Drawing as an Encoding Tool: Generalizing to Emotional and More Complex Stimuli

by

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A thesis
presented to the University of Waterloo
in fulfillment of the
thesis requirement for the degree of
Master of Arts
in
Psychology

Waterloo, Ontario, Canada, 2021

Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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Abstract

Drawing, as an encoding strategy has been shown to provide robust memory benefits primarily to memory for list of words. Past research has also shown that emotional compared to neutral information is typically better remembered. In this thesis, we examined the extent and limitations to which the memorial benefits conferred from drawing at encoding extended to emotional materials and to more complex stimuli such as sentences. In Experiment 1, 50 young adult undergraduate students were presented with 42 positive, negative, and neutral words, one at a time, in random order. They were asked either to write out or to draw a picture of the referent of the word, with cue-type intermixed, making the word valence and encoding prompt manipulations within-subject. Participants were later given five minutes to freely recall as many words as possible by writing them out. Recall was higher for words drawn than written at encoding. What is more, the magnitude of the boost was further enhanced for negative compared to positive and neutral words. In Experiment 2, we examined the generalizability of this drawing benefit to memory for more complex materials - neutral sentences - which are more linguistically and semantically complex than single words. In Experiment 2, another sample of 50 young adult undergraduate students were presented with a total of 18 sentences, one at a time, with random prompts to either write or draw intermixed. In Experiment 3, we examined whether emotional valence would again combine with the magnitude of the drawing benefit, as it had in Experiment 1, even when the to-be-remembered information was sentences. Experiment 3 was identical, but sentences were either positive, negative or, neutral in valence (8 of each type; 24 sentences in total, half drawn and half written at encoding). In both of the experiments, following encoding, participants were then given five minutes to freely recall as many sentences as possible in written format. In both, recall was higher for sentences drawn than written at encoding. As well, in Experiment 3, recall for negative sentences was significantly higher than for neutral or positive sentences; there was, however, no interaction. These findings demonstrate that the memorial benefit from drawing at encoding a) extends to emotional materials, and b) is evident even when to-be-remembered information is more complex. Our findings also suggest that drawing and emotionality independently enhance retention of words.

Acknowledgements

First and foremost, I am immensely grateful to my supervisor, Dr. Myra Fernandes, for her expertise and unwavering support. Her guidance and encouragement throughout my training have helped me develop as a researcher and as an individual. Her mentorship has been indispensable throughout the completion of this thesis.

Thank you also to my thesis readers, Dr. Jonathan Fugelsang and Dr. Colin MacLeod for their invaluable insights and feedback on my thesis. I greatly appreciate their time, expertise, and engaging conversations.

I am also incredibly thankful for all the friends I have made in my program. Thank you for forcing me to take breaks to bake and watch cringe-worthy shows. Thank you also to all of my research assistants for their hard work and dedication to my various projects.

I would now like to thank my grandparents - Nga La, Lam Pham, Quyen Lam, and Thanh Tran. Thank you for leaving everything you ever knew and had behind, and coming to a strange new country with the hopes of providing a better life for your families. Special thanks also go to my Mom and Dad who have called me every single day since I moved 2,654 km away from them. All my successes in life will always belong to all of you.

I would also like to thank Auntie, Uncle, Elize, Richard, Brianna, Justin, and Chris for their unconditional love and support.

Finally, none of this would be possible without the love and support of Alex, Missy, Mocha, and Luna.

Dedication

For Missy, Mocha, and Luna.

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Chapter 1: General Introduction

Memory involves acquiring, encoding, storing, retaining, and retrieving information. The act of encoding is distinct from other memory processes as it specifically involves the input of information or experiences into memory. Kandel, Dundai, and Mayford (2014) demonstrated that encoding is sustained by long-term potentiation enabled by synaptic plasticity of hippocampal neurons. While encoding can be automatic or initiated without effortful control, as in the case of reading, it can also require attention or activation of capacity-limited resources (Schneider & Shiffrin, 1977), as when a novice learns to read for the first time. Researchers have long been interested in documenting the effectiveness of various forms of effortful encoding as well as whether and how certain techniques can influence later recall of to-be-remembered information.

Numerous studies have demonstrated enhancements to episodic memory from techniques such as deep level of processing (Craik & Lockhart, 1972), generation (Slamecka & Graf, 1978), enactment (Cohen, 1981), and production (MacLeod, Gopie, Hourihan, Neary & Ozubko, 2010), to name a few. The aforementioned effortful encoding techniques all reliably increase the information that individuals later recall in comparison with more passive methods like reading (Cohen, 1981; MacLeod et al., 2010; Slamecka & Graf, 1978). Active encoding techniques, such as enactment and production, exemplify how the mechanisms underlying memory can be strengthened by deeper semantic elaboration (Craik & Lockhart, 1972), semantic integration (McElroy, 1987), distinctiveness (Conway & Gathercole, 1987; MacLeod et al., 2010), multimodal processing (Engelkamp & Zimmer, 1984, 1985; Zimmer & Engelkamp, 1985a, b), and selective attention (Jurica & Shimamura, 1999; Tyler, Hertel, McCallum, & Ellis, 1979). These studies show that memory can be advantageously influenced by various factors not present when passively viewing or reading an item.

In this thesis, we sought to identify whether there are limitations to the effectiveness of drawing as an encoding technique a process, which has been shown to enhance memory for word lists and academic terms (Wammes, Meade, & Fernandes, 2016; Wammes, Meade, & Fernandes, 2017). We examined whether the drawing benefit generalizes or ‘scales-up’ to other types of complex stimuli. We also aimed to determine whether the boost to memory was unique, or interacted with another stimulus factor known to enhance retention - emotion.

Sketchnoting, an active visual note-taking technique that emphasizes integrating drawings as an alternative means of taking notes, has increased in popularity within classroom and boardroom settings throughout the past decade (Dimeo, 2016). The rising popularity of visual note-taking has been due largely to its accessibility and to anecdotal testimonies regarding its benefits. Specifically, there have been reports of enhanced retention of content that was drawn at encoding in comparison to when written or typed note-taking were the encoding techniques (Dimeo, 2016). The perceived benefits of visual note-taking are not surprising when considering previous studies which have identified a benefit of including diagrams to explain more complex educational materials as they promote the generation of elaborative self-explanations (Ainsworth & Loizou, 2003).

1.1 Theoretical Rationale

An early precursor alluding to a potential memorial benefit of drawing is provided by the picture superiority effect (PSE). This is the well-established finding that pictorial information is better recalled in comparison to verbal text (Paivio, 1971). Essentially, viewing a picture results in better later recall than simply writing a word out (Paivio & Csapo, 1973). Dual coding is thought to be the underlying mechanism accounting for this effect. Paivio (1971) theorized that pictures can be processed visually, in terms of the image, as well as verbally, in terms of the verbal label for the items. The additive contributions of verbal and visual codes thus confer a memorial benefit for pictures over words that are only represented verbally. The PSE exemplifies how the addition of another representation modality can enhance later recall. Similar to the presentation of pictures at encoding, a later study from Peynircioglu (1989) also demonstrated that the generation of drawings during encoding can enhance recall for pictures of objects, scenes, and nonsense figures. While this particular study aimed to examine the generality of the generation effect to nonverbal materials, demonstrated that drawing should also be examined as a potential encoding tool that would be particularly accessible in a variety of settings.

Classic research (Paivio & Csapo, 1973) and more recent work (Wammes, Meade, & Fernandes, 2016) have examined just that, demonstrating that creating one's own image by drawing during encoding can confer a benefit to memory beyond that gained from writing, viewing (PSE), imagining, or elaborating upon a stimulus (Meade, Wammes, Fernandes, 2018). The use of drawing as an encoding strategy has been shown to enhance memory in younger adults (Meade, Wammes, & Fernandes, 2019; Wammes et al., 2016; Wammes, Meade, & Fernandes, 2017; Wammes, Meade, & Fernandes, 2018; Wammes, Roberts, & Fernandes, 2018; Wammes, Jonker, & Fernandes, 2019), and cognitively healthy older adults as well (Meade et al., 2018). For example, when younger and older adults draw a picture of the word 'table', this results in better recall for the word than if they were to repeatedly write it out. The ‘drawing effect’ is speculated to stem from the integration of motoric, elaborated semantic, and pictorial processing when one draws a to-be-remembered item during encoding (Wammes et al., 2016; see also Fernandes, Wammes, & Meade, 2018, for review). fMRI studies have also demonstrated that drawing, as a complex visuomotor activity, evokes neural activity in occipital regions (V1, V2, and lateral occipital cortex), parietal regions, pre-central gyrus, and motor regions (Fan et al., 2020; Vinci-Booher, Cheng, & James, 2019). Drawing has also been associated with broader activation of the cerebellum, somatosensory regions, frontal regions, and the dorsal visual stream (Fan et al., 2020; Griffiths & Bingman, 2020; Vinci-Booher et al., 2019). All together, these findings bolster previous anecdotal accounts of the benefits of using drawing as an encoding technique to retain information in classroom and boardroom settings.

