will see a picture of a location or place. You will also hear a sentence describing what action the character is doing. Please pay attention to each character, the action they are doing and the location. Try to think about that character doing that action in that location. Please try to remember that character, that action and that location together. For each page, please click on the action and location. You will have 10 seconds to do this and after that it will go to the next page with a different action and location pictures.

First, we will practice.

ADD in practice trials

Do you have any questions? Now we will do this again, your answers here will count.

Retrieval Phase

For this part of the study, you will see a picture of a cartoon doing an action. Some of these you would have seen before, and some of them will be new. For each cartoon picture please decide whether it is old or new. You will hear a sentence asking a question. If you think the picture is old and you have seen this character doing this action, please click on the word YES. If you think it is new and you have not seen this character doing this action, please click on the word NO. For some of the questions we will ask another question after you decide whether it is old or new. We will ask you what location went with that picture.

You will hear a question about that action and where it happened. You will be shown 4 locations and asked to choose the location that went with that action when you saw it before.

First, we will practice.

ADD in practice trials

Do you have any questions? Now we will do this again, your answers here will count.

Encoding Pre-recorded Audio Sentence	Retrieval (old actions) Pre-recorded Audio Sentence	Retrieval (Backgrounds) Pre-recorded Audio Sentence
Anna is going camping.	Did Anna go camping?	Where did Anna go camping?
Bob is dunking a ball.	Did Bob dunk a ball?	Where did Bob dunk a ball?
Sara is showing a sign.	Did Sara show a sign?	Where did Sara show a sign?
Jack is serving food.	Did Jack serve food?	Where did Jack serve food?
Anna is buying clothes.	Did Anna buy clothes?	Where did Anna buy clothes?
Bob is holding flowers.	Did Bob hold flowers?	Where did Bob hold flowers?
Sara is feeding a donkey.	Did Sara feed a donkey?	Where did Sara feed a donkey?
Jack is jumping on a bed.	Did Jack jump on a bed?	Where did Jack jump on a bed?
Anna is taking a selfie.	Did Anna take a selfie?	Where did Anna take a selfie?
Bob is making a salad.	Did Bob make a salad?	Where did Bob make a salad?
Sara is raising her hand.	Did Sara raise her hand?	Where did Sara raise her hand?
Jack is looking at a tablet.	Did Jack look at a tablet?	Where did Jack look at a tablet?
Anna is watching a movie.	Did Anna watch a movie?	Where did Anna watch a movie?
Bob is swimming.	Did Bob swim?	Where did Bob swim?
Sara is whistling.	Did Sara whistle?	Where did Sara whistle?
Jack is playing on a seesaw.	Did Jack play on a seesaw?	Where did Jack play on a seesaw?
Anna is watering a plant.	Did Anna water a plant?	Where did Anna water a plant?
Bob is tired.	Was Bob tired?	Where was Bob tired?
Sara is pushing a grocery cart.	Did Sara push a grocery cart?	Where did Sara push a grocery cart?
Jack is kicking a ball.	Did Jack kick a ball?	Where did Jack kick a ball?
Anna is talking on the phone.	Did Anna talk on the phone?	Where did Anna talk on the phone?

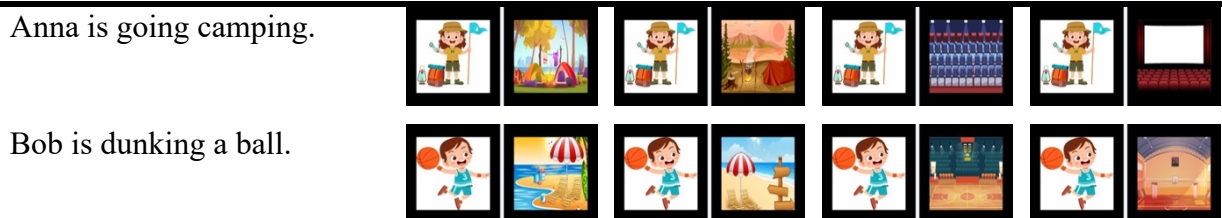
Bob is running with a racquet.	Did Bob run with a racquet?	Where did Bob run with a racquet?
Sara is saying don't cross.	Did Sara say don't cross?	Where did Sara say don't cross?
Jack is thinking.	Was Jack thinking?	Where was Jack thinking?

