Abstract

Emotion can color what we perceive and subsequently remember in myriad ways. Indeed, it is well established that emotion enhances some aspects of memory, while impairing others. For example, a number of recent episodic memory studies show that emotion—particularly negative emotion—weakens associative memory, including item-item associations. Other literature shows that emotion biases our later attitudes and preferences. That is, the coincident pairing of a negative stimulus with a neutral one can reduce one's preference for that neutral stimulus upon subsequent encounter—a 'transfer of valence' effect. In an effort to connect these two phenomena, here we ask *if* and under *what* circumstances they co-occur. Across multiple experiments, we show that negative emotion impairs associative memory for item-item pairings, in accordance with prior work. We also show a transfer of valence effect in this paradigm, such that items paired with negative versus neutral stimuli are subsequently rated as less pleasant. Our data further show that transfer of valence is contingent on episodic memory. These findings highlight the complexity and multifaceted nature of emotional effects on memory.

Keywords: associative memory, emotion, episodic memory, evaluative conditioning, transfer of valence

Introduction

When encountering a novel threat in the environment, an organism must react optimally to the situation, while simultaneously encoding in memory the relevant aspects of the situation that will help it thwart future threats. A wealth of research in episodic memory suggests that we remember the emotional aspects of an experience in rich and vivid detail—that snake in the grass or the dog that bit our leg (e.g., Buchanan, 2007; Cahill & McGaugh, 1995; Kensinger & Corkin, 2003). The emotional elements of an event usurp cognitive resources, augmenting attention and perception, and are prioritized for a cascade of post-encoding processes that seal their fate in long-term memory (see McGaugh, 2013 for review; also see Todd et al., 2020).

Research additionally shows that when emotional elements of an event are prioritized, it comes at the expense of processing other aspects of our environment. For example, whereas one is likely to remember that they were bit by a dog, they are less likely to remember in which neighbourhood park it occurred or the face of the nearby bystander trying to help (see e.g., Kensinger et al., 2007). The effect of emotion—particularly negative emotion—on associative processes in particular has been elucidated over the past few years with a number of laboratory studies showing that negative emotion weakens associative memory, including item-item or item-background associations (e.g., Bisby & Burgess, 2014; Madan et al., 2012, 2017; Bisby et al., 2018; Palombo et al., 2021). In these studies, participants typically see pairs of items (or item-background pairs), such as a snake with a tennis ball. Thereafter, associative memory is tested, typically with an alternative-forced-choice procedure. Reduced associative memory is observed for pairs that contain a negative item.

Although memory 'trade-offs' of this nature (namely superior memory for an emotional stimulus but not its associated content) may, at times, be optimal, it seems intuitive that an adaptive memory system should somehow also tag the importance of contextual information, even if limited resources do not permit detailed recollection. Importantly, a decade of research in the domain of conditioning and beyond (Delgado et al., 2006) shows that neutral elements of the environment can acquire significance when paired with a valenced stimulus, eliciting a host of responses, such as increased skin conductance (e.g., Bechara et al., 1995) and increased viewing (e.g., Riggs et al., 2014). Other conditioning work—largely studied within social psychology and often dubbed evaluative conditioning—shows that changes in attitudes and preferences can arise in a similar manner. For example, Levey and Martin (1975) showed that participants shift their preferences such that neutral images are preferred either less (or more) when they are first paired with negative (or positive) stimuli (also see, e.g., Staats & Staats, 1958; Walther, 2002; Gast, Gawronski, & De Houwer, 2012; Hofmann et al., 2010). Thus, people show a 'transfer of valence' effect, allowing a stimulus to *rub off* on its context. Note that such studies usually involved repeated stimulus pairings. It is debated whether the acquisition of preferences can occur independent of explicit knowledge of contingencies, as there is mixed evidence in the literature (see Walther, Weil et al., 2011 for review; also see Hofmann et al., 2010; Stahl et al., 2009; Bar-Anan, De Houwer, & Nosek, 2010; Baeyens, Eelen & Van den Bergh, 1990).

Here we were particularly interested in the convergence of the two effects described here: On the one hand, the episodic memory literature shows that emotion impairs associative memory (poorer memory for snake-ball type trials). On the other hand, the evaluative conditioning literature shows a transfer of valence effect (a reduced preference for ball after its pairing with snake). In an effort to connect these phenomena from somewhat siloed literatures (also see, e.g., Dunsmoor & Kroes, 2019), here we ask *if* and under *what* circumstances they co-occur.

In Experiment 1, participants encoded stimulus pairs (i.e., a neutral stimulus; hereafter referred to as conditioned stimulus/stimuli; CS) paired with either a neutral or negative unconditioned stimulus/stimuli; US), and associative memory was assessed. Note that in our work each CS-US pairing occurs only once (i.e., single-shot events). Here, we expected and showed that associative memory is worse for negative versus neutral pairs, replicating prior work. Critically, we also examined pleasantness ratings for the neutral co-pairs, wherein we expected and showed that CS paired with negative (versus neutral) US are rated as less pleasant (i.e., a transfer of valence effect). Moreover, this effect was evident only in the presence of associative memory success.

As an ancillary goal of Experiment 1, we also examined whether the associative impairment and transfer of valence effect extends to second-order pairs. Prior conditioning work suggests that a 'spreading effect' can occur, wherein a liked or disliked stimulus can not only alter preference for a neutral stimulus that is directly paired with it, but it can also affect preference for a second-order stimulus (i.e., a stimulus subsequently paired with the pre-experimentally neutral item; e.g., Walther, 2002). To reprise the above example, if the snake was paired with a tennis ball (first-order), and that tennis ball was subsequently paired with a shoe (second-order), the shoe too would be rated as less pleasant. In real life, this may manifest as a change in attitude for a neighbour after witnessing their partner walking with your nemesis. In the present study, however, no such second-order effect was observed.

In Experiments 2 and 3, we focused only on first-order pairs; here, we manipulated the familiarity of the CS to ask whether transfer of valence is augmented by novelty. Prior work suggests that novel stimuli may be more amenable to transfer of valence, as compared to familiar stimuli that already possess pre-experimental meaning (see Walther, Weil et al., 2011). That is, in the case of novel stimuli, the newly acquired valenced association is the only evaluative information the stimulus possesses. Here we explore this idea directly. Contrary to expectation, in Experiment 2 (also replicated in Experiment 3), we found that the transfer of valence effect was of equal magnitude for novel versus familiar CS. Here it was also contingent on associative memory success (i.e., episodic memory), per Experiment 1. Experiment 3 further probed the relationship between associative memory and transfer of valence (through a source memory and cued recall test). These data provide some further evidence that transfer of valence may be contingent on episodic memory by showing that performance on these tasks is correlated with the magnitude of transfer of valence.

General Methods

This work was approved by the University of British Columbia (UBC) Behavioural Research Ethics Board. The study includes a total of three experiments, as well as a stimuli norming study. Experiment 1 was collected in person, whereas Experiments 2 and 3 were collected online (due to COVID-19). All participants were undergraduate students at UBC registered through the Human Subject Pool and received partial course credit for participation.

Questionnaires

Participants completed a health and demographics questionnaire after reading and agreeing to a consent form. Participants also completed the State-Trait Anxiety Inventory (STAI; Spielberger et al., 1983) and the Center for Epidemiologic Studies Depression Scale (CES-D; Radloff, 1977) but these data are not reported here.

Stimuli

Stimuli for the experiments presented here were derived from three databases. For all experiments, negative and neutral US were selected from the Nencki Affective Picture System (NAPS; Marchewka et al., 2014) database and neutral images (i.e, CS) were chosen from the Bank of Standardized Stimuli (BOSS; Brodeur et al., 2014). For Experiments 2 and 3 only, additional (neutral) novel CS (i.e., not easily nameable objects) were selected from the Novel Object and Unusual Name (NOUN; Horst & Hout, 2016) database.

Debrief

At the end of each experiment, participants were given a standard debrief protocol where they were asked what they thought about the study and what they thought it was about. They were then provided with a debrief document that described the nature of the study. Finally, they were asked to complete a short quiz as part of their credit attainment criteria for the UBC Human Subject Pool.

Exclusions

All three experiments used the same exclusion criteria. Note that these criteria were applied in a manner that was agnostic to experimental conditions (e.g., negative versus neutral). The first criterion pertained to missed trials: If participants missed 25% or more of trials in any phase requiring a response, they were excluded. The second and third criteria targeted the uniformity of responses across trials as we noticed that a subset of participants made identical responses across all or almost all trials, suggesting questionable motivation (a particular concern in online data collection as no experimenter was present). In the rating phase, the difference between sequential responses was calculated to classify participants whose ratings did not change or changed very little from trial to trial. Participants were excluded if the standard deviation of these sequential-trial differences was less than or equal to 0.30. Similarly, a participant was excluded if more than half of their sequential-trial differences were less than or equal to $|0.01|$. The fourth criterion pertained to participant comments during the debrief and/or the experimenter notes during Experiment 1 (conducted in person). If these suggested a compromised ability to complete the study (e.g., excessive use of phone for in-lab participation, explicit comments about not paying attention, etc.), the participant was excluded. Finally, for the last criterion, we examined whether the proportion of correct trials in the test phase was three or more standard deviations away from the mean (no participant was excluded for this reason). This criterion was applied last since standard deviation was only calculated for remaining participants who had not yet been excluded.