While these previous publications focused mostly on memory for neutral word lists, researchers have also examined whether drawing as a mnemonic tool would generalize to lengthier texts such as the definition of academic terms (Wammes et al., 2017). The authors argued that as certain components that contribute to the observed memorial benefit of drawing, such as PSE, appear to ‘scale up’, then so too should drawing (Wammes et al., 2017)**.** The authors, therefore, hypothesized that the drawing effect previously observed for word memory would generalize, or ‘scale up’ to longer texts in the form of terms and definitions. In Experiment 3 of that study, participants were randomly instructed to ‘draw’ or ‘paraphrase’, rather than ‘write’. For the paraphrase encoding condition, participants were instructed to rewrite the definition in their own words (Wammes et al., 2017). The findings from this study demonstrated that later memory for terms and definitions was enhanced when they were drawn rather than written at encoding. Importantly, this experiment also showed that drawing and paraphrasing produced comparable recall of to-be-remembered terms and their definitions. This finding suggests that drawing and paraphrasing may share some features responsible for the enhancement that each confers to memory performance. Evidently, the mechanisms and processes underlying these memorial advantages require further investigation.

Examining whether drawing at encoding improves later recall of emotional and more complex stimuli should reveal more about its generalizability and, potentially, about the underlying mechanism responsible for the benefit. In previous work, it has been proposed that drawing facilitates memory by integrating various retrieval cues (elaborative, motor, and pictorial information) into one cohesive memory record. However, the findings from the Wammes et al. (2017) study offer an alternative explanation: Drawing and paraphrasing facilitate later recall because both encoding trial types require the participant to transform the stimuli, and likely engage with the text at a deeper level of processing. Wammes et al. (2017) showed that drawing and paraphrasing both improve recall of terms and definitions moreso than writing or copying out the definition. It would then logically follow that memory for a single sentence should also benefit from drawing as an encoding strategy. The definitions used by Wammes et al. (2017) consisted of coherent idea unit facts that could be semantically clustered across the sentences, to benefit retention. For example, participants could be presented with the term aridisols which was defined as “The soils in deserts that tend to be rocky or sandy and have very little organic matter (from dead plants)”. It is, therefore, possible that the observed benefit of drawing for memory for academic terms may be overestimated; memory for single sentences might not benefit to the same degree. In this thesis, we examined whether the memorial benefits conferred from drawing extend to memory for single sentences.

1.2 Emotional Enhancement of Memory (EEM)

The question of how variables such as emotion influence memory has been of interest since at least Pavlov's fear conditioning experiments. Decades of research have demonstrated that emotional valence affects episodic memory (Cahill, Babinsky, Markowitsch, & McGaugh, 1995; Cahill, & McGaugh, 1995; Finkenauer et al., 1998; Hamann, 2001; Kensinger, 2004; McGaugh et al., 1995; Rappaport, 1942; Rime, Mesquita, Philippot, & Boca, 1991; Rubin & Friendly, 1986; Reber, Perrig, Flammer, & Walter, 1994) and autobiographical memory (Berntsen & Rubin, 2002; Buchanan, 2007). Emotional memories can be positive or negative in valence, as well as low or high in arousal (calming or soothing to exciting or agitating; Kensinger, 2004); they are often better remembered, more detailed, and better preserved following delays ranging from minutes to years in comparison to neutral memories (Levine & Edelstein, 2009). Leigland, Schulz, and Janowsky (2004) labeled the phenomenon whereby emotional information is better recalled in comparison to their neutral counterparts as the emotional enhancement of memory (EEM). EEM can be observed across the lifespan and has been demonstrated in children and young adults (Kensinger, Piguet, Krendl, & Corkin, 2005; Hamann, 2001; Kreitler & Kreitler, 1968) and older adults (for review, see Reed, Chan, & Mikels, 2014; Murphy & Isaacowitz, 2008). It has been established that there is a negativity effect in children and younger adults in memory for words, sentences, and for source memory (Baumeister, Bratslavsky, Finkenauer, & Vohs, 2001; David, Green, Martin, & Suls, 1997; Kreitler & Kreitler, 1968; Rozin & Royzman, 2001; Thomas & Diener, 1990). Further, young adults will spend more time examining negative events in photographs (Fiske, 1980), suggesting differences in attentional capture by valence.

Unsurprisingly, the underlying mechanism driving EEM has been extensively examined over the past decade. Animal, human, and lesion studies have all implicated the amygdala, prefrontal regions, and thalamic connections in the formation of emotional memories (Bechara et al., 1995; Kapp, Frysinger, Gallagher, & Haselton, 1979; Kensinger 2004; LeDoux, 1994). More recent neuroimaging studies have specified that the interaction of the amygdala and hippocampal structures is particularly necessary for successful encoding of emotionally arousing information (Canli, Zhao, Brewer, Gabrieli, & Cahill, 2000; Dolcos, LaBar, & Cabeza, 2004; Hamann, Ely, Grafton, & Kilts, 1999; Kensinger & Corkin, 2004). More specifically, EEM has been suggested to enhance later recall through amygdala activation, which subsequently hones an individual's attention to emotionally salient details (Charles, Mather, & Carstensen, 2003; Kensinger & Corkin, 2003; Kleinsmith & Kaplan, 1964; Sommer, Gläscher, Moritz, & Büchel, 2008). In addition, the release of norepinephrine (NE) during emotional arousal is believed to affect the consolidation of memories by modulating synaptic plasticity of pathways to the lateral nucleus of the amygdala and the medial regions of the thalamus (Han, Yui, Cole, Hsiang, Neve, & Josselyn, 2008; McEchron, Green, Winters, Nolen, Schneiderman, & McCabe, 1996; Tully & Bolshakov, 2010). While the underlying neural structures contributing to memory for emotional materials have been relatively established, the process by which emotion enhances later memory is somewhat contested.

First, because participants are faster and more accurate at detecting emotional stimuli.it has been argued that these stimuli capture attention more readily than neutral stimuli. Researchers have demonstrated that emotional arousal also increases dwell time, and maintains attention on an emotional stimulus (Fox, Russo, Bowles, & Dutton, 2007). Another explanation is known as the prioritized processing hypothesis whereby emotional items are more likely to be processed when attention is limited, suggesting preferential processing of emotional information (Kensinger, 2004). The post-stimulus elaboration hypothesis is another theory, whereby more effortful elaboration is generated by emotionally arousing experiences in comparison to neutral ones (Christianson, 1992). However, Hulse, Allan, Memon, and Read (2007) still demonstrated an emotional enhancement of memory when a filler task was used to prevent elaborative rehearsal suggesting that the EEM cannot be solely explained by elaborative rehearsal. Notably, Christianson (1992) concluded that a combined attentional, perceptual, and elaborative processing advantage is triggered by an emotionally arousing experience and results in better recall for emotional memories, suggesting that these aforementioned explanations are not mutually exclusive.

These various explanations have been supported by findings of selective attention for emotional visual events whereby memory for central details is enhanced at the expense of peripheral details. An example of this is the weapon focus effect in which the presence of a weapon hones the individual’s attention to the weapon at the expense of peripheral details of the crime (Cutler, Penrod, & Martens, 1987a, 1987b). However, it should also be noted that the narrowing of memory for emotional events is not always replicated (Laney, Heuer, & Reisberg, 2003; Laney, Campbell, Heuer, & Reisberg, 2004).

Finally, it has also been argued that EEM results because emotional reactions trigger contextual binding mechanisms, whereby emotional information is linked to relevant contextual features (MacKay & Ahmetzanov, 2005). This explanation can be demonstrated using the phenomenon of flashbulb memories. Flashbulb memories have also been readily researched (Bohannon, 1988; Bohannon & Symons, 1992; Brown & Kulik, 1977; Davidson & Glisky, 2002; Neisser & Harsch, 1992; McCloskey, Wible, & Cohen, 1988; Neisser, 1996; Pezdek, 2003; Schmolck, Buffalo, & Squire, 2000; Winningham, Hyman, & Dinnel, 2000; Weaver & Krug, 2002). These studies have demonstrated that contextual details (what they were doing and where they were) associated with emotionally charged events were recalled with high accuracy. Further, recall accuracy correlates with the initial intensity of emotionality (Bohannon, 1988; Conway et al., 1994; Pillemer, 1984; Schmolck, Buffalo, & Squire, 2000), and confidence in these memories is also very high. In summary, many of the explanations for the emotional enhancement of memory propose that superior recall occurs due to an enhanced ability to hone attention, facilitating a deeper level of processing.

The aforementioned mechanisms proposed to underlie the memorial benefit conferred from drawing at encoding, seem to be distinct from the mechanisms that have been proposed to drive the emotional enhancement of memories. In contrast to the mechanisms underlying emotionality, drawing has been associated with broader activation of brain regions during encoding (cerebellum, somatosensory regions, frontal regions, primary visual areas, pre-central gyrus, dorsal visual stream; Fan et al., 2020, Griffiths & Bingman, 2020; Vinci-

Booher et al., 2019). Studies from Cacciamani and Likova, (2016; 2017) have also shown that drawing can promote neural reorganization.

Since the brain mechanisms underlying drawing and emotion appear to be distinct, the combination of drawing and emotionality should not only reproduce their unique respective effects, but also a potential combined effect. That is, there should be a larger boost to memory when both are combined. Previous studies have demonstrated that combining multiple factors known to boost memory can produce additive benefits on memory performance (e.g. production and picture superiority, Fawcett, Quinlan, & Taylor, 2012; generation and production, MacLeod, Gopie, Hourihan, Neary, & Ozbuko, 2010). Given this, we sought to examine whether there were additional memorial benefits of drawing when the material was emotional rather than neutral. Specifically, one goal of the current thesis was to determine whether greater accuracy in recall results from combining the drawing effect and EEM. To this end, we presented positive, negative, and neutral words (in Experiment 1), or sentences (neutral in Experiment 2 and of varying valence in 3), one at a time during an encoding phase, and participants were asked either to write out or to draw a picture of the referent of the item, with encoding type intermixed, in random order.

