Rewriting Memory Lane: Investigating the Effect of Script Retraining on Memory Recall

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Abstract

Schematic representations of the world play a crucial role in narrative learning and recall. In this study, we tested how the activation of a schematic event script impacted the semantic content of free recall. Participants were trained on one of two scripts before listening to and recalling a story. All participants were asked to recall the story twice, with half receiving training on the script they had not yet encountered between the two recall sessions. We found that the most recently activated script had a significant impact on the semantic content of the recall, as measured by its vector representation in a language model. These findings suggest that script activation before recall can enhance encoding when activated during reading and can selectively boost retrieval when activated during recall. We also observed an asymmetry between priming for a location-based (airport) script and a social interaction (breakup) script, consistent with a bias in structuring recall based on spatial context.

Keywords: script retraining, memory retrieval, multi-stage scripts

Introduction

How do we perceive, interpret, and recall events? Literature in cognitive psychology suggests that schemas, the mental frameworks that organize information, support memory (Tompary et al., 2020; Masís-Obando et al., 2022). While the term "schema" has been broadly applied in the psychology and neuroscience literature to refer to cognitive structures that influence memory, there is general consensus that the function of a schema is to guide behavior, facilitate encoding of new information, and expedite retrieval processes (Bartlett, 1932, Anderson & Pearson, 1984; Anderson & Pichert, 1978; Ghosh & Gilboa, 2014). Schemas are developed through repeated experiences, with necessary features being an associative network structure, based on multiple episodes, lack of unit detail, and adaptability (Ghosh & Gilboa, 2014). These features allow schemas to generalize to diverse situations and store large amounts of information.

A specific form of schema is the script, which contains knowledge of stereotyped event sequences. Like a general schema, scripts are cognitive structures that organize representations of events and support their comprehension (Ghosh & Gilboa, 2014). However, scripts have a temporal component, meaning that their event units are organized in chronological order (Schank & Abelson, 1977). In their book *Scripts, Plans, Goals, and Understanding: An Inquiry into Human Knowledge Structures,* Schank & Abelson (1977) propose a script theory, suggesting people use general script sequences as general knowledge to aid the processing of new inputs. They define scripts as "a structure that describes appropriate sequences of events in a particular context," with each event consisting of a slot of information that cannot transcend the event boundary (Schank & Abelson, 1977). When a story is read or heard, the brain represents the new information onto our past experiences and maps it onto pre-existing script structures, which also

allows the prediction of subsequent or missing events (Schank & Abelson, 1977; Bower et al., 1979).

The rigidity of chronological representation may differ in importance across scripts; for example, the order that food appears in a story about a grocery store is less memorable than the order that food appears in a story about a restaurant (Anderson et al., 1978). A script is activated when the understander expects events to occur in a particular sequence – an expectation built from their own experiences. For example, a restaurant script may be developed from dozens of experiences that occur over childhood. The schematic representation of a restaurant script would include a standardized template of the temporal aspects of the experience as well as what category/kinds of information that are predicted (e.g. (1) Entering restaurant, (2) Being seated, (3) Ordering food, (4) Food arriving) (Bower et al., 1979).

While the specific details may differ by stimuli, the overall situation largely remains stereotyped. Returning to the above example of a restaurant script, a person reading a story about a restaurant from the point of view of a restaurant critic may be implicitly cued to remember details important to the restaurant script. Following the story, they would be expected to accurately respond to related script questions: (1) How is the restaurant decorated? (2) What are the menus like? (3) What does each client order? (4) How do the clients like the food? The answers to these questions would differ by narrative, but the character perspective of a restaurant critic would activate a common restaurant script in the reader each time, such that the organization of the memory remains constant. Further, while reading the story, a participant may intuit script events that are not explicitly stated, which the story will either confirm or surprise. Abelson (1981) provides one example of the intuitive use of scripts:

> "John was feeling very hungry as he entered the restaurant. He settled himself at a table and noticed that the waiter was nearby. Suddenly, however, he realized that he'd forgotten his reading glasses."

The restaurant setting would lead the reader, who takes on the perspective of John the customer, to expect the menu from the nearby waiter – however, the reader would also intuit that he would be unable to order from the menu due to his forgotten reading glasses. The menu was not mentioned which Abelson proposes means that the restaurant script was activated as soon as the location was specified.

People use their prior knowledge of a subject to understand new stimuli which, in turn, facilitates faster understanding. As Abbott et al. (1985) notes, most written accounts for common events, such as going to a restaurant for dinner, are "incomplete" narratives because they leave out specific details that are automatically assumed – supplemented by script information. Take the following situations as an example:

(1) Calvin waited in line at the TSA. He boarded the plane. His driver picked him up from baggage claim.

(2) Calvin entered the department store. He boarded the plane. He purchased a new pair of shoes.

For the first statement, people can fill in the narrative gaps due to their previous experiences – Calvin sitting on the plane, disembarking, and collecting his luggage. However, in the second statement, there is no script that exists for that series of events. Readers would be confused as to how Calvin boarded the plane on a trip to the department store. Information to fill in gaps and notice inconsistencies come from the body of schemas and scripts built up over time.

Schema literature has primarily posited that these frameworks influence memory at two stages, encoding and retrieval. The extent of influence at either stage remains a point of interest among researchers. Research on encoding effects in narratives suggest that schemas help the individual understand which parts of the story are important or relevant, and provides a framework for individuals to understand when a section of a story is completed and able to be stored (Mandler, 1978). Relevant schemas are activated when the material is approached, and can also change throughout the encoding process, guided by the stimuli (Mandler, 1978). This effect has been studied by comparing conditions in which participants have and do not have relevant schematic prior knowledge (Van Kesteren et al., 2014). People tend to utilize their prior knowledge and schema when processing narratives, which enables them to draw inferences and encode information that aligns with their existing schemas (Anderson et al., 1983).

