LEE, JONG WON, M.A. The Role of Attention to Changes in Episodic Memory Updating. (2021)
Directed by Dr. Christopher N. Wahlheim 52pp.

Memory-for-Change accounts have shown that detection and recollection of change may help counteract the deleterious effect of the proactive interference and promote proactive facilitation in some cases. While it is a common understanding that people need to pay attention to the Memory-for-Change for the episodic memory updating to be successful, memory researchers are yet to define the exact role of attention in the Memory-for-Change framework. The current study is the first to investigate the exact attention to the site of change to be the key factor that drives the Memory-for-Change framework to work. To investigate such topics, current study utilized an A-B, A-D dual list paradigm by instructing participants to study two lists for an upcoming test. Throughout the two lists, participants observed three types of item, where one word set gets repeated for both lists (A-B, A-B), where the response word of the word set changes in List 2 while cue stays the same without any color change (A-B, A-D not colored), and where the word pair set changes in List 2 too but the response word in List 2 is colored in red to indicate that the item has changed (A-B, A-D colored). Color difference on List 2 response was to direct participant's attention to the site of change. This was to observe how different amounts of attention distributed to the site of change determines whether change recollection happens. During the test phase, participants completed a cued recall test for the responses from both lists, and also on whether they recollect the change. The result of the current experiment failed to observe that the attention plays a key role in the recollective procedure within the MFC framework that induces the counteraction of proactive interference but observed positive correlation between Change remembrance and attention.

THE ROLE OF DIRECTING ATTENTION TO CHANGES IN EPISODIC MEMORY UPDATING

by

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A Thesis

Submitted to

the Faculty of The Graduate School at

The University of North Carolina at Greensboro

in Partial Fulfillment

of the Requirements for the Degree

Master of Arts

Greensboro

2021

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7/19/2021
Date of Acceptance by Committee
7/2/2021
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CHAPTER I: INTRODUCTION

After the internet became common in our daily lives, sending and receiving new information became easier and faster. As a result, people get updates on their knowledge much more easily once the correction has been made by the informer. While getting new updates in the virtual world happens quite frequently, people do not always get to successfully update the new information in the real world. For example, the International Astronomical Union decided that Pluto is no longer a planet in August of 2006 because the orbit of Pluto is far from that of typical planets (Broughton et al., 2013). This news was published on the internet immediately, while textbooks were yet to incorporate this change. Even though textbooks still stated that Pluto is a planet, some school teachers decided to inform their students of this news. In such scenarios, competing facts can be encoded as separate episodic memories associated with different points in time. Here, learning from a textbook that Pluto is a planet would be represented as an earlier memory than learning from a teacher that Pluto is no longer considered a planet. Successful episodic memory updating entails later remembering how the classification of Pluto has changed. Hence, given that information can change so quickly, it is important to understand how people update episodic memories.

Although it may seem that the different classifications of Pluto could be stored as separate memories, research has shown that such changes can be represented together in a more complex way. Research in episodic memory updating by Wahlheim and Jacoby (2013) and Jacoby et al. (2015) has demonstrated this using A-B, A-D paired-associate learning paradigms. The A-B, A-D paradigm refers to the conditions when cues and original responses (A-B) appear during one episode, then the same cues paired with changed responses (A-D) appear during a later episode. In the example above, Pluto's classification, "Pluto," is similar to the cue (i.e., the

A term), and the classification information "is a planet" is similar to the original response (i.e., the B term), which is associated with the students' reading in the textbook that Pluto is a planet. Finally, the classification information "is not a planet" is similar to the changed response (i.e., the D in paired-associate terms), which contains the teacher's lecture.

When students are later asked about the latest planetary classification of Pluto, which is like being asked what the response for the cue is (A-?), those who did not pay attention to the change may be more likely to experience interference from the prior classification (B response) when trying to recall the updated information (D response). However, if students were guided to pay more attention to how the information has changed and successfully recollect the temporal order of the events (i.e., remembering that listening to the teacher reminded them of the earlier learning discrepancy from the textbook), then students may be more likely to counteract the interference and remember which information is more recent (Wahlheim & Jacoby, 2013; Garlitch & Wahlheim, 2020). In this example, when presenting the new classification, some teachers could direct their students' attention to the change, which may bring to mind the earlier classification, whereas other teachers could just present new information without stressing that change. However, little is known about the role of directing attention to changes in episodic memory updating.

Previously, researchers have noted that memory for the temporal order of events can enclose the memory of previous events, which will help overcome the interference (Wahlheim & Jacoby, 2013). Already, there have been inferential observations of how attention levels increase as people notice a change has occurred, which is critical to generate a temporal order of events (Garlitch & Wahlheim, 2020). However, to solidify that attention resources allocation to change leads to successful memory updating, an experiment that manipulates attention level to the items

needs to be conducted. Therefore, the goal of this experiment is to respond to such need by testing a possible causational relationship between higher attention distribution to change and its impacts on successful episodic memory updating. This goal will be met by using the variant of the A-B, A-D paired associate learning paradigm to compare how guiding one's attention to the area where the word pair has changed may benefit the memory updating process. As a method to guide attention, I will use a color change to highlight the area where the change has occurred. The following sections will review the literature on episodic memory updating and associated theoretical perspectives that lead to predictions about the role of attention to changes in effective updating.

Interference, Updating, and Memory for Change

Generally, the term *interference* refers to a situation where the memory for one event interrupts the recall of another memory. As noted in the Pluto example discussed above, interference occurs more frequently when the two memories share an overlapping feature. Traditionally, researchers have used the A-B, A-D paired associate learning paradigm to study the characteristics and theories behind the phenomenon of interference. In variants of this paradigm, participants learn two lists of paired associates, such as word pairs, including a stimulus term (A) and two responses (B and D) that change between lists. For example, in List 1, participants will be instructed to study the pair *knee-bone* (A-B), while in List 2, they will be asked to study the changed pair *knee-bend* (A-D). Often, the A-B, A-D paired associate learning paradigm includes other item types with different relationships between lists, such as repetitions across the lists (A-B, A-B), or solely existing in one list (C-D). Interference researchers have defined the interference that occurs in the A-B, A-D condition as lower recall performance relative to C-D control pairs that are not exposed to pairwise response competition. For example,

if the prior memory of A-B led to the disrupted recall of the later memory of A-D, then it is called *proactive interference*. In contrast, if the later memory A-D led to the disrupted recall of the prior memory of A-B, then it is called *retroactive interference* (as a review, see Anderson & Neely, 1996).

While there are many theories behind when and how such interference causes one to forget memories, researchers have shown that this interference can cause deleterious effects even though both memories have been properly encoded, especially during retrieval (as a review, Underwood, 1957). Moreover, researchers have proposed that such forgetting during retrieval is due to the competition that occurs between the two different stimuli that are associated to one overlapping cue, which is defined as *response competition* (McGeoch, 1942; Bjork & Bjork, 1994; Bjork & Bjork, 1996). In this example, the term *response competition* specifically refers to the competition between two memories' relative *memory strength* (McGeoch, 1942) from the *strength-dependence* assumption (Anderson et al., 1994), where the relative strength of the cue and responses' connection affects which memory gets recalled. Under the Pluto example, the simple statement of "Pluto is a planet" or "Pluto is not a planet" can be translated into A-B, A-D paradigm format by taking one sentence into two items, as "Pluto" being the cue A, while the following statement "~is a planet" will be the response B, as it was presented first, while "~is not a planet" will be the response D, as it was presented later. Anderson's assumption would propose that the relative strength of how the cue "Pluto" is attached with the first response "~is a planet" versus how the cue "Pluto" is attached with the second response "~is not a planet" plays a critical role in which response will be recalled when the cue "Pluto" is given.

As mentioned above, the competition of memories that occurs between A-B and A-D in the A-B, A-D dual-list paradigm is evident when A-B, A-D items show a lower correct recall

rate than C-D items. However, such deleterious effects of the interference can be countered by utilizing a method to differentiate two different lists and signify the order of the memory that was presented (Abra, 1972). Such an idea is based on two lines of research: Postman and Underwood's (1973)'s notion of how differentiating the two lists helped counteract the interference, and recursive reminding literatures of Hintzman (2004, 2010, 2011) suggesting the importance of temporal order of events in the preservation of the memory, and recognizing that the mechanism of recursive reminding is on utilizing the temporal order of the event.

Similarly, Wahlheim and colleagues (Wahlheim & Jacoby, 2013; Jacoby, Wahlheim, & Kelley, 2015) have successfully synthesized these two ideas and proposed that the deleterious effect of proactive interference can be countered through the reminding that was triggered via the overlapping features of two stimuli, or retrieval cue, if the participant noticed that items changed. Furthermore, they proposed that such reminding can lead to the detection of change, thus allowing the representation of the previously presented stimulus to be associated with the later presented stimulus. The association between previously presented stimulus and later presented stimulus is called *configural representation*, which is suggested to preserve the temporal order of the stimuli, resonating with Hintzman's (2011) account. The suggestive role of the configural representation is based on the general notion of the initiator of the reminding, or the reminder, needs to come prior to the object that is being reminded. Based on this, the reminder needs to occur more recently than the items that are being reminded during the recall test to successfully bring back both original and changed responses. Furthermore, such preposition indicates that the temporal order of events (i.e., event memory of original items or changed items) may play a critical role in configuring the participant's mind to bring back both original and changed items (Wahlheim & Jacoby, 2013). Consequently, the configural representation is suggested to provide

memory benefits as it includes the list membership of the stimuli through bringing up memories of both stimuli and the temporal order of such memories. Retrieval of the configural representation is suggested to require a type of recollection referred to as *change recollection*. To identify the positive association between memory for change and proactive effects of memory, Wahlheim and colleagues explicitly asked participants at test if they realized that the change had occurred in the word pair stimulus during List 2 (Jacoby et al., 2013; Negley et al., 2018; Wahlheim & Zacks, 2019; Wahlheim, 2015), in addition to asking them if any other words came to mind during List 2 recall (Wahlheim & Jacoby, 2013; Wahlheim, 2014).

