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Effects of Discrete Emotions on Associative Memory Binding

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By

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ABSTRACT

The link between emotion and memory has been a topic of interest in psychological research for over a century. Typically, emotionally arousing items, especially those that are negative, are better remembered compared to neutral items. In contrast, when people are required to link multiple individual items together, negative emotional content often worsens memory, while positive content tends to improve memory for associations. Research on discrete emotions (e.g., happiness, sadness, fear, disgust) suggests that disgusting content is better remembered in item memory tests even compared to material that elicits other negative emotions. However, it remains unclear whether this unique impact of disgust would also be seen in an associative framework. In the current experiment, participants' item and associative memory for face-name pairs depicting five discrete emotions (i.e., happiness, fear, disgust, sadness, and neutral affect) were tested. It was predicted that emotional, and especially disgusted, faces would be recognized better than neutral faces. In addition, it was predicted that associative memory would be best for names associated with happy faces. I anticipated that names paired with disgusted faces could either be better remembered or more likely to be forgotten compared to names paired with other negative faces. Contrary to predictions, emotional faces were not better recognized than neutral faces in the item memory task; instead, neutral and happy faces were better remembered than fearful and disgusted faces. As well, names paired with happy and neutral faces were more likely to be remembered than names paired with disgusted faces. With respect to research showing that facial identity and expression are processed separately, it was argued that all aspects of the experimental task were in fact tests of associative memory. Implications for the field of emotional facial perception and memory and relevance to clinical work were discussed.

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CHAPTER 1

Introduction

In our modern world, humans encounter a seemingly overwhelming number of stimuli on a daily basis. In fact, a US study focusing just on media consumption in 2008 estimated that the average individual was presented with over 100,000 pieces of information each day (Bohn & Short, 2012). With the need to keep track of so much material, it makes sense that we would naturally develop ways of categorizing this information in memory. Taking this plethora of stimuli and finding relationships between certain groups of them allows us to better facilitate retrieval of these now-related items. This cognitive process of linking together previously unrelated items is commonly referred to as associative memory (Cohen et al., 1999; Naveh-Benjamin, 2000).

However, associative memory, as with so many concepts in the field of psychology, is not a unidimensional construct; this is to say that our ability to make cognitive connections is influenced by a variety of elements. One major factor which influences memory at all levels is the way in which it interacts with our emotional experience. As such, a common approach used in the study of memory has been to simultaneously examine the effects of emotion on, in this case, our ability to form associations between items in memory (e.g., Okada et al., 2011; Zimmerman & Kelley, 2010). This line of investigation has been employed for good reason, as emotional context has long been known to uniquely impact what information people pay attention to and subsequently do, or do not, remember (e.g., Cahill & McGaugh, 1995).

What is typically seen in studies on emotion and memory is that items that are emotional, whether positive or negative, tend to be better remembered than neutral items (for reviews see Dolcos et al., 2012; LaBar & Cabeza, 2006; Phelps, 2004). Interestingly though, an increasing amount of evidence is being generated which suggests the view that emotional stimuli serve to enhance memory may not be entirely accurate when applied to associative memory. While positive content does appear to improve associative memory compared to neutral content (Madan et al., 2019; Zimmerman & Kelley, 2010), a number of studies have found that negative content can actually *worsen* associative binding (Bisby et al., 2016; Madan et al., 2012; Nie & Jiang, 2019; Okada et al., 2011). Plausible explanations as to why this pattern of results may exist often refer to previous research suggesting that positive and negative emotions direct attention in distinct ways (e.g., Fredrickson, 1998, 2001), ultimately modifying the way in which information gets encoded.

With this emerging pattern in mind, the purpose of this study was to investigate the degree to which discrete positive and negative emotions uniquely impact associative memory. In the past, studies looking at emotions and associative memory have largely taken a dimensional approach, categorizing emotional stimuli according to where they fall on the continua of valence – ranging from unpleasant to pleasant – and arousal, which is a felt sensation ranging from low to high intensity/activation (Barrett, 1998; Posner et al., 2005; Rubin & Talarico, 2009; Russell, 1980). In contrast, discrete emotions are thought to be conceptually and neurologically independent of one another, representing unique experiential states that are innate across our species and categories unto themselves (Barrett, 1998; Eerola & Vuoskoski, 2011; Ekman, 1992; Posner et al., 2005; Saarimäki et al., 2016). As stated by Kranzbühler et al. (2018), "while a valenced-based approach provides a useful summary of the effects of emotions in many settings, it sacrifices specificity and explanatory power" (p. 478). Therefore, adopting a discrete emotions framework may provide more specificity to address the degree to which different discrete emotions may impact associative memory.

Recent studies support the idea that discrete emotions are uniquely processed, and suggest that the discrete negative emotion of disgust may be particularly salient in tests of item memory (i.e., tests looking at the memorability of an item itself, rather than with respect to related information as seen with associative memory), in that it draws more attention and is better remembered than other negative emotions such as sadness (Marchewka et al., 2016) and fear (Boğa et al., 2021; Chapman, 2018; Ferré et al., 2018; Marchewka et al., 2016). By contrast, it is unclear whether disgust has a similarly distinct influence on *associative memory* performance in comparison to these other negative discrete emotions. Furthermore, even if this is the case, it is also unclear as to whether such an advantage would be significant enough to overcome the detrimental impact on associative memory typically reported with negative content. It is the objective of this study to address these gaps in the scientific literature.

Emotion and Memory

Broadly stated, psychology as a discipline aims to better understand the functioning of the human mind and behaviour. Though a great number of functions of the mind, or what are often referred to as cognitive processes, have been identified and investigated over the years, there is no doubt that the processes of memory and emotion are among the earliest to have received such attention from psychologists. In fact, the ties between memory and emotion have been of interest to psychologists since near the inception of the profession. In his 1890 publication *The Principles of Psychology*, William James wrote that "an impression may be so exciting emotionally as almost to leave a *scar* upon the cerebral tissues" (p. 670). This was merely conjecture from James at the time, but modern psychological studies have gone on to support his premise. In the past few decades, research has demonstrated a pattern in which memory is reliably enhanced for emotional content over neutral content (e.g., Bradley et al., 1992; Cahill et al., 1996; Doerksen & Shimamura, 2001; Ferré et al., 2015), with relevant reviews of cognitive neuroscience echoing these behavioural findings (e.g., LaBar & Cabeza, 2006; Phelps, 2004).

The above studies looked at the enhancing effects of emotion on memory in a number of ways. For example, Bradley et al. (1992) presented participants with photographs which were rated on the dimensions of valence (i.e., pleasant/positive vs unpleasant/negative) and arousal. The researchers found that, in both immediate and delayed free recall tests, the emotional pictures (i.e., those rated higher in arousal) were significantly better remembered than their neutral counterparts. In a subsequent experiment, participants also showed faster reaction times in recognizing the emotional pictures than the neutral ones. In comparison, the valence of the materials did not significantly impact performance, leading the authors to conclude that memory was enhanced for emotional stimuli generally, whether positive or negative, over neutral stimuli.

A few years later, Cahill et al. (1996) conducted a neuroimaging study (i.e., Positron Emission Tomography) focused on the amygdala region of the brain in which they investigated whether emotional material facilitated participants' long-term memory. To do this, in two sessions separated by roughly one week, they showed participants either a series of neutral film clips or emotionally arousing film clips while they measured brain activity. Three weeks after the second session, participants were given a surprise free recall test. Cahill et al. found that participants were able to identify significantly more of the emotional film clips than the neutral ones. The researchers' neuroimaging data supported these behavioural findings, as they found a high correlation between the number of emotional film clips recalled and the level of activity in the amygdala during the initial viewing of the emotional clips. Of note, activity in the amygdala was not significantly correlated with the recall of neutral film clips, which the authors argued was an indication of the amygdala's unique contribution to the formation and maintenance of emotional memories in particular.

In an experiment investigating the impact of emotional versus neutral words on memory performance, Doerksen and Shimamura (2001) showed participants positive, negative, and neutral words which were coloured either yellow or blue, and participants were asked to read each word silently as it appeared on screen, and to remember the colour of the word. At test, participants were given a free recall task, and instructed to report as many of the words as they could remember, regardless of colour. As with the images from the experiment done by Bradley et al. (1992), it was found that emotional words, both positive and negative, were significantly better remembered compared to neutral words.

In a more recent study also looking at memory for emotional compared to neutral words, Ferré et al. (2015) presented participants with a list of words at encoding, half of which were emotional and the other half neutral. In line with the results of previous studies, performance in a free recall task found that memory was significantly better for the emotional words, whether positive or negative, than for the neutral words. Of particular interest in this study however, was that the authors controlled for the possible effects of semantic relatedness (i.e., the conceptual similarities between words in the emotional and neutral categories); in this context, semantic relatedness referred to the possibility that previous studies may have found emotional words to be better remembered than neutral ones simply due to it being easier for participants to group emotional words in memory as compared to a list of random neutral words. This is to say that if one is better able to categorize the presented stimuli according to some dimension, such as all relating to emotion, it will be easier to recall those stimuli. Ferré et al. found that even when emotional and neutral words were equivalent in their degree of semantic relatedness, the emotional words were still better remembered. Thus, even when compared to another memory-facilitating strategy, emotional content was found to be particularly effective in enhancing memory.

Item, Associative, and Episodic Memory

The studies described above are only a sample of a large literature demonstrating the ability of emotional content to facilitate memory performance (e.g., see reviews by LaBar & Cabeza, 2006; Tyng et al., 2017). However, the vast majority of these studies, including those described above, have investigated this topic by testing memory for individual items presented during the study, i.e., *item memory* (Bisby & Burgess, 2014). Another way of experimentally studying memory has been through tests of *associative memory*, which refers to our ability to cognitively link together various unrelated items as we learn relationships between them (Cohen et al., 1999; Naveh-Benjamin, 2000). In such experiments, participants are often presented with pairs of stimuli, and are later required to identify not only the individual items from the pair, but to indicate whether they were presented together during the initial viewing. Memory for associations is critical because, in day-to-day life, accurate memory involves not only remembering the individual items that we encounter, but also having an understanding of the context in which we encountered them (Bisby & Burgess, 2014), and the associated what, where, when details that combine to make up memory for an event (Tulving, 2002). For example, in recalling a recent experience you may remember such things as what day of the month last Tuesday was, dim lights, red wine, lively conversation, and soft music. While it is helpful to remember these individual components of the experience, it is our ability to connect these disparate items into a cohesive whole that allows us to more accurately represent our anniversary dinner with our partner in memory. Pierce and Kensinger (2011) aptly summarize this concept, stating that it "highlights the requirement for an episodic memory to include information not only about individual elements of an experience but also about the way in which those elements are linked together" (p. 139).