Research on retrieval effects suggest that schemas are used to identify the kind of information needed to be retrieved, and provide a hierarchical, temporal sequence to find the specific content (Mandler, 1978; Yekovich & Thorndyke, 1981). Studies that focus on repeated events suggest that people often remember the structure of how events typically occur but may forget specific details of a particular situation. They then utilize their existing schemas to make inferences to fill gaps in narrative memory or to predict relevant information (Schank & Abelson, 1977; Woiwod et al., 2019). Some studies have tested the effect of order deviations on recall, where events are presented out of order at encoding. They found that this scrambling may lead to better recall in the short term, but after a delay, the recall will look more similar to the stereotypical schema order, indicating that retrieval processes rely on schemas (Mandler & Johnson, 1977). Overall, numerous studies have provided evidence for schema effects at both encoding and retrieval, indicating a mixture between the two.

Anderson et al. (1983) conducted a study that provided a new implication for the retrieval hypothesis, and sheds light on this relationship, showing that requesting participants to adopt a specific viewpoint boosted memory retrieval during free recall. In the study, participants were presented with a story about two boys who skipped school, which included episodic details relating to either of two content schemas. One schema was pertinent to a burglar (e.g., valuable possessions like original paintings), while the other schema was more relevant to a homebuyer (e.g., a leaky roof). These schematic details were critical to their respective perspectives.

In Pichert and Anderson's (1977) study, participants were instructed to adopt either a homebuyer or burglar perspective before reading a story. The story was about what two boys did at one of their homes while skipping school, and contained 72 idea details that were rated as relevant to one or the other perspectives. All participants were asked to recall the story twice; however, in the second recall, half of the participants were requested to recall the story from the other perspective. In these switch conditions, researchers found that across several experiments, anywhere from 65% to over 80% of the participants were able to recall at least one piece of information that was significant to the new perspective but was not remembered during the first recall (Anderson et al., 1983). In addition, they subsequently found that the perspective switch had a significant negative effect on information vital to the first perspective but that later became irrelevant during the second recall. This finding suggests that schema activation at the time of recall may provide a framework for the narrative to be remembered.

Anderson et al. utilized episodic details to assess the amount of perspective-related information that participants could recall. However, it is worth noting that semantic knowledge, or the comprehension of the meaning of the text, is not always conveyed through episodic events. Recent advances in technology have made it possible to measure semanticity within a

text and calculate its similarity to a semantic structure. This study aims to build on Anderson et al.'s research and re-examine the encoding and retrieval hypotheses by employing schematic scripts that describe stereotypical sequences of events. The study specifically employs a narrative featuring two distinct scripts - a breakup at an airport - which enables us to manipulate which script participants use during encoding and retrieval.

When presented with a story, individuals tend to naturally adopt a specific schema through which they interpret the information. In our study, we aimed to activate particular schemas by explicitly training participants to use a specific multi-stage script. This procedure ensures that all participants within the same priming condition are activating the same script, which provides a targeted scaffold for each of the individual events in the story. The reading and recall process in this study closely followed that of Anderson et al., with some participants receiving training in an alternate script between their first and second recalls. We mapped participant recalls to a semantic vector space and then compared them to a script-specific template, allowing us to test our hypothesis that both encoding-time and retrieval-time script activation can impact the semantic properties of free recall.

Materials and Methods

Participant Sample

65 fluent English speakers (40 female, 20 male, age range 20-69 years, mean = 37 years) completed the experiment for pay ($12/h). The racial makeup of the sample was Hispanic or Latino (n = 6); White (n = 50), Asian (n = 7), Black (n = 10), American Indian/Alaskan Native (n = 2). Participants were recruited online through Prolific and randomly assigned to one of four conditions: Location/Location (n = 15), Social/Social (n = 18), Location/Social (n = 16), and Social/Location (n = 16). Informed consent was obtained from participants under Columbia

University IRB protocol #AAAS0252. Participants were compensated a base rate of $5 to complete the 25 minute study, with the possibility to earn up to $2 more through their recalls.

Experimental Design

Our dataset consisted of 65 participants who wrote two free recalls after reading/listening to the story "Hop on the Liberty Plane." This story was developed as part of a larger story set in which location-based scripts and social interaction scripts were combined to form narratives (Soares & Baldassano, 2021). "Hop on the Liberty Plane" is a story that depicts a breakup (social script) in an airport (location script) between the characters Calvin and Jessie (full text in Appendix A). Based on a previous pilot study using all 16 stories from the set, we analyzed the effect sizes of correlation measures for each participant priming group (no prime, social prime, location prime) per story. We selected "Hop on the Liberty Plane" because it was the story where the cross group correlation was lowest and the individual priming effect was highest.

Participants were randomly assigned to complete the training for one of two scripts (airport or breakup). Each training consisted of asking participants to remember a sequence of questions that correspond with the schema events, and then testing them on the order. The test asked participants to take on the perspective of a job (Airport Customer Experience Manager or Couples Therapist), and select the correct order of events that would occur. For example, when taking on the role of Airport Customer Experience Manager, the first question participants should be thinking of is "When the clients arrive at the airport how much time do they have until their flight departs?." The four questions were randomly presented as multiple-choice with two distractor items (eg. Toward which security line are the clients walking?)(Appendix B). Participants had to repeat the test until they passed.

After completing the first training, participants were asked to keep the same perspective in mind while reading/listening to the story. The story was presented line by line, with the text on the screen and the corresponding audio that had to be played before moving on to the next line. Following the story, participants were asked to recall every detail they remembered from the story. In order to incentivize participants to provide a full recall, a monetary bonus was offered. Participants received the $1 bonus if their recall word count was 100 or more words.