Retrieval (new actions) Pre-recorded Audio Sentence	Training Pre-recorded Audio Sentence
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Did Anna learn about Electricity?	Anna is brushing her teeth
Did Anna paint?	Jack is giving a lecture
Did Anna listen to the music?	Sara is tying her shoes
Did Bob weight himself?	Bob is practicing yoga
Did Bob put a puzzle together?	Anna is playing drums
Did Bob wear a coat?	Did Jack give a lecture?
Did Sara walk with an umbrella?	Where did Jack give a lecture?
Did Sara drink milk?	Did Anna play drums?
Did Sara see an apple through magnifying glass?	Where did Anna play drums?
Did Jack fall on the ground?	Did Sara dance?
Did Jack sweep the floor?	
Did Jack eat carrot?	

Images of the action/background scene during encoding phase for each group

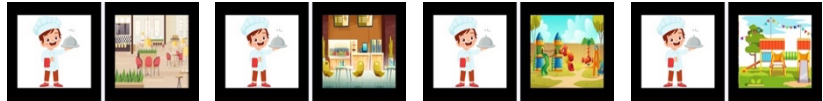
Pre-recorded Audio Sentence	Group A	Group B	Group C	Group D
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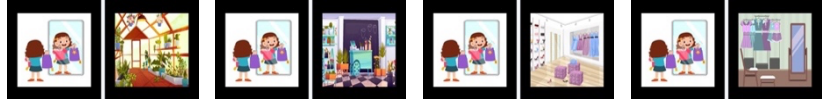
Sara is showing a sign.



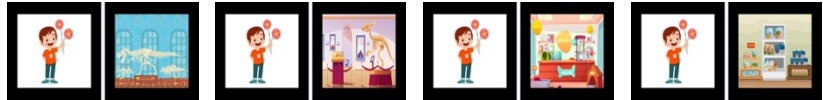
Jack is serving food.



Anna is buying clothes.



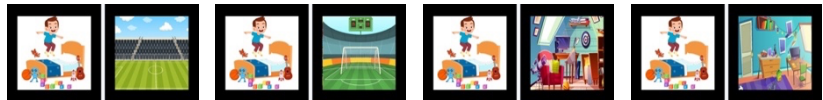
Bob is holding flowers.



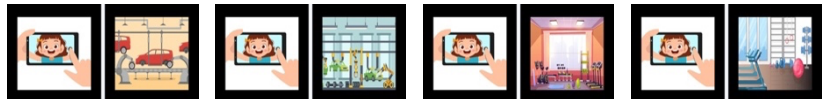
Sara is feeding a donkey.



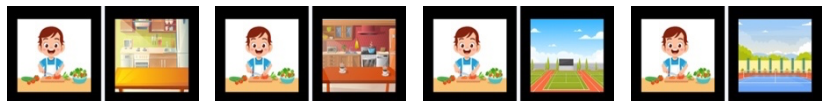
Jack is jumping on a bed.



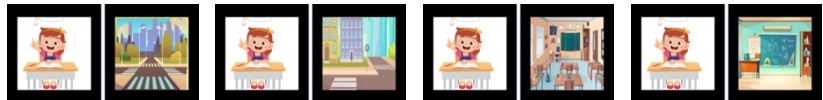
Anna is taking a selfie.



Bob is making a salad.



Sara is raising her hand.



Jack is looking at a tablet.



Anna is watching a movie.



Bob is swimming.



Sara is whistling.



Jack is playing on a seesaw.



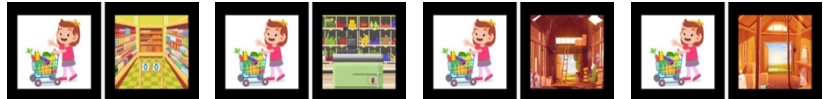
Anna is watering a plant.



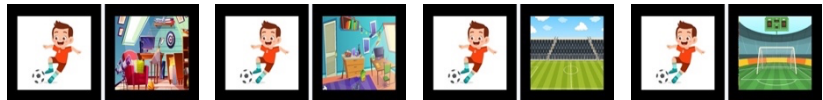
Bob is tired.



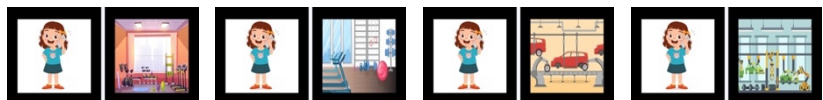
Sara is pushing a grocery cart.