In order to fully appreciate the differences between item and associative memory, it will be helpful to unpack the concept of episodic memory. Fifty years ago, Endel Tulving (1972) introduced and distinguished between two forms of memory, those being semantic memory and episodic memory. Semantic memory was said to refer to our knowledge of the world and general facts, whereas episodic memory was defined as dealing with our personal experiences of the events encountered in our daily lives. The three components of a subjective sense of time, autonoetic consciousness, and the concept of the self as existing throughout time underlie the ability to generate the contextual information necessary for successful episodic memory; put in simpler terms, we can understand episodic memory as dealing not only with the "what" of information, but also the "when" and "where", as dealing with our experiences in the context of the particular times and places in which they occurred (Tulving, 2002). In contrast, semantic memory is not tied to such knowledge regarding the context of its acquisition (i.e., it only deals with the "what" of information). In recent years, the importance of the hippocampus in the binding of contextual details needed for successful episodic memory has been highlighted by neuroimaging data (e.g., Moscovitch et al., 2016; Yonelinas et al., 2019).

In regard to item memory, Tulving (2002) explains that successful performance (i.e., correctly recalling an item from an experiment, or recognizing an item as previously seen) can be accomplished through either episodic *or* semantic memory processes. This is to say that "even in such sterile situations as list-learning experiments, subjects could either remember the event of an item's appearing in the study list, or know that it occurred, without remembering, and make appropriate experiential judgements" (Tulving, 2002, p. 4). Under this framework, experiments using an associative memory approach, which require that participants mentally time travel to determine not only if two stimuli were seen in the study, but if they were presented together (i.e., to also determine the time and place in which the stimuli were encountered), are by definition tests of episodic memory (Moscovitch et al., 2016; Tulving, 2002), and are therefore well-suited for experimenters interested in capturing this more personalized aspect of human cognition.

Emotion and Associative Memory

Whereas tests of emotion and item memory have consistently demonstrated that emotional content, whether positive or negative, improves memory compared to neutral content, tests of associative memory have found otherwise; when emotion and memory are tested in an associative paradigm, what has often been found is that positive content does indeed improve memory over neutral content (Madan et al., 2019; Zimmerman & Kelley, 2010), but that negative content appears to worsen, or at best offer no benefit toward, memory compared to neutral content (Bisby et al., 2016; Madan et al., 2012; Nie & Jiang, 2019; Okada et al., 2011; Onoda et al., 2009; Touryan et al., 2007; Zimmerman & Kelley, 2010). In order to more fully elucidate the pattern of collected evidence in this area, I will review a portion of these studies below.

Madan et al. (2012) conducted a study in which they showed participants sets of word pairs, with the instruction that participants would later be tested on their memory for these words. The words within each pair were either negative-negative, neutral-neutral or a mix. After viewing all of the word pairs, participants were shown one of the words from each pair, and were required to identify which word it had been paired with. Once each set of word pairs had been viewed and the cued recall tasks completed, participants were given a final free recall task in which they were to report as many of the individual words from the experiment as they could remember. Madan et al. found that, although negative words themselves were better remembered than neutral words (i.e., enhanced item memory for negative words), word pairs that contained negative words showed worse associative memory performance.

In follow-up research, Madan et al. (2019) used a similar design to investigate how *positive* words would fare in tests of item and associative performance compared to neutral words. This time, the word pairs were either positive-positive, neutral-neutral, or a mix. As expected, Madan et al. observed that positive words were recalled better than neutral words in a free recall task (i.e., emotional content enhanced item memory), but in their measure of associative memory performance, it was determined that word pairs made up of positive words were in fact also better remembered than neutral word pairs. Taken in combination with the results from their 2012 study, Madan et al. (2019) concluded that “positive valence exerts an enhancing influence on association-memory, distinct from the often-impairing effects of negative valence” (pp. 8–9). By this account, when it comes to associative memory it is not only whether stimuli are emotionally arousing that matters, but also the valence of the stimuli.

The above studies tackled the influence of positive and negative emotion separately. The effect of positive, negative, and neutral stimuli in associative memory performance was directly compared by Zimmerman and Kelley (2010) in a series of four experiments. In their first experiment, participants were shown word-pairs which were either negative-negative or neutral-neutral. Afterwards, they were given one word from each pair and had to report the word that it was paired with originally. They found that even though participants had rated themselves as more confident in their ability to recall negative word pairs, performance was no better for these words than for the neutral word pairs. The second experiment was a test of item memory.

Participants were now shown a list of individual new words, again either neutral or negative, and subsequently were given a free recall task in which they were to report as many of these words as they could remember. In accordance with previous research on emotion and item memory, the negative words were significantly better recalled. The third and fourth experiments were identical, with the fourth only having been done in order to replicate the findings from the third while using a new set of words. In these experiments, participants now encountered an equal number of negative and neutral word pairs, but also an additional set of positive word pairs. Results from cued and free recall tests in both experiments indicated that emotional words, whether positive or negative, were better remembered than neutral words and that negative word pairs showed no associative memory advantage compared to neutral word pairs. However, these experiments also showed that positive word pairs were significantly better remembered compared to both neutral and negative word pairs, offering further support to the idea that the valence of the presented material, while not appearing to matter in tests of item memory, is crucial in predicting performance in tests of associative memory.

These studies all used word-word pairs and cued recall performance to study the effect of emotion on associative memory. By contrast, Bisby et al. (2016) examined associative memory for picture-picture pairs using an associative recognition task. In this study, participants were presented with negative-negative, neutral-neutral, and mixed image pairs. At testing, participants were shown an image which could either be one belonging to one of the image pairs from the encoding phase, or could be an entirely new picture that was not presented previously. Participants were then shown a list of short word-descriptions of four pictures that were presented during the encoding phase, as well as “NEW” and “Don’t Know” options, and they had to select the appropriate response in relation to the cue image. While negative pictures themselves were better remembered than neutral pictures (i.e., enhanced item memory), associative memory was poorer for image pairs that contained a negative picture.

It should thus be clear that results obtained from the decades of research concerning the links between emotion and item memory cannot be neatly applied when it comes to similar tests involving associative memory. Whereas the key variable of note in tests of item memory is whether or not the stimulus is arousing, this may not be sufficient in tests of associative memory, which also require us to keep in mind the valence of the stimulus, as positive and negative content can differentially impact memory performance.

Differences Between Positive and Negative Emotion Processing

In order to explain *why* we might see these distinct results in tests of emotion and associative memory, it will be helpful to briefly delve into the literature on how emotions impact our attentional resources. Easterbrook (1959) proposed that there is a narrowing of one's attention in response to increasingly arousing stimuli, such that attention is correspondingly focused on the qualities of the arousing stimulus itself, which he termed the "central" aspect of the experience, at the expense of other contextual or "peripheral" details. Put another way, Easterbrook's hypothesis is that "arousal restricts the focus of attention, causing a person to notice information that elicits arousal but to fail to process other information" (Kensinger, 2009, p. 4).

Easterbrook's conceptualization of central and peripheral components of emotion-mediated attentional processing serves as the root of more modern theories which use related terminology such as Kensinger's (2007) "intrinsic" item details and "extrinsic" contextual details and Mather's (2007) framing of "within-object" and "between-object" features. Though these theories do differ in notable ways, what is shared by each is that "emotion leads to focal enhancements in memory… because of the way in which arousing information is attended and bound during encoding and consolidation” (Kensinger, 2009, p. 6). As an example, if one were to experience a highly arousing event such as encountering a snarling wolf while hiking through the forest, there would be a large central focus on the wolf itself, and possibly its face in particular, whereas the size of the pond and colour of the moss in the background would constitute the peripheral details that would receive significantly less attentional resources. All three of these models help to explain why we see increased attention to, and subsequent memory improvements for, emotional over neutral items generally.

Of particular note in helping to describe the findings from the associative memory studies cited above however, is additional attention research which suggests that, while emotional stimuli do attract greater attention than neutral stimuli, the way in which attention is garnered by positive and negative stimuli differs meaningfully. Negative stimuli serve to narrow attention to the item-specific details of the arousing stimulus, while positive content expands attention to include more contextual details (e.g., Basso et al., 1996; Derryberry & Tucker, 1994). In reference to such evidence, Fredrickson (2001) states in her Broaden-and-Build Theory that “positive emotions serve to broaden people’s momentary thought-action repertories, whereas distinct types of negative emotions serve to narrow these same repertories” (p. 5). The general finding that positive content leads to a broadening of attention and negative content to a narrowing of attention has since received experimental support in the literature (e.g., Fredrickson & Branigan, 2005; Gasper & Clore, 2002; Rowe et al., 2007; Talarico et al., 2009).

This theoretical approach has been used to explain findings in which positive emotion enhanced associative binding (Madan et al., 2019; Zimmerman & Kelley, 2010). The logic here is apparent, in that if positive emotions serve to expand our attention to include more contextual details, this would clearly be beneficial in tests of associative memory, which rely on the participant encoding multiple contextual elements for successful performance. On the other hand, it also would make sense that if negative emotion narrows attention to item-specific characteristics, associative memory performance would suffer. At the level of the brain, there is additional evidence to support the idea that positive and negative emotions exhibit this central/peripheral dissociation not only in the way they impact encoding of information, but also in the way they influence retrieval. Neuroimaging studies such as those conducted by Markowitsch et al. (2003) and Pieke et al. (2003) have indicated that during the retrieval of positive events, frontal regions of the brain associated with conceptual and semantic processing are recruited, whereas posterior areas more associated with sensory processing are activated during the retrieval of negative events.

Most research on emotion and associative memory as reviewed above has taken a dimensional approach focused on examining emotions based on valence and arousal dimensions. A great deal of research has also been done on the concept of discrete emotions (e.g., Ekman, 1992), and would argue that specific emotions, even those within the same general dimensional category, can have unique impacts on memory performance, and should therefore be considered on an individual basis (e.g., Marchewka et al., 2016).

Competing Emotional Frameworks

In the history of emotion research, many theories have been proposed in order to classify and explain the wide range of feelings experienced by human beings. Two prominent models of human emotion that have stood the test of time are the *dimensional* model of emotion, and the *discrete* model of emotion. As alluded to, all of the studies hereto cited, both those testing item and associative memory, have used a dimensional model of emotion in order to answer their particular research question. It therefore seems appropriate to first outline the dimensional model, before introducing the discrete model.

Often referred to as the "father of experimental psychology", Wilhelm Wundt was perhaps the earliest proponent of what is known today as the dimensional model of emotions (Izard & Ackerman, 2000). Though Herbert Spencer (1890) was earlier to conceptualize emotions as being "dimensions" of consciousness, Wundt (1897) expanded on this premise, stating that all human emotions can be explained as falling on a continuum of three dimensions in particular, those being pleasantness-unpleasantness, calm-excitement, and relaxation-tension. In the years following Wundt's proposal the dimensional model of emotion received a great deal of attention and saw many variations (e.g., Duffy, 1941; Lindsley, 1951; Schlosberg, 1952), however, the modern version of this model used by researchers can be attributed to the work of James Russell (1980). Russell (1980) suggested that the dimensional model could be even further simplified without losing any of its explanatory power, which led him to offer what he coined the circumplex model of affect, which focused on the dimensions of valence and arousal. As neatly summarized in a more recent publication, "the circumplex model of affect, proposes that all affective states arise from two fundamental neurophysiological systems, one related to valence (a pleasure–displeasure continuum) and the other to arousal, or alertness" (Posner et al., 2005, pp. 1–2). Posner et al. go on to say that "each emotion can be understood as a linear combination of these two dimensions, or as varying degrees of both valence and arousal" (p. 2). Under a dimensional framework, emotions such as fear and anger are represented along the unpleasant/negative end of the valence continuum, and they are both quite arousing feeling states; therefore, using the dimensional model, fear and anger would be expected to act similarly in experiments involving emotional stimuli. It is with this sort of logic that experiments like the ones cited above simply refer to the emotions used in their studies as either “positive” or “negative”.