Wahlheim and Jacoby (2013) and Jacoby, Wahlheim, and Kelley (2015) extensively reviewed the exact mechanism of the Memory-for-Change (MFC) framework. Specifically, Wahlheim and Jacoby (2013) experimented with the MFC framework using the A-B, A-D paired associate learning paradigm with the dual-list design of having two lists presented consecutively (i.e., the words in List 1 were presented first then the words in List 2 were presented). In addition to affirming that the beneficial effect of change recollection for the recall of the List 2 responses, Experiment 1 specifically indicated that the recollection of change during the recall was associated with counteracting proactive interference. From their results, they concluded that the detection of change may be associated with List 1 responses being recalled during the encoding of List 2 responses. Consequently, if the change was not later remembered during the test phase, or the change was not recollected, then the participants may incorrectly recall List 1 responses as the List 2 responses, showing proactive interference. Such proactive interference as the List 1 responses might have been retrieved and practiced more often than List 2 responses because the words in List 1 were presented first. As a result, more frequent repetition of List 1 responses will lead participants to assume that List 1 responses are presented more recently. However, if the

change recollection does occur during the test phase, then the configural representation may be accessed, which will assist participants in identifying the temporal order thereby counteracting interference. This can lead to proactive facilitation when the configural representation (i.e., List 1 response) benefits the recall of the List 2 response. In short, the importance of this study is that they have securely established the co-occurrence of both proactive facilitation and proactive interference in A-B, A-D items, depending upon whether the change recollection was successful or not. Such notion is one of the fundamental presumptions of the MFC accounts, as it builds upon the occurrence of proactive facilitation in A-B, A-D paradigm, while the traditional approach only focused on the occurrence of proactive interference.

Further research about the MFC framework has reaffirmed the importance of change detection and recollection to counteract the proactive interference. Research has shown that there are factors that can influence how often the change detection and recollection do occur, like semantic associations within and between pairs (Wahlheim, 2014), List 1 repetitions (Wahlheim & Jacoby, 2013 Experiment 1; Wahlheim, 2014, Experiment 2), interpolated testing (Wahlheim, 2015), and task instructions to think back to earlier pairs (Jacoby et al., 2015). The manipulation of task instructions is most relevant to the issue being examined here as it involved controlled attention to the source of changes. Specifically, Jacoby, Wahlheim, and Yonelinas (2015; Experiments 2 and 3) showed that manipulating one's attention to changes during List 2 seemed to have a causal influence on the more frequent detection of change, while using the variation of the A-B, A-D paradigm. As for their experiment design, changes occurred between List 1 and List 2 (i.e., between-list) and within List 2 (i.e., within-list). Participants were divided into two groups: the N-back group and the Within-list back group. N-back participants were instructed to indicate changes that may occur anywhere in the experiment, which would occur between-list

and within-list. On the other hand, the Within-list back participants were instructed to only look for the change that occurred within List 2. The N-back group detected more changes between lists (List 1 and List 2) than the Within-list back group, which shows that the manipulation on the participant's direction of attention was successful. Subsequent memory effects showed that List 2 recall performance for between-list changes was better in the N-back than Within-list back group showing direct evidence for a causal role of A-B retrieval in facilitated A-D recall.

In another relevant study for the current experiment, Garlitch and Wahlheim (2020), followed up on the research conducted by Jacoby et al. (2015) by focusing on the role of attention to changes in episodic memory updating. Moreover, Jacoby et al. (2015) specifically showed the importance of list instruction in the memory updating, as list instruction instructed participants to think back to A-B pairs which improved memory for A-D pairs. Garlitch and Wahlheim (2020) specifically found interest in the Jacoby et al.'s (2015) assumption of instruction causing attention to be distributed to the change. This question was first reviewed by Garlitch and Wahlheim (2020) through showing the attention level fluctuation during the A-B, A-D paradigm presentation using the self-report of the attention level. Such measure originates from the mind-wandering literatures (e.g., Kane et al., 2017). Through utilizing self-reported thought probe, or in other words, an "on/off task" report during the study phase, Garlitch and Wahlheim (2020) showed that when participants reported to be on-task, they recollected change better than when participants reported to be off-task. Such result was deduced from observing higher correct recall rate for A-B, A-D items for the participants who paid more attention to the item, signified by reporting more on-task responses. In their results, attention level seems to specifically spike in A-B, A-D condition at the presentation of an A-D word pair, but not in the A-B, A-B condition nor the A-B, C-D condition. This ultimately indicates that the thought probe

methods were an effective measure to show how the increase in attention level when change is occurring may play an important role for the MFC framework to work. Moreover, this provides additional support to the MFC literature that the attention to the site of change (A-D pairs) pairs have successfully predicted the recall performance of the original pairs (A-B pairs), which not only suggest that the memory about the site of change (List 2 representation) works as a reminder of the original pairs A-B, but also suggest that the attention to the A-D pairs is required to trigger the reminding. However, to suggest the causational statement of additional attention to the site of change leading to the reminding of the original pair of A-B, direct manipulation to the attention level to the site of change is required as Garlitch and Wahlheim (2020) is still bounded by the limitation of being designed as a correlational study and can only provide evidence of correlation.

The current study proposes that such limitations of the Garlitch and Wahlheim (2020) can be benefited from using more direct manipulation to the attention level on change to justify the causal relationship claims between attention level to change and subsequent episodic memory updating associated with change recollection. Since Garlitch and Wahlheim (2020) have provided strong correlational evidence that attention level increases during change plays an important role in episodic memory updating, indicating where the attention may be directed to and how that influences the episodic updating performance will help making more causational and conclusive statement of how attention distribution to the change plays an important role in promoting the proposed MFC framework to work.

Relationship between Attention during Encoding and Subsequent Recollection at Test

To discuss how to induce attentional distribution change, it is worth reviewing the need for the MFC accounts to focus on the topic of attention. As noted above, the MFC framework places heavy importance on the recollective process as how being able to recollect certain information (i.e., the notion of the item has changed) plays an important role in successful episodic information updating. Research regarding the recollective process has been traditionally associated with the topic of attentional resources (e.g., Anderson, 1998) as the successful recall performance at test (i.e., recollection) seems to be dependent on how much attention was distributed during the encoding of the stimulus. In other words, if any type of recollection associated activity is involved during the information processing, changes in attentional resources will likely happen, since recollection is a resource intensive activity.

In fact, there have been other lines of research that focused on the increase in attentional resources distribution as a central cognitive resource that decides whether recollection occurs or not. For example, the Value-Directed Learning (VDL) literature by Castel (2008) incorporated the attentional control during study as an important mechanism that is heavily associated with the occurrence of recollection at test, as the level of how much attention has been distributed decides whether the memory becomes a Gist memory or a Specific memory. In here, the Gist memory refers to the feeling of knowing, while Specific memory refers to the clear word-to-word remembering (Castel, 2008). In terms of their logic for the VDL framework, Castel (2008) proposed that the increased attention distribution would lead the memory to become a Specific memory, which would increase the chance for such memory to be recollected, ultimately leading to better recall performance signified by a higher accuracy rate. For this study, the concept of

value has been operated as assigning a numerical value ranging from 1 to 7, with 7 being the most important and 1 being least important. Castel (2008) argued that the reason why participants remembered the words with higher value was because the process of recognizing and evaluating the value naturally involved higher attention distribution to such materials which consequently led to the higher chance of instigating recollection.

Likewise, researchers Hennessee, Castel, and Knowlton (2016) dove deeper into the concept of value and its role in recollection using Remember-Know tasks under the guise of the dual-processing theory (e.g., Yonelinas et al., 2010; Jacoby, 1991). Assuming the response *remember* indicates recollection and the response *know* represents familiarity motivated from the quality perspective of the dual-processing theory, Hennessee and colleagues (2016) showed how the concept of value is useful for recollection but do not induce same level of benefit when the memory is close to familiarity during recall (Hennessee, Castel, & Knowlton, 2016 Experiment 1 and 2). In addition, such phenomenon may mainly be due to the difference at the recollection stage, as the value manipulation occurred during the encoding. These results indicate that the perception and processing of the value in VDL is specifically tied to the recollection, which verifies the reason why attention distribution has gained much interest in VDL literature. Overall, such works have shown that the attention allocation is heavily associated with determining whether the memory gets recollected or not.

Following such a track of thoughts, the MFC literature can also benefit from clarifying the exact role of attention. By actively bringing up that the change has occurred to the participant's awareness during the encoding process of List 2 presentation may influence the attention distribution to the encoding of List 2 word pairs and the generation of configural representation, which will subsequently involve recollection of List 1 word pairs. As VDL

literature have shown through Castel (2008) and Hennessee, Castel, and Knowlton (2016), the beneficial effect of the attention on the encoding and recollection indicates that the increase in attention distribution due to bringing the participant's awareness to change will help participant to remember each component of the configural representation better, by using change as a reminder for both List 1 A-B and List 2 A-D word pair. This will subsequently increase the successful recollection of both word pairs later in the test phase.

By observing the beneficiary effect of attention to change on the MFC framework using attention increase through bringing participant's awareness to change, the current study will provide converging evidence for the proposed causational role of attention to change in the MFC framework. By doing so, this study will also provide a starting point for the future MFC framework studies to follow up on the MFC's mechanism using attention-based measurements and manipulation.