Table S1 provides a breakdown of all exclusions, stratified by experiment. We note that these are much more extensive exclusionary criteria than noted in our pre-registration for Experiment 2 (as noted, we did not anticipate online data collection). Overall exclusion rates were comparable to other recent memory studies conducted online (James et al., 2020; Mason et al., 2020; Yeh & Koen, 2020).

Experiment 1

Methods

Participants

This study was conducted with 79 participants. A total of 11 participants were excluded (see Table S1), resulting in a sample of $N = 68$. The final sample comprised 45 females and 21 males (with missing gender data for two participants) with an education range of 12 to 22 years and a mean age of 20.74 years ($SD = 2.06$). A power analysis based on Madan et al.'s (2017) second experiment (first-order pairs only) indicated that a sample size of 32 is adequate for detecting a significant effect ($\alpha = .05$, $1 - \beta = .80$) of emotion on associative memory ($d = 0.52$). For second-order effects, we turned to Bisby et al.'s (2018) second experiment for an estimate of effect size (also $d = 0.52$) since it was conceptually similar to our second-order condition (except in their experiment the first and second order stimuli are presented continuously and ours are blocked). Finally, for transfer of valence, a meta-analysis of evaluative conditioning studies (Hofmann et al., 2010) suggested an overall effect size of (coincidentally, also) $d = 0.52$, although we acknowledge that most evaluative conditioning studies use multiple presentations of stimulus pairs, while our study involved single-trial presentation. Given the rarity of evaluative conditioning paradigms that examine second-order effects, particularly with single exposure to CS-US pairs, we were not able to confidently calculate power for the second-order transfer of valence effects.

Measures

Stimuli for Transfer of Valence and Memory Tasks. Using normative ratings from the NAPS database (Marchewka et al., 2014), 30 negative and 30 neutral images were selected, which differed in arousal (from 1 = relaxed to 9 = aroused, with 5 = neutral/ambivalent), valence (from 1 = very negative to 9 = very positive, with 5 = neutral), and approach/avoidance (from 1 = to avoid to 9 = to approach, with 5 = neutral). The images were matched in terms of image properties (e.g., luminance, contrast, entropy, etc.) and image category (animals, faces, landscapes, objects, people); see Tables S2 and S3. Any repetitive or unclear images were avoided. We opted to choose from multiple categories in order to keep the images more distinct from one another (i.e., to reduce confusion).

One hundred and twenty BOSS objects (Brodeur et al., 2014) were chosen as US based on subjective uniqueness across images and did not include those with the potential to evoke valenced responses (e.g., food, pets). These 120 object images were randomly and evenly divided into the first-order group, meaning that they would be directly paired with a negative or neutral US, and the second-order group, meaning that they would be indirectly paired with US via pairing with first-order CS.

Procedure

The study was conducted with PsychoPy (v3.0.0b13) run on a PC computer (Pierce et al., 2019). Participants completed a total of five phases of the experiment, as summarised in Figure 1; all occurring in a one and a half hour time slot. Participants completed the study in the laboratory.

First-order Encoding Phase. First, participants saw 60 neutral CS, each randomly paired with either a neutral or negative US on the screen (‘US-CS_1’), presented in a random order. Participants were given the prompt *“Remember that these images go together”* and were shown the US-CS_1 pairs for five seconds. The side of the screen on which the US and CS_1 appeared was randomized. The pairing of CS_1 and US was counterbalanced (CB) across participants (i.e., CS_1 paired with negative US in CB1 were paired with neutral US in CB2). On the next screen, participants were given the prompt *“What is the likelihood that you will remember this pair?”* and provided a slider scale from 0% to 100% on which they indicated their response. Participants had unlimited time to make a response. Again, the CS_1 in this phase are referred to as “first-order” because they were directly paired with the US.

Second-order Encoding Phase. Following this phase, participants saw a series of 60 pairs of first- and second-order CS together on the screen, in a random order (‘CS_1-CS_2’). That is, within a pair, one CS was a first-order image and one was a second-order image (i.e., not directly paired with a US), paired randomly (but constant throughout the study).The presentation of the CS pairs followed the same procedures as the first-order encoding phase (i.e., participants saw the same prompts). The side that the CS_1 and CS_2 appeared on the screen was randomized. Participants were not told that one of the images was previously paired directly with another image in the prior phase. The CS_1 and CS_2 were chosen randomly but remained the same for all participants.

Short Break. Participants were given a 10 minute break, where they were asked to color a drawing using pencil crayons.

First-order Associative Test Phase. Participants next completed an alternative forced choice memory task, in which they were asked to identify the correct matches for images that were presented in the first-order encoding phase (‘US-CS_1’). Participants were presented with six images on the screen (trial order random). In the middle was the cued US, surrounded by five images. Of these five, one was the correct match for the cue. The four other images were lures (previously seen CS_1). For each trial, lures were selected quasi-randomly from the list of 60 CS_1 stimuli so that they contained CS_1 previously paired with a negative or neutral US. The position of the CS_1 was randomized. Participants were given five seconds to select the correct match with the computer mouse. Participants completed 60 trials (i.e., all US). For the first 24 participants, one trial for this phase was removed due to the erroneous placement of two identical lures (i.e., experimenter error). Analysis of these participants’ data was done for the remaining fifty-nine trials of this phase.

Second-order Associative Test Phase. The second-order test phase was procedurally identical to the first-order test phase but involved pairing of first- and second-order CS (‘CS_1-CS_2’), with the CS_1 as the cue.

Transfer of Valence Rating Phase. In a final phase, participants were shown all of the 120 CS again (in a random order) and were asked to rate their pleasantness. Each image appeared on the screen with the prompt *“How pleasant is this item?”* and participants had up to four seconds to select a rating on a slider scale between 1 *(Very Unpleasant)* and 6 *(Very Pleasant).*

Results

Associative Memory

A repeated-measures ANOVA was conducted with within-subject factors of emotion (negative, neutral) and order (first, second) for participants' associative memory performance. As expected, there was a significant main effect of emotion, $F(1,67) = 13.47$, $p < .001$, $\eta_p^2 = .17$, with negative pairs remembered worse than neutral pairs, as shown in Figure 3A. There was also a significant main effect of order, $F(1,67) = 98.74$, $p < .001$, $\eta_p^2 = .60$, with first-order pairs remembered better than second-order pairs. The emotion x order interaction was also significant, $F(1,67) = 4.63$, $p = .035$, $\eta_p^2 = .07$. To decompose the interaction, paired-samples t-tests were conducted. There was a significant effect of emotion only in the first-order pairs ($t(67) = 4.45$, $p < .001$, $d = 0.54$), such that performance was lower for the negative ($M = 0.60$, $SD = 0.16$) versus neutral pairs ($M = 0.67$, $SD = 0.16$). Note that the effect size is very consistent with Madan et al. (2017). In the second-order pairs, there was no significant memory difference between the negative ($M = 0.44$, $SD = 0.18$) and neutral ($M = 0.46$, $SD = 0.19$) pairs ($t(67) = 0.88$, $p = .382$, $d = 0.11$). Thus these findings show that memory was better for CS_1-US pairings involving neutral versus negative CS. Ancillary analyses of reaction time (RT) for correct trials showed that participants were slower to make their decision in the negative versus neutral condition for first-order pairs only (see Supplementary Materials).

Transfer of Valence Ratings

A repeated-measures ANOVA was conducted with within-subject factors of emotion (negative, neutral) and image order (first, second) for participants' ratings of the CS. In accordance with our hypothesis, there was a significant main effect of emotion, $F(1,67) = 4.93$, $p = .030$, $\eta_p^2 = .07$, with CS previously paired with a negative US rated as less pleasant than CS previously paired with a neutral US, as shown in Figure 3B. There was no significant main effect of order, $F(1,67) = 2.70$, $p = .105$, $\eta_p^2 = .04$. The emotion x order interaction was significant, $F(1,67) = 11.18$, $p = .001$, $\eta_p^2 = .14$. To decompose the interaction, paired-samples t-tests were conducted to compare pleasantness ratings differences between emotion conditions for CS_1 and CS_2, which revealed an effect of emotion in the first-order pairs ($t(67) = 3.39$, $p = .001$, $d = 0.41$), wherein CS_1 previously paired with negative US ($M = 3.25$, $SD = 0.58$) versus CS_1 previously paired with neutral US ($M = 3.37$, $SD = 0.50$) were rated as less pleasant. This effect size is consistent with that of Hofmann et al., 2010, albeit slightly weaker. In the second-order pairs, there was no significant difference ($t(67) = 0.35$, $p = .725$, $d = 0.04$) between ratings of CS_2 in the negative ($M = 3.35$, $SD = 0.49$) versus neutral ($M = 3.34$, $SD = 0.49$) condition. Thus, these findings show that CS pairings with negative versus neutral US reduced the pleasantness of CS but only on the first-order. Ancillary analyses of RT did not reveal any significant condition differences, neither in the first- nor second-order condition (see Supplementary Materials).

