THESIS

THE ROLE OF FAMILIARITY IN ILLUSIONS OF PREDICTION

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Andrew M. Huebert

Department of Psychology

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Master's Committee:

Advisor: Anne M. Cleary

Carol S. Seger
James E. Folkestad

ABSTRACT

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Some researchers have argued that the ability to recall (or the recollection of specific details from the past), and the mechanisms involved in doing so, are also used in imagining and predicting future events. However, the ability to recall is only one facet of memory ability. Another is the ability to detect familiarity with stimuli that relate to previously experienced episodes. One might expect that recall is needed to predict future events, as recollection of what occurred in the past might enable prediction of what happens next in a current ongoing episode. However, research on déjà vu has shown a link between familiarity-detection and illusions of prediction and suggests a role of familiarity intensity in these illusions. The purpose of the present study was to examine the role of familiarity-detection more generally in illusory feelings of prediction and to explore possible mechanisms. Increasing cue familiarity led to a systematic increase in prediction confidence despite having little to no effect on prediction accuracy. These results did not differ according to whether the decision was past or future oriented. The results also did not differ according to whether the future oriented prediction was logically possible or irrational in nature.

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CHAPTER 1 – INTRODUCTION

Attempting to predict the future is an important human ability. Predicting the future can be based on memory for the past and can allow people to make smart decisions and plan accordingly. However, even when grounded in memory and experience, predicting the future is not easy. A person may have no relevant memories on which to base their predictions, or an outcome could be random. Despite the difficulty in predicting the future, a person might still feel as though they can predict what will happen in the future. Why might a person feel an illusory sense of prediction? In this thesis I investigate one possible cognitive factor: familiarity.

There are in fact several recent examples of illusory prediction such as Bear and Bloom (2016), who showed that participants can be fooled into thinking that they made predictions they never made. Participants were shown a set of white circles and at random, one of the circles would turn red. Participants' job was to predict which circle would change before the change occurred. Even when participants did not have enough time to make a prediction, they often reported having correctly predicted which circle would change color. Bear et al. (2017) have shown that these illusions are linked to delusionality in ways that relate to erroneous timing mechanisms in the brain.

Very recently, Cleary and Claxton (2018) showed that reported déjà vu states are associated with illusions of prediction. When people report experiencing déjà vu, they are more likely to report feeling like they know what will happen next, even though that is not the case. In reality their predictions are not above chance. What might create these illusions of prediction during déjà vu? One factor appears to be the perceived familiarity of the event. Cleary et al. (2018) have shown that high familiarity intensity is associated with feelings of prediction during déjà vu states. In the present study, I examined whether familiarity-detection more broadly—beyond the study of déjà vu—can also lead to illusions of prediction, and if so, what the underlying mechanisms might be. For example, preliminary data suggests that familiarity can lead to illusions of recollection (Huebert et al., 2020). Given the fact that recollecting the past and thinking about the future are closely linked (Szpunar et al., 2014), I also compared the effect of familiarity-detection on illusions of past recollection to any effect of familiarity-detection on feelings of prediction. Specifically, how does the illusion of recollection that is brought on by familiarity compare to the possible illusion of prediction?

Similarity Between Past and Future Thinking

Memory obviously has the function of enabling remembrance of past events. However, some argue that the real function of memory is to enable thinking about the future (Schacter et al., 2007). Schacter et al. argue that similar to how memory is not a replay of the past but involves construction of the past, constructing possible future events requires the same ability. There is indeed substantial evidence that the ability to remember past events and imagine future events are closely linked. This can be seen in a number of different ways. In terms of cognitive impairments, Klein et al. (2002) examined how a patient (patient DB) with impairments in memory for past events would fair in imagining future events. Patient DB had a great deal of trouble remembering past events that were personally relevant. He did not show problems in recalling past events not relevant to him. The authors found that patient DB also had trouble imagining his own personal experiences in the future. He did not have trouble anticipating possible future events less relevant to him. Klein et al. argued that just as the ability to remember past events can be divided into episodic (personally relevant) and semantic (not personally relevant) events, so can imagining future events.

Similar results have been found with aging. Addis et al. (2008) had older and younger participants recall past events in as much detail as possible. Participants were given a noun as a cue word and asked to imagine a past event somehow related to the cue word. They were also asked to imagine a future event involving the cue word. Responses were also recorded for being episodic (personally relevant) or semantic (factual). Addis et al. found that older adults were able to construct fewer episodic details about past events than younger participants. The authors also found that older adults were able to construct fewer episodic details and more semantic details for future events as well. There was also a correlation between the level of past detail and the level of future detail. Gaesser et al. (2011) also found similar results using picture cues. Older and younger participants were given a picture and asked to describe a possible event that might occur in the future that would occur in the general setting of the picture. They found that older adults reported fewer imagined details than younger adults. Similar concurrent declines in remembering and future thinking have been found with depressed patients. Williams et al. (1996) examined badly depressed participants in their ability to remember past events and imagine future ones. Participants were given scenarios and responses were scored in terms of how specific they were. The authors found that depressed participants were less specific in remembering past events as well as future ones. There was also a strong correlation in both groups between how specific memories for past events were and how specific imagined future events were.

Hassabis et al. (2007) have also found similar concurrent declines in past and future thinking for certain brain lesions. They compared patients with bilateral hippocampus damage to controls on imagining future events. Participants were shown a cue and instructed to imagine a new event and give a description of the event. They were scored on the overall richness of the imagined event. Those with hippocampus damage showed a sharp decline in detail for the imagined event. Hassabis et al. argued that impairment to retrieval of specific memories is likely not simply responsible for trouble with imagining a future event. In other words, it is not the case that participants cannot imagine future events in more detail simply because they recall less past detail on which to rely. One reason is that participants were instructed to not use any actual memories. They also used commonplace cues with the goal of having participants use generalized semantic representations rather than specific episodic memories in the construction of an imagined event. Lastly, one participant with hippocampus damage did not show impairment in episodic retrieval prior to the experiment, yet still showed the predicted problem imagining future events.

Evidence of the overlap between remembering past events and imagining future ones can also be found in the neural correlates of healthy patients. Addis et al. (2007) have found similar FMRI activation between recalling the past and imagining the future. Participants were shown a noun as a cue and asked to construct a past event or future event related to the cue. They were then asked to elaborate on the event as much as they could. Addis et al. found some different activation for the initial construction of the event. Namely, the left hippocampus activated for both construction of a past event and imagining a future one. However, the right hippocampus was mostly engaged in future event construction and not past event construction. During the elaboration phase almost all areas shared activation for both tasks, including both sides of the hippocampus. Furthermore, Szpunar et al. (2007) also found similar activation for remembering and imagining a future event. Participants were given a cue word such as birthday and asked to either imagine reliving a related event or imagine themselves in a related future event. In another condition participants were asked to imagine Bill Clinton doing something related to the cue word. This was done to examine activity for non-personally relevant events. Some areas did show more activity for future events, namely areas involved in motor control. However, many areas (including the bilateral parahippocampal gyrus) showed indistinguishable activation for past events and future events. There was also less activation for imagining Bill Clinton than imagining oneself doing something.

Why then are memory and future thinking closely linked? Many have argued that the ability to retrieve and flexibly use memories allows simulation of possible future events (Schacter, Addis, & Szpunar, 2017, Schacter, Benoit, & Szpunar, 2017). However, other than comparing semantic and episodic memory (Addis et al., 2008), little research has examined exactly what kinds of memory are involved in thinking about the future, and more specifically, in ways that enable people to think about predicting or anticipating future events or outcomes. Szpunar et al. (2014) discuss prediction as one form of future thinking. For example, a person might predict that a company will do well by merging with another. However, this type of prediction might require recollection of some specific details of past events. The person thinking about the companies merging might need to recall specific details of past events that suggest the merger would succeed. This, along with the studies of hippocampal involvement in imagining future events, suggests that recall processes are involved in prediction (Hassabis et al., 2007). However, there is another type of memory that can occur in the absence of recall—familiarity-detection. In contrast to recall, or calling specific information to mind, familiarity-detection involves simply having a feeling about a current situation, that it somehow relates to something from the past. This familiarity feeling could conceivably play a role in feelings of prediction.

Familiarity-Detection in the Laboratory

Research on familiarity-detection largely stems from the study of recognition memory. Recognition memory, which itself has been studied for over 50 years, is the ability to discriminate recently studied from non-recently-studied items on tests given using list-learning paradigms. A major theoretical approach to recognition memory, known as dual-process theory, holds that it can be broken into two underlying bases: recollection and familiarity (Yonelinas, 2002). A real-life example of recollection would be encountering someone on the bus and remembering that the person works at the butcher shop. In the laboratory, recollection-based recognition would occur when recognizing that a test item was studied on an earlier study list by recalling the exact instance in which it was presented (e.g., remembering the thoughts accompanying the word's presentation when it appeared, what the word looked like on the screen, etc.). In contrast, familiarity is simply a feeling that a stimulus has been encountered before, but without remembering when or where that stimulus was encountered. A real-life example would be recognizing a person's face as having been seen before without being able to recall anything specific about where or when the person was seen before. In the lab, familiarity-based recognition occurs when the participant recognizes a test item as familiar without recollecting any specifics about its study list presentation (Mandler, 2008; see Yonelinas for a review).

There are a number of ways to dissociate familiarity and recollection-based decisions. The most common is the remember-know procedure (Gardiner et al., 2002). In this procedure participants indicate whether each test item is simply familiar (know), or they remember seeing it in context (remember). For example, if a participant remembers seeing an item as the first word studied, the participant would make a remember judgment. If the item just feels familiar the participant would make a know judgment. A number of dissociations have been found between remembering and knowing. These dissociations are taken as evidence that recollection and familiarity are unique processes. For example, Yonelinas (2001) used the remember know procedure and found that dividing attention during the study phase produced a decline in remember responses but had negligible effects on know responses. Participants also studied words in a more conceptual manner (rate the pleasantness of each word) or perceptual (count the number of syllables in each word). Conceptual processing had much larger effects on remember responses than know responses. From these results Yonelinas also argued that familiarity is a continuous signal detection process that occurs quickly and without effort, whereas recollection is a threshold like process that is slower and requires conscious effort. Familiarity is also a quantitative process where it is felt in different levels of strength, whereas recollection involves the retrieval of qualitative details of the studied event.

Another method of measuring recollection is to test source memory (Yonelinas, 1999, Johnson et al., 1993). In a typical source memory paradigm, stimuli are studied, and memory for context is tested. For example, words are heard in either a male or female voice. At test the participant is presented with studied and not studied words. The participant must then decide if the word is old or new, and then decide if it was presented in a male or female voice. Similar versions include trying to remember the background color of the word, or where on the screen the word appeared. In the butcher on the bus example recollection is trying to remember the context of when or where the person was encountered, just like how in a source memory task a person is trying to remember the context of what the background color was. Yonelinas argued that familiarity is only useful in discriminating sources for certain tasks. For example, when deciding whether a word was studied in a more recent list, Yonelinas suggested that familiarity can contribute because more recent items will feel more familiar. In remembering the background color of a word, familiarity is not helpful since both sources are (or at least should be) equal in familiarity. Instead a participant must rely on recollection to discriminate between sources.

Another measure of familiarity is recognition without identification (Cleary & Greene, 2000). In this procedure participants study a list of words (e.g., craft) and are given word fragments at test. Half of the test words are fragments of studied words (e.g., c___t) while some are fragments of unstudied words (e.g., f___t). Participants first try to complete the fragment and then they rate how certain they are that the word that completes the fragment was studied. Even when participants are unable to complete the fragment, they still give higher ratings to fragments that correspond to a studied word.

Cleary and Greene (2001) have argued that recognition without identification reflects familiarity instead of recollection. To test this participants completed either the standard recognition without identification task, or an associative recognition test. In the associative recognition test a participant would study word pairs and at test would first see word fragments and try to complete them. The participant would then be shown another word and asked the likelihood that the first word was studied with it. Memory for whether a word was studied with another word is a type of contextual memory. Thus, it is thought to reflect recollection (Yonelinas, 1997). As before, even when failing to identify a word, fragments from studied words still showed higher recognition ratings than those that were fragments of new words. During identification failure associative ratings showed a smaller effect than old new status. This supports the notion that recognition without identification reflects familiarity, since associative recognition is thought to rely less on familiarity and more on recollection.

Further evidence that recognition without identification reflects familiarity can be found in different effects of encoding. Levels of processing (encoding words via meaning vs perceptual features) can affect remember and know judgments differently (Yonelinas, 2001). These two methods of encoding also have different effects on recognition without identification versus recognition with identification. Cleary (2002) found that encoding words in terms of meaning had an effect on completing word fragments and recognition with identification but had no effect on recognition without identification. The same results were found when participants rated words in terms of self-relevance instead of counting vowels, which was another way of manipulating levels of processing.

Another way to separate familiarity from recollection is the recognition without cued recall paradigm (Cleary, 2004). In this paradigm, participants are shown study words and at test are shown certain types of cues that either resemble a studied word or do not resemble a studied word. They are first asked to recall the study word that the cue is similar to. Then they are asked to rate how certain they are that a similar word appeared at study. Of particular interest are the ratings given when participants are unable to recall the cued study word. Participants will still rate the test cue higher if it resembles a study word than if it does not. This resemblance can be based on several dimensions. Experiment 1 examined this for orthographically similar cues. For example, studying the word cheetah and being tested on the word cheetohs. Experiment 2 used the same approach, but study words were heard instead of being seen. Experiment 3 examined the role of phonology (since cheetah and cheetohs both look and sound similar) by using words that sounded similar but did not look similar (e.g., raft and laughed). Lastly, Experiment 4 used semantic similarity such as studying the word cheetah then being tested on the word jaguar. All four experiments showed similar results. Even when participants are unable to use the cue to recall the studied word, they still give higher ratings to cues that resemble a studied word in some way. This overlap in features can be orthographic, phonological, or semantic. Cleary argued that recognition without cued recall can be interpreted as a dual process similar to remember know. If a participant shows successful cued recall this is thought to reflect recollection. When cued recall fails but the cue is recognized this is thought to reflect familiarity in the absence of recollection.

The various types of recognition without identification or recognition without cued recall are rooted in the global matching models of recognition (Clark & Gronlund, 1996). Under these models the individual features of a test item are matched with all features in memory to produce a familiarity signal that will be greater or lesser, depending on the degree of feature match between the test item and all of the items stored in memory. Therefore, recognition without identification and recognition without cued recall can be explained as occurring because a fragment (Cleary & Greene, 2000) or a feature-overlapping cue (Cleary, 2004) corresponding to a studied word has more overlapping features with a studied word than does a new word. As a result, even when identification or cued recall fails those fragments and cues that correspond to studied words still feel familiar and will be more familiar with greater degrees of feature overlap with studied information.

Ryals and Cleary (2012) have shown dissociations suggesting that recognition without cued recall is consistent with the dual process models of recognition (Yonelinas, 2002). Just like with remember know, if recognition with and without cued recall are unique processes, then certain manipulations should show effects on one and not the other. The authors first examined how the concreteness of the word would affect the two processes. They argued that concreteness tends to affect recall (or recollection) and not familiarity. The authors found that concrete words did increase cued recall but did not increase recognition without cued recall. In a second experiment, the authors manipulated the emotionality of the words. They again found an increase in cued recall but not in recognition without cued recall.

In a third experiment Ryals and Cleary (2012) showed another dissociation, one that had a larger effect on recognition without cued recall than recognition with cued recall. Under global matching models (Clark & Gronlund, 1996) a word is matched on all features in memory, not just ones that correspond to a single trace. Therefore, if a cue resembles multiple studied words then it should feel more familiar than if it resembles one or no studied words. To test this Ryals and Cleary had participants study words, some of which shared features with three other study words (e.g., pitchfork, patchwork, pocketbook, pullcork) and some of which were unique on the study list (e.g., spells). Participants later received a test list containing structurally similar non-words that resembled either four studied feature-overlapping words (e.g., potchbork), one studied word (e.g., stells), or no studied words (e.g., neast). As before participants attempted to recall the corresponding studied target word(s) and also rated the familiarity of the test cue itself. Ryals and Cleary found that higher feature overlap led to higher familiarity when recall failed. Recognition ratings for successful recall were affected by overlap, but less so than when recall failed. If recognition with cued recall and without cued recall are just stronger and weaker versions of the same process, then this interaction would not be expected, supporting the idea that recognition without cued recall is based on familiarity-detection that itself results from a feature-matching process.

This dissociation has also been observed for semantic feature matching (Cleary, Ryals, & Wagner, 2015). Participants were tested on cues (e.g., cedar) that semantically related to either 4 studied words (*birch*, *oak*, *pine*, *willow*), or two studied words (*birch*, *oak*), or no studied words.

The results were smaller but overall showed the same pattern as Ryals and Cleary (2012). Increasing semantic overlap increased familiarity when recall failed, and this effect was larger than when recall succeeded.

Ryals, Cleary, and Seger (2013) have found distinct neural signatures for recognition with and without cued recall. They found that the hippocampus showed increased activation for successful over failed recall. Other areas such as the perirhinal cortex showed increased activation for matching over novel cues. This also supports the notion that recognition with and without cued recall are unique processes since they are showing different neural activation.