In contrast, discrete models of emotion hold that humans experience a number of “basic” emotions (Ekman, 1992), those being happiness, sadness, disgust, anger, surprise, and fear, which are considered categories unto themselves. Basic emotions are thought to be conceptually and neurologically independent of one another, representing unique experiential states that are innate across our species (Barrett, 1998; Eerola & Vuoskoski, 2011; Ekman, 1992; Posner et al., 2005; Saarimäki et al., 2016). By this account, “positive” and “negative” emotions must be specified (e.g., positive as happiness, joy, pride etc., and negative as sadness, fear, disgust, etc.), as the fact that two emotions may fall into the same general descriptive category does not entail that they can be treated similarly or used interchangeably within an experimental setting.

The origins of this body of research can be traced back to the later work of Charles Darwin. In 1872, Darwin published *The Expression of the Emotions in Man and Animals*. Before that time, interest in the face was primarily focused on measurements of facial structure as an index of qualities such as intelligence or personality (e.g., phrenology), but Darwin was concerned with the appearance of the face, and more specifically how it changed in response to the environment. As opposed to classifying emotional expressions in terms of general valence and arousal, Darwin addressed the different human expressions as representing distinct, separable emotions. Later on, other researchers such as Tomkins (1962, 1963) discussed emotions in terms of being discrete entities, identifying eight individual categories of emotion. This line of research continued on, with seminal works being published by Izard (1971) and Ekman (1972), two researchers who brought the discrete model into the modern age, with each having been primary authors on relevant publications within the last 10 years (e.g., Ekman, 2016; Izard et al., 2015).

Discrete Emotions and Memory

In laying out the theoretical background pertinent to my thesis, I have thus far addressed a number of important questions, including what we find in tests of emotion and associative memory, and the different ways that we can conceptualize positive and negative emotion. However, with respect to the discrete emotions model, there is yet one more question to ask: What do we see in tests of discrete emotions and memory? As I will outline below, discrete emotions, even those within the same general category, can impact memory in distinct ways; in particular, recent research looking into discrete emotions has revealed an interesting pattern in which items eliciting the emotion of disgust appear to be better remembered than items eliciting other negative emotions such as sadness (Marchewka et al., 2016) and fear (Boğa et al., 2021; Chapman, 2018; Charash & McKay, 2002; Croucher et al., 2011; Ferré et al., 2018; Marchewka et al., 2016).

In a neuroimaging study conducted by Marchewka et al. (2016), they used a directed forgetting paradigm to look at participants' memory for stimuli related to three discrete negative emotions, disgust, fear, and sadness, as well as neutral items. During encoding the participants were presented with various images and told to either remember or forget the picture, and then had to later judge if the same picture was old or new (with an equal number of old and new pictures being shown). As expected based on prior research, the to-be-remembered items were more accurately identified regardless of emotional category, but interestingly, there was a unique impact of disgust. At the behavioural level, all emotional images were better remembered than neutral images, but disgust-eliciting images were found to be significantly better remembered than pictures evoking sadness, with the data trending in the same direction compared to the fear-eliciting images. Of note given the models of emotion presented above was the result that, even though participants rated disgusting pictures higher on measures of arousal and valence than the other categories, the improvement seen in recognition memory for the disgusting stimuli remained significant when these dimensions were controlled for. The unique impact of disgust on recognition memory was corroborated by the fact that disgusting images elicited the greatest activity in the amygdala at encoding. This study provides evidence for disgust being a particularly salient negative emotion when elicited at encoding, and suggests a dissociation between different discrete negative emotions beyond negative valence.

In other research on discrete negative emotions, Chapman et al. (2013) showed that disgusting images were better remembered than fearful ones in work that controlled for potential confounds including subjective distinctiveness, luminance, contrast, hue, and edge density/visual complexity as possibly accounting for this disgust advantage. In a subsequent study, Chapman (2018) addressed the additional possibility of the disgust advantage in memory being due to "organisation", which she defined as the degree of relation between the set of items used for each emotion condition, or, harkening back to the Ferré et al. (2015) study described earlier, their "semantic cohesiveness". Chapman's reasoning here was that disgusting items may have been better remembered in previous experiments (e.g., Chapman, 2013) due to the items used for that category being easier to group together. To eliminate this potential confound, Chapman (2018) showed participants an equal number of fear and disgust-eliciting images (as well as neutral images), ensuring that they were matched in ratings of valence, arousal, distinctiveness, and most importantly, interrelatedness. In a surprise free recall task 45 minutes after the study phase, participants still recalled significantly more of the disgusting images than the fear-evoking ones.

Further analysis found that attention mediated this effect, in that disgusting images received more attention during the study phase, which was correlated with better memory for these items at test. This study again highlights the unique salience of disgust in memory when compared to other discrete negative emotions. Additionally, since Chapman presented all items in this study in the same way and for the same time frame, it is interesting to note that disgusting stimuli would appear to naturally garner more attentional resources than fear-related stimuli.

Although there have been a number of studies, such as the two just described above, that indicated a disgust advantage in memory for *images*, relatively few studies have been conducted on disgust versus fear-eliciting *words*. One of the first studies to use words as their stimuli in this domain of research was done by Charash and McKay (2002). In their study, participants were presented with a list of words in a Stroop Colour-Naming Task. In such tasks, participants are shown a number of words on screen and must identify the word the colour is printed in, often as quickly as possible. The words were broken into those eliciting disgust, fear, and neutral affect, and could appear on screen in any of five colours, in response to which participants had to press a corresponding key. At test, participants were given a free recall task in which they were to report as many of the previously seen words as they could remember. Two relevant findings emerged from this study. The first is that the authors observed an attention bias for the disgust-words, meaning that participants took longer to identify the colour of the word when it was from the disgust category than from the neutral category; longer latencies for disgust words compared to fear words was also observed, but this difference was non-significant. The second finding was that, while the emotional words were better remembered than neutral words overall, on an individual level the disgust words were also significantly better remembered than the fear words.

This study provides evidence that the disgust advantage in memory is not mediated by the type of stimulus used (i.e., images versus words).

Building on the research conducted by Charash and McKay (2002), Ferré et al. (2018) also ran a study looking at how disgust and fear-eliciting words impacted memory. Importantly, Ferré et al. identified a number of confounds in the study done by Charash and McKay. With this in mind, they ran a similar study to Charash and McKay while controlling for confounds such as valence, arousal, and emotion-category specificity (i.e., is the chosen stimulus truly representing the desired emotion). In accordance with prior research, results from the free recall task indicated that the disgust words were better remembered than either the fear or the neutral words. Ferré et al. (2018) then conducted a second experiment, in which they found that disgust-eliciting words were also better *recognized* than the fear-related words. This is important as it echoes Chapman's (2018) findings, in that while the potential interrelatedness of items may explain better performance of disgust words in a free recall task, this is ruled out in a recognition task; this is because the participant is not free to list off a number of items that they had grouped together in memory, and instead must address each item individually. Interestingly, in yet a third experiment Ferré et al. showed that the disgust advantage disappeared when the study phase required all items to be more deeply processed. Since participants were not given any particular instructions during the encoding phase of the first two experiments in which disgust words were better remembered and recognized respectively, this may suggest that disgusting stimuli are naturally processed at a deeper level than at least fearful and neutral stimuli, unless prompted to do otherwise. This adds further support to the proposition that the discrete negative emotion of disgust has a particularly strong impact on attention and memory processes.

Building on studies such as those mentioned above, Boğa et al. (2021) tested whether a disgust advantage in memory would also be observed in older adults when given a surprise recognition task 45 minutes following the study phase. As expected, they replicated prior research in that their sample of younger adults did show a disgust advantage, correctly recognizing more disgust-related pictures than fearful, happy, or neutral ones; interestingly, as opposed to the Chapman (2018) and Ferré et al. (2018) studies, this effect was independent of level of attention given to stimuli during encoding, providing even stronger evidence for disgust having a unique effect on memory compared to other negative emotions. Furthermore, the other affective categories of fear and happiness did not significantly differ from each other. These results did not extend to the older adults, who did not show a disgust-related advantage in recognition memory. This finding is consistent with work suggesting attenuated negative memory enhancement for older adults (for a review see Reed & Carstensen, 2012). Therefore, with respect to my target population of younger adults, the results from Boğa et al. provide further support that disgust is uniquely salient in memory when compared to other emotions.

Facial Expressions as Stimuli for Representing Discrete Emotions

As detailed above, a few studies focusing on discrete emotions have used words as their stimuli, with many more having used images. Among the types of images that have been used to represent discrete emotions (e.g., wildlife, landscape/scenery), there is a longstanding history in the use of facial expressions (Darwin, 1872). The work of Paul Ekman has been influential in the use of facial expressions as stimuli for discrete emotions research. Ekman (1972, 1987) reviewed the research on how people judged the emotion shown by particular facial expressions, and found that there were six “basic” emotions identified in every study he reviewed; these emotions were happiness, sadness, surprise, anger, fear, and disgust. He therefore argued that humans were programed to display and recognize a number of core/basic/discrete emotions. In subsequent work, Ekman (1992) argued that "the strongest evidence for distinguishing one emotion from another comes from research on facial expressions" (p. 175). In a more recent publication, Ekman (2009) echoed this statement, saying that "to date, facial expression has been found to be the richest source of information about emotions" (p. 3449).

In addition to the fact that facial expressions have been found to be particularly good stimuli with which to represent discrete emotions, they are also practical for use in a study of episodic memory. Episodic memory deals with the details of events encountered in our daily lives, lives which are often carried out within the context of social settings. Most people are constantly attempting to interpret emotional cues when in a social environment, and the facial expressions of those around them serve as particularly valuable sources of information toward that end (Aviezer et al., 2008). Indeed, Ekman (1992) was of a similar mindset, writing that "emotional expressions are crucial to the development and regulation of interpersonal relationships" (p. 177). Thus, faces, and facial expressions in particular, represent important stimuli encountered within a social context on a daily basis. For example, a common social experience is one in which we meet a new person. Upon introduction, we typically first see the person's face, and then begin to link together aspects such as their name and tone of voice; if the conversation continues we may also learn information like where they live, what they do for work, whether they are a dog or cat person, and other relevant "person knowledge" (Wang et al., 2017).

