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Dawn Nguyen March 16, 2022

Examining the Content of Recollected Emotional Memories

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Abstract

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Memory for emotionally arousing events is often stronger, more vivid, and is accompanied by a stronger sense recollection of the context of the event such as its associated thoughts and perceptual characteristics, relative to affectively neutral memories. This enhanced recollection occurs for both emotionally negative and positive events but is usually stronger for negative events. Influential recent theories of emotional memory have proposed that enhanced recollection for negative events is due to enhanced reinstatement in the brain of the sensory aspects (e.g., visual detail) during retrieval and increased binding or association of the emotional aspects of the event to its memory representation, leading to greater re-experiencing of emotion during retrieval. Based on these theories, the recollective content of retrieved negative emotional events should contain relatively more perceptual details and emotional responses. However, almost all studies of recollection during recognition memory tasks have failed to analyze the nature of recollective content. The one study that did analyze recollective content for emotional events only examined negative events, so the nature of recollective content for positive emotional events remains unknown. To address this gap, we used a standard measure, the Remember/Familiar recognition task, to assess recollection in the context of a recognition memory task for negative, positive, and neutral pictures, focusing on the types of recollective content that participants retrieved. As expected, recollection was greater for both negative and positive pictures, relative to neutral pictures. Our results were inconsistent with the prediction that recollection for negative pictures was associated with a significantly higher percentage of perceptual (or intrinsic) details compared to both positive and neutral pictures. However, in line with predictions, emotional responses were associated with recollection responses significantly

more often for negative pictures compared to both positive and neutral pictures. These findings support the predictions of current theories of recollection for emotional events, suggesting that enhanced recollection of negative emotional events reflects increased encoding of emotional event properties.

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Table of Contents

Examining the Content of Recollected Emotional Memories

In our lifetime, we encounter countless pictures, a myriad of sounds and songs, and innumerable faces. What makes us remember some of these memories? The capacity for recognition memory allows us to determine whether something has been experienced before (old information) or is novel (new information). Two basic component memory processes have been identified as the most important ones mediating recognition memory: *recollection* and *familiarity* (Yonelinas, 2002). According to widely accepted dual-process models of recognition memory, when an individual recognizes an item as having been previously experienced (i.e., judges an item to be "old" on a recognition memory test) this correct judgement results from the combined influences of recollection and familiarity, two underlying memory processes that have been dissociated in numerous studies.

Recollection is defined as episodic memory retrieval, or memory for facts and events (Tulving, 1985), that is accompanied by the retrieval of contextual details of the original encoding event (e.g., what one felt or thought at the time, or aspects of the surrounding environment). In contrast, *familiarity* is defined as a feeling of knowing (which can range continuously from a weak feeling to a strong feeling) that a stimulus or event has been previously experienced (in recognition memory terminology, judged as being "old"), in the absence of the ability to retrieve any of the contextual details of the event. For example, a student may recognize a woman at a coffee shop as having been seen before on the basis of a feeling of familiarity but have no recollection of who that person is and how they know that person. That is, the student has a sense that they know this person, but there is no contextual information that brings back to mind why that might be the case. However, the student suddenly realizes that they saw the person before because they were wearing a distinctive hat or because of an emotion they

had at the time, this would correspond to recollection of the prior event as a recollective experience. Although recollection and familiarity can be separately analyzed, in most situations these two processes work together and are not mutually exclusive.

A standard method to examine recollection and familiarity is the Remember/Know (or Remember/Familiar) task procedure (Tulving, 1985). In this task, participants decide whether items that they judge to be "old" (previously studied) are *remembered* (indicating recollection) or whether they simply *know* them because the item feels *familiar* (indicating familiarity). Novel distractor items on the recognition memory task that participants have not experienced previously in the experiment are referred to as *new* items. A large number of studies have used this procedure to examine the processes of recollection and familiarity in recognition memory tasks (Migo et al., 2012).

Memory for emotionally arousing events is often stronger, more vivid, and is accompanied by a stronger sense of recollection of the context of the event such as its associated thoughts and perceptual characteristics, relative to affectively neutral memories (Kensinger & Corkin, 2003; Mather, 2007). This emotional enhancement effect in memory has been observed in studies involving emotional stimuli presented in a wide variety of formats, such as pictures, words, and scenes (e.g., Hamann, 2001; Rimmele et al., 2011). The overwhelming majority of studies have found that this emotional enhancement effect is primarily associated with the process of recollection rather than familiarity (Sharot et al., 2004). This enhanced recollection occurs for both emotionally negative and positive events but is usually stronger for negative events.

Influential recent theories of emotional memory have proposed that enhanced recollection for negative events is due to enhanced reinstatement of neural activations in the brain of the sensory aspects (e.g., visual detail) during retrieval and increased binding or association of the emotional

aspects of the event to its memory representation, leading to greater re-experiencing of emotion during retrieval (e.g., Bowen et al., 2018; Clewett & Murty, 2019). One prominent recent, the Negative Emotional Valence Enhances Recapitulation (NEVER) model (Bowen et al., 2018), proposes that negative emotion increases the encoding of sensory details, and this, in turn, results in memory traces that are more likely to be reinstated during retrieval. In other words, previous neural activations and patterns during encoding are reactivated during retrieval. This enhanced recapitulation of perceptual details is proposed to be specific to negative emotion and is not predicted to occur for memory for positive events. This suggests that this enhancement effect of intrinsic details is more pronounced for negative stimuli over positive stimuli since greater recapitulation of sensory processing regions in the brain are associated with recollection of negative events (e.g., Kark & Kensinger, 2019). Based on these theories, the recollective content of retrieved negative emotional events should contain relatively more perceptual details and emotional responses. However, almost all studies of recollection during recognition memory tasks have failed to analyze the nature of recollective content.