Present Study

For the present study design, I created two conditions for the word pair items within A-B, A-D Item Types, as one might actively bring participant's awareness to change, while the other one might not. This might create a comparative condition of where the participant paid more attention to change versus when they did not. Using these two conditions, the current study extensively reviewed how attention to the site of change (List 2 response) in A-B, A-D dual list paradigm worked as an important factor that might promote the recollective process during the Memory-for-Change framework.

In terms of what type of attention this study will be experimenting with, it is critical to understand where the MFC account has suggested the potential areas where the attention may be

contributing heavily. There are two regions in the MFC framework where attention has been suggested to play a vital part. The first region is during the recognition memory task in the study phase where participants look back at their subjective experience of studying such words to decide if the items that they are observing have changed or stayed the same (Wahlheim & Jacoby, 2013). The second region is when the changed word pair item (List 2) is being presented to the participants, given that the prior presentation (List 1) of the word pair A-B has been encoded. This is because the detection of change needs to happen for the MFC framework to work, and without the successful change detection during study phase, change recollection does not seem to cause a meaningful amount of improvement in the recall performance (Wahlheim & Zacks, 2019; also reference Garlitch & Wahlheim, 2020, as a comprehensive review). While assuming that the participant will be actively engaging in the task and successfully paid attention to think back of what they observed, this study will directly target on manipulating the attention level to the second region by varying the attention level to the site of change (List 2 response) using different colors.

Similar approaches have been attempted in the episodic memory literature, since researchers have consistently reported the importance of attention during the recollective process of episodic memory retrieval before (for a review, reference De Brigard, 2012). Specifically, a variation of the VDL literature, Siegel and Castel (2018), indicated the critical contribution of attention in the binding process in the associative memory through using item-location recall task by showing the superior recall performance of the full attention against divided attention condition. On a similar note, MFC framework's configural representation perspective suggests the importance of binding in the encoding of between-episode associations. Therefore, examining how instructing participants to allocate attention to associations between two pairs of

items (i.e., A-B and A-D) affects the subsequent retrieval dynamics of the unique responses in each pair will further develop the underspecified role of awareness of changes in the memory consequences posited by the MFC framework. Specifically, the current study will examine whether telling participants to consider between-list relationships when studying changes marked by a unique font color leads to evidence that more configural representations were established during List 2 encoding.

Goals and Hypothesis

The main purpose of this study is to investigate the hypothesized causational relationship between attention to change and successful change recollection that may counteract proactive interference and induce proactive facilitation instead. This study will manipulate the attention level to change and observe its consequential effect on change detection, change recollection, and associated recall performance. This will test the key assumption of the MFC framework. To accomplish these goals, this study will be based on the variant of the A-B, A-D paradigm using color change as a manipulation feature.

As Garlitch and Wahlheim (2020) have shown with their thought probe, attention level does seem to fluctuate specifically at the site of change (i.e., List 2 presentation). Such fluctuation, as increased level of attention, seems to be closely associated with the better recall performance of the A-B, A-D items as the proactive interference being countered, although these are speculative results. Since this study is planning to follow up on their primary findings by directly manipulating the attention level to change and confirm their proposed positive relationship between attention distribution to change and proactive facilitation, this study will implement the variation of the A-B, A-D paradigm design and manipulate attention level to the

List 2 response (site of the change) by using a color change. The purpose of using color change in here is to instigate attention-capturing behavior from the participants. In this experiment, the study phase will contain three types of word pairs. As for the first type, the same word pair items show up in both List 1 and List 2 (A-B, A-B). The second type is when the word pair items appear differently across the Lists, but the color of the List 2 response (D) will not be eye-catching as it is in a white color just like the other words (A-B, A-D not-colored). Finally, the third type is when the word pair item shows up differently across the Lists but during List 2, the color of the List 2 response word will be presented in a red color. This red color is to signify and catch the participant's attention to indicate that the item has changed in that exact site of change (A-B, A-D colored).

Typically, the A-B, C-D item type has been presented in the MFC framework related work as a control item, but I excluded that condition to focus power on changed A-B, A-D items. In addition, MFC framework researchers has been revisited and experimented with not only just word pairs but with other type of stimulus too (e.g., Wahlheim, 2014; Wahlheim, 2015, Wahlheim & Zacks, 2019; Garlitch & Wahlheim, 2020; Negley et al., 2018). Likewise, these researchers found that the performance difference due to change detection and recollection within the A-B, A-D item type was significant even without comparing it to the control items (A-B, C-D), so it is expected that the exclusion of the control items will not impact the data analysis.

This type of design for the study phase is intended to encourage participants to specifically pay attention to the site of change to ultimately generate two conditions within the A-B, A-D item types. The two conditions are where participants pay more attention to the site of change, and where participants pay relatively less targeted attention to the site of change. Again, MFC researchers already know that the detection of change plays a significant role in whether

the change recollection will generate configural representation or not (Wahlheim & Zacks, 2019). Also, Garlitch and Wahlheim (2020) have shown that attention level increases around the place where change detection occurs. Thus, comparison between two conditions in this experiment will provide conclusive evidence that attention to the site of change will lead to the proposed mechanisms of the MFC framework.

In summary, I am hypothesizing that there is a positive association between attention to the site of change and the occurrence of proactive facilitation, which would support assumptions of the MFC framework outlined above. These relationships will be observed through better recall performances of the response words, change detection rate, and change recollection rate in the A-B, A-D colored condition compared to the A-B, A-D not-colored condition.

Specifically, those specific goals can be met through analyzing the following multi-step hypothesis. As a first step, I hypothesize that coloring the changed response (i.e., A-B, A-D colored) should increase the List 2 recall performance relative to the uncolored changed response (i.e., A-B, A-D not-colored). This is to observe how awareness of changes can benefit the recall of the marked changes by encouraging remindings that lead to configural representations.

Once I observe the coloring changed response increases the List 2 recall, then I hypothesize that coloring changed response will increase the frequency of change being recollected, comparatively to the changed response without directed attention to change. This can be observed through the List 1 response recall performance, as Wahlheim and Jacoby (2013) and Jacoby et al. (2015) have shown that the recall performance of the List 1 response is a good indicator of whether the recollection of the both A-B and A-D had occurred. If the coloring changed response increased List 2 recall and also the frequency of change being recollected, then

I hypothesize that change recollection is more associated with better List 2 recall performance than when change was not recollected. For this, I will be comparing three possible cases where the participant recollects that change has occurred and remembers List 1 response, recollect change but fail to remember List 1 response, or fail to recollect that change happened. If my hypothesis is correct, the chance of recollecting change and List 1 response would be higher for the A-B, A-D colored than the A-B, A-D not-colored. By doing so, the current study will be able to suggest causational influence of attention's role in MFC framework.

CHAPTER II: METHODS

This proposal was reviewed and overseen by the Institutional Review Board of the University of North Carolina at Greensboro, while following the current American Psychological Association standard to protect the human participants.

Participants

For this experiment, 34 participants were tested using the Prolific participant recruitment platform. Participants received $3.25 for 30 minutes of participation, which is equivalent to $6.50/hour through Prolific. As for the restrictions/prerequisite for the participation of this study, participants needed be above the age of 18. The sample had an average of 30.26 years of age (*range* = 18-54, *SD*= *9.*13), with 12 male (35%) and 22 female (65%). The sample composition was as follows: 3 Asian or Pacific Islander (8%), 5 Black or African/Caribbean descent (14%), 1 Hispanic or Central/South American descent (3%), 24 White or European/Middle Eastern descent (70%), and 1 reporting two or more (3%). The minimum number of participants (*n* =34) was specifically chosen from the following calculations. As stated in the introduction, attention distribution to the site of change is a critical factor that will divert the two conditions that I will be comparing (i.e., A-B, A-D colored and A-B, A-D non-colored). Currently in the field, as of my knowledge, this approach has not been done before. Therefore, there is a challenge in terms of measuring the appropriate effect size for the current study. However, such difficulties can be overcome by parsing the effect that this study is utilizing.

Mainly the effect size of this study will be affected by whether the participant's additional attention to the site of change will lead to a better chance of successful change recollection. Siegel and Castel (2018) have reported the interaction effect of attention to the key

associative feature (i.e., grid) to the item-location pair recall performance to have a medium effect size (η^2 = .11, p < .001), which was used as an evidence of the causational role of attention for triggering associative memory encoding. Since the current study is also about how additional attention to the key features (i.e., second response word) will benefit the binding that occurs at the MFC framework, I am expecting to see a similar effect size. The η^2 of 0.11 is equivalent to the 0.7 in Cohen's *d* (Cohen, 1988).

Another useful reference is the effect size of the various manipulations on the memory updating in paired associate learning. The prior experiments in the MFC framework associated research (e.g., Garlitch & Wahlheim, 2020) have indicated that the effect size for the change recollection and recall performances being affected by the external variable manipulation has been reported to have small to medium size effects, with η^2 values ranging from 0.06 - 0.09, which is equivalent to 0.5 to 0.63 in Cohen's *d*. While the medium effect size is expected for the purpose of current study, such approach has not been made before under the context of MFC framework. Therefore, this study will utilize the lowest expected effect size to ensure that the suggested effect to be observed even when it is with the smallest effect, which will be Cohen's *d* of 0.5.

With this effect size, according to G*Power Version 3.1.9.2 (Faul, Erdfelder, Buchner, & Lang, 2009), a total sample size of 34 subjects was sufficient to detect a medium size effect (*d* = .5) at power = .80 and α = .05 in two-tailed matched pair mean comparison (i.e., pairwise t-test).