Participants in each script group we then further subdivided into two subgroups. One subgroup did not receive a new schema prime, but completed a primacy/recency distractor task where they were asked to memorize a series of words that blinked on the screen, and submit as many of them as they could recall at the end. The other subgroup was a "switch" condition, in which participants completed the training for the script they had not been trained on before. Following these tasks, participants were asked to recall every detail they remembered from the story again and asked explicitly to "focus on details you may have forgotten the first time," with another monetary bonus incentive. Participants received the $1 bonus if their second recall word count was 100 or more words, making the maximum compensation for the study $7. A flowchart of the experimental design can be found in Appendix C.

NLP with Universal Sentence Encoder

There has been growing interest in using artificial intelligence (AI) to comprehend and imitate natural languages. Schank and Abelson (1977) highlighted the potential of AI to model subconscious mechanisms that govern our memory. Natural Language Processing (NLP) tools, such as the Universal Sentence Encoder, are also able to provide systematic approaches to measure the total amount of semantic similarity between given texts which we operationalize in this study.

Each recall was converted into a vector representation using TensorFlow's "universal-sentence-encoder_4" model (TensorFlow). This model utilizes transformer architecture to model dependencies between different parts of a sequence, which allows it to represent the meaning of complex texts. The model has demonstrated good transfer learning to other NLP tasks (Cer et al., 2018). The entire text of each recall was processed by the model and transformed into a 512-dimensional embedding that captures the semantic meaning of the recall. This standardized embedding can then be used to compare and analyze the similarity or classification of different texts. USE embeddings have performed well on the STS (Semantic Textual Similarity) Benchmark which evaluates the degree that similarity scores between sentence embeddings align with human judgment (TensorFlow).

Each participant recall was converted into an embedding to be compared in similarity to other participant recalls and templates of each script. Script templates were created by vectorizing a paragraph that contained the four sentences from the story that answered the four chronological priming questions. Each of the questions had an answer within the story, with no overlapping sentences between scripts. For example, one of the Couples Therapist questions was "For how long has the initiator of the breakup been thinking about breaking up with his/her partner?," so the story sentence "It had been a tough vacation, which was planned well before Jessie began to think of breaking up with Calvin 6 weeks ago" was included in the script template paragraph (see Appendix B). We computed the cosine similarity of each participant's recalls to the vector embeddings for the social and location scripts respectively, which were then used in further analysis.

Results

Recall Analysis

On average, participant recalls for Recall 1 contained 164.4 words (SD = 79.72, Range = 44-425) and Recall 2 contained 135 words (SD = 96.71, range = 1-492). A paired t-test found a significant decrease in length between Recall 1 and Recall 2 ($t(64) = 3.15$, $p < .05$). We attributed the difference in recall lengths to participant motivation around completing the same recall task again, and proceeded with analysis.

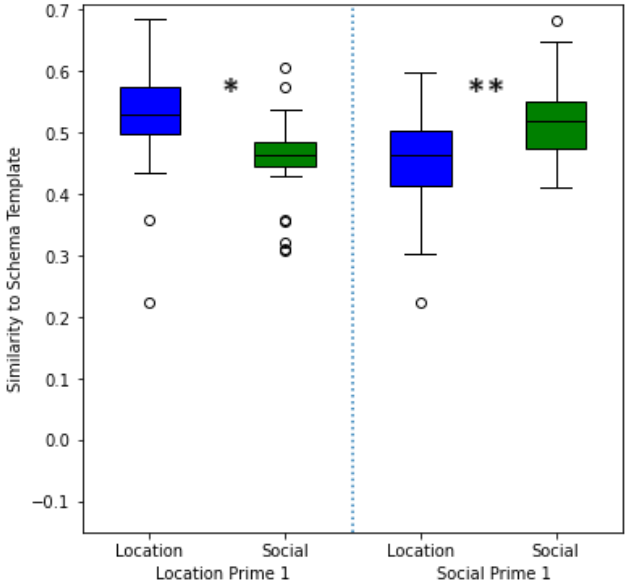
Script Template Development

We conducted several exploratory analyses before determining that a script template comparison was the most standardized way of measuring the semanticity of the recalls. While the findings from our exploratory analyses utilizing cross participant pairwise similarity did not make it to the final version of our results, a brief summary of the procedure and results are included in Appendix D.

We first tested whether the degree of location vs. social content was different at the first recall for participants who initially received the location or social script priming (Figure 1). We found that location-primed participants were significantly more biased toward the location-based rather than the social-based template ($t(30) = 2.74$, $p < .05$). Similarly, social-primed participants were significantly more similar to the social-based rather than location-based template ($t(33) = -2.93$, $p < .01$). This suggests that the location and social schemas affected the semanticity of the first recall, validating our methods of priming, and suggesting an effect at encoding and initial retrieval.

Figure 1

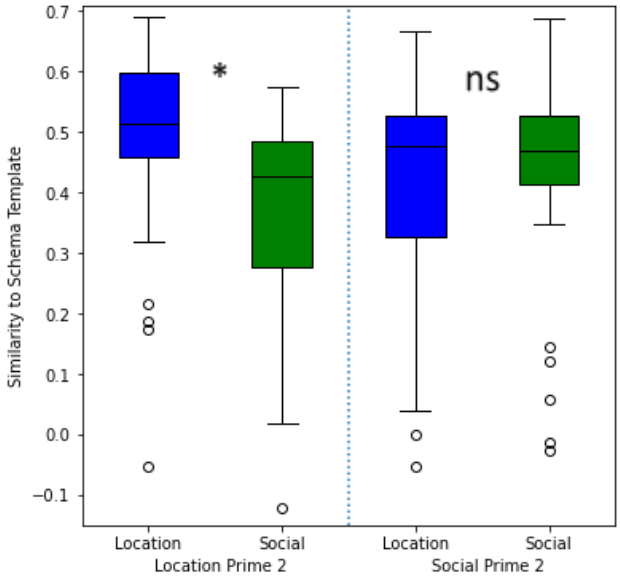
Recent Priming Effect on Recall 1



A paired t-test was then conducted between location similarity and social similarity for Recall 2, based on the most recent prime that participants had been given before this second recall (Figure 2). For participants who most recently had a location training, there was a significantly higher amount of location-related information ($t(30) = 2.90$, $p < .05$). For participants who most recently had a social training, there was no significant differences between the location and social similarity ($t(33) = -0.52$, $p = .61$). This suggests that at least the location schema has an effect on the semanticity of the second recall, suggesting a retrieval effect of the script activation.