Transfer of Valence Ratings Conditionalized on Associative Memory

To determine if the effect of emotion on valence ratings in the first-order pairs was contingent on performance in the associative memory phase, a repeated-measures ANOVA was conducted with within-subject factors of emotion (negative, neutral) and memory (correct, incorrect) for participants' ratings of CS_1 only. Due to missing data (e.g., a participant who only had correct or missed test trials would have no average rating for incorrectly associated CS) a listwise deletion resulted in $N = 67$ for this analysis. The emotion x memory interaction was significant, $F(1,66) = 6.61$, $p = .012$, $\eta_p^2 = .09$. To follow up on the interaction, paired-samples t-tests were conducted to compare pleasantness rating differences between emotional conditions for correctly associated and incorrectly associated CS. For correct trials (negative: M = 3.19, SD = 0.63; neutral: M = 3.36, SD = 0.52; $t(66)$ = 3.56, p = .001, d = 0.43), but not incorrect trials (negative: M = 3.40, SD = 0.54; neutral: M = 3.37, SD = 0.62; $t(66)$ = 0.58, p = .565, d = 0.07), there was an effect of emotion. Thus, these findings suggest that the effects of emotion on valence ratings (transfer of valence) were specific to trials in which participants explicitly remembered the association. As an exploratory analysis, we examined the correlation between individual differences in transfer of valence, namely valence rating difference scores (negative − neutral) and associative memory performance for negative pairs for first order. This correlation was not significant ($r(66)$ = −.025, p = .837).

Experiment 2

This study was pre-registered as an in-person study: https://aspredicted.org/blind.php?x=qb4sm2. However, this was adjusted to be completed entirely online (due to the COVID-19 pandemic). Deviations from the pre-registration (e.g., online data collection instead of in person, additional exclusionary criteria for online testing, etc. are explicitly noted). The purpose of this experiment was to examine the role of stimulus novelty in transfer of valence (and to replicate key findings in Experiment 1).

Methods

Participants

This study was conducted with a new set of 88 participants. A total of 38 participants were excluded based on the criteria outlined earlier (see Table S1), resulting in a sample of N = 50. Note that this is lower than our target sample of N = 60 from our pre-registration (but was still sufficiently powered to detect significant effects based on the effect sizes observed in Experiment 1). However, we initially did not anticipate such a high exclusion rate with online data collection. The final sample comprised 37 females and 13 males with an education range of 12 to 18 years and a mean age of 20.90 years (SD = 2.53).

Measures

The NAPS images (Marchewka et al., 2014) used in this experiment were identical to those used in Experiment 1. To select BOSS (Brodeur et al., 2014) and NOUN (Horst & Hout, 2016) images, hereafter referred to as familiar and novel CS, respectively, a norming study was conducted in an independent sample to ensure that the final images differed in familiarity but not in other relevant image characteristics (see Supplemental Materials for details of the norming study).

Procedure

The study was conducted online on Pavlovia.org with PsychoPy (v2020.1.2; Pierce et al., 2019). Participants completed a total of three experiment phases, all occurring in a one-hour timeslot.

Encoding Phase. Participants were shown 30 familiar and 30 novel CS, each paired with either a neutral or a negative US. The encoding phase in this experiment was procedurally identical to Experiment 1. The pairing of familiar/novel CS and negative/neutral US was counterbalanced across participants. As noted in the introduction, Experiment 2 involved only first-order pairs.

Short Break. Participants were given a 10 minute break, where they were presented with a word search puzzle to attempt. After 10 minutes, the experiment automatically proceeded to the next phase.

Associative Test Phase. Participants next completed an alternative forced choice memory task involving all of the encoded US that was procedurally identical to the test phases in Experiment 1 but the cued US was surrounded by either five familiar or five novel CS from the encoding phase, one of which was the correct image.

Transfer of Valence Rating Phase. Participants were shown each of the 30 familiar and 30 novel CS from the encoding phase in a random order and asked to rate their pleasantness, as in Experiment 1.

Results

Associative Memory

A repeated-measures ANOVA was conducted with within-subject factors of emotion (negative, neutral) and image type (familiar, novel) for participants' associative memory performance. As expected, there was a significant main effect of emotion, $F(1,49) = 14.75$, $p < .001$, $\eta_p^2 = .23$, with negative CS-US pairs ($M = 0.54$, $SD = 0.19$) remembered worse than neutral CS-US pairs ($M = 0.61$, $SD = 0.18$). There was no significant main effect of image type, $F(1,49) = 3.36$, $p = .073$, $\eta_p^2 = .06$. The emotion x image type interaction was not significant, $F(1,49) = .74$, $p = .394$, $\eta_p^2 = .02$, as shown in Figure 4A. As the Kolmogorov-Smirnov normality test was significant for at least one variable, we reran the analysis (negative versus neutral) with non-parametric tests (Wilcoxon Signed Rank Test), as per our pre-registration, and the pattern of significance did not change.

Transfer of Valence Ratings

A repeated-measures ANOVA was conducted with within-subject factors of emotion (negative, neutral) and image type (familiar, novel) for participant's pleasantness ratings. As expected, there was a significant main effect of emotion, $F(1,49) = 11.22$, $p = .002$, $\eta_p^2 = .19$, with CS paired with negative US ($M = 3.20$, $SD = 0.65$) rated as less pleasant than CS paired with neutral US ($M = 3.32$, $SD = 0.64$). There was also a significant main effect of image type, $F(1,49) = 8.03$, $p = .007$, $\eta_p^2 = .14$, with novel CS ($M = 3.13$, $SD = 0.76$) rated as less pleasant overall than familiar CS ($M = 3.39$, $SD = 0.65$). Contrary to our hypothesis, however, the emotion x image type interaction was not significant, $F(1,49) = 0.07$, $p = .796$, $\eta_p^2 = .001$. In other words, the magnitude of the transfer of valence effect was not larger for novel CS; see Figure 4B. The comparison of negative versus neutral was also significant with non-parametric testing.

Transfer of Valence Ratings Conditionalized on Associative Memory

To determine if the effect of emotion on valence ratings was contingent on performance in the associative memory phase, a repeated measures ANOVA (not pre-registered) was conducted with within-subject factors of emotion (negative, neutral) and memory (correct, incorrect) for participants' ratings (collapsed across novel and familiar CS). Again, due to missing data, a listwise deletion resulted in a sample of *N* = 48 for this analysis. There was a significant main effect of emotion, $F(1,47) = 7.76$, $p = .008$, $\eta_p^2 = .14$, with CS paired with negative US rated as less pleasant than CS paired with neutral US. There was also a significant main effect of memory, $F(1,47) = 4.40$, $p = .041$, $\eta_p^2 = .09$, with correct trials rated as more pleasant than incorrect trials. Crucially, the emotion x memory interaction was not significant, $F(1,47) = 0.19$, $p = .669$, $\eta_p^2 = .004$. Because we were particularly interested in how the transfer of valence effect may be related to episodic memory, we conducted exploratory post-hoc analyses, although the interaction was not statistically significant. These tests revealed that the transfer of valence effect was statistically significant only for correct trials (negative: *M* = 3.23, SD = .71; neutral: *M* = 3.39, *SD* = .65), $t(47) = 2.50$, $p = .016$, *d* = 0.36, while there was no significant difference for incorrect trials (negative: *M* = 3.15 *SD* = .78; neutral: *M* = 3.26, *SD* = .79), $t(47) = 1.14$, $p = .259$, *d* = 0.17). This pattern of results were confirmed with non-parametric tests. As an exploratory analysis (not pre-registered), we examined the correlation between individual differences in transfer of valence, namely valence rating difference scores (negative − neutral) and associative memory performance for negative pairs. This correlation was not significant ($r(48) = .027$, $p = .850$).

Experiment 3

Experiment 3 was also conducted online with the same procedure as Experiment 2. This experiment was conducted to replicate Experiment 2 and further explore the effect of explicit memory in transfer of valence. To do so, we devised a source memory and open-ended cued recall task to probe how much participants explicitly remembered when seeing each neutral CS.

Methods

Participants

This study was conducted with a new set of 85 participants. A total of 27 participants were excluded (see Table S1), resulting in a final sample of 58 participants. This sample comprised 42 females and 16 males with an education range of 12 to 20 years and a mean age of 21.74 years (*SD* = 3.16).

Measures

The stimuli were the same as the ones used in Experiment 2.