With respect to experiments of associative memory, many have tested this construct using word-word pairings (Hockley, 2008; Kuhlmann et al., 2021; Madan et al., 2012; Madan et al., 2019; Nie & Jiang, 2019; Zimmerman & Kelley, 2010) and image-image pairings (Bisby et al., 2016; Bridger et al., 2017; Hockley 2008; Luck et al., 2014). Still others have tested this form of memory through the use of object-word pairs (Bellander et al., 2017) and word-non-word pairs (Nadarevic, 2017). However, insofar as one is interested in capturing the more social, day-to-day experiencing of human beings, an effective way of researching associative memory has been to present participants with face-name or face-word pairings, and to later show them one item from the pair and test their memory for what the other item was (e.g., Amariglio et al., 2013; Matzen et al., 2015; Okada et al., 2011; Rubiño & Andrés, 2018; Sperling et al., 2003; Zeineh et al., 2003). Notably, it is unclear how *emotional* facial expressions or discrete emotions as represented by facial stimuli may impact associative memory performance. As I will expand upon below, this point is a key component of my thesis.

The Current Study

To summarize the most relevant findings from the cited literature, research on emotion and item memory has consistently demonstrated a pattern in which memory is reliably enhanced for arousing material, whether positive or negative, over neutral content (e.g., Bradley et al., 1992; Cahill et al., 1996; Doerksen & Shimamura, 2001; Ferré et al., 2015). This pattern of results is not mirrored by the related research on emotions and associative memory, which indicate that positive emotion enhances performance while negative emotional content worsens it (e.g., Madan et al., 2019; Zimmerman and Kelley, 2010). One potential explanation for these findings is consistent with Fredrickson's (1998, 2001) Broaden-and-Build Theory, which predicts that positive emotion broadens attention at encoding in a holistic manner to include contextual details whereas negative emotion narrows attention to the arousing stimulus itself, therefore sacrificing accurate encoding of more peripheral information. The research in the area of emotions and associative memory has been dominated by a dimensional framework, but there are potentially valuable results that may be gleaned from using a discrete emotions approach; of the discrete negative emotions of disgust, sadness, and fear, the emotion of disgust has been found to be particularly salient in tests of item memory (e.g., Chapman, 2018; Ferré et al., 2018).

What I believe to be the most interesting aspect of my study, however, is the following: Considering the research indicating that disgust appears to be uniquely processed in tests of item memory compared to sadness, fear, and happiness (e.g., Boğa et al., 2021), it seems plausible to think that, at least relative to other negative discrete emotions, this unique processing of disgust may also lead to an enhancement of associative memory performance. From a biological viewpoint, this idea is supported by theories which conceptualize the function of disgust as signaling an environmental threat, such as disease or some form of contamination (Curtis et al., 2011; Oaten et al., 2009). From this perspective, "disgusted faces… should facilitate processing of contextual information, as the observer surveys the environment in an effort to localize the source of the threat" (Chapman, 2021, p. 1318). On the other hand, with respect to the research indicating that negative emotion leads to increased attentional resources being devoted to central aspects at the expense of peripheral components (e.g., Easterbrook, 1959; Fredrickson, 2001), one may expect that associative memory will actually be *worst* with disgusting stimuli. This may be due to its reported salience potentially being a result of it acting as a sort of "supercharged" negative emotion within this context, leading to an even more pronounced item-specific focus of attention and resulting loss of extra-item features.

To this end, the purpose of the current work was to examine how discrete emotions as represented by facial stimuli impact associative memory. Therefore, the current study examined the differential impact of specific positive and negative discrete emotions as represented by facial stimuli on our ability to remember the related contextual details from past experiences.

This is to say that I analyzed how people remembered the contextual details of their personal experiences (i.e., episodic memory) within an associative binding paradigm, and I determined the degree to which discrete positive and negative emotions modulated this process.

In order to accomplish this, this study used emotional face-name stimuli to assess both item and associative memory. Undergraduate psychology students from the University of Windsor were recruited for the study and were shown 40 face-name pairs at encoding. Facial stimuli chosen from validated sets of emotional expressions (i.e., Conley et al., 2018; Ebner et al., 2010) were used in order to represent discrete emotions of happiness, sadness, fear, and disgust, along with neutral expression. During the study phase of the experiment, participants were shown each face-name pair one at a time. They were shown an equal number of faces expressing each of the desired discrete emotions. Notably, the emotion expressed by any particular face was counterbalanced across participants such that each selected model depicted each emotion. At testing, I distinguished between item and associative memory effects. In order to assess item memory, participants were presented with each of the previously seen faces (along with an equal number of new faces) and were required to identify whether it was encountered during the study phase or not. If a participant judged a face as having been presented during the study phase, associative memory was tested by showing them a list of names, and they had to identify the name that was paired with that particular face; in order to successfully complete this part of the task, it was not enough for participants to simply remember that a particular name and face were previously seen, but they needed to be aware of “when” and “where” (i.e., contextual information) they were seen. In other words, they had to mentally time travel to recollect the specific time and place-related details from their past experience.

In accordance with previous research, I had six hypotheses. The first three hypotheses were designed to conceptually replicate previous findings relevant to how emotion impacts cognition at the item-specific level under both dimensional and discrete frameworks (e.g., Boğa et al., 2021; Bradley et al., 1992; Fredrickson, 2001). The final three hypotheses explored the unique impact of discrete emotions on item and associative memory. Notably, my sixth hypothesis was exploratory in nature, and is phrased heterogeneously to reflect this fact:

I. Emotional faces will be better remembered than neutral faces (i.e., item memory will be enhanced by emotional content)

II. Overall, faces displaying the negative expressions of sadness, fear, and disgust will be better remembered than those displaying positive or neutral expressions (i.e., greater item-specific processing will take place for negative content)

III. Individual faces displaying a disgusted expression will be best remembered (i.e., disgust-eliciting stimuli will best facilitate item memory)

IV. Associative memory will be best for names originally paired with happy faces

V. Associative memory will be poorest for the names originally paired with faces displaying sadness and fear

VI. Disgust may have a unique interaction with associative memory. On the one hand, if there is a general disgust advantage in memory, names paired with disgusted faces will be better remembered than names paired with other negative, and potentially even neutral, faces. Alternatively, these names may be least remembered as a function of disgust increasing processing of the faces themselves at the expense of contextual information.

CHAPTER 2

Method

Participants

This study took place at the University of Windsor and was completed entirely online. The sample for this study was recruited online from the psychology undergraduate participant pool, with a final sample size of 120 participants, all of whom were awarded course credit in exchange for their participation. Sample size was determined through use of the G*Power 3 statistical program (Faul et al., 2007), which takes into account the design of the experiment (i.e., repeated measures ANOVA) as well as the anticipated effect size based on prior research. I chose to take a conservative approach here. Therefore, my sample was determined in anticipation of a small effect size (i.e., $\eta^2_p = 0.01$). Exclusion criteria included individuals above the age of 35 (given evidence of age-related changes in emotion processing, Reed & Carstensen, 2012) and/or who had a self-reported history of psychiatric or neurological illness, as well as individuals with uncorrected visual impairments.

Prior to any analyses being conducted, four participants' data were removed due to having multiple (i.e., more than one) trials in the Old/New task in which they responded in less than 250 ms. Therefore, the final sample included 116 participants. This cut-off was used in light of the fact that studies assessing simple (visual) reaction time have shown that it takes participants approximately 180–200 ms to detect a stimulus (e.g., Thompson et al., 1992). This is to say that it takes roughly 200 ms to simply register that a stimulus has been presented. Given that participants had to not only register that a stimulus was being shown to them, but had to also decide if it was one that had been previously seen, it is believed that the 250 ms cut-off is a conservative approach to discriminating those participants who did not adequately assess the stimuli before making an Old/New decision. These four participants were therefore excluded to reduce noise in the analyses. Of note, two of these same four participants were also excluded due to failing the PVT at the end of the experiment. Cut-offs for effortful performance on my PVT aligned with those used in the Warrington Recognition Memory Test for Faces (RMT-F; Warrington, 1984), and so was set at 67.50% accuracy or a minimum of 27 out of 40 trials correct. The impact of discrete emotions on item and associative memory performance was analyzed for the remaining 116 participants (see Table 1).

Table 1

Descriptive Statistics for Sample Demographic Information

Variable	*M*	*SD*
Age (years)	21.35	3.30
Education (years)	14.47	1.30
Gender (Female)	91%	
English as first language	73%	
Right-handed	91%	
Ethnicity		
White	52%	
Arab	12%	
Black	11%	
South Asian	9%	
Latin American	3%	
Chinese	3%	
Southeast Asian	2%	
West Asian	1%	
Other [a]	7%	

[a] Other reported ethnicities were Turkish, Biracial, Italian, Lebanese, and Middle Eastern.

Materials

Coding Software

As this was an online study, participants accessed the experiment using their own electronic devices. The experiment was coded using the program *PsychoPy* version 3.2 (Peirce et al., 2019), or more specifically, *PsychoJS*, its online counterpart which is programmed in

Javascript. From there, the *PsychoJS* code was uploaded to *Pavlovia*, which is a compatible host server (Sauter et al., 2020). This allowed the experiment to be accessed over the web by any device with the proper link, as opposed to needing participants to come into the lab and use a particular computer.

Facial Stimuli

The primary stimuli used in this experiment were images of emotional facial expressions. Participants were presented with forty images in the study phase of the experiment, with eight pictures depicting each of the five desired emotional expressions, those being positive (happy), neutral, and negative (sad, fearful, disgusted). An additional 40 images were added in during the test phase, again with eight pictures representing each emotion, which acted as foils for the original images. Thus, each participant saw a total of 80 different faces during the experiment.

The faces corresponding to each of the appropriate emotions were chosen from the Max Planck FACES Database (Ebner et al., 2010), as well as the RADIATE Face Stimulus Set (Conley et al., 2018). Two separate stimulus sets were used as, while the FACES Database is well validated and appropriate for studies on the interplay between cognition and emotion, it lacks in racial and ethnic diversity. The RADIATE set was specifically designed to be able to be combined in a “mix-and-match” fashion with other stimulus sets in order to provide more accurate representation of various ethnicities.

Importantly, facial stimuli were counterbalanced in the following manner: During the study phase, each participant saw one facial expression, paired with a name, from each of the 40 models chosen from the FACES and RADIATE sets. Then, during the test phase, participants were shown those same faces, but now not paired with a name, with an additional 40 models acting as foils. In order to ensure that each model depicted each expression at an equal frequency, this therefore necessitated the creation of five counterbalanced lists that participants were randomly assigned to view. For example, all participants saw the face of “Sarah”, “Mark”, “Jack” etc., for a total of 80 different faces between the study and test phases. However, during the study phase one participant could see a happy face from Sarah, a neutral face from Mark, and a disgusted face from Jack, while another saw a fearful face from Sarah, a disgusted face from Mark, and a happy face from Jack. Furthermore, to control for the possibility of there being any significant differences between the faces used as part of the face-name pairs and those used as foils (e.g., face attractiveness impacting memory performance: Wiese et al., 2014; Zhang et al., 2011), an additional five counterbalanced lists were created. In these lists, the models originally used as foils during the test phase were now used as part of the face-name pairs during the study phase, and vice versa. This meant that the models originally portraying Sarah, Mark, and Jack were now the new faces presented during the test phase without an associated name, while models previously used as foils now took the place of Sarah, Mark, and Jack. As such, there were a total of 10 counterbalanced lists, in which each of 80 individual models depicted one of five discrete emotions, resulting in a total of 400 images that were used in this study.