1.3 Complexity of Stimuli

So far, a benefit of drawing the referent of words and academic terms at encoding has been demonstrated in previous studies. The generalization of this benefit to academic terms showed that drawing as an encoding technique could 'scale-up' and offer benefits for the memory of a lengthier and more complex stimulus (Wammes et al., 2017). As sentences are lexical units made up of grammatically linked words that convey an overall meaning when combined, we also sought to examine whether the facilitation (better later recall) conferred by drawing could also be observed to memory for sentences. Although sentences are made up of individual words, they differ from word lists in terms of the degree of semantic elaboration, as one can elaborate on the meaningfulness of the association between the words in a sentence (Brennan & Pylkkänen, 2012; d'Arcais, 1974). Unsurprisingly, it has been demonstrated that participants engage in different encoding strategies when studying words presented within a meaningful context, such as a sentence, or when creating stories (Bartsch & Oberauer, 2021; Gershberg & Shimamura, 1995; Larkin & Burns, 1977; Matzen & Benjamin, 2019; Miller, 1956a; Miller & Isard, 1964). Bartsch and Oberauer (2001) have specifically noted that on a delayed serial recall test, a larger memory boost was associated with connecting nouns into a meaningful sentence to assist elaboration in comparison with providing longer interleaved free time intervals to attend to and process individual words. Further, when studying words presented within a sentence, participants tend to encode the overall meaning or the gist of the sentence rather than each word (Bock & Brewer, 1974; Matzen & Benjamin, 2019). Researchers have also demonstrated that when individuals try to memorize sentences, they do so by building an internal representation of the action or situation described by the text (Barclay, 1973; Bransford & Franks, 1972). As such, memory for sentences might not benefit further from a drawing versus writing manipulation. That is, memory for sentences may already benefit from greater semantic elaboration in comparison to words, and drawing might offer no further enhancement.

Paraphrasing in the Wammes et al. (2017) study was shown to facilitate a comparable level of memory for academic terms and their definitions to that shown for drawing. The authors suggested that paraphrasing invoked significant semantic elaboration and transformation of the material into a personally relevant representation. It is this factor that was proposed to account for the finding that paraphrasing and drawing led to similar levels of memory. In the current thesis, we wanted first to determine whether the emotionality of the stimuli can be combined with drawing to further boost memory and this thesis also aimed to determine whether this effect would replicate when the stimuli were sentences. If the underlying mechanism for the EEM effect is the same as that for drawing, no additional enhancement to memory is expected. If, however, the influences of emotionality of the stimuli and the encoding technique (drawing versus writing) arose from unique mechanisms, we would expect a greater combined effect from drawing emotional versus neutral material.

Mehler (1963) has previously concluded that subjects do not recall sentences verbatim and a study conducted by Potter and Lombardi (1990) also showed that readers seem to reconstruct each sentence based on their memory for its general meaning at recall. Further, past work has also demonstrated a memorial benefit when linguistic units are organized in a way that is similar to phrases or sentences (i.e. words combined into a sentence; Marks & Miller, 1964; Miller & Selfridge, 1950). This finding is often referred to as a sentence superiority effect (SSE) and the memorial benefit from this effect is theorized to result from chunking words into a larger meaning (Marks & Miller, 1964). Given this, whether memory for sentences will receive a boost from drawing versus writing at encoding remains relatively unclear, and as such, we sought to examine whether the drawing effect generalizes to such materials.

1.4 Multimodal Encoding Contributions to Memory

Several studies have demonstrated that engaging in multimodal encoding during study improves later recall (Engelkamp & Zimmer, 1989; Kinjo & Snodgrass, 2000; Zormpa, Brehm, Hoedemaker, & Meyer, 2019). The idea that multimodal processing facilitates memorial benefits is in line with the component process model of memory which states that numerous distinct brain regions are recruited in various combinations for different memory tasks (Moscovitch, 1992; Witherspoon & Moscovitch, 1989). More recently, the neural correlates of successful multimodal processing have been investigated. The intra-parietal sulcus (IPS; Uncapher, Otten, & Rugg, 2006) and the angular gyrus (AnG) are areas activated during multimodal processing of contextual and episodic features (Yazar, Bergström, & Simons, 2012).

Researchers have proposed that the advantage for information drawn at encoding can be attributed to multimodal encoding (Wammes et al., 2018; Wammes et al., 2019). Drawing is a particularly efficacious and active encoding strategy because it engages multiple cognitive processes or sensory components producing a subsequent memory boost (Wammes et al., 2019). Essentially, drawing is a multifaceted process that requires inputs from various systems and therefore, integrates several different interactive sources of encoded information to build a multimodal memory trace (Wammes et al., 2019). Multiple experiments have demonstrated that the use of drawing can provide greater memorial benefit than unimodal encoding techniques, including deep level of processing and visualization (Wammes et al., 2016). This thesis aims to examine whether the drawing effect and EEM utilize distinct underlying mechanisms to enhance subsequent memory performance and whether a combination of these techniques could potentially lead to a greater memorial benefit. Drawing may lead to the creation of an integrated multimodal representation, while emotional items would also benefit from increased attention during encoding, as well as the activation of the amygdala, a region not activated by drawing. Therefore, we predicted a greater memorial benefit when drawing and emotionality are combined.

As emotional words are better and more vividly recalled than non-emotional ones (Kensinger, 2009; Levine & Edelstein, 2009), we also predicted that the magnitude of the drawing effect would be significantly higher for emotional stimuli, than for neutral valence ones. Further, as the memorial benefit of EEM and the drawing effect are both theorized to result from activation within distinct brain regions (Charles, Mather, & Carstensen, 2003; Fan et al., 2020; Kensinger & Corkin, 2003; Kleinsmith & Kaplan, 1964; Sommer et al., 2008; Vinci-Booher et al., 2019), a greater memory boost should be observed for emotional items drawn regardless of the complexity of the stimuli.

1.5 Overview of Studies

In Experiment 1, participants were randomly prompted to write or draw positive, negative, and neutral words. After a 20-second filled delay, participants were asked to freely recall as many of the to-be-remembered items as possible. The same paradigm was used for each of the following experiments, but words of varying valence were exchanged for neutral sentences (Experiment 2), and sentences of varying valence (Experiment 3). The purpose of the current thesis was to examine whether the drawing effect and EEM confer distinct enhancements to memory.

Chapter 2: Replication and Extension to the Drawing Effect: The Influence of Emotionality

In this first experiment, we aimed to replicate the drawing effect (Meade et al., 2019; Wammes et al., 2016; Wammes et al., 2017; Wammes et al., 2018; Wammes et al., 2018; Wammes et al., 2019), and also the EEM effect (Cahill et al., 1995; Cahill, & McGaugh, 1995; Finkenauer et al., 1998; Hamann, 2001; Kensinger, 2004; Leigland et al., 2004; Levine & Edelstein, 2000; McGaugh et al., 1995; Rappaport, 1942; Reber et al., 1994; Rime et al., 1991; Rubin & Friendly, 1986; Sommer et al., 2008).

The majority of previous studies have primarily examined memory for neutral words (Wammes et al., 2016) and academic terms (Meade et al., 2019; Wammes et al., 2017; Wammes et al., 2018; Wammes et al., 2018; Wammes et al., 2019). Experiment 1 examined whether drawing as an encoding technique also conferred a benefit to memory for emotional words. We predicted main effects of both drawing (drawing effect) and word valence (EEM effect). As well, we predicted that the drawing and EEM effects would combine such that there would be a greater number of emotional words (positive and negative) recalled overall in comparison to neutral ones; however, there would be an added memory boost for emotional words drawn at encoding in comparison to those written. This prediction is based on the literature which suggests that these effects arise due to the engagement of distinct brain regions. Moreover, we predicted that negative words drawn at encoding would be better remembered than positive words drawn at encoding, in line with the majority of previous literature (Baumeister et al., 2001; David et al., 1997; Kreitler & Kreitler, 1968; Rozin & Royzman, 2001; Thomas & Diener, 1990).

2.1 Method

Participants

A power analysis using G*Power 3 (Faul, Erdfelder, Lang, & Buchner, 2007) was conducted assuming a large effect size (*d* = 1.26) as found in Meade, Wammes, and Fernandes (2016), and an alpha of .05. Results revealed a sample size of 8 would be required to achieve a power of .80. A power analysis was also conducted for a smaller effect size (*d* = 0.87) of EEM found in Kumfor, Irish, Hodges, and Pigue (2014), and an alpha of .05. Results suggested a sample size of 13 would be required to achieve a power of .80. A total of 50 undergraduate students (40 female; 9 male; 1 other), with a mean age of 21.40 (SD = 4.88) enrolled in a psychology course at the University of Waterloo were recruited for this study and received course credit as remuneration for 30 minutes of their time. The Mill Hill English comprehension assessment was used to assess English proficiency (Raven, 2003). We excluded data from those who scored below 30% on the Mill Hill Vocabulary Scale (MHVS), indicating poor English language competency (Raven, 1958). Participants were excluded based on linguistic proficiency to allow us to reliably interpret variability in memory performance as a function of trial type (experimental manipulation), and not as a result of language difficulties.