To our knowledge, only one previous study has examined recollective content for emotional memories. Mihaylova et al. (2019) used a Remember/Know recognition memory task to examine the recollective content for negative and neutral pictures. Participants encoded emotionally negative and neutral pictures and were tested after a short delay interval. To probe recollective content during recollection, for each picture during the recognition task that participants judged as being remembered (i.e., recollected), they were asked to give reason to justify why they judged the item to be remembered, explaining what they specifically recollected from the time they viewed the picture during encoding. The major finding of this study was that remember responses for negative pictures were associated with a greater percentage of perceptual (which

they termed “intrinsic”) details than remember responses for neutral pictures. Conversely, remember responses for neutral pictures were associated with a greater percentage of details not belonging to the picture itself (for example, thoughts while viewing the picture) than the remember responses for negative pictures. As noted by the authors, an unexpectedly low percentage of remember responses were associated with the retrieval of emotional context (for negative pictures approximately 9% and for neutral pictures approximately 3%). Because Mihaylova et al. (2019) only analyzed recollective content for negative emotional stimuli, the nature of recollective content for positive emotional events remains unknown. Given that influential current theories of emotional memory predict that increased recollective content for perceptual details is specific to negative emotion, it is important to determine whether the findings of Mihaylova et al. (2019) are valence-specific and are unique to negative emotion.

The goal of the current study was thus to attempt to replicate Mihaylova et al.’s (2019) findings and extend them by also examining the same questions with positive emotional stimuli, given that this previous study only examined negative and neutral. In other words, our aim was to analyze recollective content for emotional memories by examining both negative *and* positive stimuli relative to neutral stimuli. In line with previous studies, our first prediction was that recollection will be enhanced for emotional stimuli (both positive and negative stimuli) relative to neutral stimuli. Given that negative stimuli have been reported to be associated with increased retrieval of intrinsic details during recollection (Mihaylova et al., 2019), we also expected a similar finding in the current study. Additionally, based on recent emotional memory models (e.g., Bowen et al., 2018; Kensinger, 2009), our second prediction was that recollection of negative stimuli will be associated with higher retrieval of intrinsic details compared to neutral and positive stimuli.

While Mihaylova et al., (2019) reported the percentage of emotional details retrieved during recollection, they did not report any statistical analyses on these data. Therefore, our third prediction was regarding emotional reactions during recollection. First, because emotional reactions are salient aspects of encoded memories, we predicted that recollection of emotional details will be more frequent for negative stimuli than for neutral stimuli (since by definition, emotional pictures contained more encodable emotional elements). Second, we predicted that the increase in emotional details will be stronger for negative pictures than for positive pictures, based on theoretical views that propose that recollection for negative emotional pictures stems in part from increased association or binding of the emotions experienced during encoding with the rest of the memory representation (Yonelinas & Ritchey, 2015). Thus, our third prediction was that recollection of negative stimuli will be associated with higher retrieval of emotional details compared to both neutral and positive stimuli.

Previewing the current study, participants viewed negative, positive, and neutral stimuli (one at a time) while performing an incidental encoding task (judging whether the picture showed an indoor versus an outdoor scene). After a delay task, participants completed a Remember/Familiar recognition memory test that included all of the previously encoded pictures together with new emotional and new neutral distractor items. For stimuli they judged as being recollected, participants also provided a brief justification for why they made that judgment. On the basis of recollection justification categories identified in previous research (Gardiner et al., 1998; Mihaylova et al., 2019; Perfect et al., 1996), remember justifications were analyzed according to four different categories of justifications: intrinsic, extrinsic, emotional, and task. These previously established categories allowed us to classify qualitative explanations of remember responses for emotional and neutral picture stimuli.

Intrinsic responses were defined as being made based on the content relating to the image such as its visual appearance and physical features or identifying the specific location from the image's details. Extrinsic response justifications described thoughts associated with the image (for example, associations made with other items), but not with details belonging to the image itself or its perceptual features. Emotional response justifications described emotional reactions or descriptions of an emotional experience the image had elicited during encoding. Finally, task response justifications were defined as references to the indoor/outdoor orienting task completed during encoding for each item.

Methods

Participants

Participants between the ages of 18 to 23 years old (M = 19) were recruited from Emory University's Department of Psychology Student Pool (SONA). The study was approved by the Emory University Institutional Review Board. Data was collected for 76 participants, but 30 participants were excluded due to accidentally lost data from software malfunction, internet connectivity issues, time constraints, and failing to understand the retrieval instructions (based on incorrect term definitions given in the post-study survey). This left a total of 44 participants (32 female, 12 male). All participants gave informed consent and received two research credits for their participation.

Materials

Affective stimuli

Images were selected from a variety of emotional stimuli databases and online digital photo-sharing platforms, including the International Affective Picture Survey (IAPS)

library (Lang et al., 2008), OASIS (Kurdi et al., 2017), and two online photo-sharing sites, unsplash.com, and pixabay.com. The stimuli consisted of 180 images selected based on pre-collected valence and arousal ratings from Emory University students to ensure these ratings were valid for our sample population. We selected 60 images for each valence group: positive (M = 7.23, SD = 0.45), negative (M = 2.89, SD = 0.37), and neutral (M = 5.15, SD = 0.28). Positive images and negative images were matched for average arousal (positive images, M = 5.50, SD = 0.83; negative images, M = 5.50, SD = 0.83) and did not significantly differ in luminance, $t(59) = 1.09$, $p = .28$, or complexity, $t(59) = 0.35$, $p = .73$. Images were also checked for face validity to ensure the images matched the valence they represented. Semantic diversity was also checked to ensure that there were no visual or content patterns (e.g., having frequent photos of one same animal) across the valence groups. The means and standard deviations of image characteristics are shown in Table 1.