Procedure

The study was conducted online on Pavlovia.org with PsychoPy (v2020.1.2; Pierce et al., 2019). Participants completed a total of three experiment phases, all occurring in a one-hour timeslot. See Figure 2.

Encoding Phase. Participants completed the exact same encoding phase as in Experiment 2; including the same counterbalancing procedure.

Short Break. Participants were given a 10 minute break, where they were presented with the same word search puzzle as in Experiment 2. After 10 minutes, the experiment automatically proceeded to the next phase.

Transfer of Valence Rating Phase. Participants completed the same valence rating task as in Experiment 2.

Source Memory and Cued Recall. Participants were presented with the 30 familiar and 30 novel CS they previously encoded in a random order and were first asked to indicate whether that image was paired with a neutral or negative US (source memory test). The familiar or novel CS was shown in the middle of the screen with the word ‘neutral’ on the left and ‘negative’ on the right. Participants had up to five seconds to click on either word that indicated their response. Immediately after, participants were shown the same image with the prompt *“In 4-5 words, please describe the image that was paired with this item. This may seem like a hard task but try your best. If you are really unsure, please type ‘I don't know’”.* Participants were given up to 10 seconds to provide a typed response (open-ended cued recall). This response appeared on the screen as they typed it out. The scoring of the open-ended responses for ‘correct’ or ‘incorrect’ is described in the Supplemental Materials.

Results

For consistency with prior experiments, the results of the memory tasks are reported before the transfer of valence task.

Source Memory

A repeated-measures ANOVA was conducted with within-subject factors of emotion (negative, neutral) and image type (familiar, novel) for participants’ source memory. There was a significant main effect of emotion, $F(1,57) = 4.08$, $p = .048$, $\eta_p^2 = .07$, with source memory worse for the negative ($M = 0.52$, $SD = 0.24$) versus neutral ($M = 0.63$, $SD = 0.21$) condition. There was no significant main effect of image type, $F(1,57) = 0.49$, $p = .488$, $\eta_p^2 = .01$. The emotion x image type interaction was not significant, $F(1,57) = 1.28$, $p = .263$, $\eta_p^2 = .02$; see Figure 5A. (We note that this negative versus neutral comparison was only marginal with the non-parametric test, $p = .08$.) To determine if participants’ source memory performance was above chance, a one-sample t-test for each emotion condition was conducted. The results show that source memory performance was not significantly different from chance in the negative condition, $t(57) = 0.70$, $p = .488$, $d = 0.09$. By contrast, in the neutral condition, source memory performance was significantly above chance, $t(57) = 4.73$, $p < .001$, $d = 0.62$. Overall, these results suggest that, in an explicit memory test, participants were not good at identifying the valence source of the US when presented with the CS. Nonetheless, these analyses are limited in that we did not include lure items, and thus cannot account for bias. Moreover, they do not rule out the possibility that source memory contributed to transfer of valence. Accordingly, we next asked: are participants who are more likely to choose negative when the source was in fact negative (Negative|Negative) as opposed to neutral (Negative|Neutral) more likely to show a larger transfer of valence effect (i.e., Negative|Negative – Negative|Neutral)? We found that the Pearson correlation was statistically significant: (r = −.529, p < .001; see Figure 5D). Note that we reran these analyses with a Spearman correlation due to the possible presence of multivariate outliers and the result was still statistically significant (rho = −.317, p = .015).

Cued Recall

A repeated-measures ANOVA was conducted with within-subject factors of emotion (negative, neutral) and image type (familiar, novel) for participants’ cued recall memory performance. There was no significant effect of emotion, $F(1, 57) = 0.10$, $p = .752$, $\eta_p^2 = .002$ or image type, $F(1, 57) = 1.81$, $p = .184$, $\eta_p^2 = .03$ on cued recall memory performance. Additionally, the emotion x image type interaction was not significant, $F(1, 57) = 0.03$, $p = .858$, $\eta_p^2 = .001$; see Figure 5B Performance on this task was overall very poor (see Table S4). These results suggest that participants were not able or willing to generate episodic details about the US previously paired with the CS. We next asked: do participants with better free recall performance in the negative condition have a larger transfer of valence effect? We found a statistically significant correlation: ($r = -.404$, $p = .002$; see Figure 5E). The spearman correlation was also significant (rho = −.277, $p = .035$).

Transfer of Valence Ratings

A repeated measures ANOVA was conducted with within-subject factors of emotion (negative, neutral) and image type (familiar, novel) for participants' ratings. As expected, there was a significant main effect of emotion, $F(1,57) = 19.51$, $p < .001$, $\eta_p^2 = .26$, with CS paired with negative US ($M = 2.63$, $SD = 0.81$) rated as less pleasant than CS paired with neutral US ($M = 2.86$, $SD = 0.70$). There was also a significant main effect of image type, $F(1,57) = 4.15$, $p = .046$, $\eta_p^2 = .07$, with novel CS ($M = 2.69$, $SD = 0.76$) rated as less pleasant than familiar CS ($M = 2.80$, $SD = 0.76$). The emotion x image type interaction was not significant, $F(1,57) = 1.29$, $p = .261$, $\eta_p^2 = .02$. Hence, the ratings results of Experiment 3 replicate those of Experiment 2; see Figure 5C.

Discussion

In the present study, we show that negative emotion impairs associative memory. Critically, within the same paradigm, we show that negative emotion reduces preference for associated stimuli (i.e., transfer of valence). As detailed below, our findings align two bodies of work in important ways.

First considering our associative memory effects, across all three experiments, we show that negative emotion impairs associative memory. In Experiments 1 and 2, this was evidenced by reduced recognition performance for negative versus neutral US cues; in Experiment 3, we show reduced source memory (i.e., was the US negative or neutral) for negative CS cues. (We did not observe an impairing effect of emotion on cued recall in Experiment 3, likely due to near floor-level performance in this task.) Our findings broadly align with prior literature using different types of associative paradigms, including words, static images, and video clips (e.g., Bisby & Burgess, 2014; Fujiwara et al., 2021; Madan et al., 2012, 2017; Palombo et al., 2021; Rimmele et al., 2011; Zimmerman & Kelley, 2010).

Why does negative emotion impair associative memory? Are these results due to augmented attention (i.e., attentional bias for emotional items themselves)? Although attentional capture certainly accounts for some effects of emotion on memory, such an explanation is unlikely to be the dominant mechanism at play. First, emotion can disrupt associative memory, even for negative-negative pairs (Bisby & Burgess, 2014; Fujiwara et al., 2021; Madan et al., 2012, 2017; Zimmerman & Kelley, 2010), as well as pairs with sequentially presented items (i.e., when the neutral item either precedes or follows a neutral item; e.g., Madan et al., 2012, 2019), where the influence of attentional narrowing or competition between items would be more limited. Second, when participants encode item-context pairs, wherein the background context predicts either safety or threat (mild shock), item memory is not affected but associative memory for the item-context pairing is impaired (Bisby & Burgess, 2014). Albeit a different paradigm, those latter results also speak against a simple attentional account for associative disruption due to emotion. Moreover, impairments are observed both in incidental (e.g., Bisby & Burgess, 2014) and intentional paradigms (e.g., Madan et al., 2012; 2017; the present paradigm), the latter of which is more likely to augment attention to the pairs. Instead, it seems that emotion disrupts stimulus-stimulus binding per se, resulting in a weakening of associative representation. We note though that such binding effects seem to be specific to *between-item* associations, as emotion seems to enhance *within-item* associations (e.g., the color of a stimulus; see Mather, 2007, for a review). Still, it is important to highlight that there are important boundary conditions for these effects, including valence, retention interval, etc., (Pierce & Kensinger, 2011, Madan et al., 2012, 2017, 2020) and potentially goal relevance or predictive utility, which may produce opposite effects (Mather & Sutherland, 2011; Levine & Edelstein, 2009; Palombo & Cocquyt, 2020). Insufficient effort to encode emotional associations may also be a cause for this impairment, as several studies have observed over-estimations in judgements of learning for emotional pairs (Caplan et al., 2019; Palombo et al., 2021; Zimmerman & Kelley, 2010).

Turning to our transfer of valence findings, we showed, across all three experiments, that preferences are reduced for neutral CSs when they occur alongside negative US. These findings align with prior work in the field of evaluative conditioning (e.g., Levey & Martin, 1975; Staats & Staats, 1958, Walther, 2002; Gast et al., 2012; see Hofmann et al., 2010), as well as a recent study that also examined transfer of valence and associative memory (Madan & Kensinger, 2021). While Madan and Kensinger (2021) did observe the two effects observed here, their design prevented them from finding both in the same experiment. In comparison to their study, the current experiments are further refined in two substantial ways: (1) While associations here did not involve highly familiarized images, Madan and Kensinger used images of famous places as the first-order associate for the transfer of valence to occur. Pre-experimental familiarity with these images may have led to some resistance to the transfer of valence. (2) The famous place pictures were used to test for a summation of transfer of valence across accumulated episodic associations, which led to relatively poor associative memory performance (in their Experiment 1). In contrast, in the present study, we had fewer associations for participants to learn. As a result of poor associative memory performance, Madan and Kensinger's findings were not suitable for conducting conditionalized analysis to examine how the transfer of valence was related to associative memory. Nonetheless, in a subsequent experiment that did not measure transfer of valence, associative memory was indeed impaired for negative emotional associations as compared to neutral ones.