Materials

Word List. Words were selected as stimuli using the English Lexicon Project (ELP) which includes descriptive characteristics of the words used in the study, including word length, type of word, number of syllables, and valence (Balota et al., 2007). From the ELP, 14 words of each valence were selected for a total of 42 words. Words included in our stimulus set were all concrete nouns with a maximum of two syllables and six letters. We also controlled for word frequency (Average: 25.23, *SD* = 2.83) and the emotional arousal of words ranged from a rating of 3 to 5 on an 8 point scale (Warriner et al., 2013). On a 9-point scale, negative valence words selected had a rating of less than three (*M* = 2.48, *SD* = 0.32), neutral words were given a rating of 5 (*M* = 5.00, *SD* = 0.00), and positive words received a rating greater than 7 (*M* = 7.43, *SD* = 0.25; Warriner et al., 2013).

Procedure

The researcher scheduled individual video-conference meetings with each participant using Microsoft Teams. During these meetings, the researcher and participant would share their video and audio through MS Teams. The session was also recorded to confirm the fidelity of the drawing and writing manipulation and participants also had the option of sending in their writings and drawings for additional compensation. All experiments used an incidental memory paradigm, and participants were kept unaware that their memory would be tested until the retrieval phase. Participants were told that the researchers were interested in examining the effect drawing had on the stimuli and they were not informed about a later memory test.

Participants were sent an executable file containing the experiment implemented using E-Prime Go 1.0 (Psychology Software Tools, Pittsburgh, PA) software, to present items for the encoding phase. Instructions in English were presented to participants in the E-Prime Go file and read aloud by the researcher. Emotional words were sequentially presented and prompts to either ‘WRITE’ or ‘DRAW’ were intermixed, in random order. Depending on the prompt, participants were told to either draw a picture illustrating the word on the screen and to continue adding detail for the allotted time, or to write out the word multiple times on a piece of paper. Participants were also instructed to flip to a new page prior to starting the next prompted trial. The prompts to either ‘WRITE’ or ‘DRAW’ were presented at the top of the screen in purple, in Verdana 70-point font size. The stimuli were presented in the middle of the screen in black, in Arial 90-point size font. The prompts and to-be-remembered stimuli were presented simultaneously for 3500 ms. A blank screen would then appear for 15,000 ms and this is when participants were instructed to begin writing or drawing. A medium tone would play for 500 ms to indicate that the participants’ allotted encoding time was up. After participants encoded all 42 words, the executable file would automatically exit. Participants were then told to put away their encoding papers (containing their written or drawn stimuli), and asked to count aloud backwards by threes, starting at 99. This was done to prevent participants from rehearsing the words. Participants were then given 5 minutes to recall as many words as possible.

Upon completion of the Retrieval phase, participants completed Set A of the MHVS. This scale was administered and scored through Qualtrics. Following this, participants were thanked for their time, awarded partial course credit, and asked to send the experimenter their drawings and writings for an additional $10 e-gift card as remuneration. Participants were asked to either scan their drawings and writings into pdf files and email these to the experimenter, or to mail in their sheets of paper with drawings and writings using the postal service. A total of 16 participants submitted their files electronically and 2 by mail (see Figure 1 for samples).

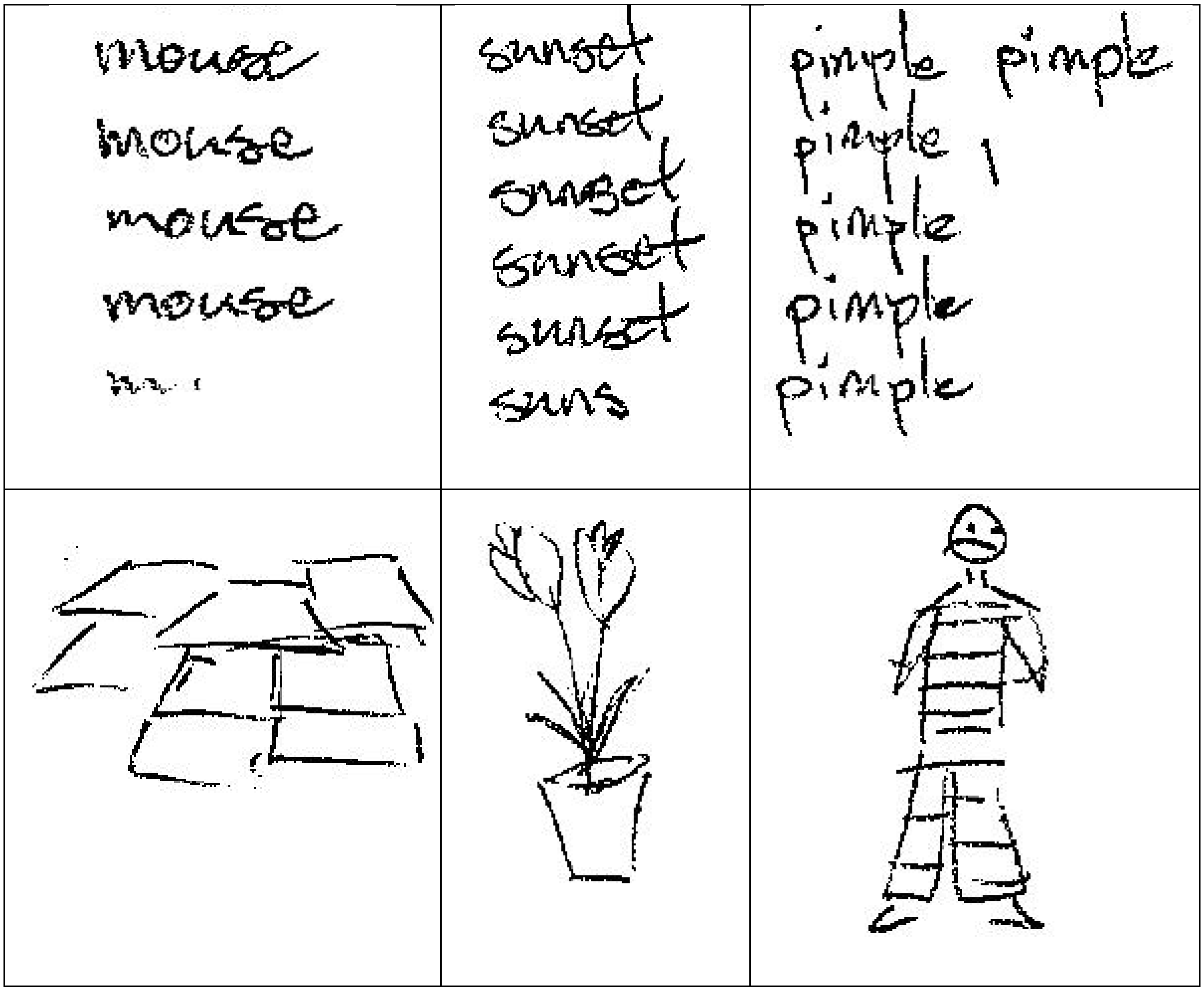

Figure 1. Examples of participant's writings and drawings in Experiment 1.

2.2 Results

Proportion of words recalled was computed, separately by valence, and encoding type (written or drawn), as the number recalled was divided by 7 (there were 14 words per valence, and half were presented with a write prompt and half with a draw prompt). Data were analyzed in a 2 Encoding Type (Drawing and Writing) x 3 Valence Type (Positive, Neutral, and Negative) repeated-measures ANOVA (see Table 1). Simple effect contrasts were conducted to better understand the main effect of valence. Follow-up pairwise comparisons with Bonferroni correction were also conducted to interpret the interaction. Due to Mauchly's test indicating that the assumption of sphericity had been violated, $\chi^2(2) = 11.12$, $p = .004$, a Greenhouse-Geisser correction was applied when determining significance.

Table 1

Means and Standard Deviations of the Proportion of Words Recalled in Experiment 1

	Neutral		Positive		Negative	
	Write	*Draw*	*Write*	*Draw*	*Write*	*Draw*
Mean	0.13	0.19	0.14	0.34	0.14	0.50
SD	0.13	0.15	0.14	0.21	0.17	0.23

As expected, the analysis revealed a main effect of encoding type, $F(1, 49) = 65.80$, $MSE = 0.05$, $p < .001$, $\eta_p^2 = 0.57$, such that drawn words were better remembered than written words. There was also a main effect of valence, $F(2, 98) = 27.33$, $MSE = 0.02$, $p < .001$, $\eta_p^2 = 0.36$, such that negative words were recalled the most, and neutral the least.

Simple effects contrasts showed that the proportion of negative words recalled was significantly higher than that for both positive ($F(1, 49) = 12.06$, $MSE = 0.06$, $p = .001$, $\eta_p^2 = 0.20$) and neutral words ($F(1, 49) = 69.67$, $MSE = 0.04$, $p < .001$, $\eta_p^2 = 0.59$). Further, a significantly greater proportion of positive words were recalled compared to neutral words ($F(1, 49) = 12.63$, $MSE = 0.05$, $p = .001$, $\eta_p^2 = 0.21$).

These main effects were qualified by a significant interaction, $F(2, 98) = 22.72$, $MSE = 0.03$, $p < .001$, $\eta_p^2 = 0.32$. To better understand the interaction, mean differences were calculated using pairwise comparisons with Bonferroni correction. For words drawn at encoding, the proportion of negative words recalled was significantly higher in comparison to both positive (*M* = 0.17, *SE* = 0.04, $p < .001$) and neutral words drawn at encoding (*M* = 0.32, *SE* = 0.03, $p < .001$). A significantly greater proportion of positive words was also recalled in comparison to neutral words drawn at encoding. (*M* = 0.15, *SE* = 0.04, $p < .001$). For words written at encoding, there was no significant difference between the negative, positive, and neutral words (ps > .05).