The selected images were presented in a pseudorandom order and reviewed for patterns of semantic similarities and valence. Images were then divided into three sets of 60 images. The stimulus order was randomized, and the pictures sets were counterbalanced across encoding and retrieval to avoid order and material effects. That is, the set that was used in the encoding phase of one counterbalancing group served as a group of foils (or “lures”) for the retrieval phase for other counterbalancing groups.

Design and Procedure

The study was conducted remotely via Zoom and Pavlovia software. Participants used their personal computers and were asked to share their screens with the experimenter for the duration of the study. Since there was limited control over the participant’s testing environment, participants provided information about their testing environment at the start of the study. They

were asked questions about their location to ensure they were in a distraction-free environment (i.e., “Are you in a quiet environment?” or “Where are you currently located?”) and technology to ensure their devices could run the Pavlovia software (i.e., “What kind of laptop are you using?” or “What is the size of your laptop screen?”). After completion of the study, participants gave subjective arousal and valence ratings for the images presented and took a Qualtrics survey to assess their understanding of the instructions.

Encoding phase

Before beginning the encoding task, participants completed a practice encoding round with six images (two images of each valence). Participants then encoded a total of 120 images (40 images per valence). Each trial started with the presentation of the image for four seconds before a prompt with an orienting question appeared, which was used to help participants focus their attention on all of the images thoroughly. Participants indicated whether they thought each picture depicted an indoor (Q) or outdoor (P) scene by pressing the corresponding key on the keyboard. Thus, on each trial, each image was presented for a total of six seconds, followed by a blank screen with a centrally presented fixation cross for one second (see Figure 1). After each trial, the next trial was immediately presented. The images were presented in four blocks of 32 trials. Each block had two neutral buffer items (to reduce primacy and recency effects) one at the beginning and one at the end. 10-second breaks were given between each of the 4 blocks to reduce fatigue.

Delay phase

Immediately after the completion of the encoding phase, in the 15-minute delay phase, participants completed a shape task for 8 minutes. The shape task actively engaged participants’

attention, to prevent participants from rehearsing the images from the encoding phase. On each shape task trial, participants judged whether the two shapes presented were the same (S) or different (D), pressing the corresponding key on the keyboard. Individual trials were self-paced. The remainder of the delay phase consisted of the presentation of the instructions for the retrieval phase.

Retrieval phase

In the retrieval phase, 180 images were presented, of which 120 (40 per valence) images were targets (items presented during encoding) and 60 (20 per valence) were lures (new items that were not previously presented) in a justified Remember/Familiar recognition memory task (see Figure 2). A 2:1 ratio of targets to lures was used during retrieval to provide relatively more opportunities for remember judgments to be made because the nature of remember justifications was a question of primary interest and correct remember responses can only be made for target items. On each trial, after the presentation of a one second fixation cross, a target or lure image was presented along with a prompt asking whether the participant judged the image to be *new*, *familiar*, or *remembered* (Migo et al., 2012). Participants were asked to indicate their judgment of new (N), familiar (F), and remember (R) by pressing the corresponding key on their keyboard. For each remember answer given, a prompt would appear asking "What was the one reason you chose this item as being remembered?" and participants were asked to explain aloud why they chose the item as remembered before pressing the spacebar to continue to the next image (i.e., the recollective content leading to the remember judgement was assessed. Experimenters live-transcribed the participant reasons for giving remember responses concurrently as the subject responded. To ensure accurate transcription of the participant responses, the retrieval session was recorded and transcribed using Zoom software.

Before the retrieval phase, participants were instructed regarding the meaning of the remember, familiar, and new responses, and we verified that participants understood these terms accurately by asking them to give their own examples of each type of response. To avoid overtly biasing the kind of explanations the participants were to give in the retrieval, no specific examples of possible justifications were given in the instructions.

To familiarize the participants with the task, participants were given a practice round with the justified Remember/Familiar recognition memory task, using six target images (two per valence) and three lure images (one per valence), with the distribution of image valence and target:lure ratio as the retrieval task. These images were only used for practice trials and did not appear elsewhere in the experiment.

Ratings phase

Following the retrieval task, participants rated all images (targets and lures) on a scale of 1-7 for pleasantness (1 = no pleasant feelings, 7 = very pleasant feelings) and a scale of 1-7 for unpleasantness (1 = no unpleasant feelings, 7 = very unpleasant feelings). The sum of the two separate unipolar scales of pleasant and unpleasant valence were then used to measure arousal (Kron et al., 2013). Conversely, subtraction of the two scales were used to measure valence, with higher values being associated with positive valence and lower values with negative valence (Chikazoe et al., 2014).

Data Analysis

Memory performance

Recognition memory performance was assessed by examining hit rates and false alarms. Hits were target images correctly identified as having been seen before, while false alarms were

defined as lures being incorrectly identified as old. Corrected overall recognition scores were calculated by subtracting false alarm rates (the sum of overall false alarms divided by the total number of new images) from hit rates (the sum of overall hits divided by the total number of targets). Recollection and familiarity processes were estimated using the Independence Remember/Know (IRK) procedure (Yonelinas & Jacoby, 1995; Yonelinas & Levy, 2002), in which "remember" responses are assumed to estimate recollection whereas familiarity is estimated as the proportion of "familiar" responses divided by the proportion of non-remember responses. The recollection and familiarity estimates were corrected for their respective false alarm rates by subtracting the proportion of remember responses for new (distractor) items from the proportion of remember responses for old (target) items, and for familiarity, using the formula familiarity = ((hit rate for familiar items)/(1 – hit rate for remember items)) – (false alarm rate for familiar items)/ (1- false alarm rate for remember items) (Yonelinas & Levy, 2002).