Figure 2

Recent Priming Effect on Recall 2



Through these analyses, it was clear that all recalls contained elements of both social and location scripts, so our next step in analysis was concerned with measuring whether the priming shifted the recalls in the direction of one script or another. To further understand the range of semanticity present in the recalls, we devised a script similarity scale to measure the extent of location or social similarity in each recall. The social similarity score was subtracted from the location similarity score for each recall to compute one value. For example, if a specific participant recall had a 0.575 similarity to the location template (recall_location), and a 0.456 similarity to the social template (recall_social), we computed recall_location minus recall_social for a value of 0.575-0.456 = 0.119. A positive value on this scale meant that the recall was shifted towards a location schema. A negative value meant that the recall was shifted towards a social schema, and a zero value meant that there was no difference between the semantic similarity to the social and location templates. This similarity scale was plotted on the y-axis of Figures 3 and 4.

A t-test was run between the similarity values for participants who received location priming first versus social priming first. Location-primed participants had recalls that were significantly more biased toward the location schema ($t(64) = 4.01$, $p < .001$) (Figure 3). We were interested in whether the initial priming effect persisted into the second recalls of our control participants who only received one priming. We conducted paired t-tests to compare the similarity of each control participant's Recall 1 and Recall 2 to the script templates (Figure 4A and 4B). We found no significant differences between recalls within our location control group ($t(14) = -.69$, $p = .50$) or our social control group ($t(17) = -1.80$, $p = .89$) who only received one priming. We found a significant difference when we used a t-test to compare the second recall between the control conditions ($t(32) = 2.52$, $p < 0.05$) (significance bars between Figure 4A and 4B). This finding was in line with our expectations, as we predicted that the priming effect would persist from the first recall.

We then tested whether participants that received a second “switched” prime before their second recall exhibited changes in the schematic content of their first versus second recalls using paired t-tests. For participants that received location and then social priming, there was no significant switch effect ($t(15) = .81$, $p = .43$) (Figure 4C). However, for participants initially primed with the social script and then the location script, there was a significant switch effect towards the location similarity and away from the social similarity ($t(15) = -2.43$, $p < .05$) (Figure 4D).

Figure 3

Priming Effect on Recall 1

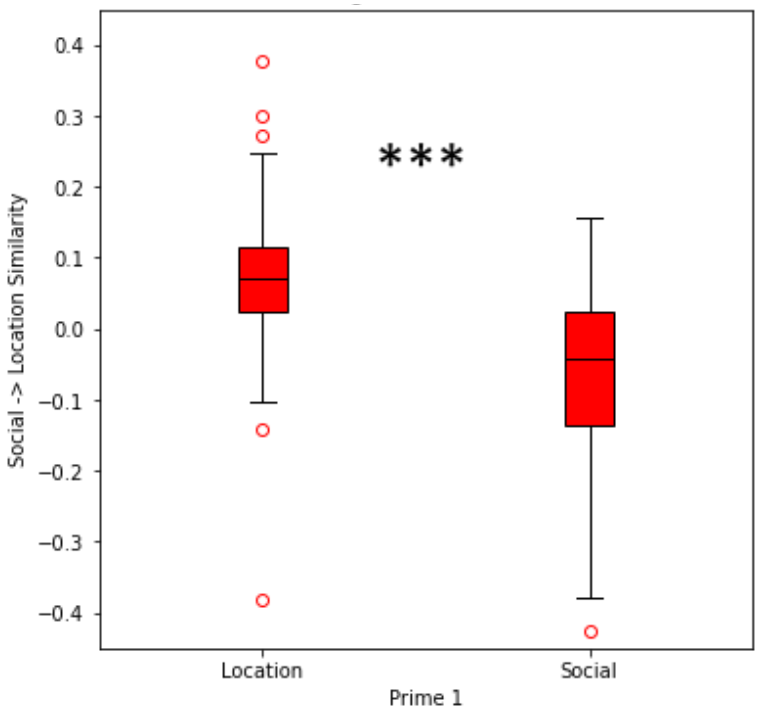
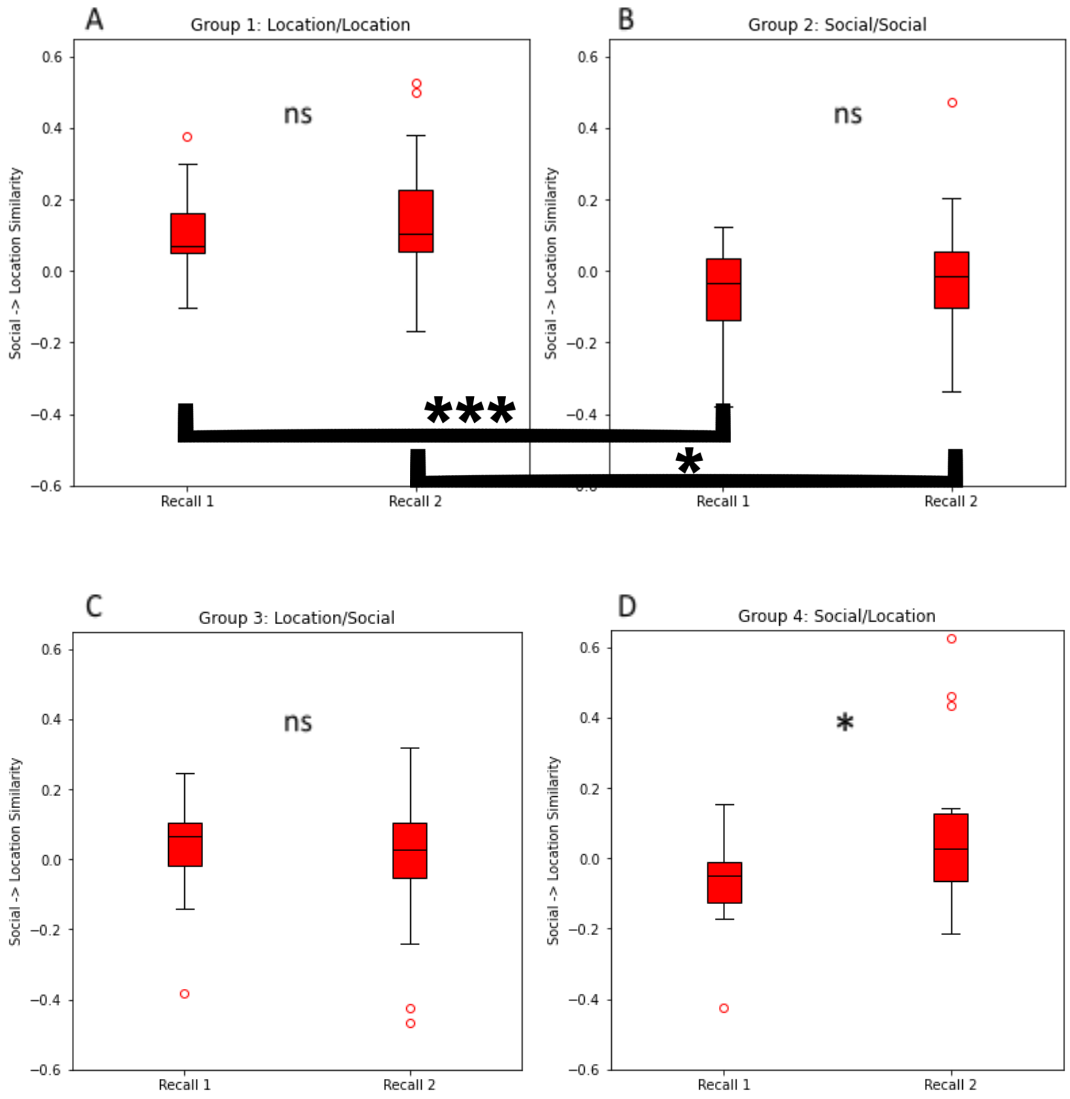