2.3 Discussion

In this study, we compared the relative benefit, on memory for a set of words, of drawing versus writing as an encoding strategy. We also compared the magnitude of the benefit when words were neutral, negative, or positive in valence. As hypothesized, and replicating past work (Meade et al., 2018; Meade et al., 2019; Wammes et al., 2016; Wammes et al., 2017; Wammes et al., 2018; Wammes et al., 2018; Wammes et al., 2019), the use of drawing as an encoding technique resulted in greater subsequent memory, in comparison to the use of writing during encoding. We also showed that this effect occurred regardless of the valence of the to-be-remembered words. This further suggests that drawing uniquely confers benefits to subsequent recall. We also found that, overall, negative words were significantly better remembered than positive and neutral words, replicating previous EEM studies (Cahill et al., 1995; Cahill, & McGaugh, 1995; Finkenauer et al., 1998; Kensinger, 2004; Leigland., 2004; Levine & Edelstein, 2000; McGaugh et al., 1995; Rappaport, 1942; Reber et al., 1994; Rubin & Friendly, 1986; Rime et al., 1991; Sommer et al., 2008).

Our prediction, that words negative in valence that were drawn at encoding would have the greatest memorial benefit, was supported. In addition, positive words that were drawn also resulted in better recall than neutral words drawn. These two findings taken together, suggest that combining valence and encoding type resulted in a larger memorial benefit. However, we also showed that while EEM boosted the drawing benefit, the proportion of words recalled did not differ across the three levels of emotions in the ‘write’ condition. The absence of an EEM benefit within the ‘write’ condition could be driving the observed interaction and is a surprising finding given previous literature.

This contradictory finding may have occurred due to the use of a within-subjects design. As the design of the study requires that participants recall both words that were drawn and written, and the average recall for words was generally high (M = 10.04). It is thus possible that participants were already at capacity for the number of words they could freely recall and emotional words that were drawn not only benefited from more thorough encoding, but also prioritized attention and processing. As a consequence, participants recalled very few words that were written (M = 2.92), potentially masking an EEM effect within the written condition. As previous studies have also demonstrated that negative words are better remembered than neutral ones even when simply viewed (Kensinger & Corkin, 2003), it seems unlikely that writing should impact an EEM effect.

Nonetheless, this first experiment demonstrated that drawing and emotionality can be combined to further enhance word memory. The memorial benefit from drawing at encoding extends to emotional stimuli. This experiment demonstrates that drawing is a practical and effective tool that enhances subsequent recall for a variety of stimuli, which now includes negative and positive words, as well as neutral words.

Chapter 3: The Effectiveness of Encoding Techniques on Memory for Sentences

In Experiment 1, we examined the generalizability of drawing as an encoding technique by assessing whether the memorial benefit from drawing during encoding extended to emotional stimuli. To further assess the extent and limitation of drawing as an encoding tool, we next sought to determine whether drawing also conferred a benefit to memory for commonplace sentences in Experiment 2. We then combined the manipulations of emotionality and complexity to investigate whether the benefit from drawing words at encoding generalized to sentences of varying valences in Experiment 3.

As previously described in chapter 1, many of the early studies examining the benefits of drawing as an encoding tool focused largely on memory for neutral words. It was later demonstrated that drawing was an effective method to enhance the learning of conceptual material such as definitions of academic terms (Wammes et al., 2017). In that study, participants were asked to either copy a definition of, for example, the term *photosynthesis* or to draw an image depicting the process. This study demonstrated that drawing was an effective tool for remembering facts and demonstrated possible scholastic applications for drawing.

As previously mentioned, Experiment 3 of the Wammes et al. (2017) study also investigated whether writing out a paraphrased version of the definition would also confer a benefit to memory. The idea there was to examine the utility of paraphrasing during encoding; like drawing, and in contrast with verbatim writing, paraphrasing requires self-generated elaboration, and transformation of the to-be-learned content into a more personalized representation. They found that drawing improves later memory for the definition of academic terms regardless of pre-existing familiarity and even when fictitious terms were used to eliminate familiarity. The authors also observed that drawing and paraphrasing resulted in similar levels of later recall. These findings suggest that drawing and paraphrasing are both effective encoding tools that could confer their benefit by engaging transformative and self-generated elaboration. Experiment 2 aimed to extend this finding by examining whether more commonplace sentences of varying valences would independently benefit from being drawn at encoding. Further, experiment 3 sought to examine whether drawing and EEM (Leigland et al., 2004) independently or interactively enhanced later recall for sentences of varying valence, as was demonstrated with words in Experiment 1.

Interestingly, previous studies have demonstrated that a memorial benefit from drawing leads to better memory accuracy in comparison to when the individual benefits of each of three components are added together: view (pictorial), trace (motoric), and imagine (elaborative) encoding conditions (Wammes et al., 2019). Findings from previous studies also suggest that the act of drawing in itself provides some additional benefit beyond the effective incorporation from distinct elaborative, motoric, and pictorial components and then subsequent transformation into a self-generated and self-referential drawing (Wammes et al., 2019). It is likely, then, that the use of drawing, which has been theorized to incorporate these various components, would also confer a memorial benefit for sentences of varying valences as well. As such, we predicted that the memorial benefits observed from drawing words of varying valences and the definition of academic terms would generalize to sentences in Experiment 2.

We also saw that sentences of varying valences as appropriate stimuli to use with respect to complexity as they are lexical units composed of words that, when combined, convey a single overall meaning similar to words and facts. As drawing already requires that participants think about the overall meaning of the to-be-remembered item, drawing would likely be an ideal encoding tool for neutral, positive, and negative sentences, too. Neurophysiological evidence has also suggested that although the anterior temporal lobe (aTL) is active during word processing and to a greater extent during sentence processing, there is also a broader network of regions activated during the latter (ventromedial prefrontal cortex, left inferior frontal gyrus, Broca's Area; Brennan & Pylkkänen, 2008; Rogalsky & Hickok, 2009; Brennan & Pylkkänen, 2010; Caramazza & Zurif, 1976; Stowe, Haverkort, & Zwarts, 2005; Zurif, 1995). Therefore, while there are similarities in how words and sentences are processed (aTL), encoding a sentence invokes a broader and more complex pathway of activation. As it was previously argued that EEM and drawing would have individual and additional combined benefits on later recall, the same logic should follow in the case of neutral, positive, and negative sentences.

It should be noted that there is a larger overlap between drawing and sentence processing in terms of areas of activation. As noted previously, sentences already benefit from linguistic organization and invoke semantic elaboration and generation effects during recall; therefore, this type of more complex stimulus might not benefit further from being drawn at encoding (Craik & Lockhart, 1972; Craik & Tulving, 1975; Hyde & Jenkins, 1973; Miller & Selfridge, 1950; Marks & Miller, 1964; Potter & Lombardi 1990; Schulman, 1970). As mentioned previously, the definitions used by Wammes et al. (2017) contained coherent idea units that could be semantically clustered to benefit retention. Therefore, it is possible that the observed memory boost associated with drawing academic terms was overestimated, and individual sentences might not benefit to the same degree.

Lastly, we also know from past work that the cognitive processes implicated in sentence and word processing differ: Sentence processing not only requires examination of sentence structure (syntactic parsing), but also the composition of complex meaning (semantic composition), and pragmatic inferences (Brennan & Pylkkänen, 2012), both of which require deeper levels of semantic elaboration. In addition, emotionally arousing experiences have been shown to trigger enhanced attentional, perceptual, and elaborative processing, ultimately benefitting memory. Thus, adding emotionality to sentences (in Experiment 3) may invoke even deeper levels of semantic elaboration during encoding. As such, memory for emotional sentences could benefit less from the use of drawing at encoding. Essentially, a drawing boost might not be as beneficial as emotional sentences already invoke such deep levels of processing.

3.1 Experiment 2

Now that we have established that drawing words of varying valences at encoding results in better recall (Experiment 1), the objective of Experiment 2 was to examine whether the memorial benefit for drawing neutral words at encoding extended to neutral sentences, a more complex stimulus. There are two potential outcomes for this experiment. As previous studies have demonstrated that sentences may already benefit from semantic elaboration, linguistic organization, as well as a sentence superiority effect (d'Arcais, 1974; Gershberg & Shimamura, 1995; Marks & Miller, 1964), we might predict that there would be no further improvement to memory. However, as drawing also consists of a pictorial component, this could allow for enhanced processing, and uniquely boost memory. As well, previous studies examining the effect of paraphrasing during encoding suggest that it is the transformation of to-be-remembered materials (from verbal to another personally-relevant format), that provides a boost to memory. Sentences, in this thesis, could however differ from academic terms taken from textbooks (as in Wammes et, al., 2017) in terms of familiarity. As noted by Wammes et al. (2017), if participants had previous experience writing or paraphrasing the textbook definition, this could have negated any advantage from the addition of a pictorial trace. As it is unlikely that participants are familiar with the sentences used in this current experiment, this experiment can more directly assess whether drawing confers a benefit to more complex stimuli.

3.2 Method

Participants

A total of 50 undergraduates (41 females, 8 males, and 1 other), with a mean age of 21.14 (*SD* = 4.88) enrolled in a psychology course at the University of Waterloo were recruited for this study and received course credit as remuneration for 30 minutes of their time. One participant scored below the 30% exclusion criteria for the MHVS and was excluded from the final analysis (Raven, 1958).