Max Planck FACES Database.

Forty-three facial identities (for a total of 215 total images displaying all 5 facial emotions) were selected from the Max Planck FACES database. This facial database (Ebner et al., 2010) is composed of 2052 images generated from 171 Caucasian individuals of varying ages (58 young adults, 56 middle aged, and 57 older). Ebner et al. coached each model through “face training” before being photographed numerous times while they were displaying six emotions (i.e., happy, sad, angry, fearful, disgusted, and neutral). Trained raters then picked out the two pictures from each participant that best reflected the emotional category being photographed.

These two images were then validated by a separate group of participants to ensure that the facial expressions were seen as representing the appropriate emotional category. Face stimuli were selected to include the highest rated faces for each discrete emotion of interest in my study (see Table 2 for validity ratings from Ebner et al. on how well each selected face depicted the intended emotion). All models in this database are pictured from the neck up, are forward-facing towards the camera, and are standing in front of a uniform grey background. Of note is that I selected models solely from the young adult group of the FACES database, as the age range for this group is extremely similar to the sample used in the RADIATE set (i.e., 19–31 vs 18–30 respectively).

Table 2

Validity Ratings for the Modelled Emotional Expressions used from the FACES Database

Model	Happy	Neutral	Sad	Fear	Disgust	Average
Female	96.86	92.38	85.95	83.62	82.43	88.25
	(3.21)	(4.27)	(6.28)	(6.97)	(7.32)	(3.14)
Male	96.64	92.86	87.86	84.77	79.55	88.34
	(2.24)	(4.23)	(7.60)	(8.25)	(8.39)	(3.43)
Total	96.74	92.63	86.93	84.21	80.95	88.29
	(2.73)	(4.21)	(6.97)	(7.58)	(7.93)	(3.25)

Note. All values are reported as means with standard deviation in brackets. Ratings were obtained and reported by Ebner et al. (2010) and reflect the percentage of raters who agreed that a pictured face depicted the desired emotion.

RADIATE Face Stimulus Set.

Thirty-seven facial identities (for a total of 185 individual face images) were selected from the RADIATE Face Stimulus Set. This database (Conley et al., 2018) is composed of 1721 images generated from 109 individuals (22 Asian, 38 African American, 28 Caucasian, 20 Hispanic/Latino) between the ages of 18 and 30. Following a procedure laid out by Tottenham et al. (2009), Conley et al. trained each model on how to display each of eight distinct expressions (i.e., happy, neutral, calm, fear, disgust, sad, angry, and surprise) in both closed and open mouthed versions. They then obtained validity ratings from a sample of 662 participants recruited through Amazon's Mechanical Turk (MTurk). On average, each face received roughly 50 individual ratings, in which participants had to classify which emotion they felt the face was displaying. Face stimuli were selected from the most representative pictures from each emotion category relevant to this study (see Table 3). All models in the database are pictured from the neck up, are forward-facing towards the camera, and are standing in front of a uniform white background. Following final selection of the appropriate images, the backgrounds used from each database were photoshopped to be the same colour (i.e., white), so as to harmonize the stimuli. All images selected from each of the facial databases were in colour.

Table 3

Validity Ratings for the Modelled Emotional Expressions used from the RADIATE Database

Model	Happy	Neutral	Sad	Fear	Disgust	Average
Asian Female	99.60	91.60	73.60	74.20	66.60	81.12
	(0.49)	(3.38)	(10.48)	(11.91)	(12.44)	(7.74)
Asian Male	97.33	81.00	67.67	68.67	77.33	78.40
	(2.31)	(4.36)	(7.77)	(15.50)	(13.50)	(8.69)
Asian Total	98.75	87.63	71.38	72.13	70.63	80.10
	(1.75)	(6.61)	(10.25)	(13.35)	(13.91)	(9.17)
Black Female	98.14	88.71	71.29	61.43	71.14	78.14
	(1.95)	(4.19)	(9.93)	(6.53)	(5.05)	(5.53)
Black Male	98.14	81.71	70.71	62.29	76.14	77.80
	(1.86)	(6.21)	(13.01)	(7.72)	(8.28)	(7.42)
Black Total	98.14	85.21	71.00	61.86	73.64	77.97
	(1.83)	(6.25)	(11.12)	(6.88)	(7.08)	(6.63)
Hispanic Female	99.17	88.17	76.67	68.33	76.17	81.70
	(1.17)	(4.40)	(9.03)	(7.34)	(7.44)	(5.88)
Hispanic Male	99.67	85.00	71.33	64.67	74.00	78.93
	(0.58)	(12.29)	(11.59)	(7.77)	(8.72)	(8.19)

Model	Happy	Neutral	Sad	Fear	Disgust	Average
Hispanic Total	99.33	87.11	74.89	67.11	75.44	80.78
	(1.00)	(7.24)	(9.57)	(7.22)	(7.40)	(6.49)
White Female[a]	98.00	95.00	85.00	75.00	87.00	88.00
White Male	96.60	86.20	81.20	69.40	72.20	81.12
	(1.82)	(13.81)	(11.01)	(7.23)	(9.44)	(8.66)
White Total	96.83	87.67	81.83	70.33	74.67	82.27
	(1.72)	(12.86)	(9.97)	(6.86)	(10.39)	(8.36)
Overall Female	98.84	89.63	74.32	67.68	72.37	80.57
	(1.46)	(4.26)	(9.89)	(9.93)	(9.66)	(7.04)
Overall Male	97.83	83.39	73.22	65.72	74.89	79.01
	(1.95)	(9.13)	(11.77)	(8.90)	(8.92)	(8.13)
Overall Total	98.35	86.59	73.78	66.73	73.59	79.81
	(1.77)	(7.65)	(10.71)	(9.37)	(9.27)	(7.75)

Note. All values unless otherwise indicated are reported as means with standard deviation in brackets. Ratings were obtained and reported by Conley et al. (2018) and reflect the percentage of raters who agreed that a pictured face depicted the desired emotion.

[a] Only one white female was used from the RADIATE set. Therefore the values are individual ratings for each emotion category rather than group means, and as such do not have an associated standard deviation value.

Names

The names used in this study were intended to be common names used in North America within roughly the last 30 years, and so were collected from a list of 400 popular baby names throughout the 1990's decade as provided by the American Social Security Administration (SSA) website (SSA, 2022). One name was placed below each of the 40 faces during the study phase. For each counterbalanced condition in the experiment, a list of eight names was selected. The lists were roughly equivalent in terms of the average number of letters (M = 6.38) and syllables (M = 2.43) within the names. Names were presented in a multiple-choice format during the test phase in an associative recognition task. Each of 80 possible lists, one for each face that was presented during the test phase of the experiment, contained four names that the participants could choose, all coming from the original list of 40 names. If applicable, the list included the correct name associated with the face identified as previously seen, while the other presented names in the list were entered using a web-based randomizing software program (https://www.random.org). The names being randomized were always of the same gender as the presented face.

Procedure

After signing up for the study, participants were provided with a link to the experiment through their university email address. Once they had clicked on this link, they were directed to a Qualtrics page which obtained informed consent before collecting demographic and mood information. Following the completion of the questionnaires, they were automatically redirected to the *Pavlovia* site the experiment was hosted on and were immediately met with some initial instructions. These instructions informed the participant that they would be exposed to a number of visual stimuli in fairly quick succession, and encouraged them to complete the experiment in a quiet room free from distractions if at all possible. Participants were explicitly told to intentionally study the pairs for a later memory test.

After clicking through the instructions, the study phase of the experiment immediately began. At a rate of one face-name pair every 5 s, participants were shown all 40 pairings, resulting in a total view time of roughly 3.33 min to complete this phase of the experiment. As stated, the faces were counterbalanced across participants. In addition, the order of these images (i.e., which model's face was shown first, second, third etc.) was randomized for each participant to help ensure that no order effects took place.

Once the last face-name pairing had been shown to the participant, they underwent a brief delay task. This was done to erase any retained stimuli from their working memory, as well as to prevent rehearsal of information. Participants were shown a number on screen (576), and were instructed to, out loud, count backwards from this number in threes until the number disappeared from the screen. The number remained on the screen for one minute, which is well above the known duration of working memory, with liberal estimates capping out at around 30 s when rehearsal is prevented (Cowan, 2008).

The test/retrieval phase immediately followed this delay task. In order to differentiate between item and associative memory, a task with three unique components was used (similar to the procedure done by Bisby et al., 2016). To specifically test item memory, participants were shown all of the previously seen faces at random, along with an equal number of foils for each category (i.e., 80 faces total), and they had to identify whether the face was new (not previously encountered) or old (presented during the study phase). If a face was endorsed as "old" the participant was then presented with an empty text box, and they were required to enter in the name they believed was originally paired with that face (i.e., associative cued recall). Following this cued recall task, participants were then shown a list of four names, and needed to select the name they believed was originally paired with that face (i.e., associative recognition). The latter aspects of the task were intended to act as measures of associative memory, as successful performance required contextual knowledge of which name was previously presented with the face. In the case that a "new" face was endorsed as "old", a text box and four-item list were still given. Incorrect names in each list were randomly generated from the original 40 names, matched to the gender of the face. All aspects of the task were self-paced.

In order to help distinguish between participants that were actively following the task instructions from those who were not, a performance validity test (PVT) was used based on the Warrington Recognition Memory Test for Faces (RMT-F; Warrington, 1984). After each phase of the experiment as described above had been completed, participants were then shown 40 pairs of faces, one pair at a time; these face pairs were composed of one face that was seen during the study and test phases of the experiment, as well as a completely new face that had not yet been shown to the participant, even as a foil. Faces were labelled with either a 1 or 2, and participants were instructed to select which face was the one that had previously been shown during the experiment. Cut-offs for effortful performance were chosen *a priori* based on those used in the Warrington RMT-F (i.e., a minimum of 67.50% accuracy, or 27 out of 40 items).

Data Analysis

Corrected recognition scores were used to assess performance from the item memory task. This was done by taking the number of correct hits for each emotion category (i.e., when a face was correctly identified as "old") and subtracting the number of false alarms made for lure faces with the same emotional expression. False alarms for item memory occurred when a "new" face was incorrectly endorsed as having already been seen during the study phase. Utilizing corrected recognition scores is a common approach in recognition memory tasks, as it nullifies the possibly of getting inflated scores that may occur from over-endorsement of stimuli (i.e., if a participant has a bias toward responding "old" to all stimuli, they will by default correctly categorize more of the previously seen stimuli), thus giving a more accurate representation of participant performance.