Semantic categorization of remember justification types

Remember justifications were scored according to four categories: intrinsic, extrinsic, emotional reaction, and task. The first three categories were used previously in studies of justifications for remember decisions (Gardiner et al., 1998; Mihaylova et al., 2019) (see Table 2 for examples). Intrinsic responses were defined as content relating to the image such as its visual appearance and physical features or identifying the specific location from the image's details. Extrinsic responses were defined as thoughts precipitated by the image or associations made with other items, but not details belonging to the image itself or its perceptual features. Emotional reactions responses were defined as reactions or descriptions of an emotional experience the image had elicited. Lastly, task responses were defined as any response relating to the

indoor/outdoor orienting task completed during encoding. However, the number of correct remember responses associated with task-related references was small (9% for both emotional and neutral images). Because correct remember responses were significantly more accompanied intrinsic, extrinsic, and emotional details, task responses were excluded from data analyses.

Remember justification categorical scoring procedure

Remember justifications were scored by two raters according to scoring procedures used in previous studies of remember response justifications (Curran et al., 1997; Mihaylova et al., 2019). For each response, raters gave one point for the respective category the response was classified under and zero points for the leftover categories. If a response combined two or more categories, the one point was divided amongst the relative categories (Gardiner et al., 1998; Mihaylova et al., 2019). For example, 0.5 points were given to each category for a justification classified under two categories. For a justification with three categories, each category would receive 1/3 of a point. In the case there was a justification that combined all four categories, each would receive 0.25 points. Inter-rater reliability calculations were measured by calculating Cohen's kappa for each category within each participant, collapsing the four statistics, and then using the individual average kappa for that participant. A group average kappa was then calculated. Thus, inter-rater reliability was 0.92 for all categories combined.

Results

Overall Picture Recognition Accuracy

As shown in Figure 3, a one-way repeated measures ANOVA on valence and corrected recognition showed that there was a significant effect of valence on corrected recognition scores, $F(2, 94) = 26$, $p < .001$. Bonferroni post-hoc tests showed that valence ratings for negative

images (M = 0.86, SD = 0.13) was significantly higher than both neutral images (M = 0.75, SD = 0.17) and positive images (M = 0.76, SD = 0.17).

Furthermore, a two-way repeated measures ANOVA revealed that there was a significant interaction between the effects of valence and recognition memory type, $F(2, 94) = 39.7$, $p <$ .001.There was a main effect of valence on both recollection estimates and familiarity estimates, $F(2, 94) = 26$, $p < .001$. There was also a main effect of recognition memory type on recollection and familiarity estimates, $F(1, 47) = 39.7$, $p < .001$.

Familiarity Estimates

As seen in Figure 4, results of a one-way repeated measures ANOVA on valence and familiarity estimates showed that there was a significant effect of valence on familiarity estimates, $F(2, 94) = 14.9$, $p < .001$. Bonferroni post-hoc tests showed that familiarity estimates for negative images (M = 0.23, SD = 0.28) were significantly higher than familiarity estimates for neutral images (M = 0.33, SD = 0.28). There was no significance between familiarity estimates for negative images relative to familiarity estimates for positive images (M = 0.26, SD = 0.27).

Recollection Estimates

As shown in Figure 5, *t*-tests on corrected recognition for remember responses indicated that there were significantly higher recollection estimates for negative stimuli (M = 0.63, SD = 0.28) compared to neutral stimuli (M = 0.42, SD = 0.28), $t(47) = 9.99$, $p < .001$. Similarly, positive stimuli (M = 0.50, SD = 0.27) also had significantly higher recollection estimates compared to neutral stimuli, $t(47) = 5.09$, $p < .001$. In addition, recollection estimates for

negative stimuli were higher than recollection estimates for positive stimuli, $t(47) = 6.55$, $p < .001$.

A one-way repeated measures ANOVA on valence and recollection estimates showed that there was a significant effect of valence on recollection estimates, $F(2, 94) = 63.3$, $p < .001$. Bonferroni post-hoc tests showed that recollection estimates for negative images ($M = 0.63$, $SD = 0.28$) were significantly higher than recollection estimates for both neutral images ($M = 0.42$, $SD = 0.28$) and positive images ($M = 0.50$, $SD = 0.27$).

Remember Response Categorization

Data analysis for 41 participants on remember responses for each category are shown in Table 3. A two-way repeated measures ANOVA revealed that there was a significant interaction between the effects of valence and category, $F(4, 160) = 12.0$, $p < .001$. There was a significant main effect of valence, $F(2, 80) = 16.0$, $p < .001$, and a significant main effect of category, $F(2, 80) = 20.4$, $p < .001$.