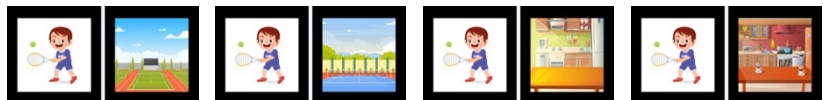
Jack is kicking a ball.



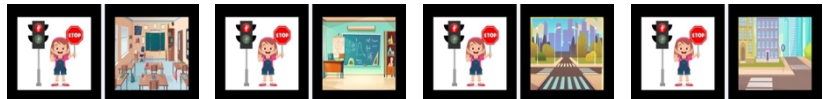
Anna is talking on the phone.



Bob is running with a racquet.



Sara is saying don't cross.



Jack is thinking.



Appendix 2.**Counterbalancing Stimuli**

Four cartoon characters (2 boys and 2 girls) presented different actions in this picture-based study. For each character 6 different actions assigned. From 6 assigned actions, 4 can only take place in specific background (e.g., playing seesaw) and reminded 2 can place every where (talking on the phone. For each action, two background scenes choose (Background scene for each action was the same location with two different versions). Please see table below.

Character	Actions	Background Scenes 1	Background Scenes 2
Anna	1-goes camping**	Forest camp 1	Forest camp 2
	2-puts on clothes**	Boutique 1	Boutique 2
	3-watches movie**	Cinema 1	Cinema 2
	4-waters flower**	Flower shop 1	Flower shop 2
	5-takes selfie*	Car factory 1	Car factory 2
	6-talks on phone*	Gym 1	Gym 2
Bob	1-plays basketball**	Basketball court 1	Basketball court 2
	2- makes salad**	Kitchen 1	Kitchen 2
	3-swims**	Beach 1	Beach 2
	4-plays tennis**	Tennis court 1	Tennis court 2
	5-holds flower*	Museum 1	Museum 2
	6-gets tired*	Pet shop 1	Pet shop 2
Sara	1-feeds donkey**	Barn 1	Barn 2
	2-raises hand**	Classroom 1	Classroom 2
	3-shops**	Supermarket 1	Supermarket 2
	4-in front of traffic light**	Street 1	Street 2
	5-holds a sign*	Library 1	Library 2
	6-whistles*	Picnic 1	Picnic 2

Jack	1-serves food**	Restaurant 1	Restaurant 2
	2-jumps bed**	Bedroom 1	Bedroom 2
	3-plays Seesaw**	Playground 1	Playground 2
	4-plays Soccer**	Soccer field 1	Soccer field 2
	5-looks at tablet*	Subway 1	Subway 2
	6- is thinking*	Changing room 1	Changing room 2

*Actions that can take place in every location.

**Action that can place only in specific locations.

Character Counterbalance:

Character counterbalanced in a way that a boy presented following a girl. For example, if the first action presented showing Anna, next action presented showing Bob, followed by Sara and then Jack. This pattern repeated across next actions. Two lists of characters doing an action prepared in counterbalanced order. In the first list, counterbalanced character accompanied with congruent background scene 1, and in second list, they accompanied with congruent background scene 2. This pattern applied for neutral actions too. For example, from two background assigned for each neutral action by specific character, once they accompanied with background scene 1, and then they showed with background scene 2 in the second list. These lists applied to counterbalance conditions.

Condition Counterbalance:

We designed this study to present actions in three conditions including congruent (semantic match between action and scene), incongruent (semantic mismatch between action and scene) and neutral (actions can take place in every scene). As a result, background scene counterbalanced for each cartoon character. For example, Anna was presented for first action, if it presented with congruent background, next action that was done by Bob, presented with incongruent background. Following action for Sara, would be presented with neutral background and proceed with Jack's action that was accompanied with a congruent background scene and so on to the last action. We counterbalanced background accompanied with each character and to omit the effect of character, background scene was not counterbalanced across characters. The provided list explained above, divided into two parts including first 12 actions and second 12 actions. For each character, in the first list (first 12 actions), incongruent background scene

selected from the second list (second 12 actions) and vice versa. Background scene for each character was selected from the backgrounds assigned for the same character. Each list also, included one neutral action for each character. The background for neutral action for each character, exchanged with the background for the same character's neutral action in both lists.