Figure 4

Effect of Priming on Recalls Within Participant by Condition

(A) Location/Location (B) Social/Social (C) Location/Social (D) Social/Location



Discussion

Support for Hypothesis

Our analysis aimed to test two research questions.

1. Does script priming impact the semantic structure of free recall?

2. Does activating a script at retrieval impact memory recall, or do scripts only influence memory when activated before initial encoding?

We hypothesized that the semantic similarity of the recall would be most similar to the semantic structure of the prime they most recently received. Thus, we expected that the participants in the switch conditions would demonstrate movement towards a different script between their two recalls, while those who did not switch schemas would demonstrate strong semantic similarity between Recall 1 and 2. Our findings are mostly consistent with Anderson et al.'s (1983) study. We found that Anderson et al.'s findings on the effects of perspective shifting were also valid when perspectives were trained using multistage scripts. Further, we found that script activation before and after encoding can affect the content of free story recall.

Our first analysis tested the effect of initial script priming on Recall 1's semantic similarity to each script. We found that each recall was significantly more similar to their primed script, with the participants who first received location priming being more similar to the location template, and those who first received social priming being more similar to the social template (Figure 2). The initial priming effect also appeared stronger for those first receiving the social prime.

The next analysis looked at the impact of recent priming on recall semantic similarity, separating participants by which prime they received second (Figure 3). There was a clear and significant shift towards location similarity for those who received the location priming second, but the social and location script similarity remained fairly equal in those who received social priming second. This demonstrated asymmetric effects between social and location priming, suggesting that location information may have a stronger impact on later retrieval, whereas social priming may have a larger effect at encoding and initial retrieval. The semantic similarity scores

overall suggest that both scripts significantly affect the semantic structure of participants' initial recalls. However, it also suggests that location and social scripts have different effects on retrieval post-encoding.

The goal of developing a script similarity scale was to measure shifts in semantic content in memory recall between script activation at encoding and retrieval, recognizing that all participant recalls would likely contain both social and location content (Figure 3 and 4). This scale also allowed us to measure shifts in recall semantics within participants. Utilizing this method of representing semanticity, we validated our previous results with participants showing greater semantic similarity to the primed script in their first recall, which validated our script training method and showed that scripts can shift the semantic structure of free recall. We found that for control participants who only completed one script training, this finding persisted when they were asked to recall the story a second time; again there was a significant semantic bias toward the primed script (Figure 4A and 4B).

For participants in the switch conditions who had a different script activated at retrieval, we found asymmetric effects. We found that participants who received location priming first and social priming second had no significant difference in their two recalls, and both recalls were more similar to the location template in the second recall (Figure 4C). However, for the participants who received social script priming first and location script priming second, there was a significant shift towards more similarity to the location template (Figure 4D). This finding suggested that the location script had an impact on shifting semantic structure at retrieval, and that *any* exposure to the location script led to a location bias in recall. Overall, these findings suggest that scripts affect memory at encoding and initial retrieval, but different scripts have varying strengths of affecting memory solely at retrieval.

Primacy of Spatial Context

Location scripts may be particularly salient due to their importance in supporting memory through spatial contexts. Support for the strength of location information is in line with recent research indicating that location plays a crucial role in the neural representation of events throughout the autobiographical memory network (Robin et al., 2018). Scene construction theory also suggests the dependence of memory on spatial representations meaning that the vividness and detail of the memory is tied to the extent the scene can be mentally reconstructed (Rubin et al., 2019). Location scripts may form a scaffold at both encoding and retrieval upon which later recalls rely on.