Design and Materials

This experiment utilized variants of A-B, A-D dual list paradigm with a within-subjects manipulation of Item Type. The following item types were A-B, A-B (e.g., silly-giggle, silly-

giggle) repeated items, A-B, A-D colored (e.g., number-forty, number-fifty), and A-B, A-D not-colored (e.g., knee-bone, knee-bend) changed items. Each word pair was presented once for each List. For this study, there were two lists, List 1 and List 2. For the word pair stimulus material, there were 86 word pair sets (84 critical and 2 buffers) taken from Nelson, McEvoy, and Schreiber (1998) free association norms. In each word set, there was a cue word (e.g., number) and two responses (e.g., forty, fifty). The cue and response words had semantic associations, while the two responses orthographic associations because they were originally created to complete the same word fragment (e.g., number – f_ _ ty). Since this study used cued recall during the Test phase, the fragments was not used.

To counterbalance the experiment, the 84 critical word pair sets were divided into 3 groups of 28-word sets. Each of those groups appeared as each item type equally as often across participants. In this type of study, it was a typical practice to counterbalance by creating 6 formats as there were three within subjects conditions and therefore the number of formats needs to be the multiple of three. However, in this study, one of the conditions (i.e., A-B, A-B) did not play an important role in the analysis in addition to the fact that throughout the format participant saw only one word pair throughout both lists. Therefore, this study focused on counterbalancing the two conditions (i.e., A-B, A-D colored and A-B, A-D not-colored) as those two conditions played a critical role in the analysis of the data. As a result, this study had four formats, as for the first two formats, the A-B, A-B condition used one word pair while the remaining two formats used the other word pair within the three-word set. For example, if there was a three-word pair set of *knee* (cue) – *bone* (response 1) – *bend* (response 2), the first two formats only showed *knee* – *bone* word pair as A-B, A-B condition while remaining two format showed *knee* – *bend* word pair as A-B, A-B condition. For the remaining two conditions, as A-B, A-D colored and A-B, A-

D not-colored, word pair set alternated for each format, as one 28-word set was distributed to A-B, A-D colored condition in first two formats, then the same 28-word set was distributed to A-B, A-D not-colored condition in next two formats and vice versa.

As an effort to minimize any unintended bias on word difficulties, the average length of cues (*M= 5.34, SD=1.53,* range = 3-9) and responses (*M=4.98 SD=1.35,* range: 3-9) were matched across groups. Also, the association across the cue and target words was checked with the index from Nelson, McEvoy, and Schreiber (1998). The association between cue and targets were low on average for both forward associative strength (*M= 0.09, SD=0.07*, range: .02-.11) and backward associative strength (*M= 0.08, SD=0.12*, range: .02-.16). For the target and its paired responses, both forward and backward association were weak (*M= 0.01, SD=0.04,* range: .001-.09). See Figure 1 for details.

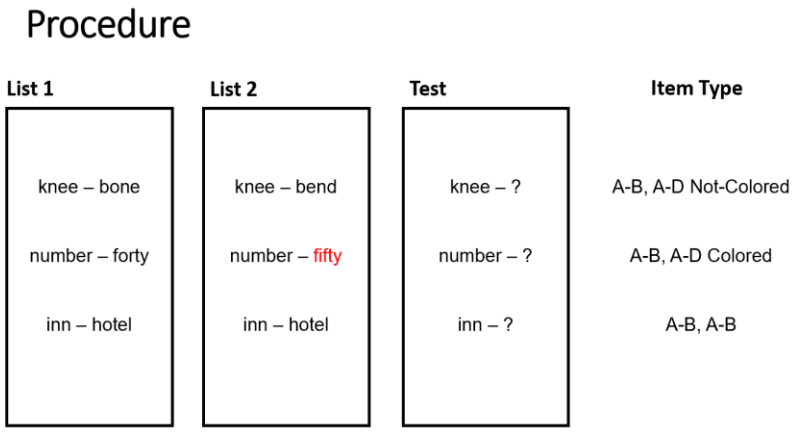

Figure 1. Schematic of Item Types and Procedure.

The study phase was composed of two stages, List 1 and List 2. In List 1, all three item types of word pairs were presented with just the cue and Response 1 words (i.e., A-B). For List 2 the participants viewed the cue and Response 2 words (i.e., A-B, A-D colored, or A-D not-

colored). List 2 is the place where participants saw the difference between each item type, as some word pairs was repeated (A-B, A-B), changed but with no color change (A-B, A-D not-colored), or changed and with color change (A-B, A-D colored). For each List, word pairs were presented in a random order. After the Study phase was over, participants proceed to the Test phase that consists of a cued recall task that assesses recall of responses from both list and recollection of changes, following the task instruction of Garlitch and Wahlheim (2020).

Procedure

All participants were tested individually online, using PsychoPy 3.0 (Pierce et al, 2019) via Pavlovia.org, which is a website specifically designed for performing online experiments made with PsychoPy. The sample version of the PsychoPy experiment was uploaded at the following link (https://pavlovia.org/j_lee45/explicit_change). All stimuli appeared in white Arial size 20 font on a black background.

Once the participant opened up the link, the demographic questionnaire was presented first. Upon the completion of both consent form and demographic questionnaire, the participant started the List 1 study phase. Participants were instructed to study each word for an upcoming memory test. Each word pair was presented altogether in one screen for 4 seconds and participants had to press the Spacebar during the interstimulus interval to proceed to the next word pair. This was to ensure that the participant was present and actively participating at the task. The instruction slide for List 1 is attached below as Figure 2.

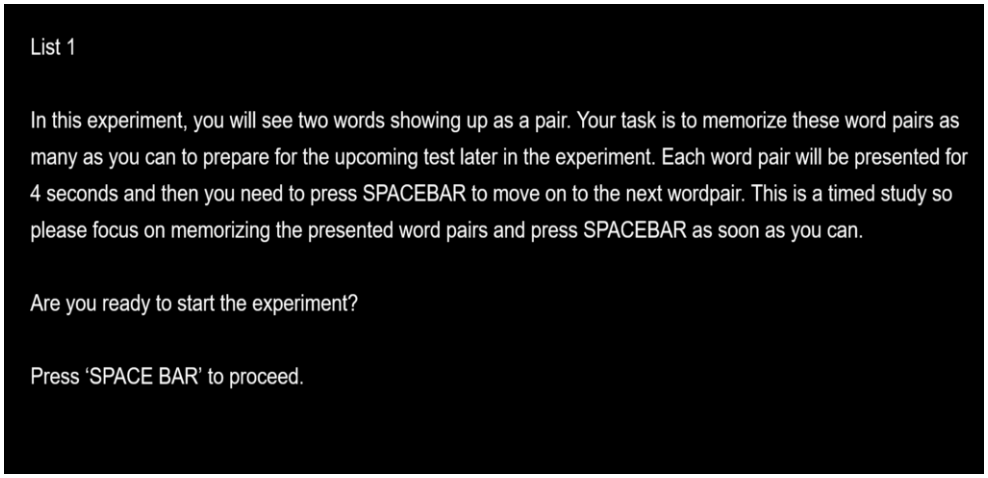

Figure 2. Instruction for List 1.

After the participant finished viewing the List 1, the instruction for the List 2 showed up (see Figure 3, below). In this phase, it was fully explained how the second word of the pair may change compared to List 1 and that the red color would be used on some of the changed word pairs -- although it was not always the case. To help the participant to understand how the color of the word pair changed, they were presented with examples and a step-by-step explanation of what the color change indicates and when it happened.

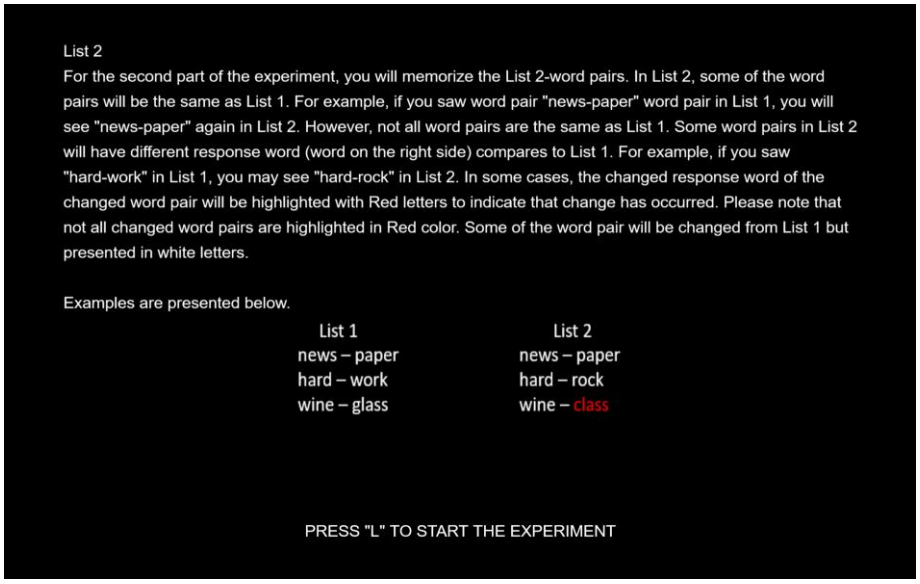

Figure 3. Instruction for List 2.

After the instruction was presented, the List 2-word pairs were presented upon the participant signaling that they understood the instruction by pressing the letter 'L' through the keyboard. Next, word pairs were presented for 4 seconds again and participant was asked to press Spacebar during the interstimulus interval to proceed to the next word pair to ensure that the participant was actively participating. After the Study phase of the experiment was complete, the participant proceeded to the Test phase of the experiment. In this phase, the participant received an instruction that they were tested with previously studied word pairs by typing in what the response word was for List 2 while only the cue word is given. In other words, the first question looked like "knee -?" when the cue word was "knee." Then, the participant answered the *change classification judgment* task, which asked "Has the item changed?" For this task, the participant was instructed to answer via typing either 'q' to indicate "Yes it has changed" or 'p' to indicate "No it has not changed". If the participant answered the change detection task with 'q', then they received another question that asks, "What was the second word of the pair from List 1?" Then, participants were asked to type in response words. Every step of the testing phase was carefully briefed, and the participant could ask questions about the instruction at any time. Before the task starts, the participant did a practice trial that showed how the test was held. For instructions of the Test phase, please reference Figure 4 as a reference.