Materials

Sentence List. Eighteen sentences of neutral valences were selected from the Minho Affective Sentences (MAS) database. All sentences in the MAS database were rated on valence, arousal, and discrete emotions (anger, sadness, disgust, fear, and happiness). On 9-

point scales, the neutral sentences selected for use in this experiment had an average valence rating of 4.98 (*SD* = 0.78) and an average arousal rating of 4.10 (*SD* = 1.80).

Procedure

This experiment used the same procedure as in Experiment 1, except that neutral sentences were used as the target stimuli. A total of 11 participants submitted their samples of writing and drawing files electronically (see Figure 2 for samples).

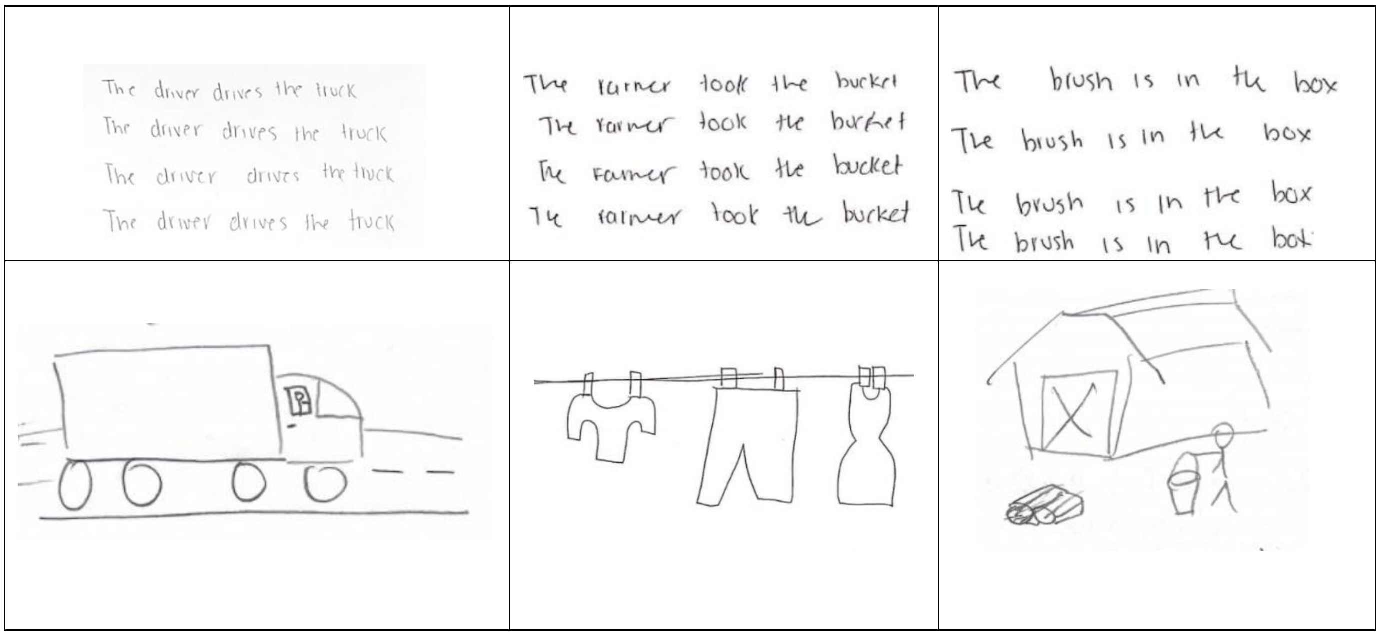

Figure 2. Examples of participants' writings and drawings in Experiment 2

3.3 Results

Participants' recall was coded for accuracy using a gist-based criterion. Participants were given a recall point if they remembered the general meaning conveyed by the sentence and if the ordering of the words (syntactic parsing) was mostly maintained. Proportion of sentences recalled was computed separately by encoding type (written or drawn), as the number recalled was divided by 9 (of the 18 sentences, half were presented with a write prompt and half with a draw prompt) (see Table 2).

Table 2

Means and Standard Deviations of the Proportion of Sentences Recalled in Experiment 2

	Write	Draw
Mean	0.22	0.63
SD	0.16	0.19

Data were analyzed using a paired-samples t-test. As predicted, there was a significant difference in recall $t(49) = 10.85$, $SE = 0.04$, $p < .001$, $d = 1.70$, such that sentences drawn at encoding were better remembered than those written. Forty-three of the fifty participants showed this pattern.

3.4 Discussion

Our results showed a significant difference between writing and drawing, indicating that the memorial benefit seen when drawing words (Wammes et al., 2016) and academic terms (Wammes et al., 2017) does extend to neutral sentences. While Wammes' 2017 study demonstrated that drawing is beneficial for learning definitions of terms, there was a degree of uncertainty in regard to whether sentences would benefit to the same degree, as the sentences likely already benefit from deeper levels of semantic elaboration invoked during typical sentence processing (Brennan & Pylkkänen, 2012; d'Arcais, 1974). The observation of a drawing benefit aligns with previous studies that have suggested that this memorial boost cannot be explained by elaborative encoding (deep level of processing, LoP) alone (Wammes, Meade, & Fernandes, 2016). As suggested by Wammes et al. (2016), drawing likely improves memory through the integration of semantic, visual, and motor aspects of a memory trace. Finally, the results from this study suggest that drawing does confer a memorial benefit to another complex and arguably more commonplace stimuli.

The results of Experiment 2 of this thesis are in line with Wammes and colleagues' (2017) study. In Experiment 1 of that work, participants were asked to write or draw academic terms at encoding. Recall scores showed a 25% to 58% improvement (depending on when their familiarity scale was given) in memory for terms that were drawn compared to written. This is conceptually in line with Experiment 2 of this thesis, in which drawn sentences were remembered 182% better. Differences in the percentages of improvement may be due to how sentences were coded during recall in comparison to the point system used to assess recall of terms. Regardless, Experiment 2 shows that the drawing benefit extends and may even be of greater magnitude when to-be-remembered information is a sentence.

3.5 Experiment 3

We have now demonstrated that drawing words of varying valences and neutral sentences results in better later recall in comparison to writing as an encoding technique. The objective of Experiment 3 was to combine the aims of Experiments 1 and 2 and examine whether drawing sentences of varying valences yields the same memorial benefit that has been demonstrated in the previous experiments. Essentially, our final goal was to manipulate the emotionality and the complexity of the stimuli to further examine the extent and limitation of the generalizability of drawing as an encoding tool. We expected a similar pattern of findings to that seen in Experiment 1. However, as previous findings have established that memory for sentences already benefits from semantic elaboration, linguistic organization, and a sentence superiority effect (d'Arcais, 1974; Gershberg & Shimamura, 1995; Marks & Miller, 1964), and emotional sentences are better remembered than neutral ones (for review, see Baumeister et al., 2001), it may be that emotionality provides a strong enough memory boost that any further enhancement from drawing at encoding is nullified.

In Experiment 3, neutral, positive, and negative sentences were used as targets. Experiment 1 indicated that drawing and EEM enhanced later recall individually and additively. Experiment 2 demonstrated that there is also a memorial benefit even when targets are sentences. The results of Experiments 1 support previous findings that suggest the engagement of distinct brain regions give rise to the memorial benefits from drawing and emotionality (Charles, Mather, & Carstensen, 2003; Kensinger & Corkin, 2003; Kleinsmith & Kaplan, 1964; Fan et al., 2020; Sommer et al., 2008; Vinci-Booher et al., 2019). As such, we predicted main effects of both Encoding and Valence type. Similarly to Experiment 1, we also predicted that the drawing and EEM effects would result in a joint effect such that emotional sentences would be better remembered compared to neutral ones, but there would be an added memory boost for emotional sentences drawn as opposed to written at encoding in comparison to written (Baumeister et al., 2001; David, Green, Martin, & Suls, 1997; Rozin & Royzman, 2001; Thomas & Diener, 1990).

3.6 Method

Participants

A total of 50 undergraduates (40 females, 7 males, and 3 preferred not to say), with a mean age of 21.21 (*SD* = 3.92) enrolled in a psychology course at the University of Waterloo were recruited for this study and received course credit as remuneration for 30 minutes of their time. A total of three participants scored below the 30% exclusion criteria for the MHVS (Raven, 1958); their data were excluded, and replaced with data from additional participants.

Materials

Sentence List. Twenty-four sentences of varying valences were selected from the Minho Affective Sentences (MAS) database. All sentences in the MAS database were rated on valence, and on arousal. On a 9-point scale, the average valence rating of the 8 neutral sentences was 5.06 (*SD* = 0.73), of the 8 positive sentences was 8.01 (*SD* = 1.19), and the 8 negative sentences was 1.75 (*SD* = 1.05), with a lower number indicating a more negative rating and a higher number a more positive rating. Again on a 9-point scale, the average arousal ratings of the 8 neutral sentences was 3.99 (*SD* = 2.23), of the 8 positive sentences was 4.51 (*SD* = 2.79), and the 8 negative sentences was 7.15 (*SD* = 1.91), with a lower number indicating a lower arousal rating and a higher number a greater arousal rating. For the negative sentences, 2 were selected from each of the following categories: anger, sadness, disgust, fear. For the positive sentences, all 8 were selected from the happiness category.

Procedure

This experiment used the same procedure as in Experiment 2, except sentences of varying valences were used as the target stimuli. A total of 17 participants submitted their writing and drawing files electronically (see Figure 3 for samples).