What mechanisms account for transfer of valence effects? Several theoretical accounts have been posed (Hofmann et al., 2010; see Walther, Weil et al., 2011): According to propositional accounts (e.g., Mitchell et al., 2009; De Houwer, 2009), transfer of valence occurs via the formation of a proposition that a CS *goes with* a US. By contrast, according to referential accounts, transfer of value occurs because the CS and US become linked (Baeyens et al., 1992). In one earlier version of this latter account, Levey and Martin (1975) suggest that co-occurrence of a CS-US results in a holistic formation of a representation that includes stimulus elements of both the CS and US. Similarly, Walther et al. (2018) recently proposed an integration mechanism where features of the CS and US are 'fused' into a representation. Still it is notable that it is less clear from these models precisely how this 'fusing' process manifests. Perhaps because emotional items evoke a strong context (namely, a mental representation triggered by the presence of stimuli, such as feelings of fear or physiological changes), it is the context that gets tagged onto adjacent stimuli (Howard & Kahana, 2002; Talmi et al., 2019; Palombo & Cocquyt, 2020).[1]

One key difference between these models is their position on the role of awareness in transfer of valence. In propositional models, knowledge acquisition of the CS-US link is effortful and requires conscious awareness (and can possibly be used as justification for a change in preference). A related view likewise postulates a role of episodic memory but not necessarily the formation of propositions per se (see Stahl & Aust, 2018). In referential models, the CS-US linking is thought to be automatic (and does not require explicit awareness of the CS-US pairing). Relevant to this issue, a key question for us in the present study was whether the emotional associative impairment and transfer of valence effect co-occur: Even when emotion impairs the ability to remember associations, does transfer of valence still take place? The answer to this question speaks to the issue of awareness that has been debated. Accordingly, Experiments 1 and 2 showed that the effect only occurred when associative memory (in the alternative forced choice task) was successful.

In both Experiments 1 and 2, participants' explicit memory was tested using a recognition procedure—thus, both associates were visually available. In contrast, the transfer of valence tests occurred with the CS in isolation. Accordingly, in Experiment 3 we further asked: What do people remember when they are only presented with the CS (comparable to the conditions in which they make their preference judgements)? Here we found that participants were no better than chance at recognizing when a CS had previously been paired with a negative US (although they were slightly above chance with neutral US) and their cued recall was overall quite poor. However, we note that our source memory task was somewhat flawed as we did not account for bias effects due to the absence of lures. Critically, however, we found that the strength of source memory as well as cued recall was associated with transfer of valence, suggesting again, that episodic memory may be important for transfer of valence. The observed role of episodic memory is thus more broadly aligned with propositional models, or at a minimum, models that endorse the role of episodic processes (see Stahl & Aust, 2018).

Our results are consistent with some but not all studies of transfer of valence that highlight the role of explicit memory processes. Notably, our results align with a compelling study by Bar-Anan et al., 2010, which used a large sample (N = 570 and N = 591 across two experiments) to show that transfer of valence is contingent on awareness and may be used by participants as a basis for judging the CS. Nonetheless, the majority of published studies on this topic focus on repeated presentations of CS-US pairs (see Walther, Weil et al., 2011 for discussion) making comparisons difficult to our single-trial encoding paradigm. Critically, our results are also in line with data from the few studies that likewise use single-trial exposure, including a recent study showing that a directed forgetting manipulation reduced memory as well as transfer magnitude (Gast & Kattner, 2016). Moreover, in a recent single-trial exposure study

[1] Indeed this notion is somewhat reminiscent of other accounts that focus on the misattribution of the US to the CS, which is thought to be an implicit process that results in the CS acquiring the US valence (e.g., see Jones, Olson, & Fazio, 2010).

by Forester et al. (2020)[2], the effect of encoding-related neural activity (frontal slow-wave activity measured with ERPs) contributed to both successful episodic encoding and transfer of valence. Trial-level analyses showed that the relationship between this neural pattern and transfer of valence depended on the strength of episodic memory. Thus, these data suggested common encoding mechanisms for episodic memory and transfer of valence (also see Stahl & Aust, 2018). Nonetheless, the magnitude of the transfer of valence effect is subject to a host of boundary conditions, as evidenced by meta-analytic data provided by Hofmann et al., 2010, which summarizes a number of evaluative conditioning paradigms.

Traditionally, conditioning and episodic memory have been part of siloed literatures ("ships passing in the night"; Dunsmoor & Kroes, 2019). Yet, it is important to consider the extent to which the mechanisms that support transfer of valence and episodic memory are related. Relevant to this, at the neural level, fMRI data suggest that dampening of hippocampal activity during emotional encoding may underlie disrupted associative processing due to negative emotion, such as the ones observed here (Bisby et al., 2016; Fujiwara et al., 2021; Madan et al., 2017). It is less clear what neural mechanisms support negative transfer of valence, although other data implicates the hippocampus, striatum, and vmPFC in the realm of reward-based transfer of valence (Wimmer & Shohamy, 2012; Benoit et al., 2019), findings that align with the broader neural connectivity patterns and functional synergy of these regions. Based on the conditioning literature more broadly, a network involving the amygdala is also likely relevant for supporting this effect (also see Yonelinas & Ritchey, 2015). Future neuroimaging research could help elucidate this and can shed light about whether, mechanistically, these brain regions support a transfer of valence 'on the fly' during encoding *or* at the time of retrieval (see Stahl & Aust, 2018). Note though that the type of 'conditioning' examined here, namely evaluative conditioning, is thought to be somewhat distinct from classical (Pavlovian) conditioning in terms of patterns of presentation, acquisition, and extinction (see Hoffman et al., 2010).

In Experiment 1, we did not observe a second-order associative or transfer of valence effect. Second-order effects are less commonly explored in episodic memory paradigms with single CS-US pairings, although there is some data to support such effects. For example, Bisby and colleagues (2018) had participants encode sequential pairs of stimuli (i.e., AB BC CD), such that in the first pair, B items were either negative or neutral. Emotion impaired associative memory not only for AB and BC pairs, but critically it also impaired memory for CD pairs. However, we note that the pairs in that study were presented in a sequential format, whereas our paradigm involved blocking of first- and second-order trials (there are a number of other differences between their paradigm and ours). In terms of transfer of valence effects, our findings are in contrast to work by Walther (2002) where pre- or post-spreading effects were observed (also see Wimmer & Shohamy, 2012, which used reward stimuli). Other work has also shown higher-order effects, but they tend to be related to a stimulus category (i.e., 'generalization'), such as exemplars of a social category that is shared in common with the CS (e.g., Spruyt et al., 2014; Hütter et al., 2013; Glaser et al. 2017). We speculate that second-order effects are harder to observe with single CS-US pairings (for comparison Walther, 2002, repeated each CS-US pair five times) as additional exposure would strengthen the memory trace. Arousal might also be a relevant factor. Indeed, literature shows that transfer of valence effects (first-order) are more pronounced when CS-US pairings involve mild electronic shock as the US (Hofmann et al.,

[2] Akin to our study, Forester also used intentional encoding.

2010; meta-analysis). Had we used a stronger US, this might have facilitated second-order effects, even with only one exposure.

Contrary to our expectation, novelty did not alter the magnitude of the transfer of valence effect. Prior work had shown that valence can alter preferences for both familiar and novel stimuli, but it is less clear whether novel stimuli are more amenable to such effects, though some literature suggests this might be the case (Walther, Ebert et al., 2011). For example, Walther, Ebert et al. (2011) showed that transfer of valence effects were stronger for fictitious brand names as compared to known product visuals and the authors speculate that the stronger effects for the fictitious brand names may be due to their novelty. Contrary to this suggestion and our intuition, we directly manipulated novelty but did not observe an interaction with transfer of valence.

Our study has limitations. First, although we matched our US with respect to image categories (e.g., faces, objects, people, etc.), as in many prior studies, we did not control for semantic cohesiveness, namely the degree of semantic similarity of the images within valence condition (Barnacle et al., 2021; Talmi & Moscovitch, 2004). If semantic similarity were higher in the negative condition, it may have interfered with associative memory success. On the other hand, prior work shows that semantic cohesiveness cannot fully account for emotional memory phenomena (e.g., Talmi et al., 2007). Second, as we only focused on negative stimuli, we cannot speak to whether the observed effects are due to valence or arousal. Our results should be interpreted with these caveats in mind.

To summarize, our data show that emotion has complex and multifaceted effects on how we later remember and the attitudes and preferences we bring to bear. That newly encountered stimuli can inherit the valence of their naughty neighbours has a host of adaptive implications for humans.