However, if location information is always key to scaffolding memory, why was there not more similarity to the location script in participants who did not receive location priming at any point? We posit that the location script is always utilized at retrieval, but script activation is needed to prompt people to utilize the location script in their conscious recall. Location information is the "stage" that the semantic details are organized upon, and where the individual mentally imagines themselves when retrieving memories (Rubin et al., 2019). This can explain why location details are easily retrieved when prompted. However, without prompting and being asked to simply recall the story, participants may default to their only training (social) when they write their recall, viewing location details as irrelevant to the main plot of the story. This is supported by research suggesting that location schemas are used during episodic retrieval mostly when it is needed to improve memory decisions – typically when time has passed since encoding (Tompary et al., 2020). In summary, participants may be automatically encoding the location script to cue recall of the entire story, but only present the location details when prompted to utilize the script in their conscious recall.

This further suggests that there may be a conscious and non-conscious aspect to script activation, drawing a link with studies looking at subliminal processing of stimuli and its effects on memory (Kouider & Dehaene, 2007). Research suggests that attention increases the effect of invisible stimuli at both perceptual and semantic levels, suggesting that our multi-stage scripts may have increased cognitive processes organizing the structure of the recalls. While there is also debate within this literature about whether semantic representations can ever be non-conscious, it is important to consider the underlying cognitive mechanisms of these findings that we are unable to measure in participants with our current data (Holender & Duscherer, 2004).

Considering Social Contexts

On the other hand, location scripts could be a surprising way of structuring memory retrieval, leading to the location script becoming more salient than the social script. In the condition where participants only received social priming, their recalls contained the most social semantic content. This could be a result of people's attention defaulting to observing social interactions. This was found in previous pilot data that compared the semanticity of people's recalls when they were location primed, social primed, or not primed. Data showed that when participants were not primed, their recalls had a similar semantic structure to those who were social primed. This suggests that the social prime effect is the default, and it is only when participants receive a novel script perspective (i.e. location) that there are significant shifts in recall structure. In order to test this interpretation, a future study will need to be conducted with a control group that receives no initial priming before encoding.

While further research is needed to confirm the defaulting to social scripts interpretation, in light of research suggesting the importance of location information above, it also bears

consideration that the nature of social scripts are more flexible than location scripts and thus are more difficult to prime participants with. Schemas and scripts are not the same across individuals. Our findings could be representative of the diversity of experience that informs the schemas of our participants, potentially in culture, age, and gender. The development of schemas is influenced by personal experiences and cultural background (Schank & Abelson, 1977). For example, some places do not have a waiter bring a check to the table in any restaurant, which illustrates how a script may be different between people. Scripts are most comparable between people when they are "culturally consensual" (Schank & Abelson, 1977). Even when the script training method is consistent, issues can arise in learning the script depending on culture, experience, and identity.

Measurement of Semanticity

In our study, we utilized a novel method of measuring semantic content by selecting the story details that corresponded with the multi-stage script to form a template for the script. Traditional free recall analysis methods often hand score recalls for their episodic and semantic details, or categorize recall information by their autobiographical relevance to personal remote memory (Anderson et al., 1983; Levine et al., 2002). Others take a computational approach by utilizing latent semantic analysis to extract meaning from text utilizing a bag-of-words model to map the occurrence and distribution of words within recall, and comparing words by their Term Frequency-Inverse Document Frequency (TF-IDF) score to determine distinctive terms that contribute to the overall semantic content of the recall (Evangelopoulos, 2013).

A primary goal of this research was to see whether we could utilize the Universal Sentence Encoder to represent semanticity and events in memory recall across participants. By utilizing the USE, we aimed to maintain the meaning behind word order in the recall, which

other NLP tools do not always maintain when measuring semanticity. We intended to test the validity of utilizing the USE to represent the underlying semanticity of memory recalls and measure how people's recalls are shifting in semantic space. Our results confirmed the validity of using the USE to represent semanticity and compute script similarity and shifting as the results of priming found in this study supported the ones found in our pilot study which utilized a word-to-vec analysis. While the USE has previously been validated to accurately represent semantic structure of text, it had yet to be used in cognitive psychology to investigate semanticity in memory recall (TensorFlow). The use of the USE in this thesis suggests increasing recognition of the role of NLP tools in representing language and order-based semantic understanding across people. This highlights potential for further psychology research to explore the utilization of these resources.

Limitations and Future Study

Future studies should explore how types of scripts differ in strength and representation. We noted a significant difference in the effects of social and location scripts in our experiment. While we are confident that the materials used in the study were successful at activating a specific script – airport or breakup – the effects of overall script retraining are less clear. Our data indicated that location priming and retraining had significant effects on the location semanticity of participant recalls, but the mechanics behind this finding cannot be fully explained through this data.

This study was limited to one story and two specific scripts. Therefore, to further test whether the effect of script retraining is differentiated by the type of script and any location script specific effects, future research should replicate this study with a larger and more diverse sample and corpus of scripts and stories that cover different location and social pairings. Future

research can determine if this re-training effect is localized to a particular type of script (only location) or specific scripts (an airport). The next step for this research would be to replicate the study with all 16 stories that were included in the pilot study. This step would allow comparisons between different combinations of location and social scripts.

Furthermore, additional participant testing should be done to gather insight on how participants interpret the scripts and the extent that they are consciously or unconsciously aware of the effects of the priming on their recall. Future studies will need to gather participants' reflections and attitude towards the scripts and story's characters following the second recall.

Conclusion

In our study, we found that activated scripts had a significant impact on the semantic content of recalls, as measured by their vector representation in a novel language model. Our findings suggest that script activation can enhance encoding when activated during reading and can selectively boost retrieval when activated during recall. This study particularly demonstrates the strength of location information in schema effects. Overall, we highlight the role of script training in shaping our memories, and underscores the importance of considering the impact of different perspectives on information processing. By demonstrating that our memory is not only influenced by what we experience, but also by what perspective we use to retrieve and interpret it, our research underscores the need for a more nuanced understanding of the factors that shape memories.