Returning to my central question, can this sense of familiarity without recall create feelings of prediction? Consider the following example: imagine a person walking down the street and seeing a truck approaching a stop sign. What might lead a person to believe that he or she can predict where the truck will turn? One possibility is that the person recollects seeing the truck on this street before. The person might also recollect that the last time the truck was on this street it turned left. Not surprisingly, this might lead the person to feel confident that the truck will turn left. However, what if instead the person cannot recollect any details about the truck in question, including where the truck turned last time, or even that it had previously been encountered on that street? Instead, the truck just feels familiar, and the person infers from this that he or she has seen the truck before. Would the person still feel more confident that he or she can predict where the truck will turn? It might seem that this sense of familiarity would not be involved in feelings of prediction. Yet, the research on déjà vu discussed next suggests that a person might think that he or she has a higher chance of predicting something when there is a sense of familiarity.

Déjà Vu and Feelings of Prediction

Déjà vu is the feeling that something has been encountered before, despite knowledge that it must be new (Brown, 2004). Cleary et al. (2009) and Cleary et al. (2012) have argued that déjà vu results from an overlap in features just as familiarity does and may even result from a special instance of the same familiarity process being tapped in recognition without cued recall paradigms. Using a variation of the recognition without cued recall procedure (Cleary, 2004), the authors were able to recreate déjà vu in the laboratory. Participants studied black and white line drawings of scenes and were later tested on structurally similar scenes and completely novel scenes. The similar scenes had the same shape and layout but had different objects than the studied scenes (see Figure 27 in appendix). Cleary et al. had participants try to recall the structurally similar scene and focused on trials when recall failed. The authors found that the probability of reporting déjà vu was higher for scenes that resembled studied scenes than for those that did not. Similar results have been found using virtual reality. Cleary et al. (2012) used a similar procedure as the above article, but instead used virtual reality. The key finding was that on trials where recall of the studied scene failed, déjà vu was more likely to occur for scenes that resembled a previous scene than those that did not and was even more likely in instances of greater feature overlap between the test scene and the earlier-viewed scene in question.

Déjà vu has also been shown to be associated with feelings of prediction. Survey reports have suggested an association between déjà vu and feelings of prediction (Brown, 2004), while Cleary and Claxton (2018) have documented this effect in the laboratory. Cleary and Claxton had participants move through a virtual environment at study. As in previous work, half of the test scenes mapped onto study scenes while half did not. In the structurally similar scenes at test, the camera stopped short of where a turn had occurred in the structurally similar study scene.

Participants had to indicate if they felt that they could predict the direction of the turn, as well as if they were experiencing déjà vu. Not surprisingly, when recall succeeded, participants were able to predict the direction of the next turn at above chance levels. Interestingly, however, Cleary and Claxton found that participants did not have any actual prediction ability (they were at chance level) when recall failed, yet despite this, participants were more likely to indicate a feeling of prediction when in a déjà vu state.

One consistent finding is the strong relationship between déjà vu and familiarity. Cleary et al. (2009) have shown that feelings of familiarity are high among déjà vu states, and that structural similarity increases both feelings of familiarity and déjà vu. Cleary et al. (2012) have also shown that high familiarity follows similar patterns as déjà vu. Specifically, that when a scene maps onto a studied scene, déjà vu is more likely and familiarity ratings are higher. In a second experiment, Cleary et al. examined familiarity and déjà vu for scenes that were identical to studied scenes but that were incorrectly labeled as new, as well as structurally similar unidentified scenes, and novel scenes. A similar relation was found where identical scenes that were labeled as new received both the highest familiarity ratings and the highest probability of déjà vu states. As in the first experiment, structurally similar unidentified scenes were next in both déjà vu and familiarity, followed by novel scenes. Given that déjà vu is associated with feelings of prediction (Cleary & Claxton, 2018) and déjà vu is related to familiarity, then familiarity may also be related to feelings of prediction. Cleary and Claxton also found that structurally similar scenes increased familiarity, déjà vu, and feelings of prediction each in similar fashion.

Cleary et al. (2018) have more directly tested the links between familiarity, déjà vu, and feelings of prediction. Using a yes/no indication of familiarity, participants were more likely to report a feeling of familiarity when in a déjà vu state. Among déjà vu states, those that came with feelings of prediction were also associated with a higher tendency to report a feeling of familiarity. When familiarity was reported, participants also reported on the intensity of the feeling of familiarity. Cleary et al. found that among familiar scenes, déjà vu states with feelings of prediction felt the most familiar, followed by déjà vu states without feelings of prediction, followed by non-déjà vu states. Lastly, regardless of déjà vu, feelings of prediction were associated with more familiarity reports and higher familiarity intensity than scenes that did not produce feelings of prediction. In short there is a strong association between familiarity, déjà vu, and feelings of prediction. This suggests the possibility that feelings of familiarity outside of déjà vu are associated with feelings of prediction.

Note that Cleary and Claxton's (2018) finding that when recall succeeded, prediction was above chance, is analogous to when a person can recollect where the truck turned last time the person would actually have some ability to predict where it will turn in the future. When recall failed, Cleary and Claxton found no predictive ability, but despite that, participants often wrongly thought they could predict the turn when experiencing déjà vu. Cleary et al. (2018) showed that familiarity seems to be at the heart of this prediction illusion. Thus, while familiarity might not help with prediction it could be the case that familiarity makes people more confident that they can predict a future event. In the truck example, a high sense of familiarity could lead participants to falsely think they can predict where the truck will turn.

Illusions of Prediction and Illusions of Recollection

If familiarity can drive illusions of prediction (Cleary et al., 2018), and past and future thinking are closely linked (Szpunar et al., 2014), then can familiarity drive illusions of past recollection? Preliminary data from our lab (Huebert et al., 2020) suggests that there may be some commonality between illusions of past occurrence and illusions of future prediction. In one experiment participants studied words that came with an arrow pointing left or right. This background arrow was included to examine recollection confidence and accuracy, with the logic being that correctly identifying the direction of the arrow requires recollection of it accompanying the word at study. Part of the logic here is that source memory tests involve recalling an aspect of the context of a presented item (Yonelinas, 1999), and the arrow in this case represents a form of context.

As in Ryals and Cleary (2012) each test cue (e.g., potchbork) mapped onto either four studied words (e.g., pitchfork, patchwork, pocketbook, pullcork), one studied word (pitchfork), or no studied words. This was done to manipulate familiarity in the absence of recall. Participants first rated the familiarity intensity of the cue. Next, participants indicated their confidence in knowing the direction of the arrow. They then indicated whether they thought the arrow was left or right. Lastly, participants attempted to recall a studied word that resembled the test cue. Participants made each of these judgments for each test cue.

Huebert et al. (2020) only examined trials where recall failed. This was done to try to isolate familiarity-based decisions. As was discussed earlier, Ryals and Cleary (2012) found evidence that recognition in the absence of recall reflects familiarity. In addition to replicating the results by Ryals and Cleary, Huebert et al. also found that cue overlap increased participants' confidence in knowing the direction of the arrow. However, during recall failure, participants were actually not above chance at selecting the correct direction of the arrow. The authors argued that when participants feel a sense of familiarity, they assume that some level of recollection is also present. These results are analogous to what Cleary and Claxton (2018) found for prediction ability; familiarity appears to have led participants to be more confident in their recollective ability when in reality, they were not above chance.

Huebert et al. (2020) used similar paradigms in Experiments 2 and 3. In Experiment 2 participants studied words on a green or blue background instead of with a background arrow. Participants rated their confidence in recollecting the background color and tried to recollect the color. In Experiment 3 each word came with a high or low-pitched sound. Participants indicated their confidence in recollecting the background sound and tried to recollect it. Just as with the background arrow in Experiment 1, the color or background sound was a source memory task to examine recollection confidence and accuracy. Experiments 2 and 3 showed the same results as Experiment 1; that increasing cue overlap increased recollection confidence (background color or sound) but not recollection accuracy.

From the example of the truck earlier, in conjunction with the findings of Cleary and Claxton (2018), who found that the ability to recollect specifics enabled above-chance prediction whereas mere feelings of déjà vu only led to illusory feelings of prediction, it might seem that recollection is required to make predictions. However, remember that thinking about the future is a key ability of memory. Thus, if familiarity can create illusions of recollection as in Huebert et al. (2020), is it possible that familiarity could create similar illusions of prediction? Similarly, another goal of this thesis was to compare the effects of familiarity on recollection versus prediction confidence.

Familiarity Use in Past and Future Judgments

While familiarity seems to create illusions of recollection (Huebert et al., 2020), and familiarity is linked with illusions of prediction (Cleary et al., 2018), some evidence suggests that there are at least some cases in which familiarity is used differently for past and future judgments. In other words, there are situations in which participants decide to differentially rely on perceived familiarity versus other information. In one examination of judgments about the future, Nomi and Cleary (2012) compared recognition without identification for scenes to feelings of knowing. In contrast to familiarity ratings given in recognition without identification paradigms (which are past-oriented), feelings of knowing are future-oriented, such as when participants rate the likelihood that they will recognize a test word on a future test. Participants were shown a list of names of famous places, then later shown pictures of those places or new places. When a picture could not be named, old scenes were rated as more familiar than new scenes. In the feeling of knowing condition, participants were asked to indicate how likely they thought it was that they would recognize the name on a later recognition test. Surprisingly, the opposite of the standard recognition without identification effect (higher familiarity ratings for scenes whose name had been studied, even when the name could not be stated) was found for feelings of knowing. Participants gave lower ratings of feelings of knowing for pictures of unnamed places whose names were studied than unnamed places whose names were not studied. Nomi and Cleary argued that recognition without identification relies on familiarity whereas feelings of knowing might rely on accessibility to idiosyncratic partial information. Studied scenes may have been primed to be identified more often, whereas unstudied words would more often contain partial identification that would have been pushed to full identification if they had been studied. Non-studied items did in fact show more partial retrieval than studied items. This partial access might have led participants to believe they would recognize the item later, since they were relying on accessibility instead of familiarity.

In contrast to the above findings, Cleary (2015) did show that people will use familiarity to guide future-oriented decisions, but not to the same extent as in past-oriented decisions. Cleary suggested that the tasks described above might have produced more partial access than the recognition without cued recall paradigm. In the recognition without cued recall paradigm participants should not have more partial access for unstudied words. Using the same procedure as Ryals and Cleary (2012), participants either made the same past judgment (a familiarity rating) or a future judgment (a feeling of knowing rating). Increasing familiarity caused participants to increasingly believe that they would recognize the item on a later test; in other words, it increased their future-oriented feelings of knowing judgments. However, this effect was smaller for feelings of knowing judgments than the past-oriented familiarity ratings used to show recognition without cued recall. The rate of increase with increasing test cue familiarity was greater for past-oriented than for future-oriented judgments. Cleary suggested that future-oriented judgments like rating feelings of knowing may rely on other processes and cue familiarity is only one of them, while past-oriented judgments are based more heavily in cue familiarity.

To the point of the present research, if familiarity itself is used to make future-oriented judgments, then it is possible that familiarity by itself can lead to illusions of prediction. However, given that familiarity seems to be used differently for future-oriented feelings of knowing judgments than past-oriented recognition judgments, I also compared the effect of cue familiarity on feelings of past recollection versus on feelings of prediction. It is unknown whether familiarity could have equivalent or different effects on feelings of recollection and feelings of prediction.

The Present Study

In short, recollection of specific details might be needed to actually predict the future (Cleary & Claxton, 2018; Schacter et al., 2007). However, familiarity is associated with illusions of prediction during déjà vu (Cleary et al., 2018). Familiarity also creates illusions of recollection (Huebert et al., 2020). Familiarity also has been shown to be used to make future-oriented judgments insofar as participants use it to gauge the likelihood of future recognition of currently inaccessible target knowledge, even if not to the same degree that they use it to gauge the likelihood of past occurrence (Cleary, 2015). The goal of the current experiments was to examine the effects of familiarity-detection on feelings of prediction using a standard memory paradigm (as opposed to a déjà vu paradigm).

Another goal of the present study was to determine if familiarity creates illusions of prediction that are equivalent, greater than, or less than illusions of recollection (as in Huebert et al., 2020). It could be the case that familiarity has a similar effect on feelings of recollection and feelings of prediction. Given Cleary's (2015) finding that familiarity has a smaller influence on future-oriented feelings of knowing than on past-oriented feelings of recognition, it could also be the case that feelings of prediction (which are future-oriented) are less influenced by familiarity than are feelings of recollection (which are past-oriented). However, given Cleary et al.'s (2018) finding that high familiarity intensity was associated with feelings of prediction in their déjà vu study, it is also possible that familiarity is strongly associated with feelings of prediction, possibly more so than with feelings of past recollection. Huebert et al. showed fairly small effects of familiarity on feelings of recollection. This difference could be due to major methodological differences between standard recognition without cued recall paradigms and déjà vu paradigms. However, it is possible that participants are more likely to use familiarity to infer prediction than to infer recollection.

Another goal of this thesis was to examine whether familiarity-based illusions are comparable across not only past-oriented illusions of recollection and future-oriented illusions of prediction, but also if they differ when future-oriented illusions of prediction are more versus less rational in nature. Returning to the truck example, if one had only seen the truck parked somewhere before, but had not seen it turn, would the familiarity with the truck still lead to feelings of prediction? In this example, a person might not feel as though he or she can predict the turn based on either recollection of specific details or a sense of familiarity. Yet there is still reason to believe a person would indicate feelings of prediction. In déjà vu reports participants believe the place is new, yet still report feelings of prediction (Brown, 2004), and even in cases where participants show no actual predictive ability, they still feel that they can predict during reported déjà vu states (Cleary & Claxton, 2018). Our own preliminary studies on tip of the tongue state biases have shown that participants feel that they can predict completely random events like a coinflip (Shock et al., 2018). It could be the case that feelings of familiarity similarly drive participants to feel that they can predict completely random events. Therefore, in the present study, I examined three judgments: Judgments of recollection (a past-oriented decision), judgments of logically-based prediction (a future-oriented judgment that is theoretically possible to predict based on the past), and irrational prediction (a future-oriented judgment that is impossible to predict based on the past). I used three variations of the procedure by Huebert et al. (2020). Specifically, the first condition of Experiment 1 was a replication of the background color recollection task used in Experiment 1 by Huebert et al. but with two additional conditions added in a between-subjects comparison. In the second condition, participants performed the same task but instead of a past-oriented feeling of recollection judgment, participants gave future-oriented feelings of prediction judgments that were based in past experience (and thus not irrational). In the third condition, participants gave future-oriented feelings of prediction judgments that were more irrational in nature, as it was theoretically an objectively unpredictable event. Experiment 2 was a conceptual replication of Experiment 1 but was based off of the sound source memory task used by Huebert et al. in Experiment 3. In short, Experiment 2 was an auditory analog to the visual Experiment 1.

Answering these questions will be important for a number of reasons. Firstly, it would enable beginning to examine the role of familiarity in decisions other than recognition memory. As was discussed earlier, recognition memory is usually examined in terms of recollection and familiarity. However, familiarity and feelings of prediction have never been examined outside of déjà vu, and even that is new work (Cleary et al., 2018). The current research will begin to extend an aspect of the recognition memory literature to feelings of prediction; specifically, the role of familiarity (as a memory process) in cognitive biases used in decision-making. Secondly, it would help to expand the knowledge of feelings of prediction. Prediction has typically been examined in the context of actual ability and how it applies to human decision making (e.g., Herdener et al., 2016), or the subjective probability of an outcome (e.g., Carroll, 1978). Predictions have been examined in terms of how people overestimate having made a conscious prediction beforehand (Bear & Bloom, 2016, Bear et al., 2017). Outside of the research on déjà vu, no research has examined illusory prediction confidence and the role of familiarity (Cleary et al., 2018).

The current research will also provide further evidence of the explanation put forth by Cleary et al. (2018). The association between déjà vu and feelings of prediction is correlational and has not been examined outside the realm of déjà vu. The current study could provide experimental evidence of familiarity creating feelings of prediction.

Lastly, the current research could further inform how familiarity is used for past versus future judgments. Cleary (2015) found that familiarity was less utilized for feelings of knowing than past exposure. Nothing is known about the role of familiarity for feeling of recollection versus feelings of prediction and feelings of irrational prediction.

Experiment 1investigated these questions using a background color recollection task (participants had to indicate their confidence in recollecting a background color) or a background prediction task (participants had to try to predict the upcoming background color). Experiment 2 was a conceptual replication of Experiment 1 and was the same except that it involved a different form of the recollection and prediction tasks (sound instead of color).

CHAPTER 2 – EXPERIMENT 1

Experiment 1 examined how different levels of familiarity in the absence of recall influence illusions of recollection, logically based prediction, and irrational prediction using three variations of the procedure by Huebert et al. (2020).

Method

Participants

One hundred and fourteen participants completed Experiment 1. Using G power (Faul et al., 2007), and based on the effect sizes of Huebert et al. (2020) and Cleary (2015), I determined that 90 participants would result in sufficient statistical power (see power analysis in appendix for further detail). However, due to unexpected sign ups and cut off dates that number was exceeded in Experiment 1. Participants were undergraduates from Colorado State University and received course credit for participating. They were male and female and mostly in their late teens to early twenties.