An important consequence of the experimental design to note is that the "opportunity" for participants to engage in the associative memory tasks was dependent on their item memory performance. This is because a face had to first be selected as “old” in order for the participant to then be asked to input, and next select from a multiple-choice list, the name previously paired with said face. Thus, excluding cases of perfect item memory performance (which was not observed), participants were only able to demonstrate their associative memory for a subset of the total possible number of trials. In order to not unfairly penalize participants for those trials they were not presented as a result of misses during the item memory task (i.e., endorsing an “old” face as “new”, and therefore not having the chance to demonstrate accurate associative memory for the paired name), associative memory performance was calculated based on the number of correct responses out of the total number of opportunities that the participants had to provide a response for each emotion category. For example, though there were always 40 “old” faces, and therefore 40 trials in which associative memory could have been tested, a given participant may have only correctly identified 25 of the “old” faces during the item memory task. Therefore, rather than calculate their total score based on associative performance out of 40 trials, associative memory scores for that participant were determined based on how many correct responses were given out of the 25 opportunities they had to provide a correct response. This approach served not only to eliminate an artificial lowering of participants’ associative performance data, but it also increased the probability that the associative memory measure remained independent of item memory performance. This was important, as I wanted to independently analyze the effects of discrete emotions on item and associative memory, and was not interested in interaction effects across these types of memory.

This within-subjects experiment had one independent variable (emotion expressed, with five levels corresponding to each discrete emotion of interest) and three dependent variables (item memory performance; associative cued recall memory performance; associative recognition memory performance). Results were independently analyzed using three repeated-measures analyses of variance (ANOVA). For those ANOVA tests in which significant differences were found, Tukey *post hoc* tests were employed in order to determine which discrete emotions drove the effect.

CHAPTER 3

Data Analysis and Results

Performance Validity

As mentioned, two participants scored below the cut-off used in my PVT (i.e., a minimum of 67.50% accuracy, or 27 out of 40 items) An additional two participants were removed who, though passing the PVT, had multiple trials in the item memory task in which they responded in under 250 ms. As intended, performance on the PVT showed that it was a fairly easy task, with the included participants performing at an average of 94.48% across all emotion conditions (see Table 4 for descriptive statistics).

Data was analyzed from the remaining 116 participants, who had one or fewer trials in the item memory task in which a response was entered in under 250 ms, and who performed at or above 67.50% accuracy in the PVT.

Table 4

Performance Validity Accuracy Overall and by Emotion-Category

	Happy	Neutral	Sad	Fear	Disgust	Average
M	94.61	93.75	94.40	94.72	94.94	94.48
SD	9.92	10.36	10.47	9.77	8.40	6.29

Note. Scores represent percentage accuracy in each condition.

Item Memory: Old/New Analysis

First, a one-way repeated measures ANOVA was conducted to examine the effect of the five discrete emotions (neutral, happy, sad, fearful, disgusted) on participants' ability to recognize previously seen faces (i.e., item memory). The dependent variable across each discrete emotion was participant accuracy in discriminating "old" from "new" faces, which was measured as the corrected recognition score (i.e., hits minus false alarms for new faces depicting the same emotional expression) in order to eliminate possible inflation that would result from a bias to respond “old”. Descriptive statistics for hits and false alarms across each discrete emotion are shown below in Table 5.

Table 5

Descriptive Statistics for Performance on the Old/New Task

	Happy	Neutral	Sad	Fear	Disgust	Average
Corrected Recognition	50.11	52.59	46.34	42.89	43.53	47.09
	(25.78)	(25.72)	(24.56)	(25.17)	(25.88)	(18.89)
Hits	57.65	58.30	53.34	53.13	51.72	54.83
	(23.30)	(23.77)	(23.68)	(24.44)	(23.65)	(18.22)
False Alarms	7.54	5.71	7.00	10.24	8.19	7.74
	(12.86)	(7.97)	(10.46)	(14.43)	(13.30)	(8.58)

Note. Values are reported as percentage means with standard deviation in brackets. Hits refer to correctly classifying a face as “old”. False alarms occurred when a new face was incorrectly classified as “old”.

Results indicated that the emotion expressed by the faces in the face-name pairs had a significant effect on participants’ corrected recognition, $F(4, 460) = 5.62$, $p < .001$, partial $\eta^2 = .047$. Tukey *post-hoc* analyses revealed (*ps* < .05) that this effect was driven by participants having better item memory for faces which expressed neutral ($M = 52.59$, $SD = 25.72$) and happy ($M = 50.11$, $SD = 25.78$) emotions than for those expressing emotions of fear ($M = 42.89$, $SD = 25.17$) or disgust ($M = 43.53$, $SD = 25.88$). In contrast, item memory for faces expressing sadness was not significantly different compared to other emotions ($M = 46.34$, $SD = 24.56$). See Figure 1.

Figure 1.

Effects of Discrete Emotions on Item Memory Performance

Note. Values represent corrected recognition scores (i.e., hits minus false alarms) for each emotion. Standard error values are used for the error bars.

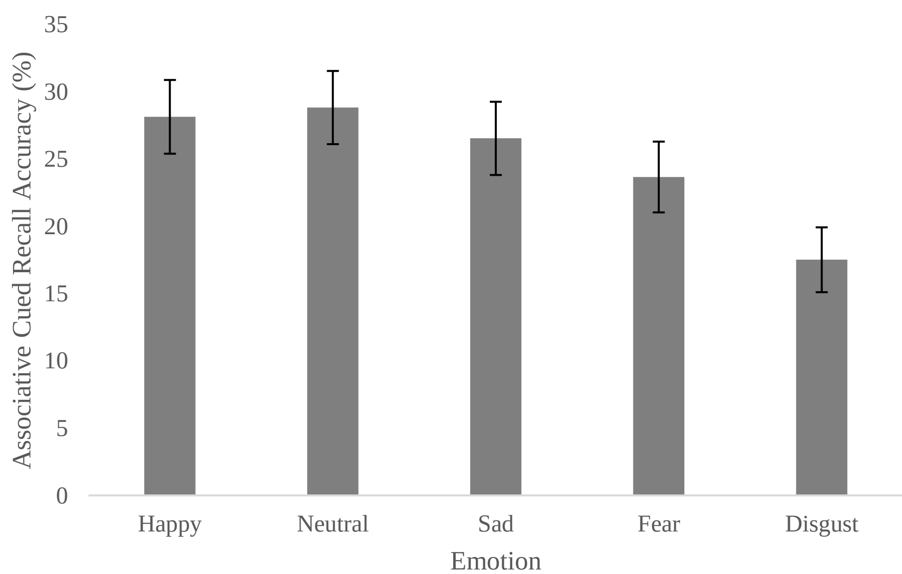
Associative Memory: Cued Recall Analysis

In similar fashion, a separate one-way repeated measures ANOVA was conducted to examine the impact of discrete emotions on participants' associative memory for the names paired with the faces. Emotion once again served as the independent, within-subjects variable. The dependent variable for this analysis was calculated as participant accuracy in recalling the name associated with a previously seen face across each emotion. As described above, the design of the experiment created a situation in which the chance to engage in the associative memory task was dependent on participants' item memory performance. This is because the associative tasks (cued recall and recognition) were only presented in cases in which the participant identified a face as "old" during the item memory task. Therefore, only the proportion of trials in which the participant had correctly identified a face as "old" in the item memory task were used in this analysis, so as to not unfairly penalize participants for those trials in which they were not presented with the associative memory task.

Results revealed a significant effect of discrete emotion on associative cued recall performance, $F(4, 410) = 5.63$, $p < .001$, partial $\eta^2 = .050$. Tukey *post-hoc* analyses indicated (*ps* < .005) that this effect was primarily due to participants having better cued recall for names which were paired with faces showing happy (*M* = 28.13, *SD* = 28.75), sad (*M* = 26.53, *SD* = 28.32), and neutral (*M* = 28.82, *SD* = 28.56) expressions than for those which displayed the emotion of disgust (*M* = 17.51, *SD* = 25.21). Cued recall for names paired with fearful faces was not significantly different compared to other emotions (*M* = 23.66, *SD* = 27.61). See Figure 2.

Figure 2.

Effects of Discrete Emotions on Associative Cued Recall Performance



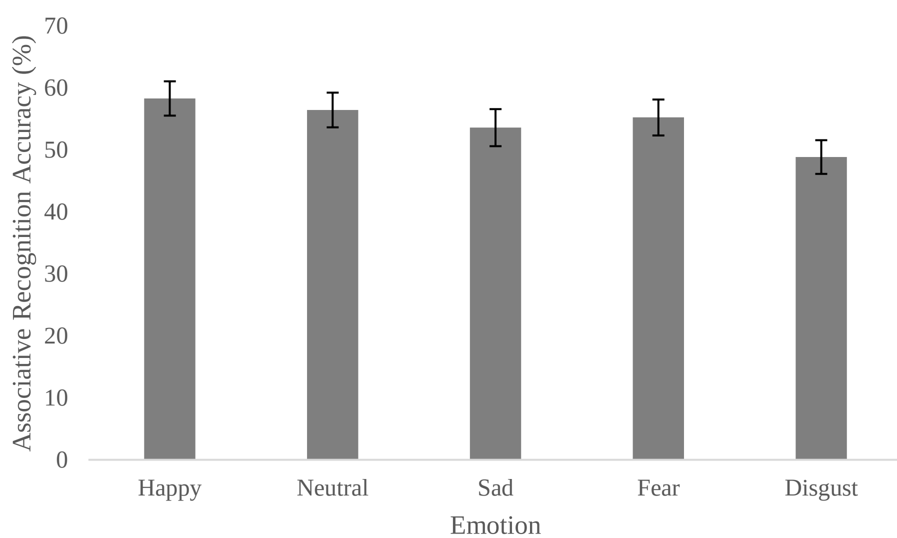
Note. Values represent the proportion of names correctly recalled for each emotion out of the total number of chances each participant had to provide a correct associative memory response. Standard error values are used for the error bars.

Associative Memory: Recognition Analysis

A final one-way repeated measures ANOVA was conducted to examine the impact of discrete emotions on participants' associative recognition memory. As with the cued recall analysis, only the proportion of trials in which participants had the opportunity to display accurate associative performance were used for this analysis. Adjusted values based on the Huynh-Feldt sphericity correction were used for this analysis, as Mauchly's W test of sphericity was significant (p = .003), indicating a violation of this assumption. Results did not indicate a significant effect of discrete emotion on associative recognition performance, $F(3.74, 407.44) = 2.05$, $p = .091$, partial $\eta^2 = .019$. This is to say that the emotion expressed by a face did not have a significant influence on participants' ability to later recognize the name that had been paired with that face. See Figure 3.

Figure 3.

Effects of Discrete Emotions on Associative Recognition Performance



Note. Values represent the proportion of names correctly recognized for each emotion out of the total number of chances each participant had to provide a correct associative memory response. Standard error values are used for the error bars.