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Appendix A

Full text of “Hop on the Liberty Plane” presented line by line to participants.

1.	It didn't help the situation that Calvin and Jessie were running late to the airport, since Jessie had already been fuming at Calvin and preparing to end the relationship with him.
2.	Upon arriving at their terminal, they had only 45 minutes until their international flight would depart from Jamaica for the US.
3.	It had been a tough vacation, which was planned well before Jessie began to think of breaking up with Calvin 6 weeks ago.
4.	Calvin knew that Jessie was upset, but wasn't sure what to do besides attempt to carry on as normal.
5.	The security line was very short, and once the online boarding passes were scanned, they put their bags on the conveyor belt.
6.	Calvin also took off his belt and watch.
7.	There was a short halt in security proceedings so that the security guards could change shifts, but, once everything was back in order, they were ushered quickly through the metal detector.
8.	The infrastructure of this airport is really quite poor," said Calvin as they waited for their bags to emerge from the x-ray machine.
9.	I could've hidden something in my shoes easily.
10.	Jessie, exasperated, scowled at the conveyor belt.

11.	What?, he asked.
12.	Balling up her fists and turning to him angrily, she said, Calvin, I want to break up because I don't think our personalities are compatible.
13.	I think it's best that once we get to the States we part ways for good.
14.	Calvin said nothing as he grabbed his bag and walked down the concourse.
15.	Jessie trailed behind him as they hurried their way quickly toward gate A28.
16.	So now you have nothing to say? Jessie asked.
17.	Calvin didn't answer, gritting his teeth and staring straight ahead.
18.	He was very frustrated that he felt he had been trying to appease Jessie for the entirety of the vacation, and it seemed to be completely unappreciated.
19.	Their silence was punctuated only by the rapid, rhythmic clacking of their suitcase wheels over the tile floor as they continued power-walking through the terminal.
20.	Calvin finally turned to address her as they continued walking: Jessie, this makes perfect sense.
21.	If you feel this way, then I think we should break up because I don't want to keep boring you.
22.	I agree, let's part ways once we make it back.
23.	You should've spoken up about my apparent intolerability before you decided to plan this vacation.
24.	He was very hurt, even though he didn't want to show it.

25.	Having made it to their gate, they scanned their tickets, and the annoyed flight attendant shooed them onto the plane and then closed the plane door behind them.
26.	Luckily, they had forgotten to arrange seats next to each other on the flight back.
27.	They were both in economy, but Jessie was headed for seat 33A while Calvin's seat was 36F.
28.	Before Jessie sat down, she took a deep breath, calmed her emotions, and then awkwardly shook Calvin’s hand, mumbling, “Have a nice flight.”
29.	Oh, and when you get a chance, could you send me back all the philosophy books I lent you?
30.	He laughed in disbelief and walked to his window seat three rows back to get ready for takeoff.
31.	Both were upset but glad that they would have this flight in solitude.

Appendix B

Script Training Questions and Answers

Table 1

Social Script Training: Couples Therapist Perspective

Training Questions	Story Answer	Text for Social Script Vector
1. For how long has the initiator of the breakup been thinking about breaking up with his/her partner?	It had been a tough vacation, which was planned well before Jessie began to think of breaking up with Calvin 6 weeks ago.	"It had been a tough vacation, which was planned well before Jessie began to think of breaking up with Calvin 6 weeks ago. Balling up her fists and turning to him angrily, she said, Calvin, I want to break up because I don't think our personalities are compatible. If you feel this way, then I think we should break up because I don't want to keep boring you. Oh, and when you get a chance, could you send me back all the philosophy books I lent you?"
2. What is the initial reason stated by the initiator for why he/she is breaking up?	Balling up her fists and turning to him angrily, she said, Calvin, I want to break up because I don't think our personalities are compatible.	
3. Does the person who is being broken up with want to break up, and what's the reason stated by them for this?	If you feel this way, then I think we should break up because I don't want to keep boring you.	
4. Who wants what items back as a result of the breakup?	Oh, and when you get a chance, could you send me back all the philosophy books I lent you?	
Distractor 1. What is the initial reason stated by the initiator for why he/she wanted to meet?		

Distractor 2. Who wants how many letters burned as a result of the breakup?		