Next, a one-way repeated measures ANOVA on valence and percentage of remember responses that brought back intrinsic details showed that there was not a significant effect of valence on percentage of remember responses with intrinsic details, $F(2, 80) = 0.565$, $p = 0.565$. Conversely, a one-way repeated measures ANOVA on valence and percentage of remember responses that brought back extrinsic details showed that there was a significant effect of valence on percentage of remember responses with extrinsic details, $F(2, 80) = 8.72$, $p < .001$. Bonferroni post-hoc tests revealed that remember responses with extrinsic details for neutral images was significantly higher than for both positive and negative images. Moreover, remember responses with extrinsic details for negative images and positive images did not differ. Finally, a one-way

repeated measures ANOVA on valence and percentage of remember responses that brought back emotional details indicated that there was a significant effect of valence on percentage of remember responses with emotional details, $F(2, 80) = 33.4$, $p < .001$. Bonferroni post-hoc tests showed that remember responses with emotional details for negative images was significantly higher than for both neutral and positive images. Emotional details for positive images was also higher compared to neutral images.

Arousal and Valence Ratings

The results of a one-way repeated measures ANOVA on image valence (positive, negative, neutral) and subjective arousal rating showed that there was a significant effect of image valence on the average feelings of arousal participants reported, $F(2, 48) = 36.7$, $p < .001$. Bonferroni post-hoc tests showed that arousal ratings for positive images ($M = 6.51$, $SD = 1.85$) were significantly higher than both negative images ($M = 6.26$, $SD = 1.81$) and neutral images ($M = 4.56$, $SD = 2.16$). Negative images had significantly higher arousal ratings compared to neutral images.

To verify that the subjective valence ratings were consistent with the associated categorical variables of image valence (negative, neutral, positive), a one-way repeated measures ANOVA was conducted. Results showed that there was a significant effect of image valence on the subjective valence ratings participants reported, $F(2, 48) = 36.7$, $p < .001$. Bonferroni post-hoc tests showed that valence ratings for positive images ($M = 3.67$, $SD = 2.20$) were significantly higher than negative images ($M = -3.13$, $SD = 2.38$) and neutral images ($M = 1.07$, $SD = 2.06$). Negative images had significantly lower valence ratings compared to neutral images.

Discussion

The present study's goal was to attempt to replicate Mihaylova et al.'s (2019) findings and extend them by analyzing recollective content for both negative and positive emotional memories. For our first prediction, we expected that emotional stimuli (positive and negative) will have enhanced recollection relative to neutral stimuli, based on previous findings of enhanced recollection for emotional stimuli (e.g., Ochsner, 2000). Our results were consistent with this prediction: we found significantly higher recollection estimates for emotional images (negative and positive) than for neutral images. Additionally, we also found that recollection was more enhanced for negative stimuli relative to positive stimuli.

Our next two predictions were concerned with the types of contextual details participants used to justify their recollection responses. For our second prediction, we expected that recollection of negative stimuli will be associated with higher retrieval of intrinsic details compared to both neutral and positive stimuli. Inconsistent with Mihaylova et al. (2019), our results indicated that valence did not have a significant effect on the percentage of intrinsic details recollected.

Moreover, our findings were inconsistent with the NEVER model (Bowen et al., 2018) which predicts that negative images are associated with a greater percentage of intrinsic details recollected compared to positive images. The NEVER model proposes that since greater recapitulation is correlated with recollection of negative valence items, this enhanced reinstatement of perceptual, intrinsic details occurs specifically to negative. In other words, negative emotion increases the encoding of sensory details, which results in memory traces more likely to be reinstated during retrieval. This lack of reinstatement seen for positive valence is theorized to demonstrate why this effect is more pronounced for negative stimuli over positive

(e.g., Kark & Kensinger, 2019). Contrary to this theory, our findings suggest that the subjective recollective experience of emotional events may not correlate with neural recapitulation patterns as predicted by the NEVER model (Bowen et al., 2018).

Furthermore, we also predicted that recollection of negative stimuli will be associated with higher retrieval of emotional details compared to both neutral and positive stimuli. Because emotional reactions are salient aspects of encoded memories, we predicted that recollection of negative stimuli will have higher retrieval of emotional details compared to neutral stimuli, and our results supported this. There was a greater percentage of emotional details for negative pictures during recollection compared to positive pictures, supporting prior theories of a negative emotion advantage such as the emotional binding model (Yonelinas & Ritchey, 2015). Thus, our results supported our third prediction of recollection of negative stimuli having a higher retrieval of emotional details compared to both neutral and positive stimuli. Moreover, recollection of positive stimuli had a greater percentage of emotional details compared to neutral stimuli.

The current study had some limitations. First, there were technical problems due to the study's online nature. Many participants experienced software malfunction and internet connectivity issues leading to about a quarter of participants being excluded from the study. Second, there were idiosyncrasies of the pragmatics of language. In other words, participants often had individual differences in their language use. For example, the response "the woman was confusing" was difficult to distinguish whether it was a perceptual aspect the participant was alluding to (making it an intrinsic response) or an external thought the participant had (making it an extrinsic response). Third, subjective arousal and valence ratings are variable across individuals, and it may be more productive to consider these subjective ratings, rather than normative ratings, when conducting analyses.

The present findings suggest some directions that future studies could take. A future study combining the behavioral tasks used here with functional magnetic resonance imaging (fMRI) would be able to examine whether the reactivation (i.e., recapitulation) of brain activity associated with intrinsic detail is directly correlated with activation of the visual sensory cortex, as suggested by previous work (Bowen et al., 2018). Such neuroimaging techniques would allow the neural correlates of intrinsic versus extrinsic recollection to be assessed, as well as how these correlates may differ for positive, negative, and neutral stimuli. Further, our findings suggest extrinsic content differs across valence, but this relationship has not been studied directly. Thus, future studies on extrinsic details will help fill this gap in knowledge and elucidate its role in our recollective experiences.