Design

Experiment 1 used a three (cue overlap; high overlap, low overlap, or no overlap) by three (judgment type; recollection, logically based prediction, irrational prediction) mixed design. Cue overlap was manipulated within subjects and consisted of high overlap (test word resembled four studied words), low overlap (test word resembled one studied word), or no overlap (test word resembled no studied words). Judgment type (recollection, logically based prediction, irrational prediction) was manipulated between subjects. In the recollection condition participants indicated their confidence in recollecting the background color of the studied word corresponding to the current test cue. In the logically based prediction condition participants indicated their confidence in predicting the upcoming background color based on the background color of the studied word. The irrational prediction condition was similar to the logically based prediction condition except that studied words did not have any background color. Therefore, there was no plausible way to predict the background color, and any feelings of prediction would be irrational.

Materials

Materials were taken from Ryals and Cleary (2012) and Huebert et al. (2020). Four study and test blocks were made from 96 cue and target sets. The full study and test materials are shown in the appendix. Each set contains a non-word test cue (e.g., POTCHBORK) and four possible study words (e.g., PATCHWORK, PITCHFORK, PULLCORK, POCKETBOOK). Recall that according to global matching models (Clark & Gronlund, 1996) familiarity arises from the amount of overlap in features between a test item's features and all features in memory. Based on global matching models Ryals and Cleary found that overlapping features with several items creates a stronger familiarity signal than overlap with only one item. Thus, it should produce a stronger familiarity signal than a cue that only resembles one study word. Furthermore, a cue that does not overlap with any studied words should feel less familiar than a cue resembling one study word. In short, since familiarity arises through feature overlap (Clark and Gronlund, 1996), manipulating overlap level served as my manipulation of familiarity.

While many types of features can give rise to familiarity (Cleary, 2004), Ryals and Cleary (2012) focused on letter overlap. In the above example POTCHBORK has letter overlap with four study items. The materials were counterbalanced so that each cue appeared equally often in all three overlap conditions. So, in one version POTCHBORK overlapped with four study words. In another version POTCHBORK overlapped with only one study word and a different cue overlapped with four study words. In another version POTCHBORK did not overlap with any study words.

As in Ryals and Cleary (2012) test cues from a set almost always had the same first and last letter since they are weighted more heavily (see Grainger & Whitney, 2004). The number of letters were not always the same between similar studied words. Since cues and targets sometimes were different lengths, Ryals and Cleary (2012) counted from the first letter to the middle letter and from the back letter to the middle letter to examine how many letters overlapped. Each cue had some letters that were in the same location as each of the four possible study words. For example, POTCHBORK is one letter less than POCKETBOOK but they both have matching letters P,O,B,O,K. Each study-test block contained 40 study words and 24 test cues.

Procedure

Before beginning the experiment, participants saw:

> In this experiment, you are going to view a list of words on the computer. The words will flash by, one at a time in the upper left-hand corner of the screen. You should try your best to remember each word for a later test. The test will be explained to you when you get to it. Altogether there will be 4 study-test blocks in this experiment.

In each block participants studied 40 words during the study phase. In the study blocks each word was shown one at a time for two seconds with a one second pause between words. In the recollection and logically based prediction conditions, each study word was presented in white on a blue or green background. Half of the words appeared on a green background and half on a blue background. This source memory task was included to assess recollection. As was discussed earlier, since both sources (green and blue) should be equally familiar recollection should be required to remember them (Yonelinas, 1999). However, in the irrational prediction condition each study word appeared in white on a grey background. Thus, when it later came to the test phase any feelings of prediction would be irrational since unlike the logically based prediction condition, there was nothing to base the prediction on. After the study phase of a block, participants saw:

> Next will be the test list. On the test, you will be presented with non-word cues. These are strings of letters that look like words but are not actual words. Sometimes these non-word cues will LOOK LIKE studied words in their visual appearance. For example, CARDLE looks like the word CANDLE. Sometimes they will not look like a studied word. Your first task will be to rate how familiar the nonword cue seems to you. We are primarily interested in feelings of familiarity when recall fails. For example, sometimes a person will just have a feeling of familiarity, like when you see a person's face and recognize the person as familiar but cannot pinpoint why. So even if you cannot recall a specific studied word that resembles the test cue, you should rate how strong your feeling of familiarity is in response to the cue on a scale of 0-10 (0=no feeling of familiarity; 10=strong feelings of familiarity). If you failed to recall a studied word in response to the cue but you have a strong feeling of familiarity, you would give the cue a high rating on the scale of 0-10. If you don't have any feeling of familiarity, you would give it a low rating.

Depending of which of the three conditions they were in participants were given slightly different instructions. In the recollection condition they saw:

> You will then be asked to indicate your confidence in recalling the background color of the word and then to guess the color, after the test block ends, we will show you what the background colors were for each cue.

Participants in the logically based prediction condition saw:

> You will then be asked to indicate your confidence in predicting the upcoming background color of the word and then to guess the color based on the studied background. After the test block ends, we will show you what the background colors became for each cue.

In the irrational prediction condition participants saw:

> You will then be asked to indicate your confidence in predicting the upcoming background color of the cue and then to guess the color. After the test block ends, we will show you what the background colors became for each cue.

Participants in all conditions then saw:

> Lastly you will be asked if you can recall a studied word that looks like the cue. For example, if the cue was CARDLE and it made you think of the word CANDLE from the

> study list you would type in CANDLE. If you cannot think of a studied word from the list that looks like the cue, simply press Enter (remember that some of the time the cue will NOT correspond to any studied word).

Participants then began a test block of 24 non-word cues. Each cue appeared in white on a grey background. Participants were asked several questions and typed their responses into a dialogue box. The first question was "Do you feel like this cue resembles a studied word? Rate the familiarity of this item on a scale of 0-10, 0=no feeling of familiarity, 10=strong feeling of familiarity". Participants then typed in a number from 0 to 10 and pressed enter. If a number was not typed and the participants pressed enter the same dialogue box stayed on the screen. This familiarity rating was the same for all three conditions.

The next question was different depending on the condition. In the recollection condition participants were asked:

> Do you feel like you recall the background color of the studied word? Rate your feeling of recalling the background color on a scale of 0-10, 0=no feeling of recalling the color, 10=strong feeling of recalling the color.

Participants then typed in a number from 0 to 10 and pressed enter. This was followed by "What was the background color? Was the background color blue or green? B=blue, G=Green".

Participants pressed B or G and pressed enter.

In the logically based prediction condition participants were asked:

> Do you feel like you can predict what the background color of this word will be based on the studied background? Rate your feeling of predicting the background color on a scale of 0-10. 0=no feeling of predicting the color, 10=strong feeling of predicting the color. Participants then entered a number from 0 to 10 and pressed enter.

This was followed by "What will the background color be? Will the background be color blue or green? B=blue, G=green" Participants pressed B or G and pressed enter.

Participants in the irrational prediction were asked:

> Do you feel like you can predict what the background color of this word will be? Rate your feeling of predicting the background color on a scale of 0-10. 0=no feeling of predicting the color, 10=strong feeling of predicting the color.

As noted before, the study words in the irrational prediction condition did not appear with a green or blue background making the outcome seem random to participants. This would be similar to predicting something like a coin flip. Any feelings of prediction would be irrational in nature since there was nothing to base the prediction on. Participants then typed in a number from 0 to 10 and pressed enter. This was followed by "What will the background color be?" Participants pressed B or G and pressed enter.

Lastly, participants were asked "Can you recall a word from the study list that looked like this? If so, type it in." Participants typed in a word and pressed enter or left the box blank and pressed enter if they had no guess. This part was the same for all three conditions.

Participants completed these judgments for the 24 test cues in that block. Of the 24 cues, 8 overlapped with four studied items each, 8 overlapped with only one studied item each, and 8 did not overlap with any studied items. This served as my manipulation of familiarity. Participants then completed three other study blocks each followed by a test block. Each block followed the same procedure except that new stimuli were used.

Upon completing a test block participants in all three conditions were shown "here is what the correct answer was for each cue". Only the high overlap and low overlap cues were shown since there was no correct answer for the non-overlapping cues. Each of the cues were shown on the screen one at a time for one second each. They were each highlighted in the correct color.

CHAPTER 3 – RESULTS AND DISCUSSION

Each trial was coded by hand (in case of spelling errors) as either recalled (the participant recalled a word resembling the cue) or unrecalled (the participant was unable to recall a corresponding word). As in Ryals and Cleary (2012) any of the four words could be recalled even if the cue was from the low overlap or no overlap condition.

Cued Recall

I performed a 3 x 3 overlap (high overlap, low overlap, no overlap) x judgment type (recollection, logically based prediction, or irrational prediction) mixed factor ANOVA on cued recall rates. In replication of prior work (Ryals & Cleary, 2012), there was a significant main effect of overlap on cued recall rates, $F(2, 222) = 500.18$, $MSE = .01$, $p < .001$, $\eta_p^2 = .82$. The means are displayed in Figure 1. There was no overlap x judgment type interaction, $F < 1$, and no main effect of task type, $F < 1$. Given the null interaction, the three judgment types were collapsed for the following analyses. High overlap cues led to more cued recall than low overlap cues, $t(113) = 16.68$, $SE = .01$, $p < .001$, Cohen's $d = 1.39$. Low overlap cues also led to more cued recall than no overlap cues, $t(113) = 18.88$, $SE = .01$, $p < .001$, Cohen's $d = 1.77$.

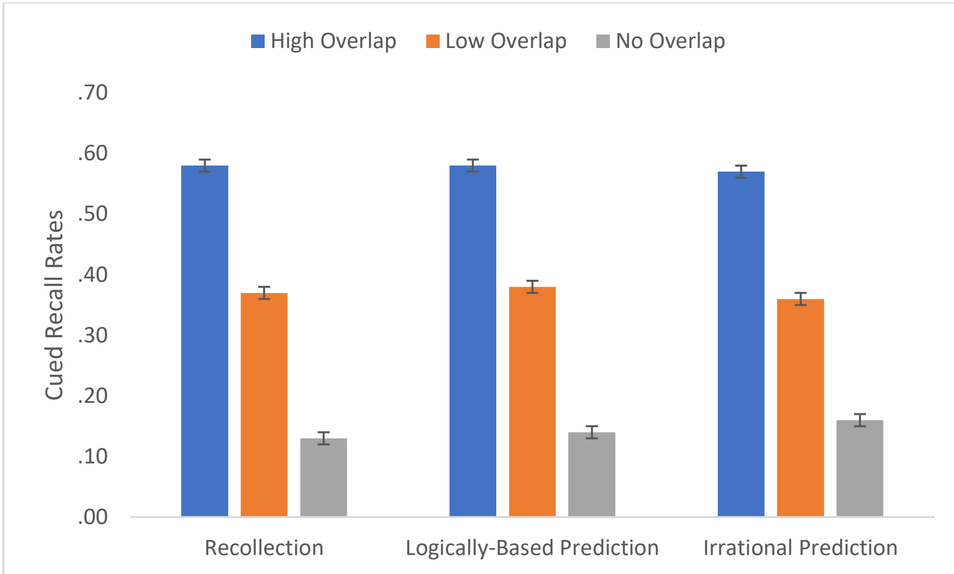

Figure 1. Cued recall rates by overlap level and judgment type. Bars represent standard errors.

Familiarity During Recall Failure (Recognition Without Cued Recall)

Next, I examined the familiarity ratings given to cues whose studied word could not be recalled (Figure 2). I performed a 3 x 3 overlap (high overlap, low overlap, no overlap) x judgment type (recollection, logically based prediction, or irrational prediction) mixed factor ANOVA on familiarity ratings. This served as a manipulation check for the familiarity manipulation. There was a significant main effect of overlap, $F(2, 222) = 98.14$, $MSE = .72$, $p < .001$, $\eta_p^2 = .47$. The overlap x judgment type interaction was not significant, $F < 1$, neither was the main effect of judgment type, $F < 1$. Given the null interaction, the three judgment types were collapsed for the following analyses. High overlap cues were rated as more familiar than low overlap cues, $t(113) = 7.12$, $SE = .12$, $p < .001$, Cohen's $d = .52$. Low overlap cues were rated as more familiar than no overlap cues, $t(113) = 7.48$, $SE = .09$, $p < .001$, Cohen's $d = .44$.

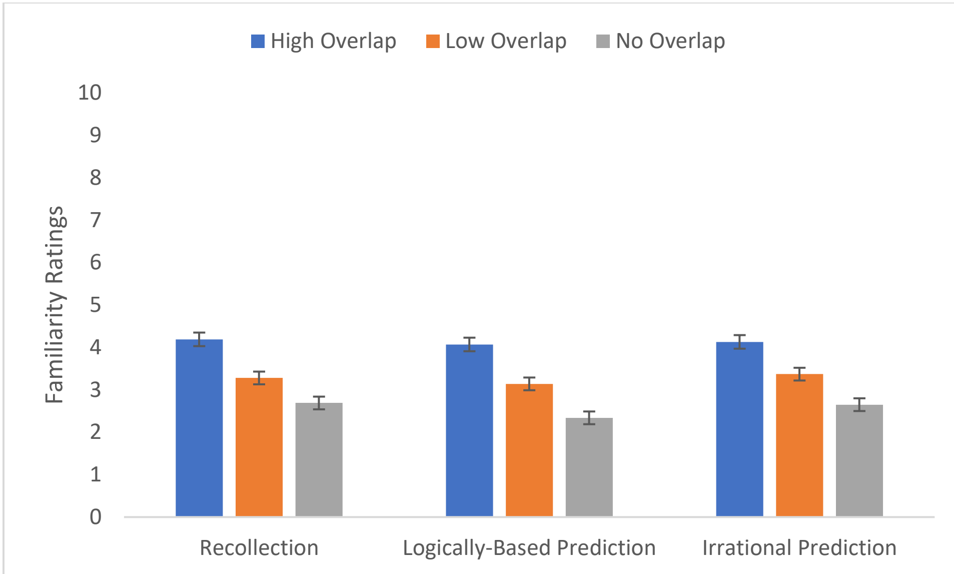

Figure 2. Familiarity ratings by overlap and judgment type. Bars represent standard errors.

Confidence in Knowing the Color

Turning to my primary question of color recollection ratings, logically based color prediction ratings, and irrational color prediction ratings, which I will refer to broadly as confidence in knowing the color ratings, I performed a 3 x 3 overlap (high overlap, low overlap, no overlap) x judgment type (recollection, logically based prediction, or irrational prediction) mixed factor ANOVA. There was a significant main effect of overlap, $F(2, 222) = 45.05$, $MSE = .34$, $p < .001$, $\eta_p^2 = .29$. The means are shown in Figure 3. The overlap x judgment type interaction was not significant, $F < 1$. There was also no main effect of judgment type, $F < 1$. Given the null interaction, the three judgment types were collapsed for the following analyses. High overlap cues received higher confidence in knowing the color ratings than low overlap cues, $t(113) = 5.38$, $SE = .09$, $p < .001$, Cohen's $d = .29$. Low overlap cues received higher confidence in knowing the color ratings than no overlap cues, $t(113) = 4.51$, $SE = .05$, $p < .001$, Cohen's $d = .15$.

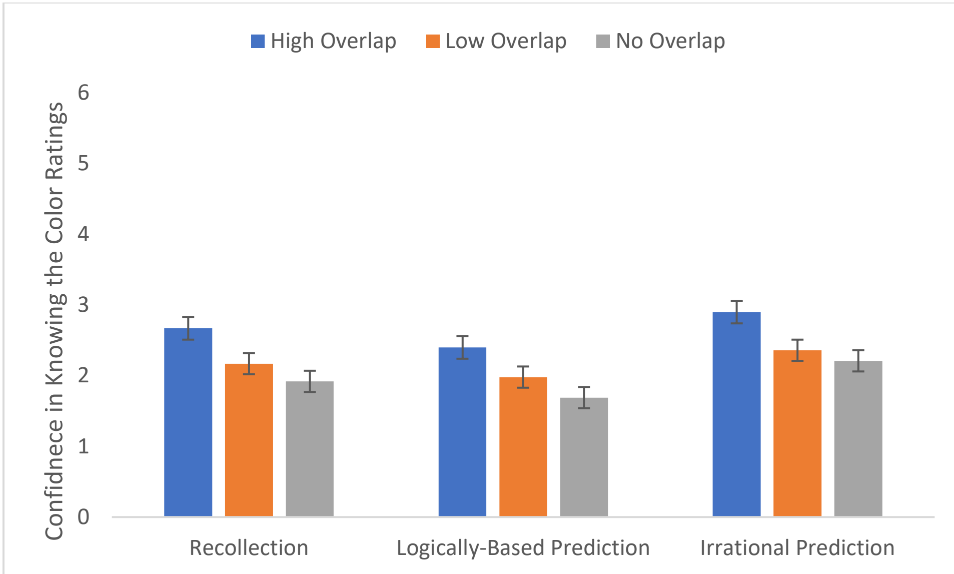

Figure 3. Confidence in knowing the color ratings by overlap level and judgment type. Bars represent standard errors.

Color Recollection and Logically Based Prediction Accuracy

During recall failure, in the recollection condition, color accuracy for high overlap cues was not above chance but approached being significantly above chance (*M* = .537, *SD* = .13), *t*(39) = 1.80, *p* = .08. Color accuracy did not rise above chance among low overlap cues, however (*M* = .49, *SD* = .11), *t* < 1. In the logically based prediction condition high overlap cues were above chance (*M* = .55, *SD* = .16), *t*(38) = 2.06, *p* = .05, whereas low overlap cues did not show above chance accuracy (*M* = .48, *SD* = .12), *t*(38) = -1.13. *p* = .27. In the irrational prediction condition, there was no basis on which performance could have been above chance (as there was no corresponding studied color information in that condition).