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Supplementary Data

Data associated with all three experiments reported in this manuscript have been deposited into the Open Science Framework: https://osf.io/s938k/?view_only=5fd2b4c65c794c79b80fb1362a45d18d; the read-only link will be made public upon journal acceptance.

References

Baeyens, F., Eelen, P., & Van den Bergh, O. (1990). Contingency awareness in evaluative conditioning: A case for unaware affective-evaluative learning. *Cognition and Emotion, 4*(1), 3-18. https://doi.org/10.1080/02699939008406760

Baeyens, F., Eelen, P., Crombez, G., & van den Bergh, O. (1992). Human evaluative conditioning: Acquisition trials, presentation schedule, evaluative style and contingency awareness. *Behavior Research and Therapy*, *30*(2), 133–142. https://doi.org/10.1016/0005-7967(92)90136-5

Bar-Anan, Y., De Houwer, J., & Nosek, B. A. (2010). Evaluative conditioning and conscious knowledge of contingencies: A correlational investigation with large samples. *Quarterly Journal of Experimental Psychology*, *63*(12), 2313-2335. https://doi.org/10.1080/17470211003802442

Barnacle, G.E., Madan, C.R., & Talmi, D. (2021). Development of a semantically related emotional and neutral stimulus set. *bioRxiv*. https://doi.org/10.1101/2021.01.18.424707

Bechara, A., Tranel, D., Damasio, H., Adolphs, R., Rockland, C., & Damasio, A. R. (1995). Double dissociation of conditioning and declarative knowledge relative to the amygdala and hippocampus in humans. *Science*, *269*(5227), 1115-1118. https://doi.org/10.1126/science.7652558

Benoit, R. G., Paulus, P. C., & Schacter, D. L. (2019). Forming attitudes via neural activity supporting affective episodic simulations. *Nature Communications*, *10*(1), 2215. https://doi.org/10.1038/s41467-019-09961-w

Bisby, J. A., & Burgess, N. (2014). Negative affect impairs associative memory but not item memory. *Learning & Memory*, *21*(1), 21-27. https://doi.org/10.1101/lm.032409.113

Bisby, J. A., Horner, A. J., Horlyck, L.D., & Burgess, N. (2016). Opposing effects of negative emotion on amygdalar and hippocampal memory for items and associations. *Social Cognitive and Affective Neuroscience, 11*, 981-990. https://doi.org/10.1093/scan/nsw028

Bisby, J. A., Horner, A. J., Bush, D., & Burgess, N. (2018). Negative emotional content disrupts the coherence of episodic memories. *Journal of Experimental Psychology: General, 147*(2), 243-256. http://dx.doi.org/10.1037/xge0000356

Buchanan, T. W. (2007). Retrieval of emotional memories. *Psychological Bulletin, 133*(5), 761-779. https://doi.org/10.1037/0033-2909.133.5.761

Brodeur, M. B., Guérard, K., & Bouras, M. (2014). Bank of Standardized Stimuli (BOSS) Phase II: 930 new normative photos. *PLOS ONE, 9*(9), e106953. https://doi.org/10.1371/journal.pone.0106953

Cahill, L., & McGaugh, J. L. (1995). A novel demonstration of enhanced memory associated with emotional arousal. *Consciousness and Cognition*, *4*(4), 410-421. https://doi.org/10.1006/ccog.1995.1048

Caplan, J. B., Sommer, T., Madan, C. R., & Fujiwara, E. (2019). Reduced associative memory for negative information: Impact of confidence and interactive imagery during study. *Cognition and Emotion*, *33*(8), 1745-1753. https://doi.org/10.1080/02699931.2019.1602028

De Houwer, J. (2009). The propositional approach to associative learning as an alternative for association formation models. *Learning and Behavior*, *37*(1), 1-20. https://doi.org/10.3758/LB.37.1.1

Delgado, M. R., Olsson, A., & Phelps, E. A. (2006). Extending animal models of fear conditioning to humans. *Biological Psychology*, *73*(1), 39-48.

https://doi.org/10.1016/j.biopsycho.2006.01.006

Dunsmoor, J. & Kroes, M. (2019). Episodic memory and Pavlovian conditioning: Ships passing in the night. *Current Opinion in Behavioral Sciences, 26*, 32-39. https://doi.org/10.1016/j.cobeha.2018.09.019.

Fujiwara, E., Madan, C. R., Caplan, J. B., & Sommer, T. (2021). Emotional arousal impairs association memory: Roles of prefrontal cortex regions. *Learning and Memory*, *28*(3), 76-81. https://doi.org/10.1101/lm.052480.120.

Forester, G., Halbeisen, G., Walther, E., & Kamp, S. (2020). Frontal ERP slow waves during memory encoding are associated with affective attitude formation. *International Journal of Psychophysiology, 158,* 389-399. https://doi.org/10.1016/j.ijpsycho.2020.11.003

Gast, A., Gawronski, B., & De Houwer, J. (2012). Evaluative conditioning: Recent developments and future directions. *Learning and Motivation*, *43*(3), 79-88. https://doi.org/10.1016/j.lmot.2012.06.004

Gast, A., & Kattner, F. (2016). Single-trial evaluative conditioning can be moderated by instructed forgetting. *Learning and Behavior, 44*(3), 260-269. https://doi.org/10.3758/s13420-016-0210-9

Glaser, T., & Kuchenbrandt, D. (2017). Generalization effects in evaluative conditioning: Evidence for attitude transfer effects from single exemplars to social categories. *Frontiers in Psychology, 8*, 103. https://doi.org/10.3389/fpsyg.2017.00103

Hofmann, W., De Houwer, J., Perugini, M., Baeyens, F., & Crombez, G. (2010). Evaluative conditioning in humans: A meta-analysis. *Psychological Bulletin*, *136*(3), 390-421. https://doi.org/10.1037/a0018916

Horst, J. S., & Hout, M. C. (2016). The Novel Object and Unusual Name (NOUN) Database: A collection of novel images for use in experimental research. *Behavior Research Methods, 48*(4), 1393-1409. https://doi.org/10.3758/s13428-015-0647-3

Howard, M. W., & Kahana, M. J. (2002). When does semantic similarity help episodic retrieval? *Journal of Memory and Language*, *46*(1), 85-98. https://doi.org/10.1006/jmla.2001.2798

Hütter, M., Kutzner, F., & Fiedler, K. (2013). What is learned from repeated pairings? On the scope and generalizability of evaluative conditioning. *Journal of Experimental Psychology: General, 143*(2), 631-643. https://doi.org/10.1037/a0033409

James, E., Ong, G., Henderson, L. M., & Horner A. J. (2020). Make or break it: Boundary conditions for integrating multiple elements in episodic memory. *Royal Society Open Science, 7,* 200431. http://doi.org/10.1098/rsos.200431

Jones, C. R., Olson, M. A., & Fazio, R. H. (2010). Evaluative conditioning: The "how" question. In M. P. Zanna & J. M. Olson (Eds.). *Advances in experimental social psychology* (Vol. 43, pp. 205-255). Cambridge, UK: Academic Press. https://doi.org/10.1016/S0065-2601(10)43005-1

Kensinger, E. A., & Corkin, S. (2003). Memory enhancement for emotional words: Are emotional words more vividly remembered than neutral words? *Memory and Cognition*, *31*(8), 1169-1180. https://doi.org/10.3758/BF03195800

Kensinger, E. A., Garoff-Eaton, R. J., & Schacter, D. L. (2007). Effects of emotion on memory specificity: Memory trade-offs elicited by negative visually arousing stimuli. *Journal of Memory and Language*, *56*(4), 575-591. https://doi.org/10.1016/j.jml.2006.05.004

Levey, A. B., & Martin, I. (1975). Classical conditioning of human ‘evaluative’ responses. *Behaviour Research and Therapy*, *13*(4), 221-226. https://doi.org/10.1016/0005-7967(75)90026-1

Levine, L. J., & Edelstein, R. S. (2009). Emotion and memory narrowing: A review and goal-relevance approach. *Cognition and Emotion*, *23*(5), 833-875. https://doi.org/10.1080/02699930902738863

Madan, C. R., Caplan, J. B., Lau, C. S. M., & Fujiwara, E. (2012). Emotional arousal does not enhance association-memory. *Journal of Memory and Language*, *66*(4), 695-716. https://doi.org/10.1016/j.jml.2012.04.001

Madan, C. R., Fujiwara, E., Caplan, J. B., & Sommer, T. (2017). Emotional arousal impairs association-memory: Roles of amygdala and hippocampus. *NeuroImage*, *156*, 14-28. https://doi.org/10.1016/j.neuroimage.2017.04.065

Madan, C. R., Scott, S. M. E., & Kensinger, E. A. (2019). Positive emotion enhances association-memory. *Emotion*, *19*(4), 733-740. https://doi.org/10.1037/emo0000465