Apart from those possible future directions, investigating the contextual details retrieved in memories is also important for us to understand not only its influence on how we learn and adapt in our daily lives but also its clinical applications. In populations affected by schizophrenia, it has been demonstrated that there are biases and deficits in the recollection of both neutral and emotional memories (e.g., Abhishek et al. 2020; Neuman et al., 2007; Neumann, Blairy, et al., 2007), possibly inducing difficulties in regulating behavior in emotional situations. Moreover, individuals with clinical depression have been shown to have an emotional memory bias specifically for negative events (Jermann et al., 2009; Kuo et al., 2012), creating a cycle of deleterious, pessimistic thoughts that leaves one vulnerable to the condition. Therefore, maladaptive emotional memory biases can aid in persisting functional impairment of populations affected by these psychopathologies. By first developing the background of how recollective experiences are remembered, strong foundational knowledge is then provided to study instances where memory functioning fails or is impaired. Knowing which specific emotional memory

processing abnormalities to target can help produce therapeutic approaches to prevent or mitigate maladaptive emotional memory biases in psychopathology.

In conclusion, our study found that recollection was higher for emotional stimuli (positive and negative) than neutral stimuli, which demonstrates the emotional enhancement effect of memory (e.g., Hamann, 2001). Furthermore, recollection was more enhanced for negative stimuli compared to positive stimuli. However, our also results found that recollection of negative, neutral, and positive stimuli had no significant differences in retrieval of intrinsic details, contrasting with our second prediction. Finally, emotional details were found to be more frequently retrieved for negative stimuli relative to both neutral and positive stimuli. In short, the current study examined the content of recollected emotional memories and, as a result, provides insight into how we may retrieve memories and interpret emotional events. Notably, our study has compelling findings of how the content of positive memories compares to negative and neutral memories. Thus, we gain a better understanding of how we interpret our past emotional experiences, how the content we retrieve differs for negative and positive memories, and how we adapt those memories in our daily lives.

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Tables and Figures

Table 1

Characteristics of Positive, Negative, and Neutral Images

	Positive		Negative		Neutral	
	M	*SD*	*M*	*SD*	*M*	*SD*
Arousal	5.50	0.83	5.01	0.60	2.40	0.57
Valence	7.23	0.45	2.89	0.37	5.15	0.28
Luminance	0.45	0.14	0.43	0.13	0.47	0.12
Complexity	260.01	421.31	234.93	320.76	299.73	283.17

Table 2

Definitions and Examples of Remember Responses for Each Category

Category	Remember response examples	
Intrinsic	"I remember noticing the deep red blood color on the face."	"I remember that because the fluffy tail stuck out to me."
Extrinsic	"This came after a photo of another concert."	"This reminded me of when I visited the beach last week."
Emotion	"I remembered it because I hate mountains."	"The cat made me feel happy."
Task	"I took a long time deciding for this one."	"I remember choosing indoors for this."

Table 3

Remember Response Percentages for each Justification Category

	Positive		Negative		Neutral	
	M	*SD*	*M*	*SD*	*M*	*SD*
% of $R_{hit\ rate\ justified\ with\ intrinsic\ details}$	0.44	0.19	0.43	0.20	0.41	0.24
% of $R_{hit\ rate\ justified\ with\ extrinsic\ details}$	0.31	0.18	0.27	0.22	0.39	0.23
% of $R_{hit\ rate\ justified\ with\ emotional\ details}$	0.18	0.13	0.25	0.18	0.05	0.06

Note. This table displays percentages of correctly identified remember responses for each category: intrinsic, extrinsic, and emotion.