Judgments During Recall Success

During recall success, participants in the color recollection condition did show above chance color recollection accuracy for high overlap cues (*M* = .56, *SD* = .14), *t*(39) = 2.61, *p* = .006, but not for low overlap cues (*M* = .52, *SD* = .18), *t* < 1. The same was found for participants in the logically based prediction condition for high overlap cues ($M = .58$, $SD = .13$), $t(38) = 3.72$, $p < .001$. Low overlap cues also showed above chance accuracy ($M = .57$, $SD = .13$), $t(38) = 3.12$, $p = .003$. The irrational prediction condition did not have a basis on which to be accurate, as there was no corresponding studied information in this condition.

For successful cued recall displayed in Figure 4, there was a difference between high overlap and low overlap cues on familiarity ratings, $t(113) = 8.06$, $p < .001$, $SE = .15$, Cohen's $d = .41$. I also performed a 2 x 2 x 3 recall status (recalled or unrecalled) x overlap (high overlap or low overlap) x judgment type (recollection, logically based prediction, or irrational prediction) mixed factor ANOVA on familiarity ratings. There was a significant main effect of recall, $F(1, 111) = 598.99$, $MSE = 2.95$, $p < .001$, $\eta_p^2 = .84$, such that higher familiarity ratings were given during successful recall. There was not a significant recall x overlap interaction on familiarity ratings as in Ryals & Cleary (2012), $F(2, 111) = 1.39$, $MSE = .68$, $p = .23$, $\eta_p^2 = .01$. There was also no recall x judgment type interaction on familiarity ratings, $F(2, 111) = 2.46$, $MSE = 2.95$, $p = .09$, $\eta_p^2 = .04$, or overlap x judgment type x recall interaction, overlap x judgment type, or judgment type effect (Fs < 1) on familiarity ratings either.

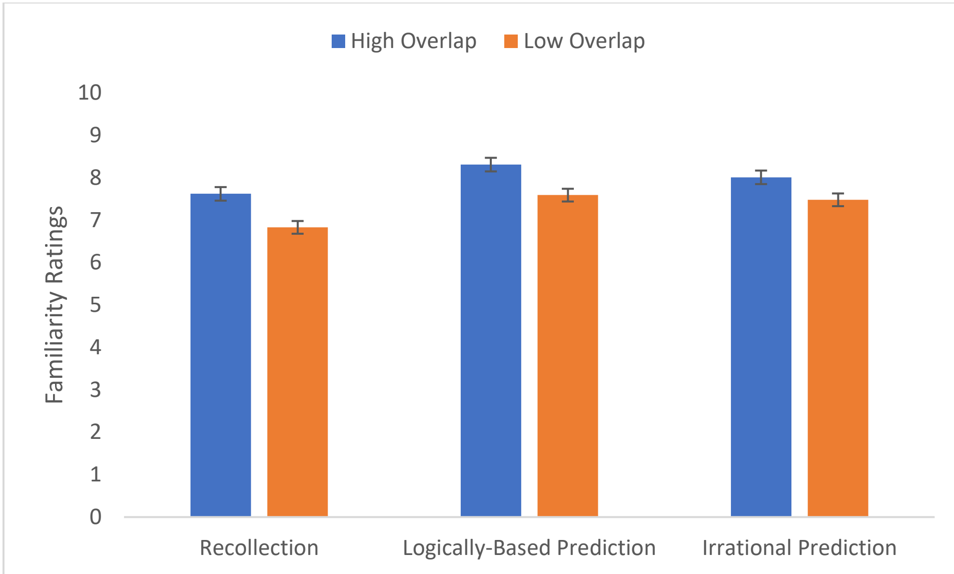

Figure 4. Familiarity ratings by overlap and judgment type for successful cued recall. Bars represent standard errors.

Collapsing across judgment type for confidence in knowing the color ratings, there was a difference between high overlap cues (M = 4.86, SD = 2.24) and low overlap cues (M = 4.45, SD = 2.25), t(113) = 4.48, SE = .16, p < .001 Cohen's d = .18. The results are shown in Figure 5. I also performed a 2 x 2 x 3 recall status (recalled or unrecalled) x overlap (high overlap or low overlap) x judgment type (recollection, logically based prediction, or irrational prediction) mixed factor ANOVA on confidence in knowing the color ratings. There was no overlap x recall interaction, F < 1. There was no main effect of judgment type, F < 1. The three-way recall status x overlap x judgment type interaction was not significant, F(2, 111) = 2.08, MSE = .62, p = .13, η_p^2 = .04. The overlap x judgment type interaction was not significant, F(2, 111) = 2.79, MSE = .31, p = .07, η_p^2 = .05. There was a significant main effect of recall, F(1, 111 = 226.76, MSE = 2.47, p < .001, η_p^2 = .67 on confidence in knowing the color ratings. However, the judgment type x recall interaction was significant, F(2, 111) = 11.62, MSE = 2.47, p < .001, η_p^2 = .17. Combining high and low overlap, recall had a larger effect in the recollection, t(39) = 10.53, SE = .22, p < .001, Cohen's d = 1.14, and prediction conditions, t(38) = 9.18, SE = .34, p < .001, Cohen's $d = 1.47$, than in the irrational prediction condition, $t(34) = 4.22$, $SE = .25$, $p < .001$, Cohen's $d = .55$ on confidence in knowing the color ratings.

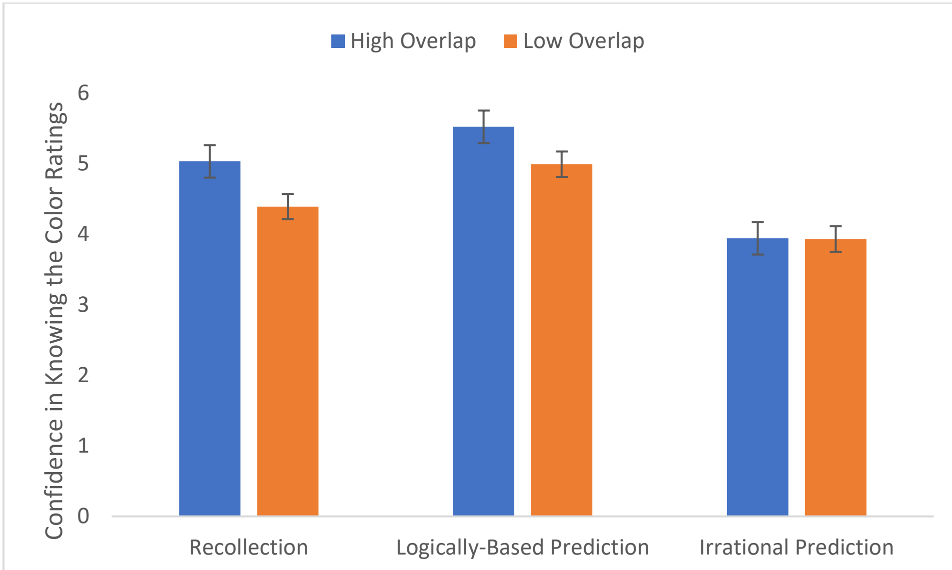

Figure 5. Confidence in knowing the color ratings for successful cued recall by overlap and judgment type. Bars represent standard errors.

Block Analyses

Huebert et al. (2020) did not provide feedback for recollection accuracy. It could be the case that when participants saw the correct answers after every block that this would diminish their sense of recollection or prediction (since they would likely be at chance). This could result in participants' recollection and prediction ratings declining with each block. To examine this possibility, I broke down the familiarity ratings and recollection or prediction ratings into the four test blocks. It could be the case that participants familiarity has unique effects for each judgment type or overall in the first block, but this diminishes over time. Cued recall and color recollection or prediction accuracy were not analyzed by block as they were not relevant to my research question. They would have simply been a fishing expedition.

Familiarity During Recall Failure (Recognition Without Cued Recall)

The means for familiarity ratings by judgment type and block are displayed in Figures 6-9. I performed a 3 x 3 x 4 overlap (high overlap, low overlap, or no overlap) x judgment type (recollection, logically based prediction, or irrational prediction) x block (first, second, third, or fourth block) mixed factor ANOVA on familiarity ratings. The overlap x judgment type x block interaction was not significant, $F(12, 612) = 1.72$, $MSE = 2.19$, $p = .06$, $\eta_p^2 = .03$. There was no significant overlap x judgment type interaction, $F < 1$. The block x judgment type interaction was not significant, $F < 1$. There was no main effect of Block, $F < 1$, or judgment type, $F < 1$. The block x overlap interaction on familiarity ratings was significant, $F(6, 612) = 3.80$, $MSE = 2.19$, $p = .001$, $\eta_p^2 = .04$.

The effect of overlap on familiarity ratings differed by block. For the first block (Figure 6), collapsed across judgment type, there was a significant effect of cue overlap, $F(2, 224) = 23.48$, $p < .001$, $\eta_p^2 = .17$, High overlap cues felt more familiar than low overlap cues, $t(112) = 3.01$, $SE = .24$, $p = .003$, Cohen's $d = .32$. Low overlap cues felt more familiar than no overlap cues, $t(113) = 4.56$, $SE = .14$, $p < .001$, Cohen's $d = .36$.

For the second block (Figure 7), there was also a significant effect of overlap, $F(2, 220) = 25.91$, $MSE = 2.77$, $p < .001$, $\eta_p^2 = .19$, High overlap cues were rated as more familiar than low overlap cues, $t(110) = 4.34$, $SE = .27$, $p < .001$, Cohen's $d = .47$. Low overlap cues felt more familiar than no overlap cues, $t(113) = 2.22$, $SE = .17$, $p = .03$, Cohen's $d = .18$.

For the third block (Figure 8), there was a significant effect of overlap, $F(2, 212) = 47.76$, $MSE = 2.76$, $p < .001$, $\eta_p^2 = .31$. High overlap cues felt more familiar than low overlap cues, $t(106) = 4.85$, $SE = .25$, $p < .001$, Cohen's $d = .45$. Low overlap cues felt more familiar than no overlap cues, $t(113) = 6.00$, $SE = .17$, $p < .001$, Cohen's $d = .51$.

For the fourth block (Figure 9), there was a significant effect of overlap, $F(2, 224) = 21.77$, MSE 2.37, $p < .001$, $\eta_p^2 = .16$. High overlap cues were not rated as more familiar than low overlap cues, $t(112) = 1.73$, $SE = .21$, $p = .09$, Cohen's $d = .16$. Low overlap cues were rated as more familiar than no overlap cues, $t(113) = 4.61$, $SE = .20$, $p < .001$, Cohen's $d = .45$. Thus, the predicted higher familiarity for high overlap cues over low overlap cues was not found in the fourth block but was consistent in all prior blocks. It is certainly plausible that the effect of cue overlap could diminish steadily across blocks due to the accumulation of features in memory. However, there was not a consistent decline in the effect of overlap with blocks, and the difference between low overlap and no overlap cues was the same across blocks.

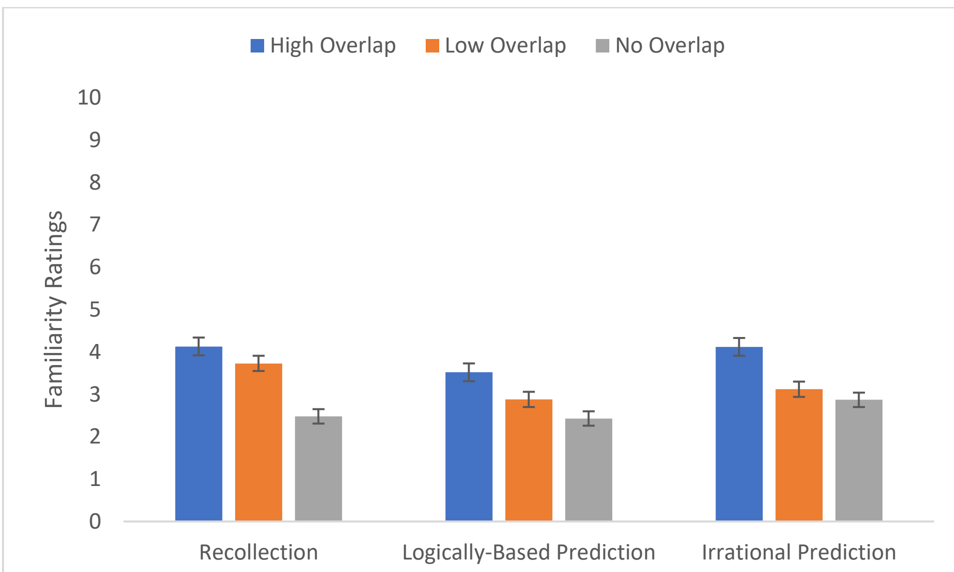

Figure 6. Familiarity ratings for failed recall by overlap and judgment type for block one. Bars represent standard errors.

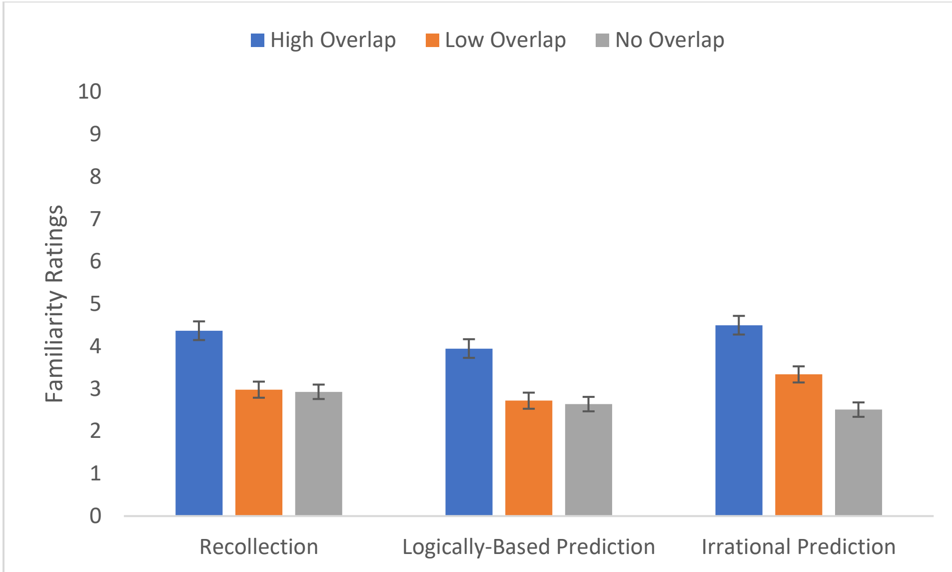

Figure 7. Familiarity ratings for failed recall by overlap and judgment type for block two. Bars represent standard errors.

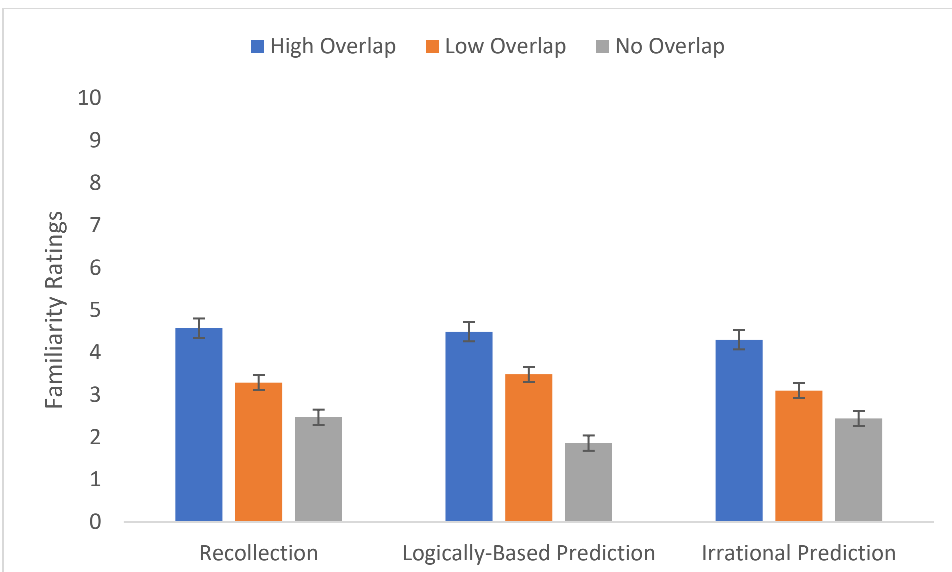

Figure 8. Familiarity ratings for failed recall by overlap and judgment type for block three. Bars represent standard errors.