Table 2

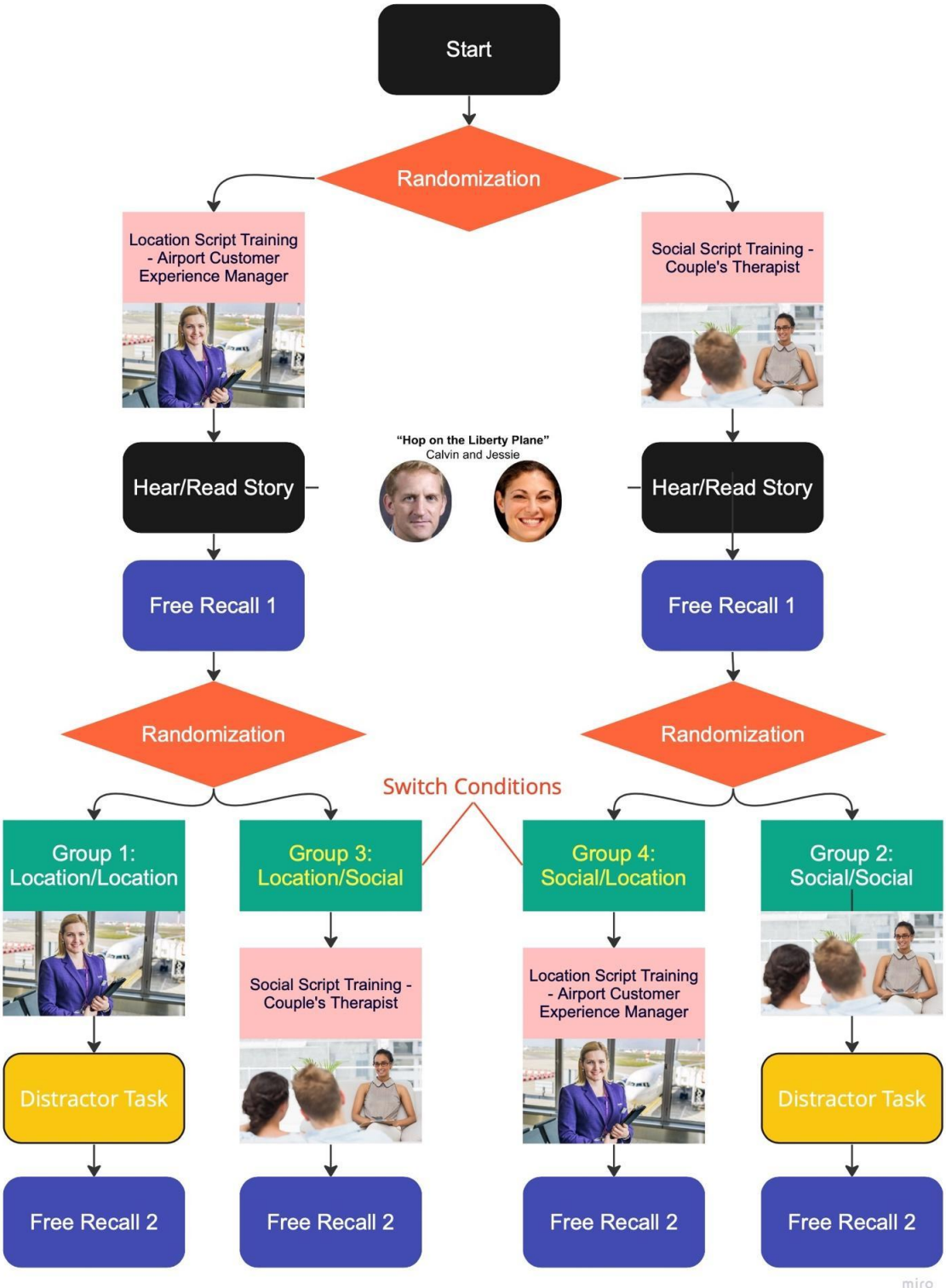
Location Script Training: Airport Customer Experience Manager Perspective

Training Questions	Story Answer	Text for Social Script Vector
1. When the clients arrive at the airport, how much time do they have until their flight departs?	Upon arriving at their terminal, they had only 45 minutes until their international flight would depart from Jamaica for the US.	"Upon arriving at their terminal, they had only 45 minutes until their international flight would depart from Jamaica for the US. There was a short halt in security proceedings so that the security guards could change shifts, but, once everything was back in order, they were ushered quickly through the metal detector. Jessie trailed behind him as they hurried their way quickly toward gate A28. They were both in economy, but Jessie was headed for seat 33A while Calvin's seat was 36F."
2. What is the reason for the hold-up at security?	There was a short halt in security proceedings so that the security guards could change shifts, but, once everything was back in order, they were ushered quickly through the metal detector.	
3. Toward which gate are the clients walking?	Jessie trailed behind him as they hurried their way quickly toward gate A28.	
4. What section and seat does each client sit in on the plane?	They were both in economy, but Jessie was headed for seat 33A while Calvin's seat was 36F.	

Distractor 1. Toward which security line are the clients walking?		
Distractor 2. What section and seat are roped off on the plane?		

Appendix C

Flowchart of Experimental Design



Appendix D

Exploratory Analysis Using Cross Participant Pairwise Similarity

Our first approach to create a template to measure the semanticity of the recalls was to use pairwise subject similarity to calculate the similarity between each Recall 1 with the average of the vectors of all other participants in each priming group. This was because we hypothesized that people's recalls would be most similar to other participants who received the same prime. We created priming templates from the average recalls of subjects' Recall 1, separating participants by initial prime. The participant whose recall similarity score was being computed was removed from the template before calculations to prevent autocorrelation. We found that there was evidence of priming having a directional effect on the similarity (Table 3).

Table 3

Participant's 1st Prime	Similarity to Template	Similarity Score
Location Prime	Location Template	0.8754847159406056
Location Prime	Social Template	0.8629595428726443
Social Prime	Location Template	0.8578558950880814
Social Prime	Social Template	0.870591292277091

The differences in similarity were in the correct direction, but non-significant. We conducted the same analysis for Recall 2, and compared them to the templates formed from Recall 1 (Table 4).

Table 4

Participant's 2nd Prime	Similarity to Template	Similarity Score
Location Prime	Location Template	0.7813740264060859
Location Prime	Social Template	0.7688399134989138
Social Prime	Location Template	0.7824434091107001
Social Prime	Social Template	0.7794205411148959

The difference in similarity was in the correct direction for the Location Prime 2 participants, in that those who were in Group 4, the switch condition from social to location priming, demonstrated higher similarity to the location template in Recall 2 than to the social template. Interestingly, those who were in Group 3, the switch condition from location to social priming also saw higher similarity to the location template in Recall 2 than to the social template, although the participants received the social priming more recently. This suggested that the location prime may be a stronger schema than the social prime, and thus have more effects on memory at encoding and recall.

While our results utilizing cross participant pairwise similarity suggested that there were differing semantic effects across the two scripts, we ultimately decided to use the story script template method for further analysis in order to remove any participant variability that may have affected the templates. We recognize that since participants only received one story, the high levels of similarity between the recalls was likely due to participants all remembering the major tenants of the story regardless of priming. Therefore, we wished to take out correlation between

participants and focus on the semantic structure underlying the recalls in reference to our priming set. The priming effects that we noticed here with the cross participant pairwise similarity template analysis were replicated with the story script template analysis.