Figure 1

Encoding Task

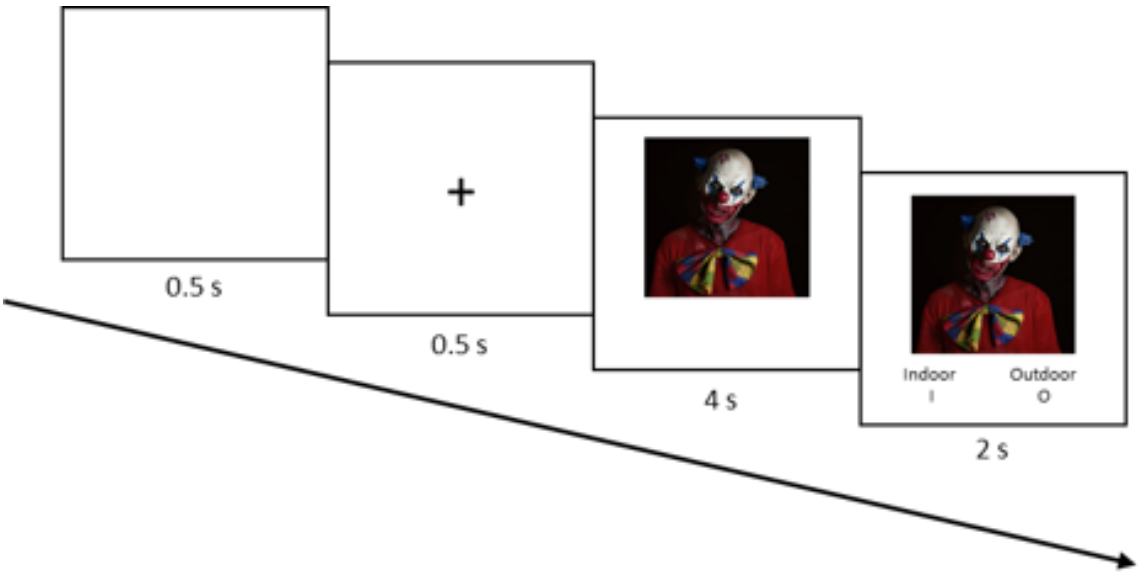

Figure 2

Retrieval Task

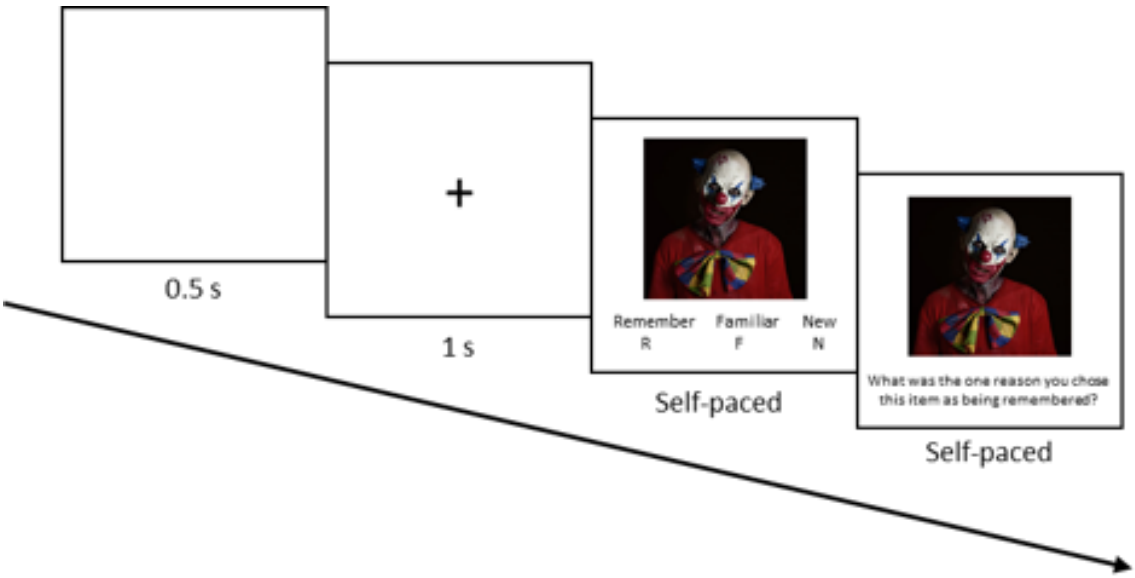

Figure 3

Overall Corrected Recognition Estimates Across Valence Categories

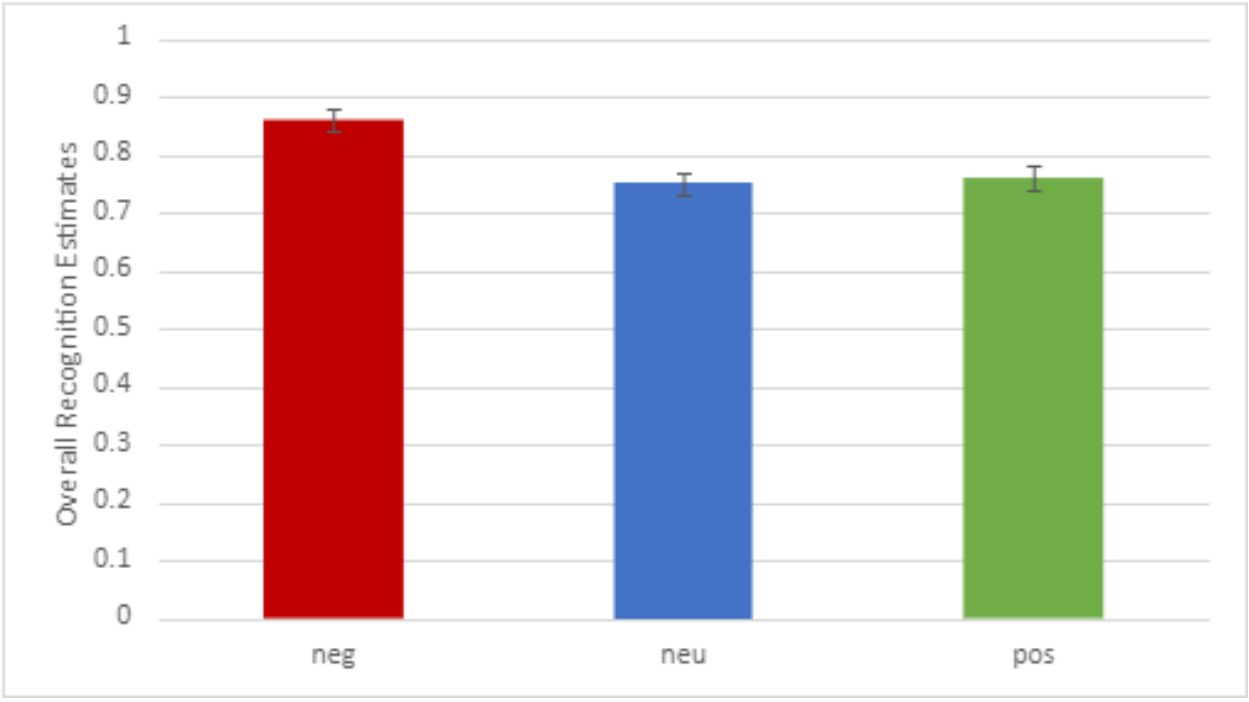

Figure 4