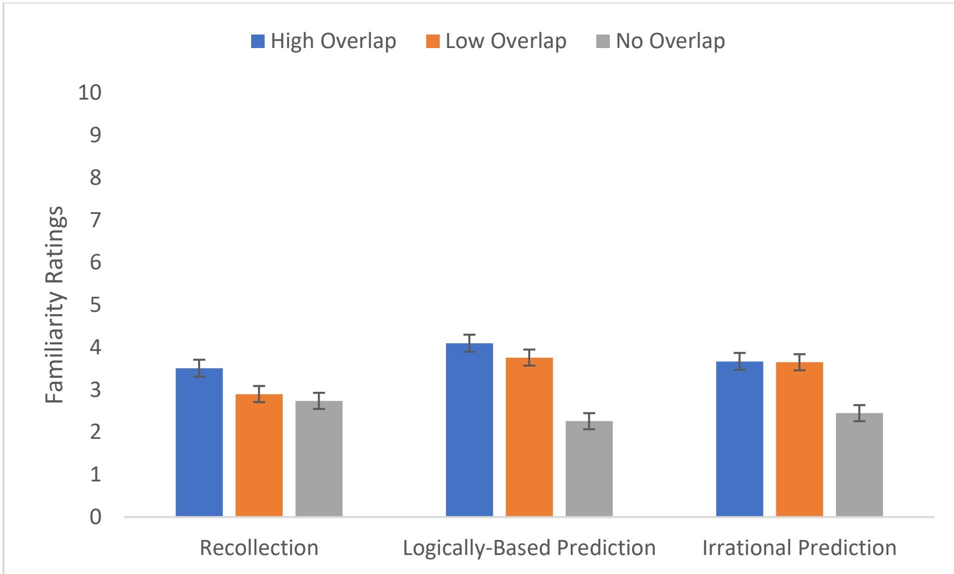

Figure 9. Familiarity ratings for failed recall by overlap and judgment type for block four. Bars represent standard errors.

Confidence in Knowing the Color

The means are shown in Figures 10-13. I performed a 3 x 3 x 4 overlap (high overlap, low overlap, or no overlap) x judgment type (recollection, logically based prediction, or irrational prediction) x block (first, second, third, or fourth block) mixed factor ANOVA on confidence in knowing the color ratings. The three-way interaction was not significant, $F(12, 612) = 1.45$, $MSE = .96$, $p = .14$, $\eta_p^2 = .03$. The block x judgment type interaction was not significant, $F < 1$. The main effect of block was not significant, $F(3, 306) = 1.02$, MSE = 2.72, $p = .39$, $\eta_p^2 = .01$. The main effect of overlap was significant, $F(2,204) = 47.64$, $MSE = 1.33$, $p < .001$, $\eta_p^2 = .32$. The overlap x judgment type interaction was not significant, $F < 1$. The main effect of judgment type was not significant, $F < 1$. The block x overlap interaction was significant, $F(6, 612) = 3.30$, $MSE = .96$, $p = .003$, $\eta_p^2 = .03$.

The effect of overlap on confidence in knowing the color ratings differed by block. For the first block (Figure 10), there was a significant effect of overlap, $F(2,224) = 9.52$, $MSE =$

1.06, $p < .001$, $\eta_p^2 = .08$. High overlap cues were given higher confidence in knowing the color ratings than low overlap cues, $t(112) = 2.37$, $SE = .16$, $p = .02$, Cohen's $d = .19$. Low overlap cues were given higher confidence in knowing the color ratings than no overlap cues, $t(113) = 2.30$, $SE = .10$, $p = .02$, Cohen's $d = .12$.

For the second block (Figure 11), there was also a significant effect of overlap, $F(2, 224) = 20.88$, $MSE = 1.06$, $p < .001$, $\eta_p^2 = .23$. High overlap cues were given higher confidence knowing the color ratings than low overlap cues, $t(110) = 4.68$, $SE = .16$, $p < .001$, Cohen's $d = .36$. Low overlap cues were not given higher confidence in knowing the color ratings than no overlap cues, $t < 1$.

For the third block (Figure 12), there was also a significant effect of overlap, $F(2, 212) = 32.08$, $MSE = 1.14$, $p < .001$, $\eta_p^2 = .23$. High overlap cues were given higher confidence in knowing the color ratings than low overlap cues, $t(106) = 4.93$, $SE = .16$, $p < .001$, Cohen's $d = .34$. Low overlap cues were given higher confidence in knowing the color ratings than no overlap cues, $t(113) = 3.50$, $SE = .11$, $p = .001$, Cohen's $d = .21$.

For the fourth block (Figure 13), there was also a significant effect of overlap, $F(2, 224) = 6.65$, $MSE = .94$, $p = .002$, $\eta_p^2 = .06$. High overlap cues were given higher confidence in knowing the color ratings than low overlap cues, $t(110) = 1.43$, $SE = .14$, $p = .16$, Cohen's $d = .10$, Low overlap cues were given higher confidence in knowing the color ratings than no overlap cues, $t(113) = 2.36$, $SE = .11$, $p = .02$, Cohen's $d = .13$.

Thus, the effect of overlap was different by block. The predicted differences in confidence in knowing the color ratings were found in all blocks except blocks two and four. In block two low overlap cues were not given higher confidence in knowing the color ratings than no overlap cues. In block four, high overlap cues were not given higher confidence in knowing the color ratings than low overlap cues.

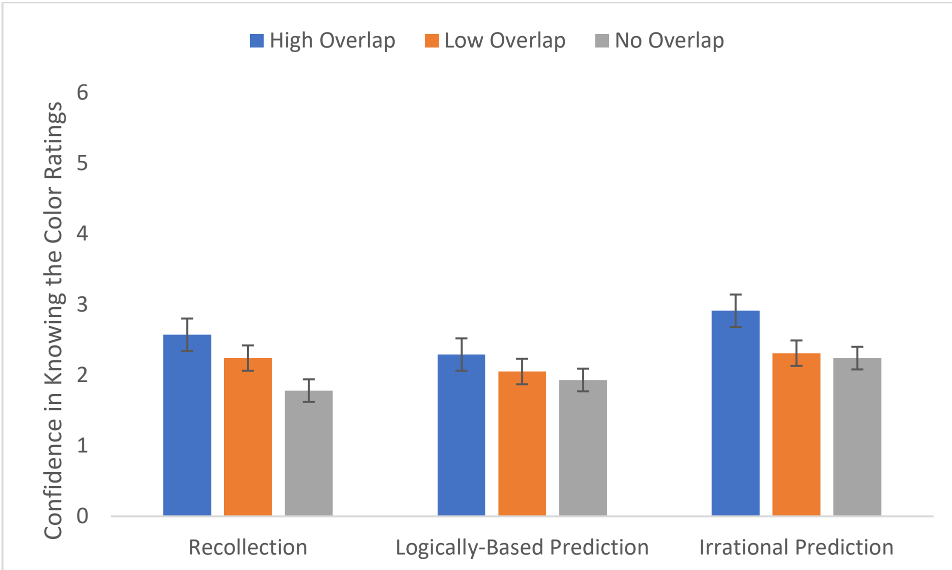

Figure 10. Confidence in knowing the color ratings by overlap and judgment type in block one. Bars represent standard errors.

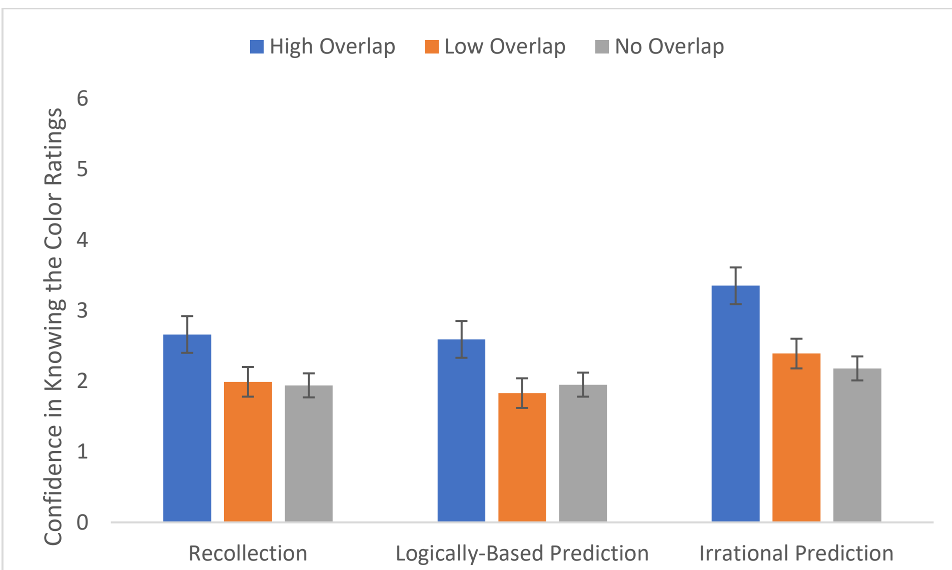

Figure 11. Confidence in knowing the color ratings by overlap and judgment type in block two. Bars represent standard errors.

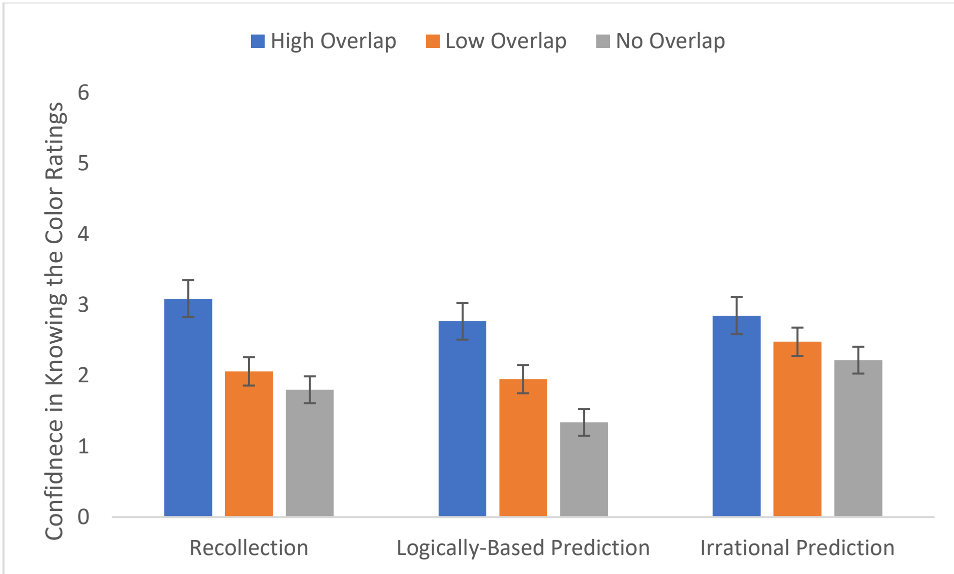

Figure 12. Confidence in knowing the color ratings by overlap and judgment type in block three. Bars represent standard errors.

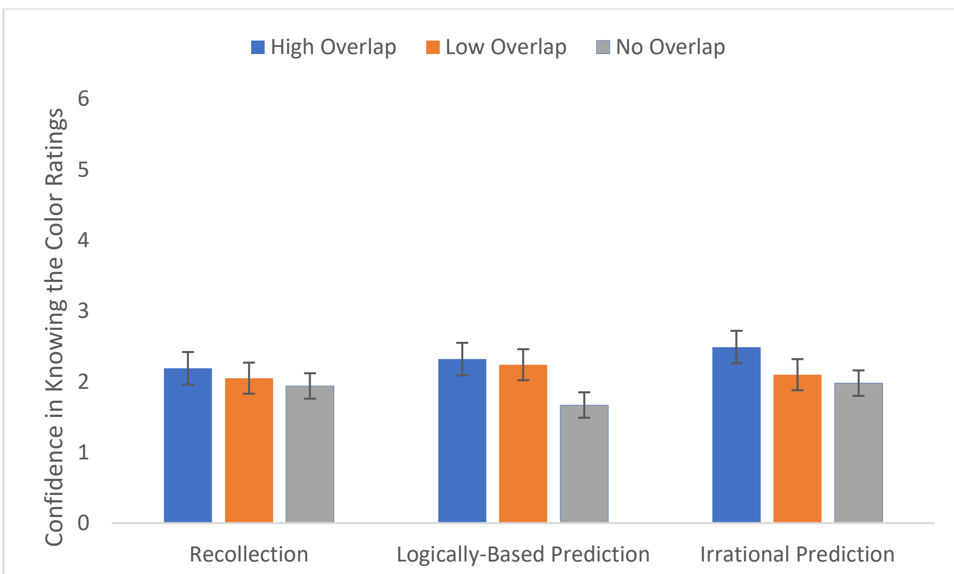

Figure 13. Confidence in knowing the color ratings by overlap and judgment type in block four. Bars represent standard errors.

CHAPTER 4 – EXPERIMENT 2

Experiment 2 was a conceptual replication of Experiment 1. Thus, it was largely the same except that it used the sound-based judgment of Huebert et al. (2020) Experiment 3. That is, study words were presented in black on a white background and a high- or low-pitched tone was played in the background in the recollection and logically based prediction conditions. No background tone was played in the irrational prediction condition. In the recollection condition participants had to indicate their confidence in recollecting the background sound. In the logically based prediction condition participants had to indicate their confidence in predicting the upcoming background sound based on the studied sound. In the irrational prediction condition participants had to indicate their confidence in predicting the upcoming background sound (with nothing to base it on).

Method

Participants

Eighty-nine participants completed Experiment 2. I determined 90 participants to be a large enough sample size based on the same power analysis discussed in Experiment 1 and the Appendix. However, unexpected no shows resulted in 89 participants.

Design

Experiment 2 used the same three (cue overlap; high overlap, low overlap, or no overlap) by three (judgment type; recollection, logically based prediction, irrational prediction) mixed design as Experiment 1.

Materials

The materials for Experiment 2 were the same materials from Ryals and Cleary (2012) and Huebert et al. (2020) used in Experiment 1.

Procedure

The procedure was the same as Experiment 1 except that the source memory/prediction judgment was based on a background sound. Participants studied words in the same manner but instead of a green or blue background each study word appeared in black on a white background and was accompanied by either a high or low-pitched sound. The sound lasted one second. This was also included to assess recollection. Both the instructions before each test block and the dialogue boxes during the test blocks were the same except that they asked about sounds instead of colors. At the end of the test block participants saw each cue from that block and the correct high or low sound was played with it.

CHAPTER 5 – RESULTS AND DISCUSSION

Cued Recall

Trials in Experiment 2 were coded as recalled or unrecalled in the same manner as Experiment 1. The cued recall means are shown in Figure 14. First, I examined cued recall rates with a 3 x 3 overlap (high overlap, low overlap, no overlap) x judgment type (recollection, logically based prediction, or irrational prediction) mixed factor ANOVA on cued recall rates. As in Ryals and Cleary (2012), there was a significant main effect of cue overlap, $F(2, 172) = 299.19$, $MSE = 0.01$, $p < .001$, $\eta_p^2 = .78$, Low overlap cues produced higher recall than no overlap cues, $t(88) = 14.12$, $SE = 0.01$, $p < .001$, Cohen's $d = 1.55$, demonstrating significant cued recall. High overlap cues produced higher recall than low overlap cues, $t(88) = 14.74$, $SE = .02$, $p < .001$, Cohen's $d = 1.33$. The recall x judgment type interaction was not significant, $F(4, 172) = 1.01$, $MSE = .01$, $p = .41$, $\eta_p^2 = .02$. The main effect of judgment type was also not significant, $F < 1$.

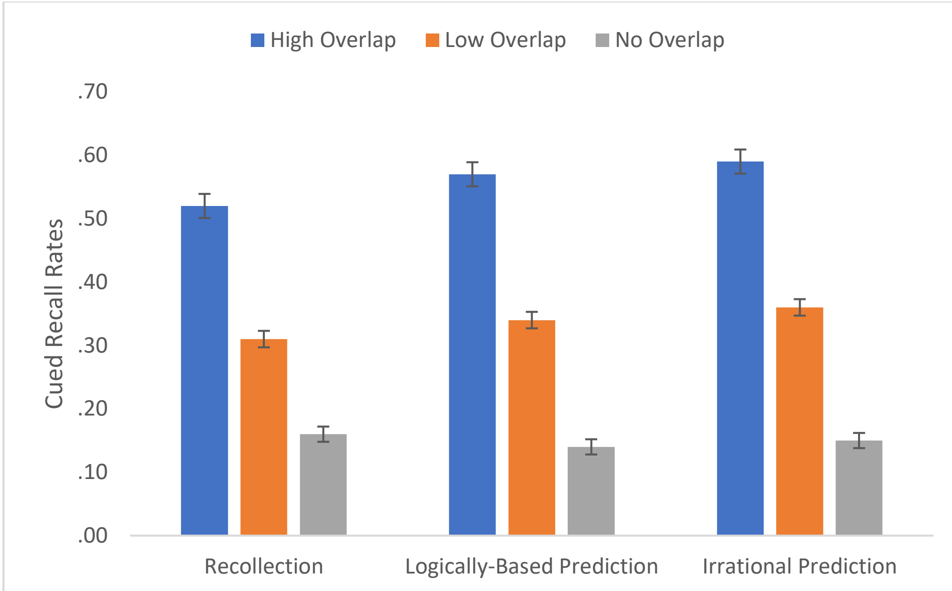

Figure 14. Cued recall rates for overlap levels and judgment types. Bars represent standard errors.