Madan, C. R., Knight, A. G., Kensinger, E. A., & Mickley Steinmetz, K. R. (2020). Affect enhances object-background associations: Evidence from behaviour and mathematical modelling. *Cognition and Emotion*, *34*(5), 960-969. https://doi.org/10.1080/02699931.2019.1710110

Madan, C. R., & Kensinger, E. A. (2021). Exploring the generalisation and specificity of affect across related experiences. *Society for Applied Research in Memory and Cognition.*

Marchewka, A., Żurawski, Ł., Jednoróg, K., & Grabowska, A. (2014). The Nencki Affective Picture System (NAPS): Introduction to a novel, standardized, wide-range, high-quality, realistic picture database. *Behavior Research Methods*, *46*(2), 596-610. https://doi.org/10.3758/s13428-013-0379-1

Mason, A., Madan, C. R., Ludvig, E. A., & Spetch, M. L. (2020). Biased confabulation in risky choice. *PsyArXiv*. https://doi.org/10.31234/osf.io/vphgc

Mather, M. (2007). Emotional arousal and memory binding: An object-based framework. *Perspectives on Psychological Science*, *2*(1), 33-52. https://doi.org/10.1111/j.1745-6916.2007.00028.x

Mather, M., & Sutherland, M. R. (2011). Arousal-biased competition in perception and memory. *Perspectives on Psychological Science, 6*(2), 114-133. https://doi.org/10.1177/1745691611400234

McGaugh, J. L. (2013). Making lasting memories: Remembering the significant. *Proceedings of the National Academy of Sciences*, *110*(Supplement 2), 10402-10407. https://doi.org/10.1073/pnas.1301209110

Mitchell, C. J., De Houwer, J., & Lovibond, P. F. (2009). The propositional nature of human associative learning. *Behavioral and Brain Sciences, 32*(2), 183–246. https://doi.org/10.1017/S0140525X09000855

Palombo, D. J., & Cocquyt, C. (2020). Emotion in context: Remembering when. *Trends in Cognitive Sciences*, *24*(9), 687-690. https://doi.org/10.1016/j.tics.2020.05.017

Palombo, D. J., Te, A., Checknita, K., & Madan, C. R. (2021). Exploring the facets of emotional episodic memory: Remembering 'what', 'when', and 'which.' *Psychological Science.* https://doi.org/10.1177/0956797621991548

Pierce, B. H., & Kensinger, E. A. (2011). Effects of emotion on associative recognition: Valence and retention interval matter. *Emotion, 11*(1), 139-144. https://doi.org/10.1037/a0021287

Pierce, J., Gray, J. R., Simpson, S., MacAskill, M., Höchenberger, R., Sogo, H., Kastman, E., & Lindeløv, J. K. (2019). PsychoPy2: Experiments in behavior made easy. *Behavior Research Methods*, *51*(1), 195-203. https://doi.org/10.3758/s13428-018-01193-y

Radloff, L. S. (1977). The CES-D Scale: A self-report depression scale for research in the general population. *Applied Psychological Measurement*, *1*(3), 385-401. https://doi.org/10.1177/014662167700100306

Riggs, L. Fujioka, T., Chan, J., McQuiggan, D., Anderson, A., & Ryan, J. (2014). Association with emotional information alters subsequent processing of neutral faces. *Frontiers in Human Neuroscience, 8*, 1001. https://doi.org/10.3389/fnhum.2014.01001.

Rimmele, U., Davachi, L., Petrov, R., Dougal, S., & Phelps, E. A. (2011). Emotion enhances the subjective feeling of remembering, despite lower accuracy for contextual details. *Emotion*, *11*(3), 553-562. https://doi.org/10.1037/a0024246

Spielberger, C. D., Gorsuch, R. L., Lushene, R., Vagg, P. R., & Jacobs, G. A. (1983). Manual for the State-Trait Anxiety Inventory. Palo Alto, CA: Consulting Psychologists Press.

Spruyt, A., Klauer, K. C., Gast, A., De Schryver, M., & De Houwer, J. (2014). Feature-specific attention allocation modulates the generalization of recently acquired likes and dislikes. *Experimental Psychology, 61*(2), 85-98. https://doi.org/10.1027/1618-3169/a00028

Staats, A. W., & Staats, C. K. (1958). Attitudes established by classical conditioning. *The Journal of Abnormal and Social Psychology*, *57*(1), 37-40. https://doi.org/10.1037/h0042782

Stahl, C., Unkelbach, C., & Corneille, O. (2009). On the respective contributions of awareness of unconditioned stimulus valence and unconditioned stimulus identity in attitude formation through evaluative conditioning. *Journal of Personality and Social Psychology*, *97*(3), 404-420. https://doi.org/10.1037/a0016196

Stahl, C., & Aust, F. (2018). Evaluative conditioning as memory-based judgment. *Social Psychological Bulletin, 13*(3), 1-30. https://doi.org/10.5964/spb.v13i3.28589

Talmi, D., & Moscovitch, M. (2004). Can semantic relatedness explain the enhancement of memory for emotional words? *Memory & Cognition*, *32*(5), 742-751. https://doi.org/10.3758/BF03195864

Talmi, D., Schimmack, U., Paterson, T., & Moscovitch, M. (2007). The role of attention and relatedness in emotionally enhanced memory. *Emotion*, *7*(1), 89-102, 89-102. https://doi.org/10.1037/1528-3542.7.1.89

Talmi, D., Lohnas, L. J., & Daw, N. D. (2019). A retrieved context model of the emotional modulation of memory. *Psychological Review, 126*(4), 455-485. https://doi.org/10.1037/rev0000132

Todd, R. M., Miskovic, V., Chikazoe, J., & Anderson, A. K. (2020). Emotional objectivity: Neural representations of emotions and their interaction with cognition. *Annual Review of Psychology*, *71*(1), 25-48. https://doi.org/10.1146/annurev-psych-010419-051044

Walther, E. (2002). Guilty by mere association: Evaluative conditioning and the spreading attitude effect. *Journal of Personality and Social Psychology*, *82*(6), 919-934. https://doi.org/10.1037/0022-3514.82.6.919

Walther, E., Ebert, I., & Meinerling, K. (2011). Does cue competition reduce conditioned liking of brands and products? *Psychology & Marketing*, *28*(5), 520-538. https://doi.org/10.1002/mar.20399

Walther, E., Weil, R., & Langer, T. (2011). Why do we like the iPhone? The role of evaluative conditioning in attitude formation. *Social and Personality Psychology Compass*, *5*(7), 473-486. https://doi.org/10.1111/j.1751-9004.2011.00366.x.

Walther, E., Halbweisen, G., & Blask, K. (2018). What you feel is what you see: A binding perspective on evaluative conditioning. *Social Psychological Bulletin*, *13*(3), 1-18. https://doi.org/10.5964/spb.v13i3.27551

Wimmer, G. E., & Shohamy, D. (2012). Preference by association: How memory mechanisms in the hippocampus bias decisions. *Science, 338*(6104), 270-273. https://doi.org/10.1126/science.1223252

Yeh, N., & Koen, J. (2020). Informative and uninformative pre-stimulus encoding cues benefit source memory. *PsyArXiv*. https://doi.org/10.31234/osf.io/qz3am