Stimuli Sets for Encoding Phase:

We counterbalanced background scene for neutral actions. After providing list of counterbalanced characters and conditions (a line showed character, actions accompanied by background scene (congruent, incongruent, neutral) as described above, each group assigned to one set of stimuli including 24 trials. In each trial, one action presented to participant accompanied with selected scene. Eight congruent, 8 incongruent and 8 neutral in counterbalanced order (2 actions for each condition per character). Participants then assigned to four groups including A, B, C, and D in order to counterbalance congruent/incongruent actions across them. From 4 backgrounds assigned to each action, each group visited specific action on different background. For example, group A visited specific character doing particular action in congruent condition (semantic matched version 1) (e.g., Anna goes camping accompanied with forest camp 1). Group B visited the same action in the same condition but with different version background scene (semantic match version 2) (e.g., Anna goes camping accompanied with forest camp 2). Group C also visited the same action but in both different condition and different version background scene (semantic mismatch version 1) (e.g., Anna goes camping accompanied with forest cinema 1). Group D also visited the same action in similar condition with group C but different version background scene (semantic mismatch version 2) (e.g., Anna goes camping accompanied with forest cinema 2). Please see table below.

Row	Actions	Group A	Group B	Group C	Group D
1	Anna goes camping**	Forest camp 1	Forest camp 2	Cinema 1	Cinema 2
2	Bob plays basketball**	Beach 1	Beach 2	Basketball court 1	Basketball court 2
3	Sara holds a sign*	Library 1	Library 2	Picnic 1	Picnic 2

4	Jack serves food**	Restaurant 1	Restaurant 2	Playground 1	Playground 2
5	Anna puts on clothes**	Flower shop 1	Flower shop 2	Boutique 1	Boutique 2
6	Bob holds flower*	Museum 1	Museum 2	Pet shop 1	Pet shop 2
7	Sara feeds donkey**	Barn 1	Barn 2	Supermarket 1	Supermarket 2
8	Jack jumps bed**	Soccer field 1	Soccer field 2	Bedroom 1	Bedroom 2
9	Anna takes selfie*	Car factory 1	Car factory 2	Gym 1	Gym 2
10	Bob makes salad**	Kitchen 1	Kitchen 2	Tennis court 1	Tennis court 2
11	Sara raises hand**	Street 1	Street 2	Classroom 1	Classroom 2
12	Jack looks at tablet*	Subway 1	Subway 2	Changing room 1	Changing room 2
13	Anna watches movie**	Cinema 1	Cinema 2	Forest camp 1	Forest camp 2
14	Bob swims**	Basketball court 1	Basketball court 2	Beach 1	Beach 2
15	Sara whistles*	Picnic 1	Picnic 2	Library 1	Library 2

16	Jack plays Seesaw**	Playground 1	Playground 2	Restaurant 1	Restaurant 2
17	Anna waters flower**	Boutique 1	Boutique 2	Flower shop 1	Flower shop 2
18	Bob gets tired*	Pet shop 1	Pet shop 2	Museum 1	Museum 2
19	Sara Shops**	Supermarket 1	Supermarket 2	Barn 1	Barn 2
20	Jack plays Soccer**	Bedroom 1	Bedroom 2	Soccer field 1	Soccer field 2
21	Anna talks on phone*	Gym 1	Gym 2	Car factory 1	Car factory 2
22	Bob plays tennis**	Tennis court 1	Tennis court 2	Kitchen 1	Kitchen 2
23	Sara in front of traffic light**	Classroom 1	Classroom 2	Street 1	Street 2
24	Jack is thinking*	Changing room 1	Changing room 2	Subway 1	Subway 2

*Actions that can take place in every location.

**Action that can place only in specific locations.

Appendix 3.

Stimuli Sets for Retrieval Phase

Each character showed 8 times during encoding phase, every time represented one action. Actions were included 2 congruent, 2 incongruent and 2 neutral. Since we need to represent 4 backgrounds in this stage (2 familiars and two novels from semantic match and semantic mismatch category), we had to select 12 actions from overall 24 visited actions. Therefore, for each of the four character, 3 actions selected (one visited in each congruent, incongruent and neutral condition). Overall, for each group of participants, 12 visited actions assigned. In this phase, it was possible to have two sets of stimuli per each group. As a result, each group divided into 2 subgroups and first subgroups assigned to set one and second subgroup assigned to set 2. Finally, we came up with 8 eight sets of stimuli assigned to 8 subgroups including A1, A2, B1, B2, C1, C2, D1, and D2. First 12 visited actions assigned to subgroups 1 and second 12 visited actions assigned to subgroups 2. Three new actions randomly selected for each character as new actions presented with old visited action at a time.