Familiarity During Recall Failure (Recognition Without Cued Recall)

The means for perceived cue familiarity (recognition without cued recall) are shown in Figure 15. I performed a 3 x 3 overlap (high overlap, low overlap, no overlap) x judgment type (recollection, logically based prediction, or irrational prediction) mixed factor ANOVA on familiarity ratings. There was a significant effect of cue overlap, $F(2, 172) = 66.76$, $MSE = 0.58$, $p < .001$, $\eta_p^2 = .44$. The main effect of judgment type was not significant, $F < 1$. There was no overlap x judgment type interaction, $F < 1$. Since the interaction was not significant, overlap levels were combined for the following t tests. High overlap cues were rated as more familiar than low overlap cues, $t(88) = 6.79$, $SE = 0.13$, $p < .001$, Cohen's $d = 0.47$. Low overlap cues were rated as more familiar than no overlap cues, $t(88) = 4.75$, $SE = 0.09$, $p < .001$, Cohen's $d = 0.26$.

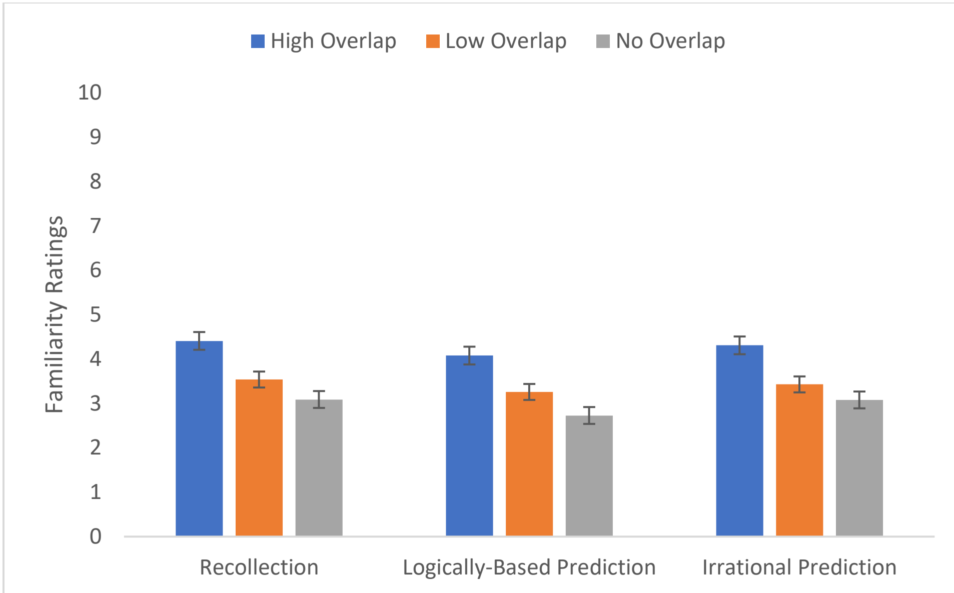

Figure 15. Familiarity ratings for overlap levels and judgment types. Bars represent standard errors.

Confidence in Knowing the Sound

Turning to my primary question, I examined the effect of cue overlap on the three judgment types (Figure 16), which I will refer to as confidence in knowing the sound ratings. I performed a 3 x 3 overlap (high overlap, low overlap, no overlap) x judgment type (recollection, logically based prediction, or irrational prediction) mixed factor ANOVA on confidence in knowing the sound ratings. There was a main effect of cue overlap on confidence in knowing the sound ratings, $F(2, 172) = 24.71$, $MSE = 0.38$, $p < .001$, $\eta_p^2 = .22$. The main effect of cue overlap was not qualified by an interaction, $F(4, 172) = 1.71$, $p = .15$, $\eta_p^2 = .04$. There was also no main effect of judgment type, $F(2, 86) = .75$, $MSE = 9.17$, $p = .48$, $\eta^2 = .02$. Judgment types were combined across conditions for the following t-tests. High overlap cues were given higher confidence in knowing the sound ratings than low overlap cues, $t(88) = 4.17$, $SE = .10$, $p < .001$, Cohen's $d = .22$. Low overlap cues were given higher confidence in knowing the sound ratings than no overlap cues, $t(88) = 2.84$, $SE = .07$, $p = .006$, Cohen's $d = .12$.

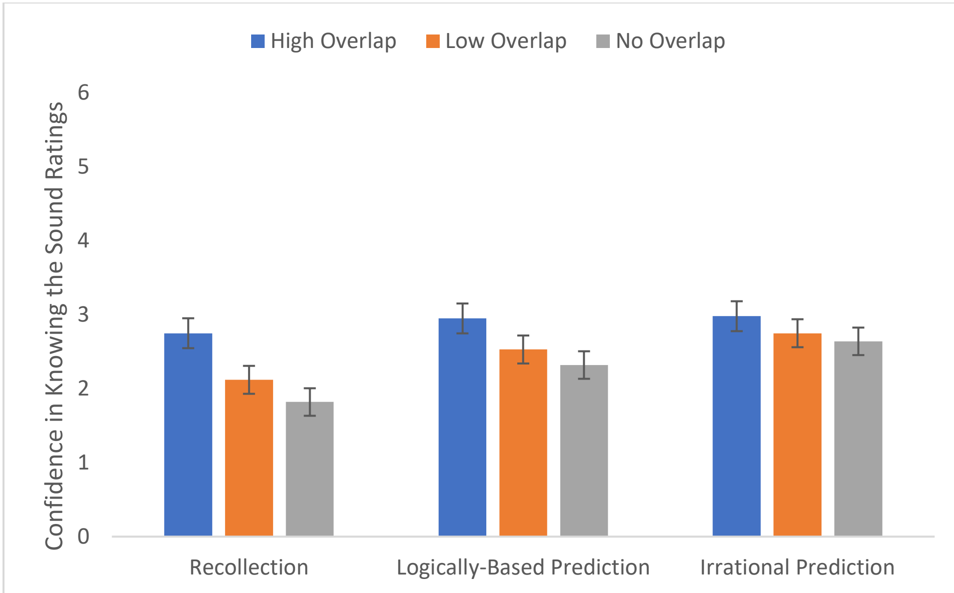

Figure 16. Confidence in knowing the sound ratings for overlap levels and judgment types. Bars represent standard errors.

Sound Recollection and Logically Based Prediction Accuracy

Next, I examined the possibility that participants did show above chance (.50) ability to recollect or predict the sound during recall failure. In the recollection condition and for high overlap cues, participants were not above chance in recollecting the background sound (M = .53, SD = .13), $t(26)$ = 1.11, , p = .28. For low overlap cues, participants were also not above chance (M = .49, SD = .11), $t < 1$.

For the logically based prediction condition and high overlap cues, participants were not above chance (M = .50, SD = .11), $t < 1$. For low overlap cues, participants were also not above chance (M = .51, SD = .51), $t < 1$, Actual predictive ability in the irrational-prediction condition was not analyzed since it would have been random guessing.

Judgments During Recall Success

During recall success, high overlap cues did not show above chance recollection accuracy (*M* = .51, *SD* = .20), $t < 1$. Participants were also not above chance for low overlap cues (*M* = .53, *SD* = .21), $t < 1$.

In the logically based prediction condition participants were not above chance in the high overlap condition (*M* = .53, *SD* = .17), $t < 1$. They were also not significantly above chance for low overlap cues (*M* = .56, *SD* = .18), $t(31) = 1.18$, $p = .09$.

For trials where recall succeeded (Figure 17), collapsing across judgment type, high overlap cues were given higher familiarity ratings than low overlap cues, $t(87) = 3.43$, $SE = .14$, $p = .001$, Cohen's $d = 0.34$. I performed a 2 x 2 x 3 recall status (recalled or unrecalled) by overlap (high overlap or low overlap) x judgment type (recollection, logically based prediction, or irrational prediction) mixed factor ANOVA on cued familiarity ratings. However, as in Ryals and Cleary (2012), there was a significant recall x overlap interaction, $F(1, 85) = 4.89$, $MSE = .62$, $p = .03$, $\eta_p^2 = .05$, where cue overlap had a smaller effect during recall success. There was a main effect of recall, $F(1, 85) = 476.87$, $MSE = 2.98$, p < .001, $\eta_p^2 = .86$, where successful cued recall led to higher familiarity ratings. The three-way interaction between recall x overlap x judgment type was not significant, $F < 1$. The recall x judgment type interaction was also not significant, $F < 1$. The main effect of judgment type was not significant, $F < 1$.

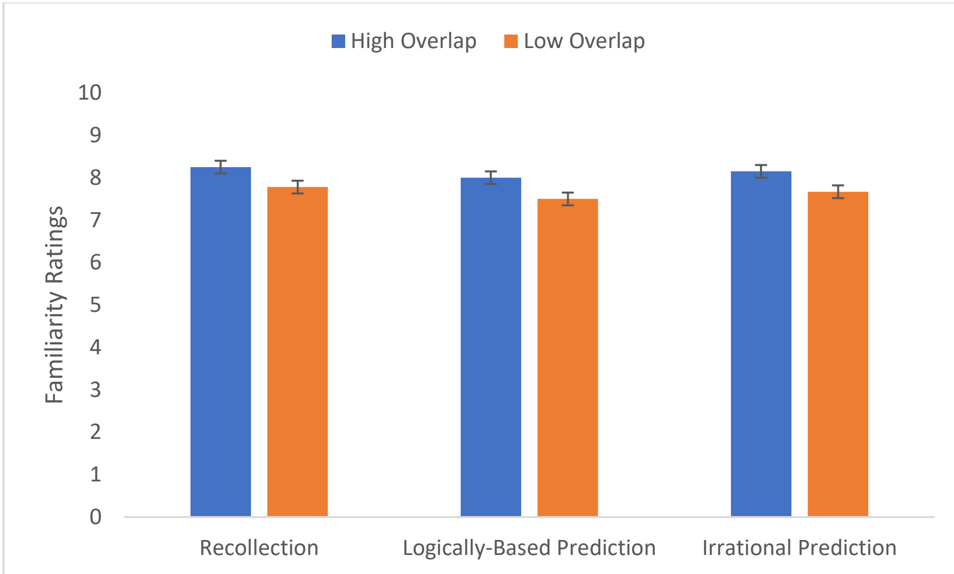

Figure 17. Familiarity ratings during successful cued recall by overlap and judgment type. Bars represent standard errors.

For trials where recall succeeded, and collapsed across judgment type, high overlap cues (M = 5.41, SD = 2.48) were given higher confidence in knowing the sound ratings than low overlap cues (M = 4.83, SD = 2.41), $t(87) = 3.46$, SE = .17, Cohen's d = .24, (Figure 18). I performed a 2 x 2 x 3 recall status (recalled or unrecalled) by overlap (high overlap or low overlap) x judgment type (recollection, logically-based prediction, or irrational prediction) mixed factor ANOVA on confidence in knowing the sound ratings, However, as in Huebert et al. (2020), there was no significant recall x overlap interaction, $F < 1$. The main effect of recall was significant, $F(1, 85) = 201.83$, $MSE = 2.51$, $p < .001$, $\eta_p^2 = .70$, where cued recall meant higher confidence in knowing the sound ratings. The three-way interaction between recall x overlap x judgment type was not significant, $F < 1$ The recall x judgment type interaction was also not significant, $F(2, 85) = 1.40$, $MSE = .62$, $p = .253$, $\eta_p^2 = .03$.

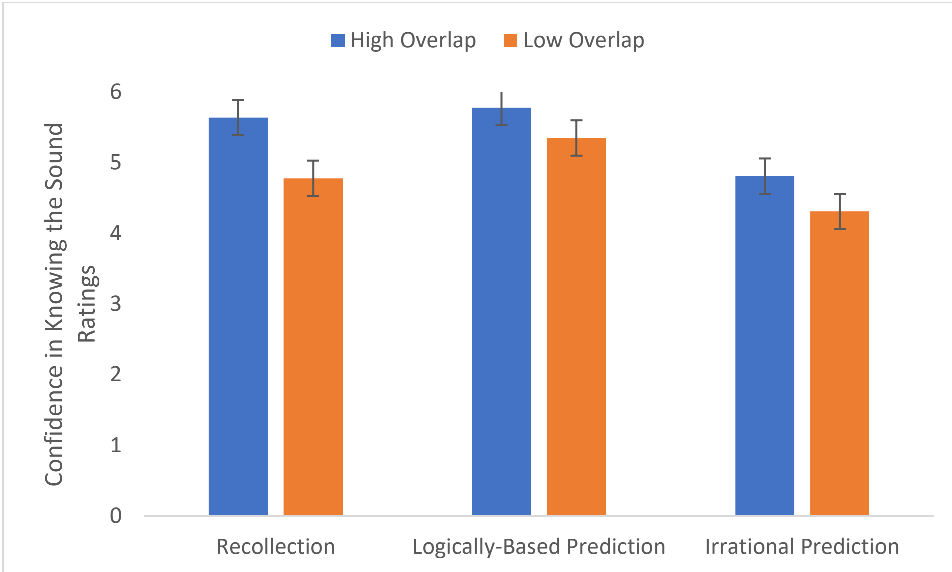

Figure 18. Confidence in knowing the sound ratings by judgment type and overlap for successful cued recall. Bars represent standard errors.

Block Analyses

Familiarity During Recall Failure (Recognition Without Cued Recall)

I performed a 3 x 3 x 4 overlap (high overlap, low overlap, or no overlap) x judgment type (recollection, logically based prediction, or irrational prediction) x block (first, second, third, or fourth block) mixed factor ANOVA on familiarity ratings (Figures 19-22). There was a significant main effect of block, $F(3, 210) = 3.43$, $MSE = 2.72$, $p = .01$, $\eta_p^2 = .05$. There was a main effect of overlap, $F(2, 140) = 52.23$. $MSE = 1.83$, $p < .001$, $\eta_p^2 = .43$. The block x judgment type interaction was not significant, $F < 1$. The overlap x judgment type interaction was also not significant, $F < 1$. The block x overlap interaction was not significant, $F(6, 420) = 1.54$, $MSE = 1.99$, $p = .16$, $\eta_p^2 = .02$,. The block x overlap x judgment type interaction was also not significant, $F(12, 420) = 1.11$, $MSE = 1.99$, $p = .35$, $\eta_p^2 = .03$. The main effect of judgment type was also not significant, $F < 1$.

With regard to blocks, there was a significant difference between the second and third block, $t(255) = 2.23$, $SE = .13$, $p = .03$,Cohen's $d = .13$, with the second block receiving lower ratings overall than the third block. The first and second, and third and fourth blocks were not different (ts < 1).

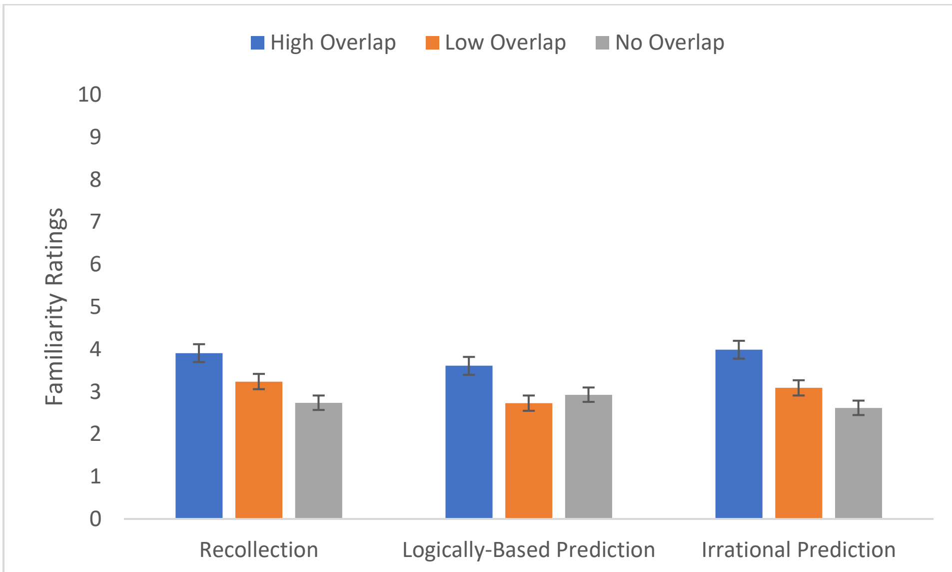

Figure 19. Familiarity ratings by overlap and judgment type for block one. Bars represent standard errors.

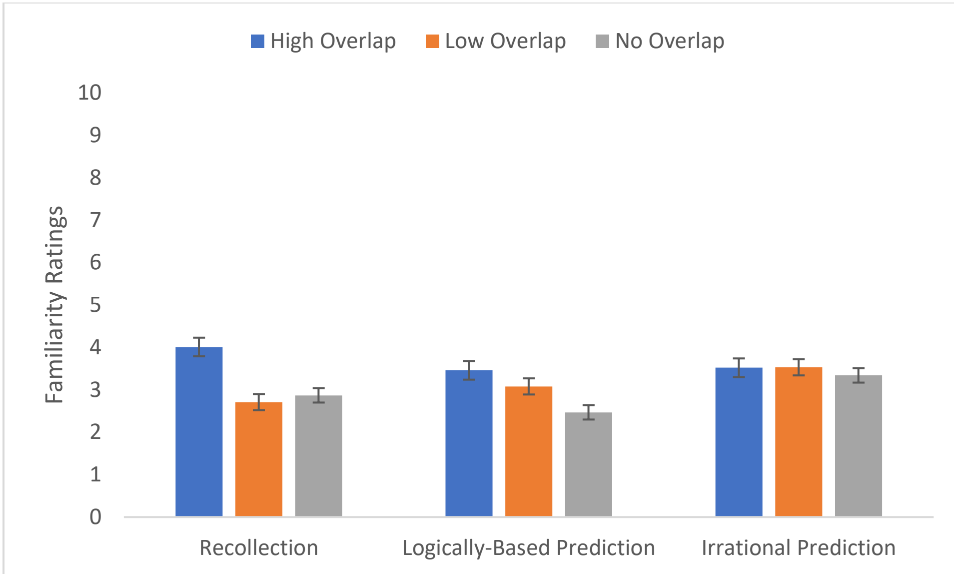

Figure 20. Familiarity ratings by overlap and judgment type for block two. Bars represent standard errors.