CHAPTER 4

Discussion

Whereas studies looking at our ability to remember single items have shown that emotions reliably enhance memory (e.g., Bradley et al., 1992; Cahill et al., 1996), when it comes to our ability to remember the contextual information relevant to when and where we encountered these items (i.e., associative memory), a distinct pattern has emerged. What we see in these cases is that positive emotional content improves associative memory and that negative content impedes it (e.g., Madan et al., 2019; Zimmerman & Kelley, 2010). The research in this area has often taken a dimensional approach, focusing on the general categories of positive and negative. However, there is research that suggests specific negative emotions (e.g., sadness, fear, disgust) affect memory in distinct ways, and that, as a result, using this dimensional framework of "positive" and "negative" may not tell the whole story (e.g., Chapman, 2018; Marchewka et al., 2016). With respect to a discrete emotions approach to emotion and memory research, disgust has been shown to be especially memorable in tests of item memory, but there are reasons to believe that it may also increase associative memory (see research on disease and contamination by Curtis et al., 2011; Oaten et al., 2009). In order to determine the degree to which discrete emotions impact associative memory performance, I chose to use facial expressions, as they are particularly good stimuli to use when wanting to represent discrete emotions (e.g., Ekman, 1992). Furthermore, faces (as well as names) are ecologically valid social stimuli that are encountered on a daily basis, and therefore are well suited to tap into the sort of experiential information captured by the episodic memory system. The primary purpose of the current study was therefore to explore whether discrete emotions have a unique influence on associative memory performance, with a particular interest in examining the effect of disgust on this form of memory.

Following from previous research, it was hypothesized that item memory would be uniformly enhanced by emotional content, with faces displaying emotional expressions being better remembered than neutral faces. Beyond this general emotional enhancement of item memory, it was also hypothesized that, due to reports of greater item-specific processing taking place for negative content in particular (e.g., Fredrickson & Branigan, 2005; Kensinger, 2009; Talarico et al., 2009), the faces displaying negative emotions would see even greater retention, with those faces displaying disgusted expressions being best recalled as a function of its increased salience relative to other emotions in item memory tasks (e.g., Marchewka et al., 2016). Contrary to these predictions, results did not support my first three hypotheses. Although a significant effect of emotional expressions on item memory performance was found, this effect was caused by happy and neutral faces being better remembered than faces depicting fear and disgust, with sad faces not being significantly better or worse remembered than any of the other emotions. Thus, not only did negative content fail to produce the best item memory performance or show disgust to be uniquely salient in item memory, but emotional content had no overarching benefit to memory as compared to neutral content. This was a particularly unexpected result, as the memory enhancing effects of emotion in item memory tasks, regardless of valence, has been a rather robust finding in the literature (see reviews by Dolcos et al., 2012; LaBar & Cabeza, 2006; Phelps, 2004).

To understand why my results may have diverged so noticeably from those of previous studies on the interplay between emotions and item memory, we must consider the stimuli used in my study in greater detail. Previous studies have investigated this relationship using stimuli such as images (Bradley et al., 1992), film clips (Cahill et al., 1996), and words (Doerksen & Shimamura, 2001; Ferré et al., 2015). In contrast, while it is true that faces are particularly good stimuli for representing emotions (especially discrete emotions), they differ from non-face stimuli in meaningful ways. Of primary importance in this regard is that they are processed differently in the brain than other stimuli. It has been known for decades that facial perception is unique and occurs in specialized brain regions, most notable among them being the fusiform gyrus which is often aptly referred to as the Fusiform Face Area (Haxby et al., 1991; Sergent et al., 1992). The key role of the fusiform gyrus in facial, as opposed to object, processing has received a great deal of support in neuroimaging experiments over the years (e.g., Grill-Spector et al., 2004; Kanwisher et al., 1997; Kanwisher & Yovel, 2006). In fact, our brain's ability to process faces independently from other objects has been observed as early as six months of age (de Hann & Nelson, 1999). It therefore becomes apparent that experimental findings which used non-face stimuli may not always neatly transfer to designs which use faces, as the underlying pathways in which these stimuli are processed are fundamentally different. In this case, we should not necessarily expect that emotional content as represented by facial expressions would have the same impact on item memory as emotional content represented by non-face stimuli.

Reflecting the point that faces should not always be grouped in with other types of experimental stimuli in terms of expected outcomes, the research on memory for emotional faces has produced mixed results. Some studies have found that faces expressing a particular emotion are easier to remember than neutral faces (e.g., Baudouin et al., 2000; Davis et al., 2011; Johansson et al., 2004; Sergerie et al., 2005), supporting the idea of emotional content enhancing memory. In contrast, others have found that facial expressions offer no benefit to memory (Chapman, 2021) or that they can even hamper memory for the faces (Redfern & Benton, 2017).

In this same line of research, Liu et al. (2014) conducted an experiment in which they investigated the “happy-face advantage”, stating that previous studies had found that the identity of a face expressing a happy emotion was often remembered and identified better than faces displaying other expressions such as neutral, anger, surprise, and fear. Some explanations for these past findings had attributed it to a potential valence effect in which the more positive a learned face is, the better the chance of its later recognition. Liu et al. addressed gaps in previous literature, which often only looked at a few discrete emotions at a time, by comparing the performance of all six basic emotions on item memory performance to see if the happy-face advantage would still be seen. They had participants view 12 pictures of emotional faces during the study phase and assessed item memory for those same faces in an Old/New recognition task at testing. Somewhat contrary to their prediction, the happy faces were only better remembered than faces displaying a disgusted expression, with there being no significant difference in memory performance for the other emotional categories. Notably, none of their learned faces had neutral expression, and so item memory for neutral faces as compared to the discrete emotions was not assessed.

In an earlier study done by some of the same authors, Chen et al. (2011) examined participants’ identity matching ability. To do this, they presented participants with a face displaying a particular emotion, and then shortly afterwards showed them another face, which could be the same person, or someone new. They found that participants were quicker to accurately identify faces when they displayed happy, sad, and neutral expressions than when they had fearful or, especially, disgusted expressions. The results of this study and that done by Liu et al. (2014) are not dissimilar to my own, in that they both showed that happy faces were among the best remembered in the item memory task, with disgusted faces being among, if not the worst remembered. Importantly, all three of these studies therefore provide evidence that item memory for faces does not follow the same pattern as item memory for stimuli such as words and images.

I would argue that part of the reason why experiments such as my own and that conducted by Liu et al. (2014), which have investigated the relation between emotion and item memory using facial expressions, have produced such divergent results to those using non-face stimuli is because it may be virtually impossible to have a "pure" test of item memory when using emotional faces; in particular, this problem may arise when facial *expressions* are used to assess memory for facial *identity* (e.g., such as in an Old/New recognition task). The reasoning for this claim comes from research suggesting that emotional faces are not processed as a single unit, but rather that the facial expression and facial identity of a person are seen as separable components. In 1986, Bruce and Young proposed a model of face recognition which held that facial expression and facial identity were processed along separate, parallel routes. Fourteen years later, Haxby et al. (2000) provided a neurological model echoing that of Bruce and Young, proposing that there are two functionally and neurologically distinct pathways that activate when visually analyzing faces; one pathway coded "changeable" facial properties such as lip movement, eye gaze, and facial expression, while the other coded more "invariant" properties such as the overall identity of the face. The changeable pathway was said to be mediated primarily by the superior temporal sulcus, whereas the invariant pathway involved the inferior occipital gyri and, notably, the lateral fusiform gyrus. The existence of these independent pathways was further supported by studies which had shown that acquired brain injury can lead to an impairment in the recognition of facial identity but not facial expression and vice versa (e.g., Etcoff, 1984; Hornak et al., 1996; Young et al., 1993).

In contrast to these dual-route theories of facial perception, more recent neuroimaging experiments have supported the idea of what is termed a late-bifurcation model (Calder & Young, 2005; Calder, 2012). This model proposes that, while they do separate for further independent processing, the initial coding of both changeable and invariant facial properties occurs in a common visual framework, with the fusiform gyrus contributing to the recognition of each. An interaction between processing of facial identity and expression, such that changes in one can impact recognition of the other, has been reported in several studies (e.g., de Gelder et al., 2003; Yankouskaya et al., 2014; Yankouskaya et al., 2017). Regardless of the exact point of divergence of these properties, what is clear across both the dual-route and late-bifurcation models is that facial expressions and facial identity are separable characteristics which receive individualized processing in the brain (i.e., they are dissociable aspects).

The reason for why I have discussed the above models of facial processing is that it raises an important question which relates directly to the results of my study, as well as those of Liu et al. (2014): If facial expression and facial identity are not processed as a single unit, but rather as unique characteristics of the facial stimulus, would it not be the case that an Old/New recognition task for emotional faces is a test of *associative* rather than *item* memory? By this argument, when viewing the faces, the emotional expression and the face itself would be seen as individual items. Harkening back to theories by those such as Kensinger (2007) and Mather (2007), to the degree that the emotional expression is focused on at the time of encoding, the facial identity itself may therefore become an "extrinsic", contextual feature of the stimulus. If that is the case, then the results of the Old/New task should not be expected to align with research on item memory showing a general emotional enhancement of memory, but rather with associative memory research suggesting evidence of positive content improving memory for contextual details compared to neutral content, and with negative content worsening it (Madan et al., 2019; Zimmerman & Kelley, 2010).

In fact, my results from the Old/New "item memory" task, while not perfectly replicating the research on associative memory due to positive content being no better than neutral content, are generally reflective of this line of research. To use matching terminology to how I have discussed other associative tasks, the faces which were paired with happy expressions were among the best remembered along with those paired with neutral expression, with faces paired with negative expressions (i.e., fear and disgust) being the worst remembered, and faces paired with sad expressions trending in the same direction. Similar findings were also seen by Liu et al. (2014) who found faces paired with happy expressions to be significantly better remembered than those paired with disgusted expressions. Thus, it may be the case that the theoretical underpinning of the "happy-face advantage" discussed by Liu et al. can, at least in part, be attributed to the literature on emotion and associative memory.

Of course, associative memory was also tested though cued recall and recognition tasks using the names in my study. However, it should be noted that if the names were indeed a second piece of associated information with the faces, then these tasks would have been slightly more difficult than intended, as the name would not be the only salient contextual detail that participants needed to remember. With that said, my strong (i.e., non-exploratory) hypotheses regarding associative memory were that names paired with happy faces would be best remembered, followed by those paired with neutral faces, and with those names paired with sad and fearful faces being worst remembered. Somewhat surprisingly given past research (e.g., Madan et al., 2019), among the faces expressing happy, neutral, sad, and fearful expressions, no significant differences in associative memory for the paired names were found. Along with the fact that the names were not the only piece of relevant associative information for participants to recall, as they were intended to be, these findings may also be due to a lack of sensitivity of the associative tasks to identify significant effects. As mentioned in Chapters 3 and 4, only those trials in which participants had the "opportunity" to provide a correct associative response were analyzed. This often meant that half or fewer of the total possible trials were used in the analyses, thus shrinking the data pool for these tasks and diminishing my ability to locate significant relationships.