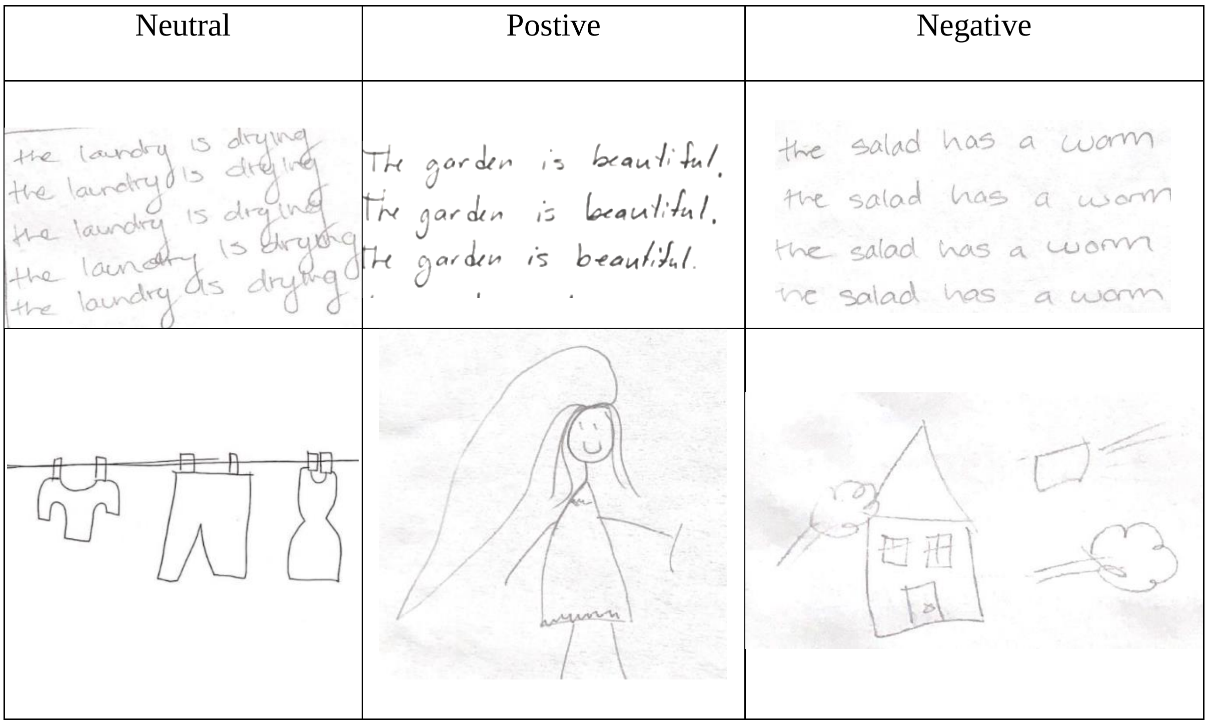

Figure 3. Examples of participants' writings and drawings in Experiment 3.

3.7 Results

Participants' recall was coded for accuracy using a gist-based criterion. Participants were given a recall point if they remembered the general meaning conveyed by the sentence and if the ordering of the words (syntactic parsing) was mostly maintained. Proportion of sentences recalled was computed, separately by valence, and encoding type (written or drawn), as the number recalled was divided by 4 (there were 8 sentences per valence, and half were presented with a write prompt and half with a draw prompt. (see Table 3).

Table 3

Means and Standard Deviations of the Proportion of Sentences Recalled in Experiment 3, by Valence

	Neutral		Positive		Negative	
	Write	*Draw*	*Write*	*Draw*	*Write*	*Draw*
Mean	0.11	0.47	0.19	0.48	.22	0.59
SD	0.18	0.29	0.22	0.30	.21	0.30

Data were analyzed in a 2 Encoding Type (Drawing and Writing) x 3 Valence Type (Neutral, Positive, and Negative) repeated-measures ANOVA. Mauchly's test was not significant indicating that the assumption of sphericity was not violated. As predicted, results revealed a significant main effect of Encoding type $F(1, 49) = 105.47$, $MSE = 0.08$, $p <.001$, $\eta_p^2 = 0.68$, with more sentences recalled that were drawn than written at encoding.

There was also a significant main effect of Valence $F(2, 98) = 7.89$, $MSE = 0.04$, $p = .001$, $\eta_p^2 = 0.14$. Simple effects contrasts showed that memory for positive and neutral sentences did not differ, $p > .05$. Memory was, however, better for negative compared to both positive sentences, $F(1, 49) = 6.24$, $MSE = 0.08$, $p < .05$, $\eta_p^2 = 0.11$ and neutral sentences, $F(1, 49) = 14.23$, $MSE = 0.09$, $p < .001$, $\eta_p^2 = 0.23$. Unlike in Experiment 1, there was no significant Encoding type X Valence interaction, $F\ (2, 98) = 0.93$, $MSE = 0.05$, $p = .40$, $\eta_p^2 =$

0.02.

3.8 Discussion

The finding of a main effect for encoding type demonstrated that memory for sentences of varying valence benefitted from being drawn compared to written during an incidental encoding task. This finding provides further insight into the generalizability of drawing as an encoding technique and, in particular, into what type of stimuli receive a memory boost from being drawn at encoding. The finding that negative sentences were better remembered in comparison to neutral ones is in line with previous research demonstrating that viewing emotional sentences, in comparison to neutral ones, leads to better memory (Baumeister et al., 2001). While positive sentences were not significantly better remembered than neutral ones, the lack of a positivity boost is actually a common finding, especially in younger adults (Gallo, Foster, & Johnson, 2009; Grühn, Smith, & Baltes, 2005; Majerus & D'Argembeau, 2011; Reed et al., 2014; Williams & Drolet, 2005).

Interestingly, our findings did not reveal a significant interaction between encoding type and valence. While there was a combined boost of emotionality and drawing, whereby negative sentences drawn at encoding were better recalled than neutral ones, the current result failed to replicate the interactive benefit of drawing and emotionality found in Experiment 1. The lack of an interaction further suggests that the memorial benefits of drawing and emotionality may be additive rather than interactive. This interpretation is more in line with neurological evidence suggesting that drawing and emotionality result from activation within distinct brain regions (Charles, Mather, & Carstensen, 2003; Fan et al., 2020; Kensinger & Corkin, 2003; Kleinsmith & Kaplan, 1964; Sommer et al., 2008; Vinci-Booher et al., 2019).

Another explanation for why the interaction from Experiment 1 did not replicate in Experiment 3 is that, as previously predicted, a drawing benefit might be negated as sentences already benefit from semantic elaboration; the added contribution of emotionality may have been nullified instead. Looking back on Experiments 1 and 3, Encoding type accounted for a larger proportion of variance in both Experiments 1 and 3 than did Valence. (See Table 4).

Table 4

Variance Accounted for by Encoding Type and Valence in Experiments 1 and 3

	Encoding Type (η_p^2)	Valence (η_p^2)
Experiment 1	0.57	0.36
Experiment 3	0.68	0.14

To our knowledge, Experiments 1 and 3 are the first to examine whether the use of drawing as an encoding technique benefits memory for emotional information. As such, the power analyses conducted may need to be adjusted to determine what sample size is necessary to properly examine the effects of the two psychological phenomena being measured. A final explanation is that the drawing boost could be overshadowing EEM. Although encoding type accounts for a greater amount of variance in both Experiments 1 and 3, the effect size for Encoding type was greater in Experiment 3 (see Table 4). In contrast, the effect size for valence was cut in half (see Table 4).

Chapter 4: General Discussion

The benefit of drawing at encoding in comparison to writing out to-be-remembered information is robust (Meade et al., 2018; Meade et al., 2019; Wammes et al., 2016; Wammes et al., 2017; Wammes et al., 2018; Wammes et al., 2018; Wammes et al., 2019). The experiments in the current thesis have expanded on these previous findings, and have demonstrated that memory for words of varying valences (Experiment 1), for neutral sentences (Experiment 2), and for neutral, positive, and negative sentences (Experiment 3) all benefit when they are drawn at encoding in comparison to written. To summarize, the findings from Experiment 1 suggest that drawing and emotionality can be combined to confer an even greater memory boost.

Experiment 2 reinforces that a drawing benefit cannot be explained by elaborative encoding alone, as proposed by Wammes and colleagues (2016). Other researchers have demonstrated that individuals encoding sentences tend to create an internal representation of the action, event, or ideas described by the text (Barclay, 1973; Bransford & Franks, 1972), rather than verbatim memorization of the text. The findings from Experiment 2 then also suggest that drawing can also be used to facilitate encoding of coherent internal representations of actions, events, ideas, as well as nouns. Both Experiments 2 and 3 extend findings from Wammes et al. (2017) which demonstrated that the memorial benefit from drawing at encoding 'scaled-up' to a lengthier and more complex stimulus. The scalability of the drawing benefit also suggests that a multisensory trace is beneficial for lengthier and more complex stimuli, as well. Results from this thesis propose that drawing is an easy-to-use encoding technique that could be applied in our day-to-day lives. Our results suggest that drawing is an effective learning strategy that could help with remembering directions, simple instructions (all simple sentences as in experiments 2 and 3), or even grocery lists. Future work can next determine if drawing can similarly benefit memory for significant personal events, or even events in a crime, both of which are emotional. Experiment 1 indeed suggests an enhanced boost to memory for emotional items that are drawn during encoding, and Experiment 3 suggests a trend in this direction for more complex stimuli (sentences).