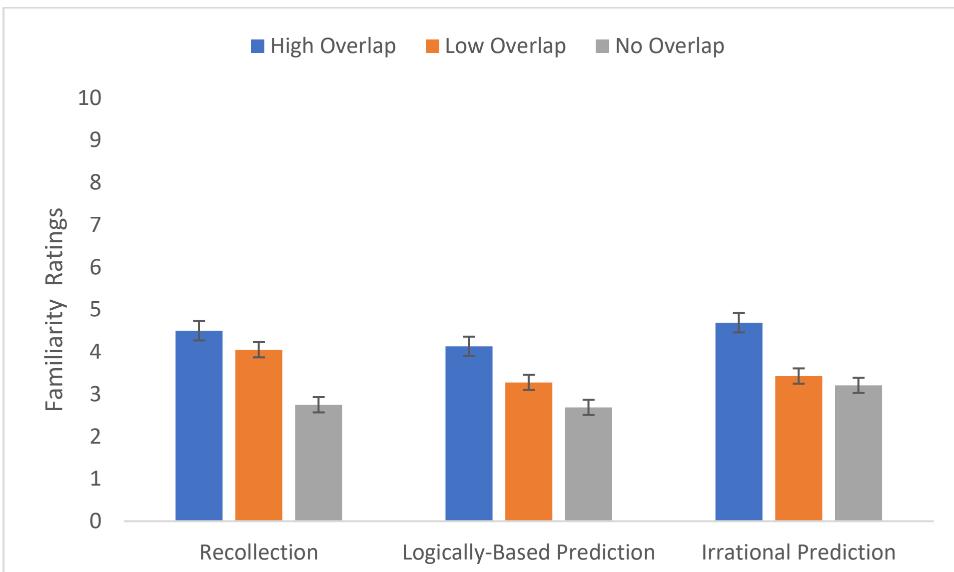

Figure 21. Familiarity ratings by overlap and judgment type for block three. Bars represent standard errors.

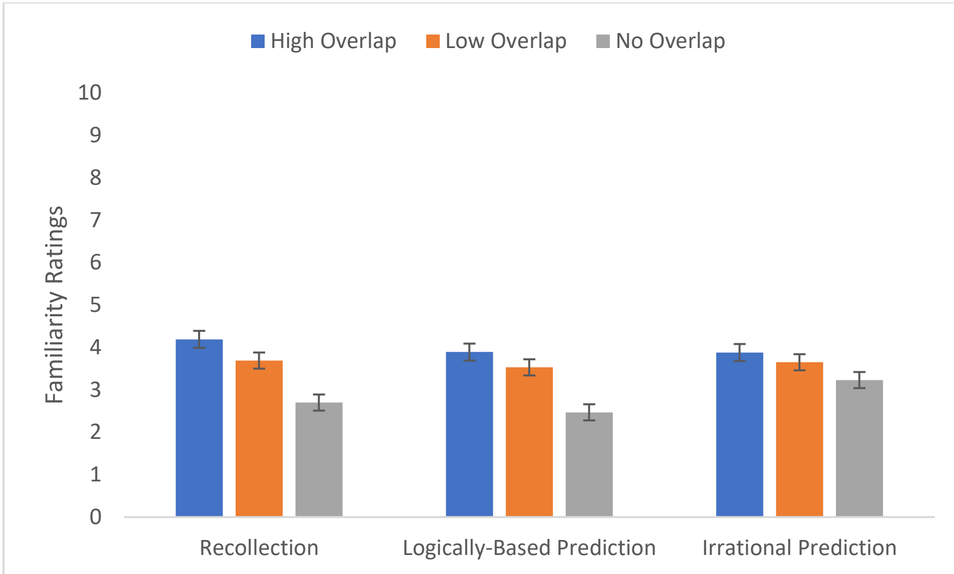

Figure 22. Familiarity ratings by overlap and judgment type for block four. Bars represent standard errors.

Confidence in Knowing the Sound

I performed a 3 x 3 x 4 overlap (high overlap, low overlap, or no overlap) x judgment type (recollection, logically based prediction, or irrational prediction) x block (first, second, third, or fourth block) mixed factor ANOVA on confidence in knowing the color ratings (Figures 23-26). There was no significant effect of block, $F(3, 210) = 2.19$, $MSE = 3.87$, $p = .09$, $\eta_p^2 = .03$, or judgment type, $F < 1$, or overlap x block interaction, $F < 1$. The block x judgment type interaction was not significant, $F < 1$. There was a significant effect of overlap, $F(2, 140) = 25.71$, $MSE = 1.11$, $p < .001$, $\eta_p^2 = .27$. The overlap x judgment type interaction was not significant $F(4, 140) = 2.04$, $MSE = 1.11$, $p = .09$, $\eta_p^2 = .06$. The block x overlap x judgment type was not significant $F(12, 420) = 1.23$, $MSE = 1.15$, $p = .26$, $\eta_p^2 = .03$.

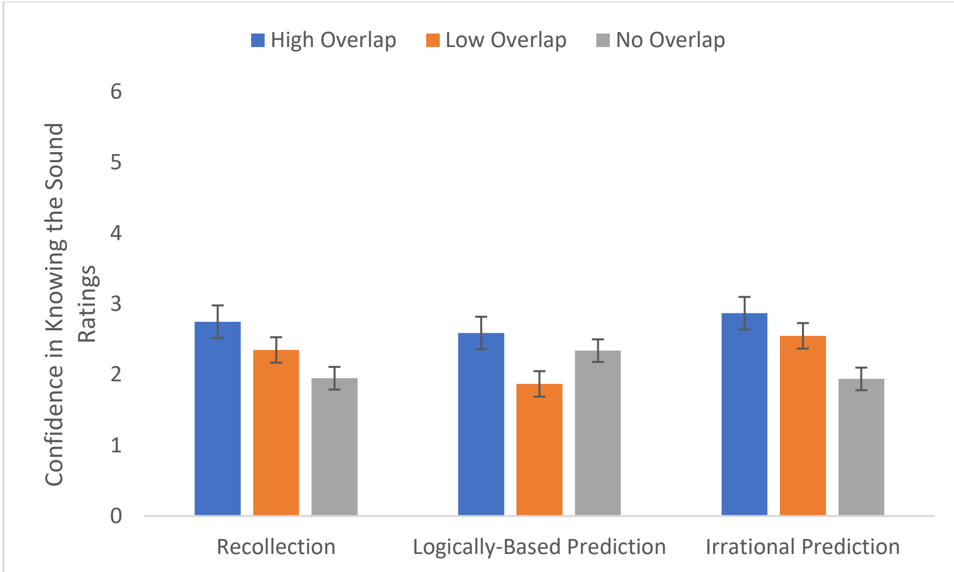

Figure 23. Confidence in knowing the sound ratings by overlap and judgment type for block one. Bars represent standard errors.

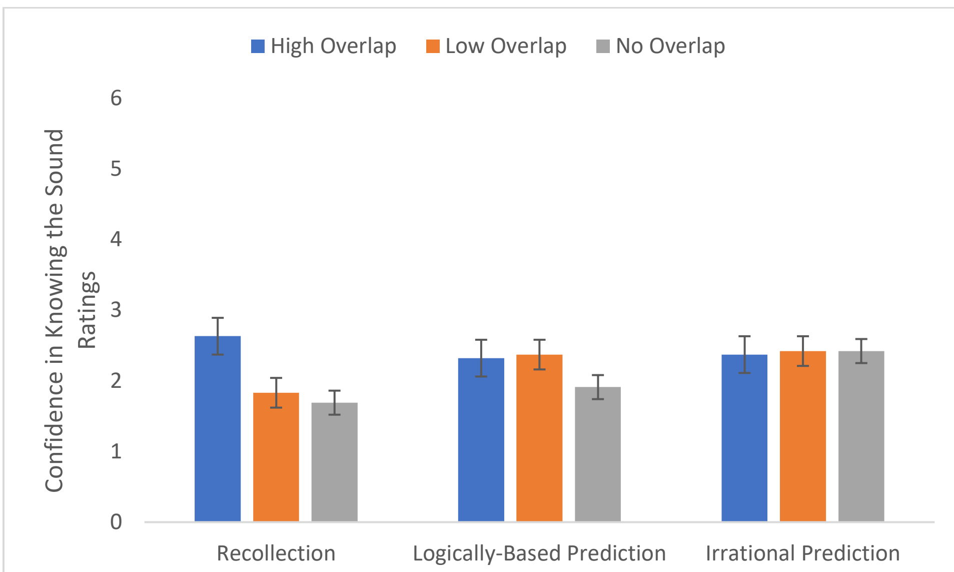

Figure 24. Confidence in knowing the sound ratings by overlap and judgment type for block two. Bars represent standard errors.

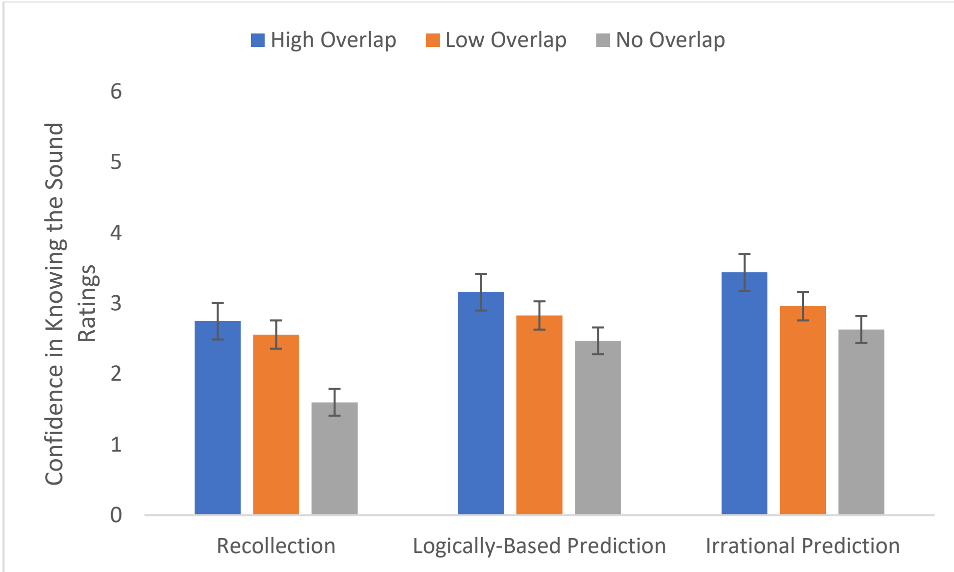

Figure 25. Confidence in knowing the sound ratings by overlap and judgment type for block three. Bars represent standard errors.

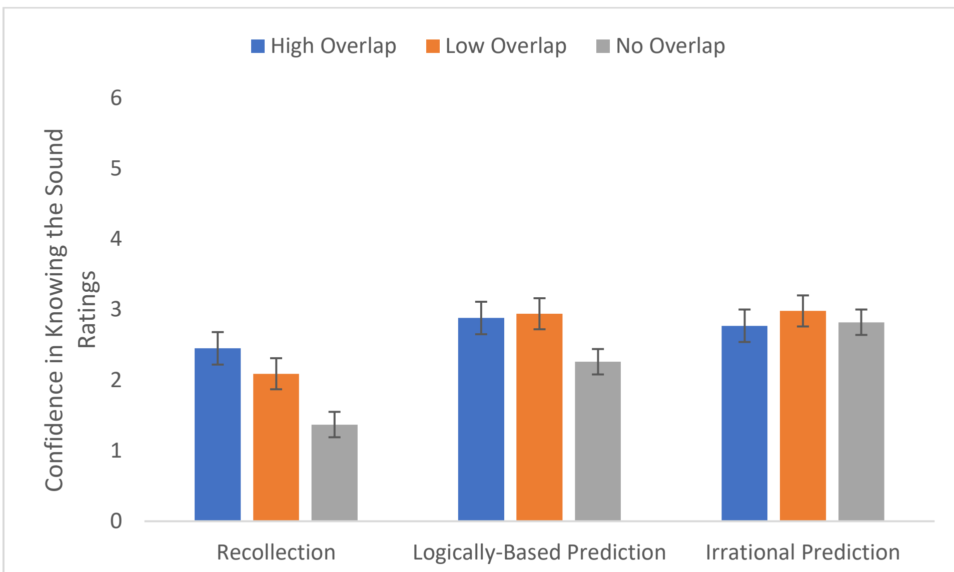

Figure 26. Confidence in knowing the sound ratings by overlap and judgment type for block four. Bars represent standard errors.

CHAPTER 6 – GENERAL DISCUSSION

Overview of the Present Study

The first purpose of this thesis was to experimentally examine the role of familiarity in illusions of prediction. It has been argued that a major function of human memory is to think about and predict the future (Schacter et al., 2007). One might expect recall of specific details to be needed for prediction, yet the research on déjà vu (Cleary et al., 2018) suggests that *illusions* of prediction can be driven by mere feelings of familiarity. Based on this work, the present study investigated whether familiarization of a stimulus contributes to illusions of prediction. The second purpose of this thesis was to examine how familiarity might uniquely affect past-oriented, future-oriented, and irrational future-oriented decisions.

In Experiment 1, there was evidence that familiarity plays a role in illusions of prediction outside the realm of déjà vu (e.g., Cleary & Claxton, 2018). Experiment 1 replicated the finding that manipulating feature overlap (as in Ryals and Cleary, 2012) led to a systematic increase in familiarity during recall failure. This was an important manipulation check (in showing that the cue familiarization manipulation for systematically increasing the perceived familiarity of cues during instances of recall failure was effective at doing so). The systematically increased familiarity of the test cues during instances of recall failure in turn led to participants either 1) feeling that they could recall the background color, 2) predict the upcoming background color based on prior background color, or 3) even predict a random upcoming background color. The effects of familiarity on these confidence in knowing the color judgments were the same for all three conditions. The logically based prediction condition did show above chance prediction, but the recollection condition did not.

Experiment 2 was designed to be a conceptual replication of Experiment 1. The only thing that changed was the recollection or prediction judgment used. Instead of displaying each study word on a green or blue background, a high or low pitched background sound was played with each study word. The results of Experiment 2 were largely the same as Experiment 1. Manipulating feature overlap again led to a systematic increase in familiarity during recall failure (as in Ryals and Cleary, 2012). This familiarity led to an increase in recollection, logically based prediction, and irrational prediction confidence each in a similar manner. In contrast to Experiment 1, neither the recollection nor logically based prediction conditions were above chance in accuracy. Thus, Experiment 2 provided further support that familiarity plays a role in illusions of prediction. Experiment 2 also extended the generality of this finding to sound related prediction.

The Role of Familiarity in Illusions of Prediction

For the primary question of familiarity and feelings of prediction, the results supported my hypothesis. Manipulating feature overlap between study and test items and thus the familiarity led to a systematic increase in feelings of prediction. This suggests that feelings of familiarity can create feelings of prediction.

Returning to the example of a truck given earlier, a sense of familiarity, without recall such as where the truck turned last time, could create feelings of prediction. However, these feelings of familiarity seem to only create *illusions* of prediction. One would expect that recollection of where the truck turned last time, or in my experiments, recollection of what the background color or sound was, would create feelings of prediction. This is because those details would likely need to be recalled to make any accurate prediction. This was seen in part from the color accuracy during recall success in Experiment 1. Participants did show some ability to predict the color when recall succeeded. Surprisingly, Experiment 2 did not show this pattern. Participants were not above chance in predicting or recollecting the background sound when recall succeeded.

If participants do show some sort of recollection or predictive ability, then one would expect their confidence to reflect that ability. Yet, when recall fails, people still show an increase in prediction confidence as a function of familiarity despite being barely above chance (Experiment 1) or not above chance (Experiment 2). This suggests that much like déjà vu (Cleary et al. 2018), familiarity creates illusions of prediction.

My results also provide evidence of a theory by Cleary et al. (2018), who suggested that familiarity may drive feelings of prediction during déjà vu. This was built on the finding that among déjà vu reports, those with feelings of prediction received higher feelings of familiarity ratings than déjà vu reports that were not accompanied by feelings of prediction. Here I have found experimental evidence of this theory: that familiarity creates feelings of prediction. However, future research could examine this theory in more traditional déjà vu paradigms involving dynamic videos. Cleary et al. (2018) found that feelings of prediction during déjà vu were associated with high familiarity. My results also show that familiarity and feelings of prediction are not unique to déjà vu, since we would not expect déjà vu to be experienced with word recognition. Although future research could examine if déjà vu is associated with feelings of prediction above just the familiarity that accompanies déjà vu.

It is important to note that the logically based prediction condition did show above chance prediction during recall failure in the high overlap condition in Experiment 1. However, Experiment 2 failed to replicate this finding. What might be the case is that during recall failure, in the high overlap condition participants do have above chance recollection or prediction ability.