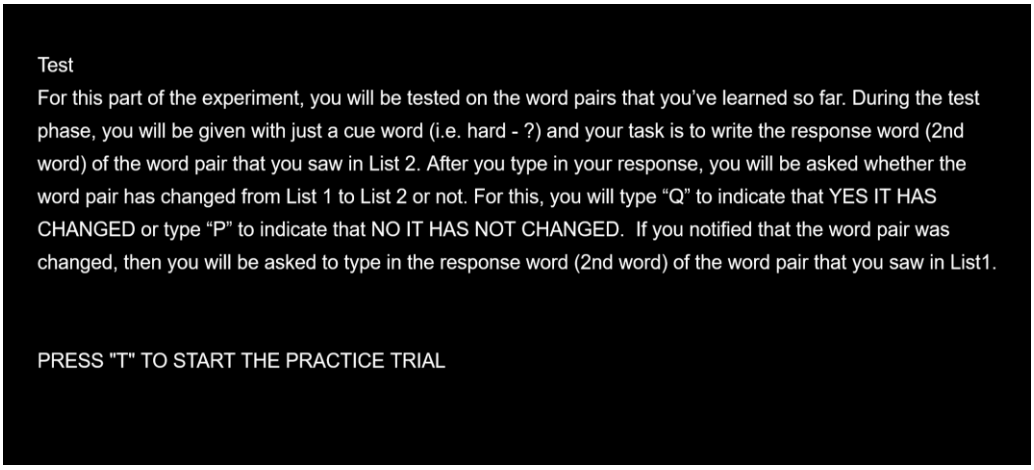

Figure 4. Instruction for the Test phase.

Finally, at the end of all tasks, participants were asked to answer a one question survey that asked them to type their answer to the following question in a short sentence: "Have you used red colored word to remember both associated word pairs or did you focus only on the red colored word? Please explain how you used red colored word in one sentence." This was to gain insight into how the red colored word was perceived and used in the participant's memory strategy. For instructions of the exit survey of the Test phase, please reference Figure 5 as a reference.

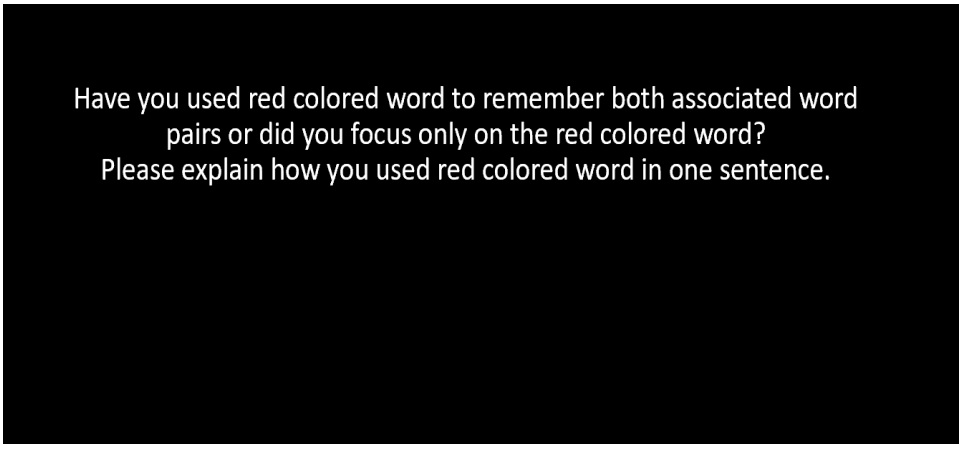

Figure 5. Final Survey.

When the participants finished the experiment, they were rewarded with $3.25 ($6.50/hr) per person as a compensation through the online participant recruitment website, Prolific. The experiment lasted approximately 30 minutes.

CHAPTER III: RESULTS

Analysis for the current study was conducted using R software (R Core Team, 2019). The first two parts of the hypotheses were performed with the t.test function from Rstatix Library rstatix library. The 2x3 repeated measure ANOVA was performed with ezANOVA function from the ez-package (Lawrence, 2016) in R. For the last part of the hypothesis, pairwise t-tests for the simple main effects were performed as a Post Hoc test, using the T-test t.test function from the Rstatix rstatix library. The effect size was measured with cohensD function in lsr package for Cohen's *d* (Navarro, 2015) and with ez-package (Lawrence, 2016) for the partial eta squared. The threshold for statistical significance was set at $\alpha = .05$.

Cued Recall Performance

List 2 Recall

Observation on List 2 word pair recalls was conducted as a measure to assess the effect of additional attention to the site of change on the recall of the most recently presented word pair. This part of the hypothesis is to observe if the additional attention to the site of change directly benefits the recall of the List 2 responses. Since the recall of the memory that was most recently encoded is the initiator of the *configural representation*'s successful generation, the difference in the List 2 recall accuracy caused by attention may be a crucial indicator for the beneficiary effect of attention to the site of change on the successful episodic memory updating in the MFC framework. To compare the effect of additional attention, the List 2 recall performance of the two item types A-B, A-D Colored and A-B, A-D Not Colored was compared as a dependent variable with pairwise t-test (see Figure 1). In this part of the hypothesis, I expected to observe significantly higher List 2 recall accuracy in the Item Type with more attention to the site of change (i.e., A-B, A-D Colored), because attention was expected to be a critical factor that promotes recollective procedures within MFC framework to counteract proactive interference.

However, the results showed that List 2 recall was not significantly different between the Colored (M = .26, SD = .17) and Not Colored (M = .25, SD = .17) items, $t(33) = .45$, $p = .66$, d = 0.08. The mean value of the A-B, A-D Colored's List 2 recall accuracy was slightly higher than the List 2 recall accuracy of the A-B, A-D Not Colored condition, but the difference was not significantly big. If the attention gathering to the site of change benefitted the recall of the List 2 response, which would be a predictor of successful recollection (Wahlheim & Jacoby, 2013), there would have been a significantly better List 2 recall performance at the A-B, A-D Colored than Not Colored Item Types.

The slight differences in List 2 recall could imply that coloring an item could have an effect by directing attention to that item. Furthermore, I believe the Change judgment is involved in the analysis of the List 2 response accuracy as a meaningful difference between A-B, A-D Colored, and Not Colored conditions were observed. A-B, A-D Colored condition reported significantly higher List 2 response accuracy for the correctly Change reported word pairs (M = .16, SD = .16) than A-B, A-D Not Colored (M = .12, SD = .14), under pairwise t-test $t(33) = 3.44$, $p < .001$, $d = .59$. These results suggest the possibility of additional attention to the site of change having a beneficiary effect on List 2 response only when it is accompanied by the correct remembrance of Change. However, the lack of significant difference between A-B, A-D Colored and Not Colored condition on List 2 response accuracy in general, regardless of whether the Change was correctly recognized or not, makes a claim of attention's beneficiary effect on the recall of List 2 response to be difficult to propose.

Change Response

The second part of the current experiment's hypothesis was to observe if additional attention to the site of change benefitted the remembrance of Change during the test phase. In MFC framework literature, the remembrance of Change from List 1 to List 2 during the test

phase has been suggested to play an important indicator of the successful counteraction of proactive interference, which can be observed through the accurate recollection of the List 2 word pairs (Wahlheim & Jacoby, 2013). This is because the memory-for-change involves the preservation of the temporal order of events, which is an important factor for the generation of *configural representation*. Since *configural representation* performs as a reminder for both List 2 and List 1 word pairs, MFC framework researches suggested that the accurate recall of Change may indicate the higher possibility of *configural representation* being generated during the recall, which subsequently increases the chance of proactive interference being countered. Therefore, the observation on the Change remembrance performance is critical to gain insight about whether the *configural representation* was generated, or at least on whether the temporal order of events was recollected along with List 2 recall.

As this study is focused on observing the effect of additional attention to the site of change (List 2 presentation) on the episodic memory updating in the MFC framework, I compared the Change remembrance rate for A-B, A-D Colored and A-B, A-D Not Colored Item Types as a dependent variable to see if attention causes significant influence to the generation of the *configural representation*. In this part of the hypothesis, I expected to observe higher Change remembrance performance in the A-B, A-D Colored Item Types compares to the Not Colored Item Types, because the additional attention to the site of change may have benefitted the remembrance of Change.

To analyze this comparison, I performed a pairwise *t*-test. The results indicated that the rate of correct Change report was significantly higher for Colored (M = .33, SD = .21) than Not Colored (M = .25, SD = .18) items, $t(33) = 4.43$, $p < .001$, d = .76. This result may suggest that the additional attention to the site of change gathered in A-B, A-D Colored condition

successfully supported participants to recognize and remember that there was a Change. Furthermore, this implies that the attention may be an important resource for the preservation of the temporal order of events and the generation of *configural representation*. Please reference Table 1 below to see the pairwise *t*-test results.

Logistic parameter	A-B, A-D Colored		A-B, A-D Not Colored		t(33)	p-value	Cohen's *d*
	M	SD	M	SD			
List 2 accuracy	.26	.17	.25	.17	.45	.66	.09
Change report	.33	.21	.25	.18	.43	<.001***	.76
List 2 recall w/ Correct Change	.16	.15	.12	.14	.44	.001	.59

****p < .001*

Table 1. *t*-test table for List 2 recall accuracy, Change report, and List 2 recall with correct change response.

The following section of the analysis focuses on the thorough review on the successful counteraction of proactive interference, depending on the amount of attention to the site of change (Item Types) and by the conditions of memories associated with the Change (Conditions).