In regards to the emotional enhancement of memory, we found a substantial memory boost for emotional items, particularly negative ones that were drawn rather than written at encoding. This greater combined benefit demonstrates that the stimulus attribute of emotionality and the encoding technique of drawing can be successfully combined to improve later recall. Essentially, while memory for emotional stimuli is already better remembered than their neutral counterparts, recall for emotional items can still be improved upon through the use of drawing. Previous studies have demonstrated that combining multiple factors known to boost memory can produce additive benefits on memory performance (MacLeod, et al., 2010; Fawcett, et al., 2012). MacLeod and colleagues (2010) have demonstrated additional memorial benefits when generation and production are combined, while Fawcett and colleagues (2012) observed an additive advantage of production and picture superiority effect. Taken together with our finding of a combined benefit of drawing and emotionality, it appears that combining such manipulations is particularly beneficial for later recall. This suggests that a greater number of multisensory memory traces affords greater mnemonic benefits. Combining these manipulations likely results in the encoding of additional information that would not otherwise occur.

Interestingly, while there was an EEM for words drawn in Experiment 1, emotionality as an enhancer of memory may have been overshadowed by the large observed drawing boost. Based on this, it appears that drawing, as a multimodal encoding technique, confers greater benefits to later recall than does the emotional valence of a stimulus. This is supported by the increase in variance accounted for by encoding type and the corresponding reduction of the effect size for emotionality from Experiment 1 to Experiment 3 (see Table 4).

Previous studies have suggested that brain regions activated by drawing and EEM do not overlap, thus, they should not interfere with one another. A potential explanation for the overshadowing of EEM then, is that words encoded by drawing activated broader brain regions (Vinci-Booher et al., 2019; Zurif, 1995), which afforded retrieval of information from multiple sources (e.g. motoric, elaborated semantic, and pictorial). This explanation coincides with previous studies that have shown that multimodal encoding benefits later memory (Engelkamp & Zimmer, 1989; Kinjo & Snodgrass, 2000; Zormpa et al., 2019) and superior autobiographical memory results when there is enhanced activation of several brain regions (Santangelo et al., 2018). The findings from Experiment 1 and 3 also suggest that broader activation of multiple brain regions may be more beneficial than the activation of fewer regions and future neuroimaging studies should investigate this further.

While the significant interaction found in Experiment 1 suggests that the combined boost of drawing and emotionality is interactive, the lack of an expected EEM effect in the 'write' condition and absence of a significant interaction in Experiment 3 elude moreso to an additive boost. It is important to consider an alternative explanation for the failure to replicate the interaction of Experiment 1. It is possible that the degree of semantic elaboration generated through sentence processing could be reducing the benefit that emotionality confers (McKay & Ahmetzanov, 2005). Both semantic elaboration and contextual binding, whereby emotional information is linked to features described within a sentence (MacKay & Ahmetzanov, 2005), have been shown to facilitate the establishment of meaningful associations between items (words) (Brennan & Pylkkänen, 2012; d'Arcais, 1974). We previously suggested that the semantic elaboration invoked by sentence processing may negate a drawing benefit. Instead, the added semantic elaboration could have influenced the benefit of EEM rather than that of drawing. While drawing is also thought to engage enhanced elaborative processing, the act of creating an illustration creates additional pictorial representations, which likely explains why encoding type accounts for a greater proportion of variance in memory.

Another possible explanation is that the number of observations per condition was cut almost in half, from seven observations in Experiment 1 to four in Experiment 3. Therefore, Experiment 3 may have not had enough power to find the same overall pattern as Experiment 1. The lack of a positivity effect in Experiment 3 also lends support to this explanation. Finally, the failure to replicate the interactive finding from Experiment 1 might be explained by the lack of a sufficiently large sample size. The same sample size was used for Experiments 1 and 3. While both aimed to examine the additional combined effects of drawing and emotionality, Experiment 3 used a more complex stimulus. As the majority of previous drawing and EEM studies have examined memory for words, the effect sizes used in the power analyses may need to be adjusted to account for more complex stimuli. As previously mentioned, we observed that there was a significant difference between all three valence conditions in Experiment 1, whereas the positive valence type was not significantly different from the others in Experiment 3. It is interesting that this occurred as nothing else differed between the experiments aside from the complexity of the stimuli. It also follows then that the inclusion of the non-significant positive condition could also have influenced our ability to find an interaction in Experiment 3. Nonetheless, the findings from Experiment 1 and 3 still demonstrated that drawing is a useful encoding tool for emotional stimuli.

4.1 Limitation and Future Directions

As previously alluded to, a limitation of this thesis is likely the sample size. It was difficult to determine what sample size was necessary as the individual and additional combined effects of these two psychological phenomena were being measured here for the first time. The effect sizes for drawing and EEM used in the power analyses may need to be adjusted to account for the more complex stimuli examined in these current experiments.

In this thesis, there were inconsistent findings in terms of the benefits of emotionality and drawing on memory for words compared to sentences. We have posited a few explanations as to why these inconsistencies occurred, and they should be examined in future experiments. First, it is evident that Experiments 1 and 3 could be underpowered. While both confirmed that emotionality and drawing can be combined to provide further benefits during later recall, whether this benefit is interactive or additive remains unanswered. To disentangle this, Experiments 1 and 3 should be repeated with an equal number of stimuli and without the positive valence condition. Equating the number of observations would allow us to ensure that the findings are not a result of the experimental design. The positivity effect is not a consistent finding within the literature, and the removal of this condition would result in greater power within our experimental design.

Previous studies have also demonstrated that the memorial benefit of drawing also occurs between-subjects (Wammes, Meade, & Fernandes, 2016). In Experiment 1, we did not find an emotional enhancement of memory for words written. We proposed that as our study was a within-subject design, participants were limited by the capacity of their own memory and could not recall more written words because emotional words or words that were drawn were being prioritized. As such, Experiment 1 should be replicated using a between-subjects design where participants in each group would only engage in one encoding type. This would allow us to further test how EEM and drawing uniquely and interactively influence memory.

We also proposed that the lack of an interaction in Experiment 3 was a result of EEM being overshadowed by a drawing boost. As we suggested that drawing could confer a greater mnemonic benefit than emotionality, this too should be assessed using a between-subjects design. This would allow us to directly compare the memorial benefits of drawing and EEM against one another to determine whether drawing at encoding is more beneficial than emotional enhancement of memory.

As already mentioned, paraphrasing the definition of academic terms has been shown to provide a memory boost that is comparable to drawing as an encoding technique (Wammes, Meade, & Fernandes, 2017). As paraphrasing likely boosts later memory by forcing a transformation of the to-be-remembered material (Mueller & Oppenheimer, 2014), the act of drawing could also be conferring its memorial benefit in this way. While our results demonstrated that drawing at encoding results in a memory boost for sentences, which already invokes some level of semantic elaboration as well, the processing of sentences might not invoke the same levels of semantic elaboration as when a transformation is required. The current experiments could be examined with explicit comparison to a paraphrasing condition to determine whether drawing confers a memorial benefit due to a 'transformation requirement' of the target stimuli at encoding. Essentially if paraphrasing and drawing of sentences improve memory equally, in comparison to when they are simply written out, this would suggest that transformation of to-be-remembered stimuli is the key to enhancing memory.

Previous research has also shown that there is a benefit for the recall of items related to oneself (Rogers, Timothy, Kuiper, Nicholas, & Kirker, 1977). This effect is commonly referred to as the self-relevance effect. As such, it is possible that as participants are creating self-referential images, this is also contributing to the memory boost. In the case of drawing, when each individual creates their own unique illustration of the to-be-remembered material, they may be invoking significantly greater self-referential processing than when they simply write out the information, and this accounts for the subsequent memory benefit for drawn items. Future experiments could assess this possibility by presenting words or sentences to pairs of participants: one person would draw (or write) during encoding, and the other would simply observe the creating (of the drawing or writing) at encoding. The 'observer' would in this way undergo the same procedure as the 'active participant' and would still have pictorial activation; however, they would lack the self-referential component. If self-referential processing at encoding is key to producing a memory boost, the active participant's memory should be higher than the observer's.

Finally, in future studies that I already have planned, I aim to assess the extent and limitations of the drawing effect by using the same drawing paradigm with even more complex stimuli such as videos of varying valences, crime footage, and words in different logographic and alphabetical languages. The goal of these future studies is to further bridge the use of drawing as an encoding technique into everyday, forensics, and educational settings. For example, this work may suggest more reliable ways of gathering eyewitness reports. That is, asking a witness to draw what they saw immediately after the event may help with consolidation of memory, in comparison with simply writing a verbal account of the incident.

4.2 Conclusions

This thesis compared the efficacy of drawing pictures as an encoding strategy in enhancing memory performance, for stimuli of varying emotional valence, and for more complex materials such as sentences. In comparison to writing, we found that drawing significantly improved free recall of words and sentences of varying valences on an incidental memory test. This result demonstrates that drawing can be used as an encoding tool for emotional and more complex materials. We also demonstrated that drawing is a robust mnemonic device that further enhances memory for positive and negative words compared to neutral words. This finding lends support to Wammes et al.'s (2019) suggestion that drawing is a multifaceted process that likely integrates from various brain regions to build a multimodal and self-referential memory trace. These present findings expand upon the current literature by showcasing the generalizability of drawing as an effective encoding technique. Drawing was shown to confer a memorial benefit to neutral as well as emotional words, as well as to materials that are semantically complex, and used regularly in our day-to-day lives.

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