Familiarity Estimates for Memory for Negative, Neutral, and Positive Pictures

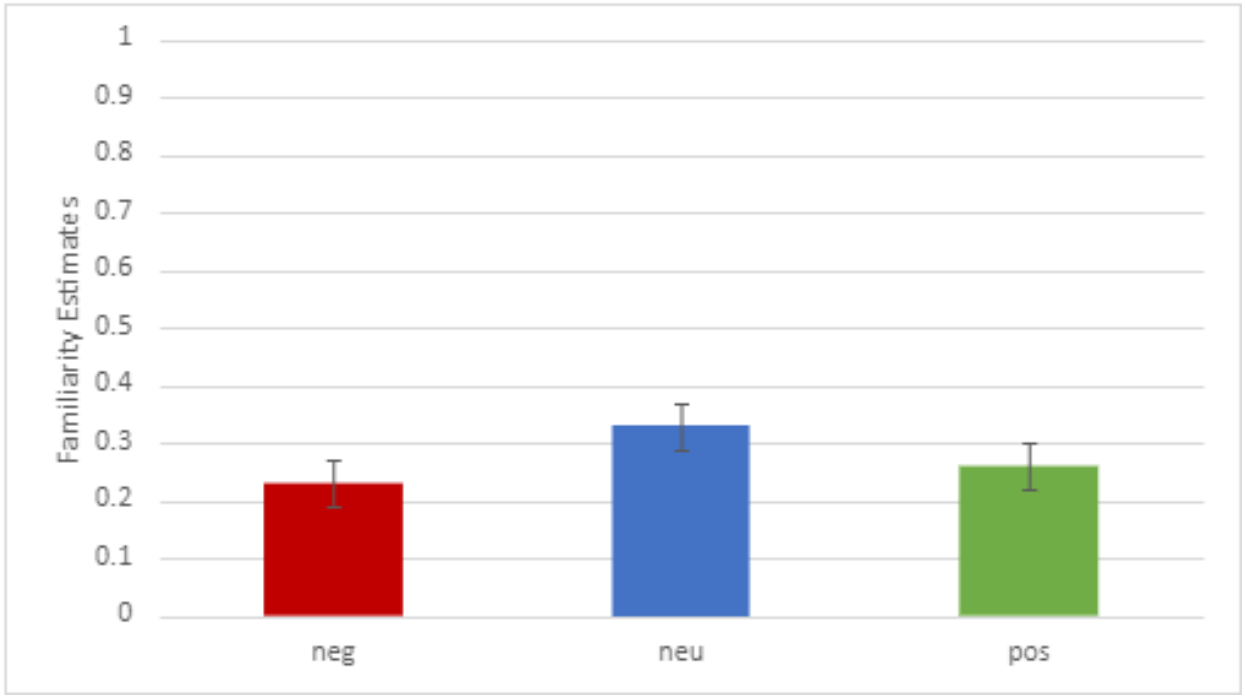

Figure 5

Recollection Estimates for Memory for Negative, Neutral, and Positive Pictures

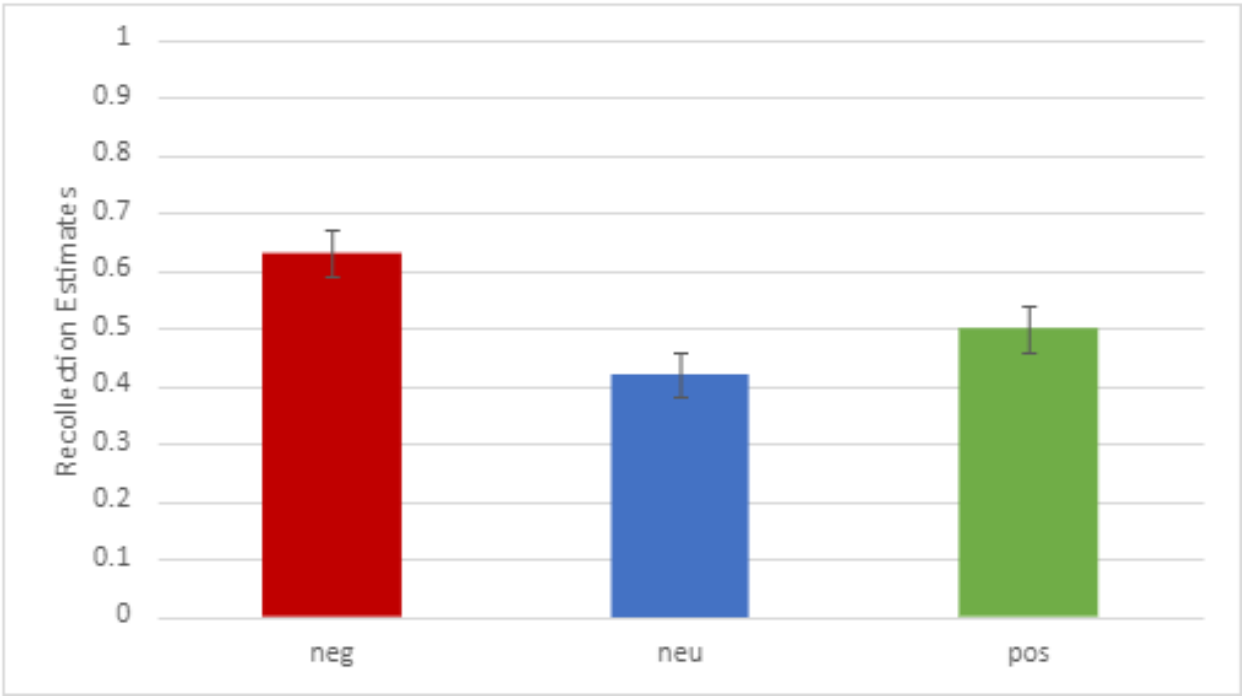

Figure 6

Percentage of Remember Responses by Justification Category and Valence