Classification of Change

As the current study is interested in reviewing the effect of additional attention to the site of change on the episodic memory updating process within the MFC framework, this study will also share the same operational definition of the Change classification (e.g., Wahlheim & Zacks, 2019, Garlitch & Wahlheim, 2021). Depending on the recall accuracy of *Change* from List 1 word pairs to List 2 word pairs, and whether the List 1 response word was accurately recalled, the *Change* was classified as the following three conditions: *Change recollected, Change remembered,* and *Change forgotten.* Each of these conditions is operationally defined as the following for the A-B, A-D item types.

First, *Change recollected* refers to the case where Change was accurately recalled, and List 1 response word was correctly recalled. This is because, under the MFC framework's view, the successful recollection through using memory-for-Change involves the remembrance of Change's occurrence and successful recollection of List 1 word pairs memory indicates that the *configural representation* was successfully generated, and the accurate recollection of List 2 word pairs were the case of *proactive facilitation*, as the memory of List 1 word pair strengthened the memory of List 2 word pairs. Second, *Change remembered* refers to the case where Change was accurately recalled but incorrectly recalled List 1 response word. This would be the case where the memory-for-Change was remembered during the test phase but failed to induce the reminding effect for the List 1 response and ultimately failed to generate *configural representation*. This means that the Change was correctly remembered, but since the List 1 memories were not recalled, the recall of List 2 word pair memories may not be from the collective memories of both List 1 and List 2 bounded by the memory about the order, triggered by the remembrance of Change. Hence, the current study will refer to this type of situation as *Change remembered*. Finally, *Change forgotten* refers to the case where the Change was inaccurately recalled, subsequently failed to even remember the existence of List 1 word pairs. This is the case where the Change was not remembered even though the word pair was A-B, A-D item types, and may suggest that the memory of List 1 and List 2 may be causing intrusion to each other. This would be the case where *proactive interference* may be observed, as the List 1 word pair memory may cause intrusion to the List 2 word pair memories.

Item Type and Change Classification on List 2 accuracy

The focus of this experiment is to test the hypothesis that attention to the site of change plays a critical role in the counteraction of *proactive interference* by promoting a beneficiary effect to the generation of *configural representation*. To test this, I conducted a 2x3 repeated

measure ANOVA, where 2x3 design was with two types of Item Types as A-B, A-D Colored and A-B, A-D Not Colored by three types of Change classification. As mentioned above, the Change classification factor includes three types of conditions: Change Recollected, Change Remembered, and Change Forgotten. For this part of the hypothesis, I expected to observe a significant interaction effect between Item Type and Change classification, which would indicate that the classification of Change and the amount of attention to the site of change is dependent on each other.

In this part of the analysis, the interaction effect was observed to be not significant $F(2, 66) = 2.69$, $p = .07$, $\eta_p^2 = .015$. For main effects, the Item Type's main effect was not significant $F(1, 33) = 1.30$, $p = .26$, $\eta_p^2 = .006$, but the Conditions' main effect was $F(2, 66) = 25.14$, $p < 0.001$, $\eta_p^2 = .17$. Since the interaction effect was not significant, post hoc test was not performed and the third part of the hypothesis was rejected. See Table 2 below for the 2x3 repeated measure ANOVA results and Figure 6 for the figures.

Note the ItemType have two types of conditions, as A-B, A-D Colored and A-B, A-D Not Colored. For the Condition variables, there are three conditions as Change Recollected, Change Remembered, and Change Forgotten.

Effect	DF numerator	DF denominator	F	p-value	Partial Eta squared
ItemType	1	33	1.30	.26	.01
Condition	2	66	25.14	<.001***	.17
ItemType x Condition	2	66	2.69	.07	.02

***$p < .001$

Table 2. 2x3 repeated measure ANOVA table for List 1 recall with Item Type and Change classification.

Note the error bar refers to the 95% Confidence Interval.

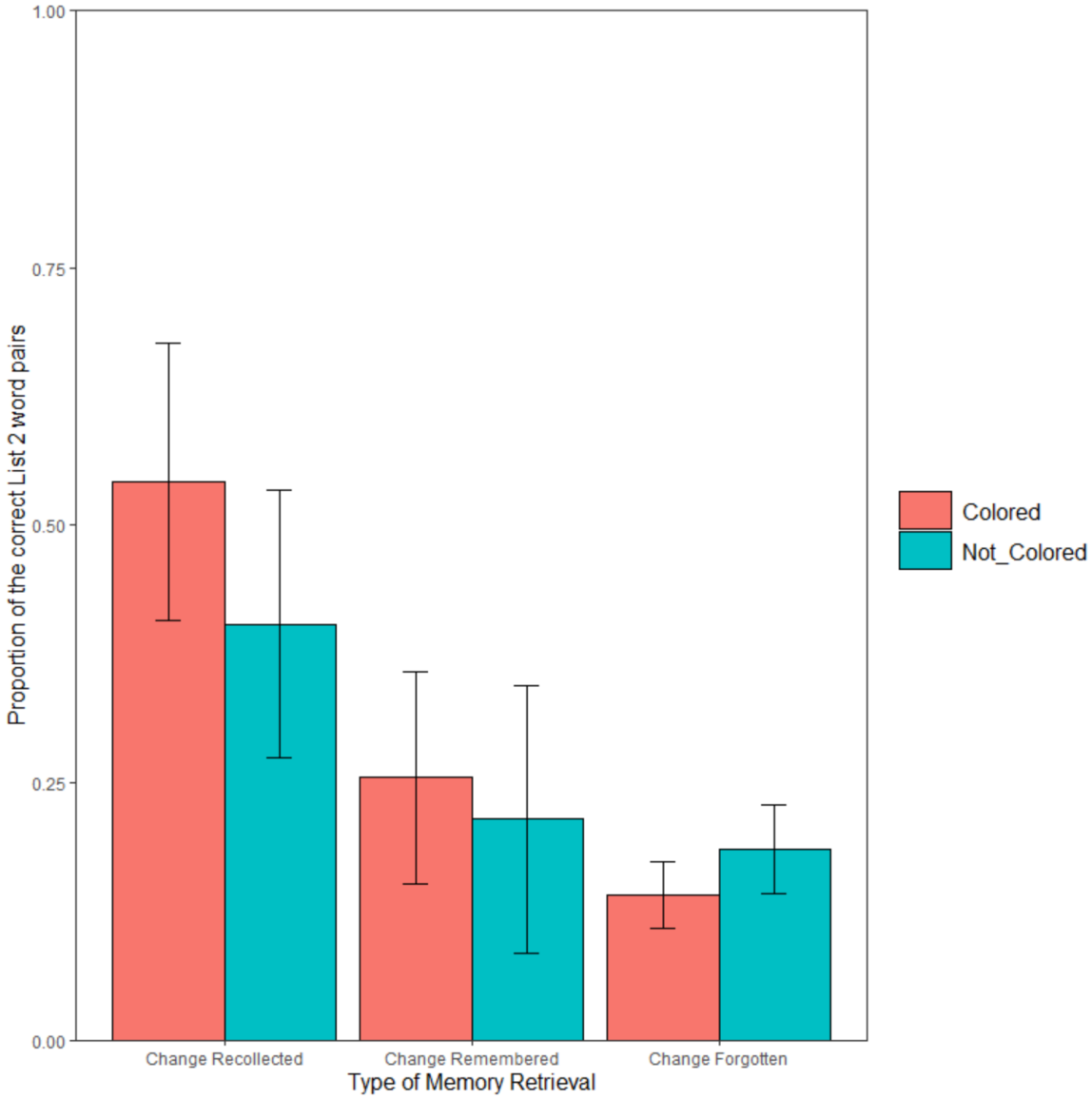

Figure 6. 2x3 ANOVA Change condition by Item Type.

While the lack of significant interaction effect in the current 2x3 repeated measure ANOVA analysis and the insignificant difference between List 2 response accuracy across A-B, A-D Colored and Not Colored Item Types suggest that the proactive facilitation effect of the MFC framework may not be present, there are tools from the MFC framework associated research works where it allows the current results to make inferences about the interplay between

the retrieval process of List 1 word pair memories and List 2 word pair memories. Typically, such needs were often met by jointly reporting the relative proportion of each Change conditions within the correctly recalled List 2 responses. In this part of the analysis, Change conditions were used to address various types of List 1 recall, as Change Recollected conditions is when List 1 word pair memories were correctly recalled, Change Remembered conditions is when List 1 word pair memories may have been recalled but only to the level where participants get the *feeling-of-knowing* on List 1 word pairs and Change Forgotten is when List 1 word pair memories were completely forgotten. Please reference Table 3 below.

Item Type	A-B, A-D Colored		A-B, A-D Not Colored	
	M	SD	M	SD
List 1 Recollected	.38	.28	.34	.32
List 1 Remembered	.15	.21	.06	.12
List 1 Forgotten	.47	.32	.60	.32

Table 3. Direct comparison between two Item Types across each Change conditions.

This part of the analysis is specifically focused on analyzing how often did the reminder of the List 2 word pairs (i.e., List 1 memories associated with Change) got reported, as the MFC framework proposes that the recollection of List 1 word pair memories reminds participants of List 2 word pair memories. As the current study proposes the role of attention to be beneficial on promoting recollective process, I was expecting to see a significant difference between A-B, A-D Colored and Not Colored condition in the List 1 Recollected conditions, as A-B, A-D Colored Item Types would have shown significant advantages on promoting List 1 memories recollection. Contrary to the hypothesized results the current experiment's result indicated that that the recollection (i.e., List 1 Recollected) did not show significant differences amongst Colored (M = .38, SD = .28) and Not Colored (M = .34, SD = .32) conditions $t(33) = 1.22$, p =

.23, d = 0.21. However, there was a significant difference between Colored (M = .15, SD = .21) and Not Colored (M = .06, SD = .12) conditions in the List 1 remembered conditions $t(33)$ = 2.43, p = .02, d = 0.42. With these results and the non-significant interaction effect in 2x3 repeated measure ANOVA, the results may suggest that the attention gathered by Color change did not seem to directly benefit the recollective process in this current experiment. However, there are some circumstantial findings in the current experiment that may suggest that the attentions could potentially benefit the recollective process, as the List 1 Remembered condition may indicate that the participants felt a *feeling-of-knowing* since they could recall the List 1 word pair memories to the level where they felt the presence of List 1 memories and report the Change's presence, but not strong enough to recollect List 1 memories. However, such a claim can only be circumstantial and cannot be confirmed by the scope of the current experiment.