This would fit with what Cleary and Claxton (2018) found, which was that a meta-analysis indicated above chance predictive ability when considering all experiments. However, this effect was extremely small and weak compared to the feelings of prediction. So, while participants might show a very small amount of memory-based predictive ability during recall failure, their feelings of prediction are more often an illusory product of déjà vu and the feelings of familiarity from déjà vu. The same could be said here, participants in the high overlap condition might have above chance recollection or prediction that was inconsistently obtained across experiments. However, their increase in confidence is almost entirely a familiarity driven illusion.

There are a number of reasons why familiarity could create feelings of prediction. One possibility is that familiarity creates feelings of positivity (Monin, 2003). Being able to successfully predict something is a positive outcome. Participants might associate a sense of familiarity with this positive outcome of being able to predict either the sound or color. Another possibility is that familiarity operates in a manner similar to tip of the tongue states. Cleary and Claxton (2018) argued that the continued familiarity of a dynamically unfolding scene would create a feeling of knowing how the scene will unfold is on the verge of retrieval. This is similar to how a word may feel on the verge of retrieval during a tip of the tongue state.

Another possibility is that familiarity has a learned association with predictive ability. For example, consider an employee entering the building the employee has worked at for a number of years. The employee would have plenty of ability to predict who might be encountered on the way up the stairs, or who will be in their offices as the employee passes by. Having worked at the building for several years, the employee would of course have a strong sense of familiarity with the building. Thus, perhaps the employee would have learned an association between familiarity and predictive ability. However, in this example, recollection of specific details would likely be required to predict such encounters. With the paradigm used, it would be as if the employee still interprets their familiarity as predictive ability, but with the recollection of specifics removed the employee would have largely or entirely illusions of prediction.

Yet another possibility is one put forth by Cleary et al. (2019). This was that people often report feelings of hindsight bias during déjà vu states. Specifically, participants are more likely to think they predicted the outcome of a turn in a déjà vu state. Cleary et al. also found that this hindsight bias was associated with high familiarity ratings. They argued that participants misinterpret feelings of familiarity as having successfully predicted something. Although feelings of postdiction were not investigated here, their possible relation to the current findings is also something for future research. If feelings of postdiction are driven by familiarity, then this could also explain why people associate familiarity with feelings of prediction. That is, a person might often feel a sense of familiarity and interpret that has having predicted something successfully. This would in turn lead them to associate familiarity with the ability to predict something before it happens. Future research could attempt to tease apart these various explanations for why familiarity tends to create feelings of prediction.

Comparing Recollection, Logically Based Prediction, and Irrational Prediction

Another question of this thesis was if past and future oriented decisions would be differently affected by familiarity. As was discussed earlier, past and future thinking are closely linked (e.g., Addis et al., 2007). However, familiarity can also be used differently for past recognition and judgments of future recognition (Cleary, 2015). I found that familiarity had similar effects on recollection and prediction. The judgment essentially was the same between the recollection and logically based prediction conditions, simply phrasing the judgment as being a matter of recollection or prediction did not alter the use of familiarity. This is more consistent with the notion that past and future thinking are largely the same. Still, future research could investigate other situations where familiarity is used uniquely for past and future thinking.

Another question of this thesis was to what extent the prediction judgments needed to be rational in nature. One might expect that the prediction needs to be something that could at least plausibly be predicted in order to have feelings of prediction. Again, returning to the truck example, a person might need to at least feel that where the truck turned last time could possibly be remembered or predicted based on some prior memory. In these experiments, participants in the logically based prediction conditions were given something which they could plausibly predict; an upcoming color or sound based on a studied color or sound. In the irrational prediction condition, they attempted to predict something with no basis to make that prediction. However, I found that participants still showed increases in feelings of prediction as a function of familiarity when the outcome was random. Previous research has not investigated familiarity and irrational prediction directly, however this result is not unheard of. With regard to déjà vu, participants of course show feelings of prediction (Cleary & Claxton, 2018). This is despite the fact that déjà vu is defined as a feeling of familiarity despite knowing the situation is new. So logically participants should not report any feeling of prediction during déjà vu. Bear and Bloom (2016) have also shown that participants feel that they predicted a random outcome more often than they could have. Furthermore, the effect of familiarity on irrational feelings of prediction were not significantly less than the effect of familiarity on recollection or logically based feelings of prediction.

The finding that familiarity creates irrational feelings of prediction also has implications for the reason why familiarity creates logically based feelings of prediction. Participants should base their prediction on the background color or sound of the study word, which would be recollection based. One might argue that familiarity creates these feelings of recollection (as in Huebert et al., 2020), which in turn creates feelings of prediction, since the prediction is based on past recollection. However, this might not be the case given the findings of the irrational prediction conditions. Since study words were on a gray background or had no sound, there were no feelings of past recollection to be created by familiarity. Thus, rather than the mediation discussed, familiarity might more directly influence feelings of prediction, however, future research could also test these two explanations through mediation models. Such models would be beyond the scope of this thesis but could be a useful future direction.

Block Effects

I also examined for various effects of blocks. Though block effects in recognition without identification are not typically seen (Cleary & Specker, 2007), participants were shown that they were (presumably) only around chance after every block. It could have been the case that providing the answers after every block could have diminished recollection or prediction confidence. Therefore, the early blocks could have shown higher confidence than the later blocks. Familiarity broken into blocks was also analyzed since it was the key manipulation.

There was some evidence of block related effects on familiarity. One might expect feature overlap to have smaller effects in later blocks due to the accumulation of features in memory. In Experiment 1, the manipulation of feature overlap had somewhat different effects by block. For the last block, high overlap cues did not differ from low overlap cues in their familiarity. Otherwise, there was not a consistent decline in the magnitude of the effect of feature overlap. Furthermore, this block related effect was not replicated in Experiment 2. Given the lack of reason behind it, the failure to replicate, and marginally significant interaction, this block related effect was likely a type one error.

Somewhat of a similar pattern was found with confidence in knowing the color ratings in Experiment 1. High and low overlap cues did not differ in the last block, but again there was no consistent effects of blocks. This and any other block related effects were not replicated in Experiment 2.

It is important to note that breaking down each analysis by block introduces a lot of noise. Participants would have only a small number of trials, particularly in the high overlap condition where failed recall is less common. Basing an analysis on fewer trials made it more difficult to see a clear pattern. There could be real block related effects on both familiarity and confidence in knowing the color or sound, but they are difficult to observe due to a small number of observations.

Summary and Conclusions

Familiarity is a curious sensation that everyone has experienced. It is not only a method of recognition (Yonelinas, 2002), but that it can be manipulated through feature overlap (Ryals & Cleary, 2012) to create (largely) illusory feelings. These feelings can be recollective, logically based predictions, or even irrational predictions to the same magnitude. Future research should examine the role of familiarity in other cognitive illusions, whether they are past or future oriented.

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APPENDICES

Appendix A: Figures

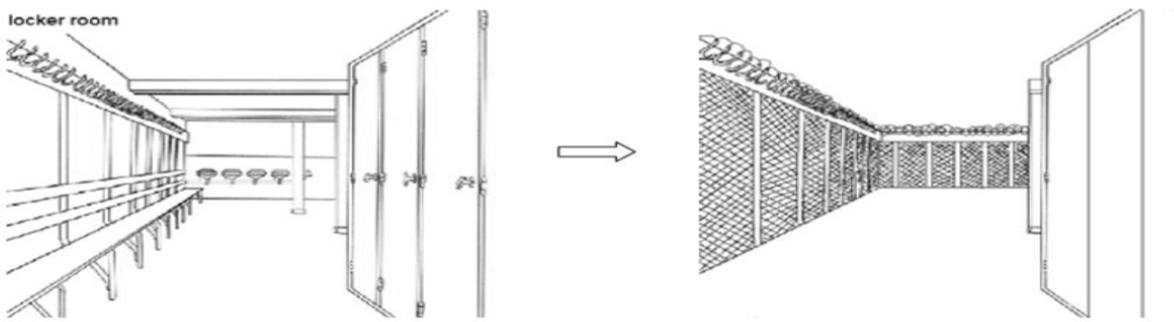

Figure 27. Scenes that overlap in structure, from Cleary et al. (2009)

Appendix B: Power Analysis

Since this was not a replication there were no specific effect sizes to use, However, some inferences were made from related studies. In Huebert et al. (2020), the effect sizes were fairly small. In Experiment 2 The effect of cue overlap on source memory confidence had a η^2_p of .237 (Experiment 3 had a slightly larger effect). While the interaction between recall status and cue overlap was also small in Experiment 3 (η^2_p = .316, smaller than Experiment 2). Cleary (2015) found a judgment type (feeling of knowing vs recognition) x feature overlap interaction was also small (η^2_p = .282). Lastly, the effect of feature overlap on Feeling of knowing judgments was also small (η^2_p = .238).

To be conservative, I assumed that the effect size would be less than the smallest of effect sizes for related studies. Thus, I used the η^2_p of less than .238 to test for the effect of feature overlap on the prediction condition. For the within between interaction I used a η^2_p of less than .282.

For the power analysis I used G power (Faul et al., 2007). G power allows for the calculation of the required sample size for a desired statistical power and estimated effect size. I used an alpha level of .01, and a power of .99. Using a η^2_p of .12 (around half of .238 to be safe), G power recommends a total sample size of 84 to detect a within participants effect. For the within between interaction, I used a η^2_p of .14, around half of the effect size by Cleary (2015), G power recommends a sample of 63. For the sake of an even number I used 90 participants total, meaning 30 per condition. It might seem overly cautious to use such a stringent alpha level and require such high power. However, given that these experiments are minimal risk, and relatively short it is reasonable to be cautious.

Appendix C: Stimuli

Study Word 1	Study Word 2	Study Word 3	Study Word 4	Test Cue
ADRIFT	ADEPT	ADOPT	ADAPT	ADEIFT
ANGLE	AMBLE	AMPLE	ANKLE	ARBLE
AUTOMATIC	AUTOMATON	AROMATIC	AUTOPILOT	AUROMORIC
BALLROOM	BALLOON	BUFFOON	BEDROOM	BARELOOM
BEHOOVES	BEEHIVES	BELIEVES	BEETHOVEN	BELHOVES
BARROW	BARREL	BORROW	BURROW	BERRLOW
HATCH	CATCH	BATCH	BOTCH	BETCH
BAKED	BARED	BASED	BASKED	BOSKED
CABINET	CABERET	CABERNET	CAVELET	CABELET
CRACKLE	CACKLE	CHUCKLE	CRINKLE	CARKLE
CHAPSTICK	CHOPSTICK	CHADWICK	COWLICK	CHAWCHICK
COMMENCE	COMMERCE	COMMENTS	COMMUTES	COMMORNCE
COMPETE	COMPOSE	COMPOST	COMPOTE	COMPORE
CONCATENATE	CONCENTRATE	CALCULATE	CALIBRATE	CONCULTATE
CONSTRUCTION	CONSTRICTION	CONTRITION	CONTRACTION	CONSTRATION
CHORUS	CORPUS	CORPSE	COARSE	CORTHUS
CREATED	CREASED	CREAMED	CHEATED	CREAVED
CLASHES	CRASHES	CRUSHES	CLASSES	CRISHES
DELICATE	DELEGATE	DEVESTATE	DEDICATE	DEVICATE
DISTRICT	DESTRUCT	DIALECT	DISSECT	DIATRICT
DROID	DRUID	DRIED	DREAD	DROUD
ELEGANT	ELEPHANT	ENCHANT	EGGPLANT	ERLIGANT

EXCURSION	EXPULSION	EXPANSION	EXCISION	EXHURSION
EXPERT	EXERT	EXCERPT	EXCEPT	EXOPT
FELLOW	FOLLOW	YELLOW	FERLOW	FENLOW
COOKS	LOOKS	BOOKS	HOOKS	FOOKS
FLANNEL	FUNNEL	FENNEL	TUNNEL	FRONNEL
GURGLE	GIGGLE	GOGGLE	GOOGLE	GORGLE
GARBLE	GERBLE	GAMBLE	GUMBALL	GORMBLE
GRAPES	GRIPES	GROPES	GRAVES	GRODES
GRAPHITE	GRAPHEME	GRAPHIC	GRAPH	GROPHOME
HEADING	HEATING	HERDING	HEAPING	HELDING
HIPSTER	HAMSTER	HOLSTER	HOISTER	HELPSTER
IMPLEMENT	IMPORTANT	IMPOTENT	IMPATIENT	IMPRUTENT
INCULCATE	INTUBATE	INCUBATE	INORNATE	INCORCATE
LAUNCH	LUNCH	LURCH	LINCH	LAURCH
LIBERATION	LITIGATION	LIGATION	LACERATION	LIGEROTION
LANDLOCK	LIVESTOCK	LOVESTRUCK	LIPSTICK	LINDEVOCK
LONGER	LONGED	LINGER	LOGGER	LORGER
LEAVES	LOAVES	WEAVES	HEAVES	LOURVES
LAQUER	LIQUID	LIQUOR	LOQUAT	LUQUET
MARSUPIAL	MANIACAL	MUNICIPAL	MAGICAL	MARNORPICAL
MITIGATE	MIGRATE	MEDICATE	MEDITATE	MATIGOTE
CAVED	SAVED	RAVED	PAVED	MAVED
MONKEY	MURCKY	MICKEY	MONEY	MORCKY
BEAST	YEAST	FEAST	LEAST	NEAST
NETTLE	KETTLE	NESTLE	NEEDLE	NERTLE
NECESSITY	NATIVITY	NOTARIETY	NOVELTY	NORCOSSITY
ORNITHOLOGY	OPTHAMOLOGY	OPTOMETRY	ORTHOGRAPHY	ORNHATROLOGY
POCKET	TICKET	PACKET	PICKET	PERKET
PHILOSOPHY	PHOTOGRAPHY	PHILANTHROPY	PHONOLOGY	PHICTALOPHY
FINDER	BINDER	HINDER	GRINDER	PINDER
PINNACLE	PINEAPPLE	PINENEEDLE	PARABLE	PINNABBLE
PALLET	PELLET	PLATELET	PIGLET	PITLET
PLANTS	PLANKS	PLUNKS	PLANES	PLARKS
PLEASANT	PHEASANT	PRESENT	PREVENT	PLORVANT
PORTAL	PARCEL	PARTIAL	PENCIL	POIRTIAL
PORCH	PERCH	POUCH	POOCH	POLCH
PEPPER	POPPER	PORTER	POTTER	PORPER
PATCHWORK	PITCHFORK	PULLCORK	POCKETBOOK	POTCHBORK
PIXEL	PIXIE	VOXEL	VIXEN	POXEN
PRODIGAL	PORTUGAL	PROTOCOL	PIVITAL	PROTUGAL
PRINCE	PRANCE	FRANCE	TRANCE	PRUNCE
REWIND	REMIND	RESCIND	REMAND	REBIRND
REFRACTORY	RECTORY	REFLECTORY	REDACTORY	REFENCTORY
RETAIN	REMAIN	REGAIN	REFRAIN	REGREIN

REWARD	RETARD	REGARD	REWORD	RELARD
REFURBISH	RELINQUISH	REVARNISH	REGARNISH	REMANISH
RECANT	REPENT	RELENT	REMNANT	REVANT
SAVAGERY	SURGERY	SAVORY	SYNERGY	SAVORGY
SMACKS	SNACKS	STACKS	SLACKS	SCACKS
SCONCE	SCIENCE	SILENCE	SALIENCE	SCORENCE
SECURITY	SECRETARY	SECRETLY	SECULARLY	SECORITLY
SHAMROCK	SHIPWRECK	SHELLSHOCK	SHEETROCK	SHEMPHOCK
SHATTERED	SPATTERED	SHUTTERED	SPUTTERED	SHETTERED
SHARK	STARK	SPARK	SHIRK	SHONK
SCOOP	SNOOP	SCOOT	STOOP	SHOOP
SPEAK	STREAK	SNEAK	STEAK	SKEAK
SLIPPER	SLIPPED	SLOPPED	SLAPPED	SLARPED
SULLY	GULLY	SILLY	PULLY	SOLLY
SLOUGH	TOUGH	ROUGH	DOUGH	SOUGH
SHOWER	SKEWER	SLOWER	SHAVER	SPAWER
SPUMONI	SPAGHETTI	SALAMI	SERENGETI	SPURGONI
SWELLS	SPELLS	SHELLS	SMELLS	STELLS
STILL	SPILL	SKILL	STALL	STOLL
STONE	STOVE	STOKE	STOLE	STOPE
STIFF	STUFF	SNUFF	STAFF	STURF
TAUPE	TROUP	TORTE	TROUT	TORPE
TRANSPORT	TRANSPLANT	TRANSPARENT	TRANSVARIANT	TRENSORENT
TEMPER	TIMBER	TAMPER	TIMBRE	TUMPER
WASTE	HASTE	PASTE	TASTE	VASTE
VOGUE	ROGUE	VAGUE	PLAGUE	VEIGUE
VENOUS	VENEMOUS	VOLUMINOUS	VORACIOUS	VERAMOUS
WAGER	WAFER	WATER	WAITER	WAIBER
WEDDED	WELDED	WADDLED	WADED	WIDDRED
WORDS	WELDS	WOODS	WORLDS	WONDS