After recognition of correct action, participant should visit 4 background scenes and selected the one that was accompanied with the actions during encoding phase. Background scenes supposed to include a) Semantic match familiar (background that matches the action; background seen during encoding), b) Semantic match novel (background that matches the action; background was not seen during encoding), c) Semantic mismatch familiar (background that does not match action; background seen during encoding), and d) Semantic mismatch novel (background does not match action; background not seen during encoding). Option A is the target for the congruent condition. Option C is the target for the incongruent condition. Also, the background options for each neutral trial were : a) Target (background paired with the action during encoding; e.g., old car factory), b) Target category match novel (background that matches the category of the target; background was not seen during encoding; another version of car factory), c) Target category mismatch familiar (background that does not match the category of the target; background seen during encoding e.g., old gym), and d) Target category mismatch novel (background does not match the category of target; background not seen during encoding; e.g., another version of gym). For example, Group A visited Anna goes camping along with forest camp 1 as background scene, Group B visited Anna goes camping along with forest camp 2 as background scene, Group C visited Anna goes camping along with cinema 1 as

background scene, and Group D visited Anna goes camping along with forest camp 2 as background scene. Background options included forest camp 1, forest camp 2, cinema 1, and cinema 2 for all subgroups. However, the options for target, semantic match or mismatch, familiar or novel were different across each subgroup. Please see table below. Possible backgrounds for each action during retrieval phase revealed in a line in front of every actions. First 12 actions selected for subgroups 1 and second 12 actions selected for subgroups 2.

Row	Actions	Subgroup	Group A	Group B	Group C	Group D
1	Anna goes camping**	1	Forest camp 1	Forest camp 2	Cinema 1	Cinema 2
2	Bob plays basketball**	1	Beach 1	Beach 2	Basketball court 1	Basketball court 2
3	Sara holds a sign*	1	Library 1	Library 2	Picnic 1	Picnic 2
4	Jack serves food**	1	Restaurant 1	Restaurant 2	Playground 1	Playground 2
5	Anna puts on clothes**	1	Flower shop 1	Flower shop 2	Boutique 1	Boutique 2
6	Bob holds flower*	1	Museum 1	Museum 2	Pet shop 1	Pet shop 2
7	Sara feeds donkey**	1	Barn 1	Barn 2	Supermarket 1	Supermarket 2
8	Jack jumps bed**	1	Soccer field 1	Soccer field 2	Bedroom 1	Bedroom 2

9	Anna takes selfie*	1	Car factory 1	Car factory 2	Gym 1	Gym 2
10	Bob makes salad**	1	Kitchen 1	Kitchen 2	Tennis court 1	Tennis court 2
11	Sara raises hand**	1	Street 1	Street 2	Classroom 1	Classroom 2
12	Jack looks at tablet*	1	Subway 1	Subway 2	Changing room 1	Changing room 2
13	Anna watches movie**	2	Cinema 1	Cinema 2	Forest camp 1	Forest camp 2
14	Bob swims**	2	Basketball court 1	Basketball court 2	Beach 1	Beach 2
15	Sara whistles*	2	Picnic 1	Picnic 2	Library 1	Library 2
16	Jack plays Seesaw**	2	Playground 1	Playground 2	Restaurant 1	Restaurant 2
17	Anna waters flower**	2	Boutique 1	Boutique 2	Flower shop 1	Flower shop 2
18	Bob gets tired*	2	Pet shop 1	Pet shop 2	Museum 1	Museum 2

19	Sara Shops**	2	Supermarket 1	Supermarket 2	Barn 1	Barn 2
20	Jack plays Soccer**	2	Bedroom 1	Bedroom 2	Soccer field 1	Soccer field 2
21	Anna talks on phone*	2	Gym 1	Gym 2	Car factory 1	Car factory 2
22	Bob plays tennis**	2	Tennis court 1	Tennis court 2	Kitchen 1	Kitchen 2
23	Sara in front of traffic light**	2	Classroom 1	Classroom 2	Street 1	Street 2
24	Jack is thinking*	2	Changing room 1	Changing room 2	Subway 1	Subway 2