Self-Report of Color Change usage

Based on the summary of the written response that participants provided at the end of the experiment about how they used the color change during the List 2 presentation into their Change response, 54% of the participants (n = 18) reported that they utilized color Change as a tool to remember both List 2 response word and that the item Changed from List 1; 17% of the participants (n = 6) indicated that they used color change to solely focus on the memorization of the List 2 response, and 29% of the participants (n = 10) indicated that they did not focus on the color change at all. As an exploratory analysis, this self-report data indicates that more than half of the participants tried utilizing the color change to note that the item has Changed, which has shown to be beneficial for counteracting the proactive interference in the MFC framework.

CHAPTER IV: DISCUSSION

This experiment examined the effect of additional attention on the associative features of two episodic memories that are prone to experience *proactive interference*. The purpose of examining the effect of attention on the recollective procedure within the MFC framework is to further understand the exact role of attention in the MFC framework. In my results, I observed that the additional attention to the site of change gathered through the color change of the List 2 response word during encoding did not induce significant results in increasing the chance of List 2 word pairs to be recollected and failed to show that attention played a significant role in counteracting proactive interference by generating and utilizing *configural representation*. While these results suggested that there was insufficient evidence to suggest the importance of attention to the recollective procedure of the MFC framework, there were some significant effects (e.g., Change Remembrance) observed in this experiment that may suggest the role of attention in the MFC framework.

Role of attention in MFC framework

Previously in the MFC framework associated research works like Garlitch and Wahlheim (2020), attention has been reviewed as a potentially important cognitive resource of interest for the MFC framework to work, while the exact role within the framework was yet to be defined. For the current experiment, attention was hypothesized to play a critical factor in the generation of configural representation under the context of supporting the recollective procedure within the MFC framework, specifically on the counteraction of *proactive interference* in A-B, A-D dual list word pair paradigm. However, the current experiment's results indicate that the attention gathered through color change at the site of change did not necessarily provide a meaningful

effect on promoting facilitative effect on the proactive interference-prone memories in the MFC framework, specifically in the first and third part of the hypothesis.

For the first part of the hypothesis, A-B, A-D Colored condition was expected to show significantly higher List 2 response accuracy in the first part of the hypothesis, which would have suggested the attention's beneficiary effect on the counteraction of *proactive interference*, as attention was expected to benefit the recollective procedure within MFC framework. However, the first part of the hypothesis' result of insignificant difference between A-B, A-D Colored and A-B, A-D Not Colored in List 2 response accuracy indicates that there was an insufficient amount of evidence for the attention's effect on the counteraction of *proactive interference*. For the third part of the hypothesis, I was expecting to observe a significant interaction effect in the 2x3 repeated measure ANOVA that had the proportion of the accurate List 2 response as a dependent variable and Item Types and Change Classification as independent variables. The presence of interaction effect would have indicated that the attention causes a significant difference in successfully recollecting List 2 responses using *configural representation* to counteract proactive interference. However, in this part of the hypothesis, the interaction effect and the Item Type's main effect were not significant, which indicates that the counteraction of proactive interference using *configural representation* (i.e., Change Classification's main effect) was not dependent on the difference in attention to the site of change (i.e., Item Type's main effect). This indicates that the attention to the site of change did not provide a meaningful effect on promoting the generation of *configural representation*, which was not the desired outcome but was consistent with the first part of the hypothesis' result.

Overall, those two parts of the results may pose the possibility of attention not being an important contributor to the recollective process within the MFC framework and the

counteraction of proactive interference. However, there were some instances and features of the MFC framework where attention did cause a meaningful difference between A-B, A-D Colored, and Not Colored conditions, which may help to indicate the exact role of attention in the episodic memory updating of the MFC framework.

In the result, I observed the following significant differences: First, the second part of the hypothesis on Change remembrance accuracy did have a significant difference between the two conditions, as the Colored condition showed significantly higher Change remembrance accuracy. Second, although this is an exploratory analysis that can only provide circumstantial evidence, the List 2 response accuracy was meaningfully high for A-B, A-D Colored condition (M = .16, SD = .15) than A-B, A-D Not Colored condition (M = .12, SD = .14) when the accurate List 2 recall was accompanied by the accurate Change remembrance $t(33) = 4.44$, p =.001, d = .59. Third, as another exploratory analysis, the List 1 response report rate in the Colored condition was significantly higher than the Not Colored condition.

There could have been various reasons why I observed such a collection of results. The first possibility is that the List 1 word pair was not properly encoded during the Study phase of the experiment. In the A-B, A-D dual list paradigm, the *Occlusion* was proposed as the cause for the negative consequences of the competition among two memories (i.e., interference), only when both prior and later memories were properly encoded (Anderson & Neely,1996). In other words, the current experiment was designed based on the assumption that the List 1 memories was present in the participants' mind and cause intrusion to the memory of List 2 response (i.e., *proactive interference*). Although having a slightly poorer quality of the List 1 word pair memory may have limited effect on the observation of *proactive interference* counteraction in the MFC framework, substantial presence of the poorly encoded List 1 memories to the level

where participants did not focus on List 1 word pairs at all, could cause flooring effect on the current experiment's List 2 accuracy associated results, because the MFC framework proposes that the memory benefit of the memory-for-change, specifically proactive facilitation in this experiment, comes from the successful generation of the *configural representation*, which requires the accurate recall of the List 1 word pairs memory. If there were fewer List 1 memories to work with from the start, then the subsequent memory benefit of the MFC framework from the recollective process will happen far less frequently compared to the other MFC framework literatures. Especially, the VDL literature (e.g., Castel, 2008) that was referenced to predict the potential role of attention in the MFC framework indicated the benefit of gathered attention at the encoding is exclusively on promoting successful recollection, not necessarily on the *feeling-of-knowing* or the remembrance. Under this notion, the lack of available List 1 memories due to the poor encoding can lead to the situation where the effect of attention to the MFC framework's *proactive interference* counteraction may look absent, because the recollective process of recalling List 1 memories and memory-for-change to strengthen the recall of List 2 did not happen because of the lack of List 1 memories, not due to the fewer available attentional resources.

Furthermore, typically, MFC framework experiments were held in an in-lab study environment, where researchers can observe if participants are focusing on the task. Although the current experiment implemented additional steps (e.g., pressing Spacebar to move on to the next word pair during the study phase) to promote participants to be on the task and actively participate in the study, it is difficult to expect the same level of the controlled experimental environment from the online study that in-lab study may provide. Especially, given that the current study design can only work if and only when participants exclusively focus on the task,

the inability to control for the participants' experimental environment and observe their task focus is a critical limitation that can cause the current experiment's attention resources associated manipulation to be ineffective.

If the List 1 word pairs encoding quality was not the issue and participants did encode the List 1 word pairs and paid attention during the List 1 presentation phase, then the second possibility for these results is that the recollective process of the MFC framework to generate and utilize the *configural representation* may not be directly influenced by the attentional resources. Instead, the attentional benefit may be limited to promoting participants to recognize the Change better instead of directly impacting the subsequent episodic memories updating. In Garlitch and Wahlheim (2020) the self-report of attention resources fluctuation was observed at the site of change (i.e., Block 3 or the presentation of the A-D word pairs) and showed that there was a positive correlation between the self-report of being On-task and showing higher List 2 recall accuracy, with a significant positive relationship between Change report and correct List 2 recall. In the current experiment, I have implemented a design where the manipulation on the attention was directly given to the participants instead of a self-report measure to induce results that can investigate the causational relationship between attention and the MFC framework, further investigating the notion of Garlitch & Wahlheim (2020) based on the correlational results.

While there is a possibility of attentional resources manipulation that I implemented in the current study simply did not work due to the limitation of the online study, some portion of the results replicated the result that was observed in Garlitch & Wahlheim (2020). For example, the Item Types with more attention to the site of change (i.e., A-B, A-D Colored) did show higher List 2 recall accuracy when the Change was correctly recalled, resonating with the positive relationship between Change and List 2 recall accuracy in Garlitch & Wahlheim (2020).

Furthermore, while attentional manipulation in the current experiment failed to induce meaningful differences in the recollective procedures within the MFC framework, the attention to the site of change did show a positive correlation with the remembering that the Change occurred. Under the assumption that this experiment was not influenced by the flooring effect on the List 1 memory, positive correlation between Change report and higher attentional resources in the current experiment can present the possibility of attention to the site of change may not necessarily be beneficial to the recollective process of the MFC framework, but to the recognition and preservation of the memory-for-change. Under this line of thinking, the result of the current experiment may be in line with Garlitch & Wahlheim (2020) by showing that the positive correlation between higher self-report of attention and a higher chance of accurate recollection of List 2 may be because memory-for-change was an intermediate factor between attention and successful *proactive facilitation* in MFC framework. Therefore, as this experiment is focusing on the directionality of the relationship between attention and *proactive facilitation*, the result may come out insignificant because the observed correlation in Garlitch & Wahlheim (2020) was mainly due to the attention increasing the chance of recognizing and remembering that there was a Change, subsequently increasing the chance of *proactive facilitation* to occur as more word pairs with the memory-for-change were available for the *configural representation* to be utilized.