As a reminder, my final hypothesis was exploratory in nature and related to the potential impacts of disgust in particular on associative memory performance. I provided evidence to suggest that disgust is a uniquely salient negative emotion in item memory tasks (e.g., Boğa et al., 2021; Chapman, 2018; Charash & McKay, 2002; Croucher et al., 2011; Ferré et al., 2018; Marchewka et al., 2016), and wondered whether it would also show such pronounced effects in a test of associative memory. On the other hand, I suggested that it could be the case that disgust was so memorable in tests of item memory because it led to especially narrow item-level processing at the expense of encoding contextual details (Kensinger, 2009). This would entail that disgust should produce the worst associative memory performance. What I found in the cued recall task was that associative memory for names paired with disgusted faces was significantly worse than for names paired with happy, neutral, and sad faces. While no significant effect of emotion on associative recognition was found, this may in part be due to the aforementioned loss of sensitivity to identify significant relationships in the data. Additionally, though this finding cannot be meaningfully interpreted given the non-significant overall ANOVA, it may be worth noting that *post-hoc* analyses indicated names paired with happy faces were better recognized than those paired with disgusted faces ($p = .026$), while all other relationships were nowhere near significant ($ps > 0.21$).

Given my interpretation that in hindsight I did not truly have a test of item memory in my study, it is impossible to determine whether the observed poor associative performance for disgust is due to heightened item-level processing compared to the other discrete emotions. It therefore cannot be concluded that disgust acted as a "supercharged" negative emotion despite the low associative scores. Nevertheless, what is clear is that the disgust advantage previously seen in item memory tasks was not observed in tests of associative memory, suggesting that it does not generate a unique level of salience across different types of memory.

Another potential explanation for the relation found between disgust and associative memory is its role in avoidance behaviours, particularly with respect to disease avoidance. As opposed to fear which tends to lead to eye widening and increased target searching, disgust is associated with sensory closure, decreasing visual field size, slowing saccade speed, and reducing target detection (Susskind et al., 2008); importantly, the effects of eye widening and narrowing on sensory processing, such as seen with fear and disgust respectively, apply not only to the person displaying/experiencing the emotion, but also to the person viewing it (Lee et al., 2013). This would suggest that viewing disgusted faces may lead to a decreased ability for participants to encode peripheral details, thus potentially worsening associative memory performance. However, it would also suggest that viewing fearful faces should improve encoding of contextual information. This was not found to be the case in my study, nor a study conducted by Chapman (2021), who found that neither disgusted nor fearful faces improved memory for temporally presented words compared to neutral faces.

Limitations and Future Directions

The current study provided novel findings and theoretical interpretations of the ways in which emotion as expressed through facial expressions can impact multiple types of associative memory (i.e., simple recognition, cued recall, multiple-choice associative recognition). However, it is not without limitations to be noted. One particularly notable limitation of the experiment is that it was not designed in such a way as to be able to collect data about the first three hypotheses. This is because, to the degree that my argument in the discussion section above is correct, the study did not include a “pure” test of item memory. Therefore, conclusions about the impact of discrete emotions on memory for individual items could not be made.

If it is the case that testing memory for the identity of an emotional face is by definition an associative task, then it may well be that there is no way of measuring item memory using this sort of experimental design. Therefore, to analyze the differential impact of discrete emotions on item and associative memory, a better approach may be to use stimuli such as words and images. Many studies have used such stimuli to investigate the role of emotions on memory, both item (e.g., Bradley et al., 1992) and associative (e.g., Madan et al., 2019), but have traditionally used a dimensional approach to do so. Therefore, replicating this study using stimuli that would facilitate a pure test of item memory along with appropriate measures of associative memory would be beneficial in furthering our understanding of how discrete emotions may differ across various forms of memory. In addition, the discrete emotions of anger and surprise could also be added to the set of stimuli used so as to fully represent each “basic” emotion category as laid out by Ekman (1992).

Another major limitation of the study design was that the cued recall and associative recognition tasks did not guarantee that participants would have the opportunity to provide a correct response for each of the total possible trials. This often resulted in a large decrease in the amount of data that was able to be analyzed for the participants, likely decreasing the sensitivity of these tasks. A future version of this study would do well to provide the cued recall and recognition tasks regardless of the participant's response to the Old/New task. This would ensure that all participants are given the same number of opportunities to provide a correct response, along with being exposed to each face an equal number of times.

With respect to the number of times participants were shown a face, it should be noted that, in contrast to many studies using stimuli such as words and images, studies presenting faces as their stimuli often require participants to encode a smaller amount of information. For example, Chapman (2021) had participants view a total of 20 faces during the study phase. Similarly, Liu et al. (2014) presented participants with 12 faces at encoding and an additional 12 foils at test, for a total of 24 faces. Since they also depicted all six of Ekman's (1992) basic emotions, this means that each emotion was only represented by four models in the study. Furthermore, both Chapman and Liu et al. presented their facial stimuli over two blocks, meaning that participants were exposed to all of the to-be-remembered faces twice. In contrast, my study required participants to learn 40 faces shown just once during encoding, with 80 faces being presented overall, resulting in each discrete emotion being represented by a total of 16 models. Even though the current study used many more faces than similar others, requiring much more information to be retained, it is interesting to note that performance did not necessarily suffer as a result. Across each basic emotion, Liu et al. reported overall accuracy in their Old/New recognition task (i.e., hits plus correct rejections) to be between roughly 68%-78%. This is largely reflective of performance in my own task, which ranged between 71%-76%. Therefore, in the sake of experimental brevity when appropriate, my results suggest that future studies may only need to present their facial stimuli once during encoding.

Another difference between the current study and that conducted by Chapman (2021) is that, while I ensured that my selected stimuli were above a particular threshold with regard to validity ratings for each discrete emotion, Chapman also ran a pilot study to determine that her faces were matched on ratings of arousal and valence. This data was not provided in the facial databases provided by Conley et al. (2018) and Ebner et al. (2010), however, conducting a similar pilot analysis to obtain this data would likely have been beneficial. This would have ensured that the happy faces were not more positive than the negative faces were negative, and that no set of faces was found to be particularly more intense or arousing than another; this would have helped to reduce any noise in the findings resulting from certain sets of faces differing in these dimensional aspects.

In discussing increased noise in the data, at a general level it is worth noting that experiments conducted online rather than in the laboratory do not control for a number of confounds that are typically taken for granted. For example, a consequence of the remote nature of the study was that participants were able to complete the experiment on the device of their choosing and in the environment of their choosing. This meant that different participants would have experienced the study with different screen sizes, picture resolution (graphics quality), brightness settings, etc. They likely would have been seated at varying distances from their device, and been seated on furniture which varied in terms of the angle with which they would have been viewing the screen. In addition, although participants were instructed to complete the experiment alone and in a quiet room free from distractions, it cannot be known to what degree these instructions were followed. Any one of the mentioned deviations from experimental standardization is unlikely to have had a major influence on participant performance, but the culmination of factors almost undoubtedly will have introduced significant noise into the data that would have otherwise been controlled for. In order to benefit from the more controlled nature of a laboratory setting, it may therefore be worthwhile to conduct a follow-up study in which the experimental task is administered in a more uniform manner. In and of itself, it would be interesting to determine the degree to which the observed results did or did not change in response to the implementation of this greater level of control.

Beyond just refining the design elements of this study or replicating it with different stimuli, another direction for future research could be to introduce a temporal delay into the experiment. Past research on emotion and memory has shown that giving participants greater time between study and test, such as by having them sleep in the intervening period, allows for more sophisticated consolidation processes to take place. This can lead to improved memory for emotional stimuli including stories (Groch et al., 2011) and scenes (Payne et al., 2008). The reason for why we see improved memory for emotional over neutral information at longer delays is believed to be due to a modulatory role of the amygdala, which interacts with the hippocampus to strengthen the consolidation of memory traces (McGaugh, 2004). As a result, while neutral information is often quickly forgotten, emotional information is more likely to form a durable memory trace after encoding (Kensinger, 2009). In fact, this disparity is thought to only increase over time, with more recent evidence suggesting that emotional material bound by the amygdala deteriorates at a slower rate than non-emotional information bound by the hippocampus (Yonelinas & Ritchey, 2015). Conducting a version of this experiment with a more pronounced temporal delay between encoding and testing may therefore lead to insights regarding how well various discrete emotions are consolidated into memory over longer periods of time.

Summary and Conclusions

To the author's knowledge, the present study was one of the first to (intentionally) explore the link between discrete emotions as represented by facial expressions and associative memory performance. Although it was determined that the study hypotheses related to item memory could not be properly addressed, exploring the reason for this issue revealed that tests assessing memory for emotional faces may necessarily be measures of associative memory. Models highlighting the relationship between processing of facial identity and facial expression were discussed in this regard (Bruce & Young, 1986; Calder, 2005), adding support to the longstanding literature indicating that facial stimuli are unique to other types of stimuli in the way that they are processed at the level of the brain (e.g., de Hann & Nelson, 1999; Kanwisher & Yovel, 2006). In addition, a theoretical perspective was proposed to account for previous research on the happy-face advantage in memory under an associative memory framework.

The impact of the discrete emotion of disgust on associative memory was a central component of my thesis, with reason to believe that it could either enhance or worsen this form of memory. Results indicated that the previously reported disgust-advantage in tests of item memory do not necessarily translate into tests of associative memory, as information paired with a disgusted expression (i.e., facial identity, name) was consistently among, if not the worst remembered as compared to information paired with other discrete emotions such as happiness and sadness, as well as compared to neutral emotion. A conclusion could not be made regarding whether this was due to disgust leading to a hyper-focus on item-specific details and therefore a lack of encoding of other contextual information. However, ideas were proposed to address this flaw in future experiments.

Merging of the branches of literature concerning that of emotional facial perception and memory and that of item and associative memory could be useful from a clinical perspective. For example, it may add to our understanding of the frequently reported “positivity effect” in aging, in which older individuals tend to attend to and remember more positive than negative information (see Mather & Carstensen, 2005). One explanation offered to explain this effect is the socioemotional selectivity theory, which posits that older adults, in contrast to younger adults and youth, increasingly place value on emotionally meaningful aspects of their life such as a desire to feel socially interconnected and fulfilled (Carstensen & Mikels, 2005). This marks a shift from future oriented goals in younger years, and is associated with greater emotion regulation abilities. It is also well established that episodic ability tends to decline with age, both in healthy older adults (Naveh-Benjamin et al., 2003) and those with cognitive deterioration such as in the early stages of Alzheimer’s Disease (Gallagher & Koh, 2011). Taking the current findings and relevant cited literature into account, an additional consideration could therefore be that as individuals age and their episodic (i.e., associative) memory declines, the facilitation of positive content on memory for contextual information only becomes more pronounced as compared to memory for neutral or negative information, possibly due to some form of cognitive reserve (Stern, 2002). Indeed, research on older adults’ memory for emotional faces has found that both healthy older adults and those with Alzheimer’s Disease had better memory for faces which displayed happy expressions than those with neutral or sad expressions (Sava et al., 2017). In contrast, younger adults did not display a significant difference in their memory for emotional or neutral faces.

To conclude, at a general level it is clear that social functioning heavily relies on the ability to form relationships between various stimuli, as we are constantly trying to decipher and connect information we pick up from those around us, often accomplished through interpreting the facial expressions of those in our environment (e.g., Aviezer et al., 2008). It is therefore important to better understand how such associations are formed in order to develop ways of improving memory ability and/or for detecting when deficits are beginning to arise.

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