While this may provide some explanation of the current experiment's result, the role of Change being an intermediate factor is still a speculative guess that cannot be deduced from the current scope of the experiment. To suggest that the attentional resources' role is limited at recognizing and remembering the change and that it is mainly memory-for-change that drives the recollective procedure of the MFC framework, follow up studies specifically targeted on the

attention and Change recognition is required to clarify the role of attention to the recognition and remembrance of Change. The causal role of memory-for-change in the MFC framework has been consistently replicated and reviewed in the MFC literature (e.g., Jacoby et al., 2015, Wahlheim et al., 2019), and observing the causational relationship between attention and Change will help clarify the role of attention in the MFC framework.

Although it is possible to understand the current experiment's result as attention selectively benefitting the identification and preservation of the memory-for-change, such results can also be interpreted as hinting at the possibility of attention as an important cognitive resource for the recollective process of the MFC framework. This is because in the MFC framework, noticing and remembering Change (i.e., memory-for-change) was often associated with the act of recalling the List 1 word pairs, as the act of reporting that there has been a change from List 1 to List 2 during the test phase subsequently involves the acknowledgment of different List 1 word pair's presence.

Arguably, it is possible that the memory processing for the *familiarity* may be different from that for the recollection in the MFC framework since MFC literature is yet to formally articulate the memory processing process in the MFC framework when the List 1 response memories were inefficiently recalled and lead to the situation where the memory of List 1 was recalled but not recollected (i.e., remembered). However, according to the literature on recollection (e.g., Jacoby, 1991), the differences between a memory that become familiar versus recollected is at the strength of the ties between cue memory and the target memory (i.e., responses). Under this notion, if the cue memory and the target memory are strongly connected, then participants may be able to recollect the target memories when the cue was given. However, if the ties between cue and target memories were not strong enough to induce *recollection*, then

participants may have a feeling that they could recall what was the target memories but fails to recall them (i.e., tip-of-the-tongue phenomenon). In this case, participants may feel familiar with the target memories when it is given to them and recognize the correct target memories when they see one or in other words, developed *familiarity*.

While it is often a common practice to utilize recognition task to observe if participants developed *familiarity*, the current experiments' definition of Change Remembered condition in the third part of the hypothesis may also be used as a potential indicator of the presence of *familiarity*, as the act of reporting that the word pairs changed across List 1 and List 2 can only be done if participants recalled List 1 memories at least to the level where they remember the presence of List 1 word pairs and induces the *feeling-of-knowing*.

Under such notion on Change Remembered condition, the significantly higher proportions of the List 1 Remembered condition report out of all correct List 2 recall and a higher chance of reporting the Change correctly in the Colored condition may indicate that the attention does play a critical role in promoting the memory processing in the MFC framework, but the inability to recollect the exact memory of List 1 during the generation of configural representation may have caused a detrimental effect on initiating successful episodic memory updating in the MFC framework. For example, Wahlheim et al., (2019) also observed a similar pattern of observing Change Remembered condition showing lower List 2 recall accuracy than the Change Recollected condition, but still higher than the Change Forgotten condition, using cue-only reminder to promote the recollection. For such results on the Change Remembered condition, they speculated that the ineffective retrieval of List 1 responses may induce a diminished potential of List 1 memories performing as a reminder of List 2 responses due to the generation of incomplete configural representation. Following such a notion, it is possible to

suggest that the attention to the site of change may have helped the processing of List 1 and List 2 memories and promoting the generation of configural representation. However, the gathered attention to the site of change in the current experiment may not have been sufficient to help List 1 memories to be recollected, but just enough to help participants to remember the existence of the List 1 memories.

While such possibilities can only be referenced if the memory processing with the poor quality of List 1 memories is formally articulated in the MFC framework literature, such a result could have been caused by the current experiment's manipulation failing to cause a meaningful difference in the attentional resources distribution between Colored and Not Colored Item Types, or due to the possibility of attention not being an important contributor of inducing recollection to happen in the MFC framework. However, confirming either one of those reasonings as a probable cause of the current experiment's result is beyond the scope of the current experiment and may require follow-up studies with stronger attention manipulation, or with the experiment design that focuses on identifying the cognitive mechanisms at play when the List 1 memory is just remembered not recollected.

Color change as an attention gathering measure

The third possibility for such a result of the current experiment is that the attention gathering measure may have caused unintended effects that may have diverted the participant's attentional resources not in the direction that the current experiments tried to induce. In this experiment, the color change was used as a way to direct participants' attention to the site of change and ultimately have participants pay more attention to how word pairs have changed over the List 1 and List 2 phases. However, color change itself could have caused unintended psychological effects to affect the current experiment's results.

One possible effect that could be present when the color change was used as a method to gather attention is the Von-Restorff effect (Von-Restorff, 1933). The Von Restorff effect refers to the psychological effect of distinctive items that stands out, or are "isolated" from the rest of the items, tend to be remembered better during recall. The distinctiveness literature (e.g., Hunt, 1995) has shown that attention plays an important role in identifying the distinctiveness of the item subjected to the Von-Restorff effect, specifically when the item involves semantic processing to recognize the distinctiveness (Bireta & Mazzai, 2016). Following this line of research, the memory benefit on the cued recall task of this experiment that I observed in the current experiment may simply be because of the attention's effect to the color change and color change predominantly affecting the recall performance, not necessarily involving the MFC framework.

However, this case would be unlikely because of the following reasons. First, Color changes in Von Restorff's research were designed to be simple and most of the research works were not tested in dual list paradigms, unlike the current experiment. Secondly, the instructions for these experiments were usually simple and did not involve specific instructions on what features should they focus on the stimulus. This experiment provided explicit instructions to focus on how the item has changed and what the color change does to the word pairs. In other words, the current experiment's design is not similar to the typical Von-Restorff researches.

Third, the results of the current experiment indicate that the Von-Restorff effect may not be at play in this experiment. In the experiment, A-B, A-D Colored condition's List 2 response was the only one that had color changes. If the Von-Restorff effect was causing a significant impact on my experiment's results, then the Colored condition would have had higher List 2 response accuracy than Not Colored conditions. However, the current experiment's result did not

show any significant List 2 response accuracy difference among Colored and Not Colored conditions, and the difference between List 2 response accuracy only existed when the Change was correctly recalled. While this is not the desired result for my hypothesis, this indicates that the Von Restorff effect triggered by the color change may not have caused any significant effect on my experiment.

Beyond the focus on physical characteristics (i.e., the color change) of the current experiment's manipulation, another viewpoint to consider is the possibility of color change usage to gather attention to the site of change may have led participants to pay attention to the cue words instead. Although the operational objectives of the current experiment's manipulation were to guide participant's attention to the fact that Change occurred, it is also important to note that 46% of the participants reported that they used the color change in a limited fashion, as they either completely ignored it (29%) or just used it for List 2 memorization (17%). If the substantial number of participants did not use color change to recognize the occurrence of Change and tend to ignore or not focus much on the color change at all, then the List 2 presentations may have subsequently generated an environment where participants focus more on the components within the word pairs that did not have any color changes (i.e., cue word).

Such cases of where the cue word gains more focus were reviewed in Wahlheim et al., (2019) as the cue-only conditions in Experiment 4, where the participants studied the cue-only word lists along with the dual list word pair paradigm. Obviously, the color change in the current experiments did not always lead people to ignore the site of change (i.e., List 2 response word) and focus on the cue words, as 54% of the participants indicated in the exit survey that they specifically used the color change to remember that there has been a Change and used such notion of Change to reference the relationship between List 1 and List 2. However, the

substantial number of participants (29%) reported that they purposely ignored the color change so it is possible to suggest that the current experiment's result may have included the case where participants approached the experimental task comparable to the cue-only reminder conditions in Wahlheim et al., (2019). Furthermore, their result showed that cue-only reminders showed tendencies to be less effective at promoting change recollection compared to the cue-response reminder conditions due to comparably less environmental support for the List 1 retrieval during List 2 presentation in cue-only reminder condition. This may explain the current study finding no differences in List 2 accuracy and the effectivity of Change Recollection in promoting proactive facilitation across Colored and Not Colored condition may have been due to the possibility of attention that was gathered with the current experiment's manipulation was used for promoting less effective method of promoting recollection (i.e., cue-focused approach) and dampen the attention's beneficiary effect of promoting recollective process within the MFC framework. However, the current experiment's manipulation cannot make a formal claim on whether the current experiment's MFC framework mechanisms were with an extensively cue-focused approach, as the results of this experiment can only make a speculative guess about what may have happened.

Overall, the current experiment failed to observe the proposed role of attention in the MFC framework, which was promoting the recollective process that promotes the counteraction of the *proactive interference*. While some of the results seem to suggest that attention may play a role in recognizing and remembering the Change, the exact role of attention in the MFC framework is still yet to be defined in the current study and future studies on attention's role in the perception and remembrance of Change and with more controlled environments may be

necessary to achieve the experimental objective of identifying the exact role of attention in the MFC framework.

Experiment Limitations

As for the limitation of this study, the current study was held online. Being an online study, itself does not necessarily indicate poor quality of the data acquisition process and Prolific has multiple precautionary measures within their data acquisition policy, like automatically excluding participants who went idle and/or takes more than 2 hours to finish a 30 minutes task. However, there were few minor instances where participants showed insufficient evidence that they faithfully performed the task. For example, there were 2 suspected cases where participants predominantly pressed “P” during the Change classification task at the test phase to bypass the List 1 response question. However, these cases did not affect my analysis as much since those were a very small number of cases, and the data analysis for this study mostly focused on the accuracy of the List 2 response, List 1 response, and Change response. However, follow-up studies with more traditional in-lab studies may be beneficial to ensure that participants are completely focusing on the task.

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