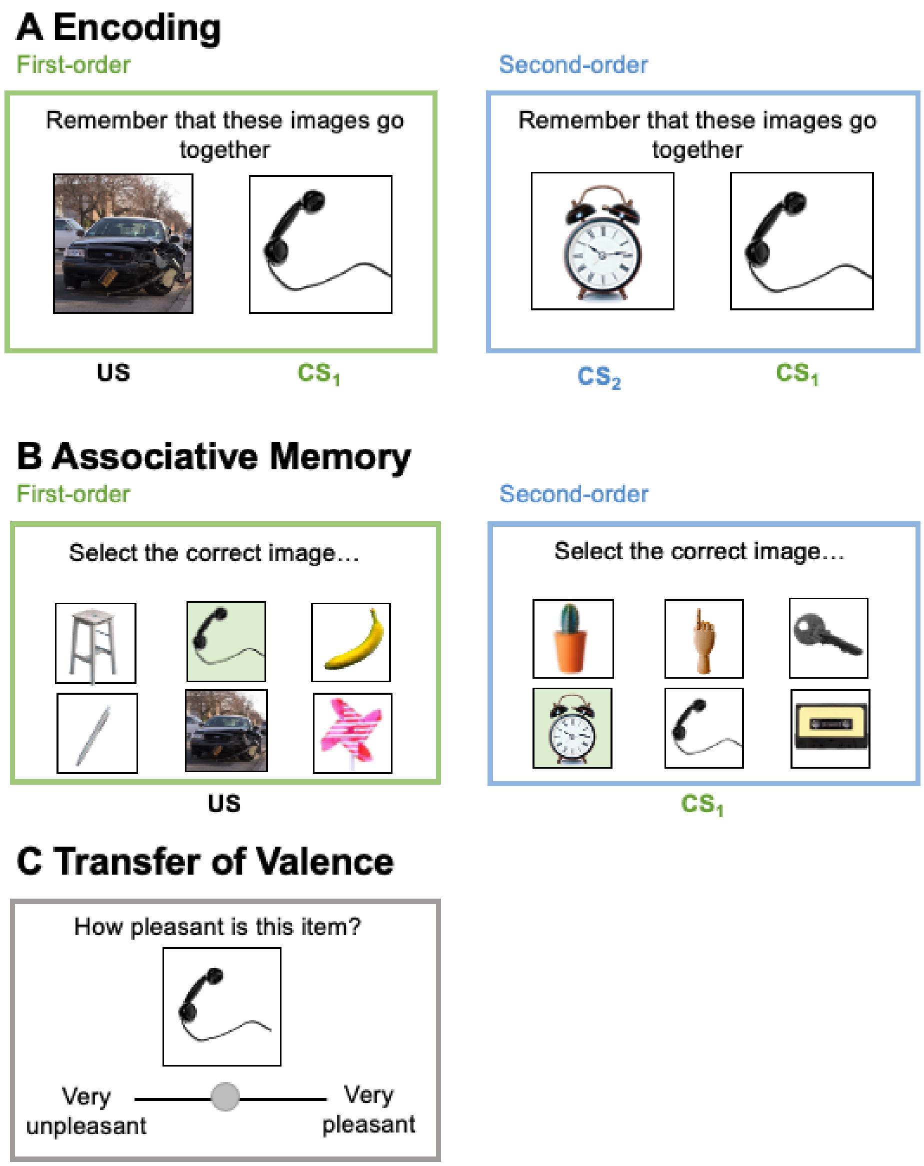
Yonelinas, A. P., & Ritchey, M. The slow forgetting of emotional episodic memories: An emotional binding account. *Trends in Cognitive Sciences, 19*(50), 259-267. https://doi.org/10.1016/j.tics.2015.02.009

Zimmerman, C. A., & Kelley, C. M. (2010). "I'll remember this!" Effects of emotionality on memory predictions versus memory performance. *Journal of Memory and Language, 62*(3), 240-253. https://doi.org/10.1016/j.jml.2009.11.004

Figures

Figure 1

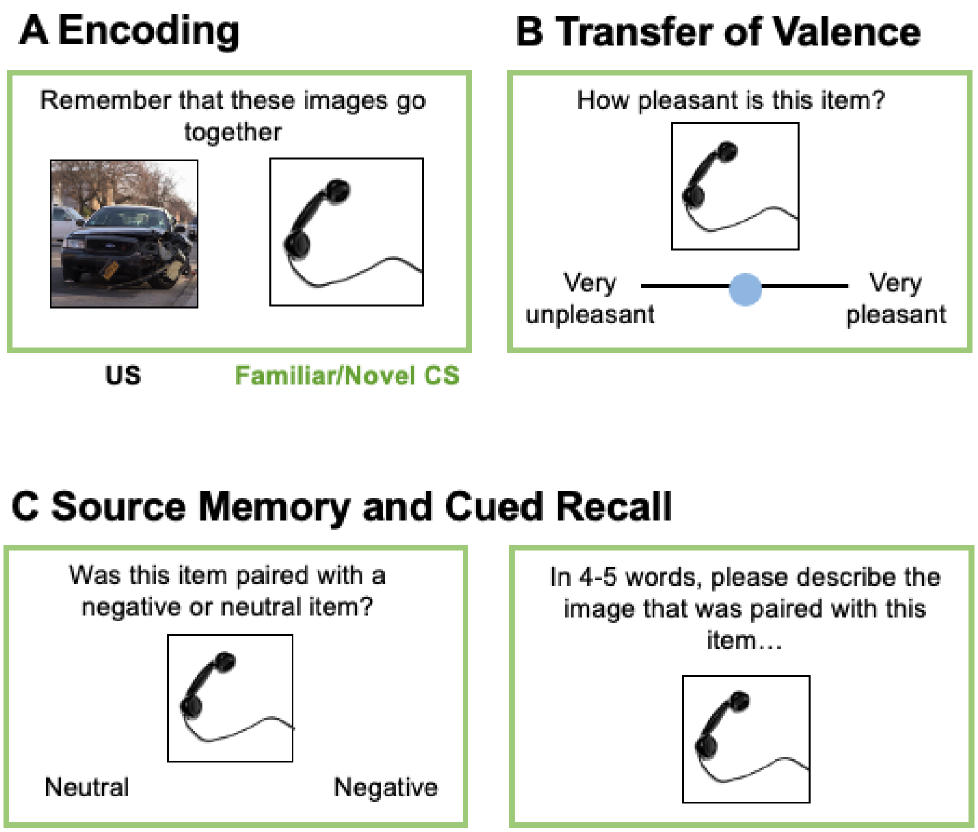
Experiment 1 Paradigm



Note. The images presented here are not from the original databases used. Example images are reprinted from the website *Unsplash*, and are free for use.

Figure 2

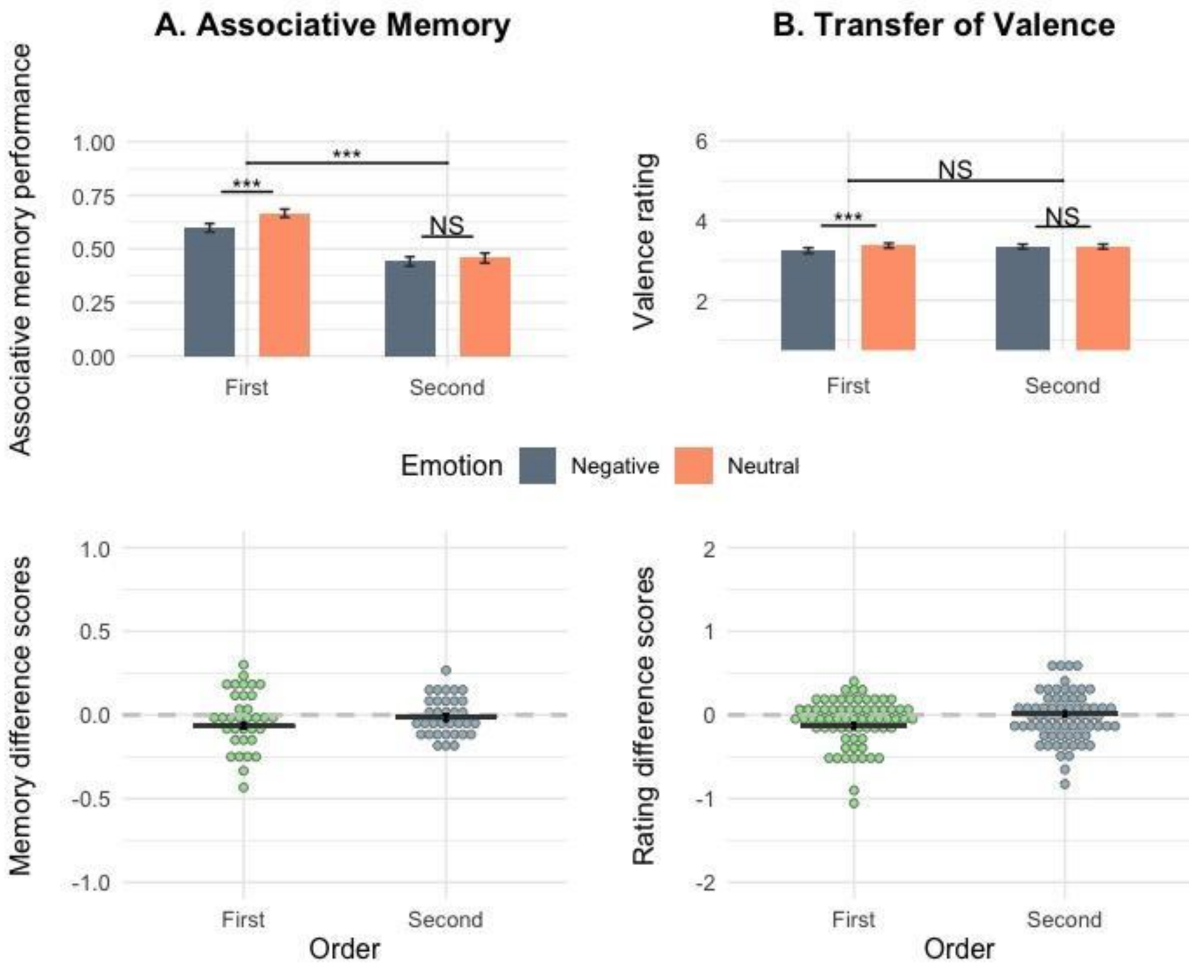
Experiment 3 Paradigm



Note. The images presented here are not from the original databases used. Example images are reprinted from the website *Unsplash*, and are free for use.

Figure 3

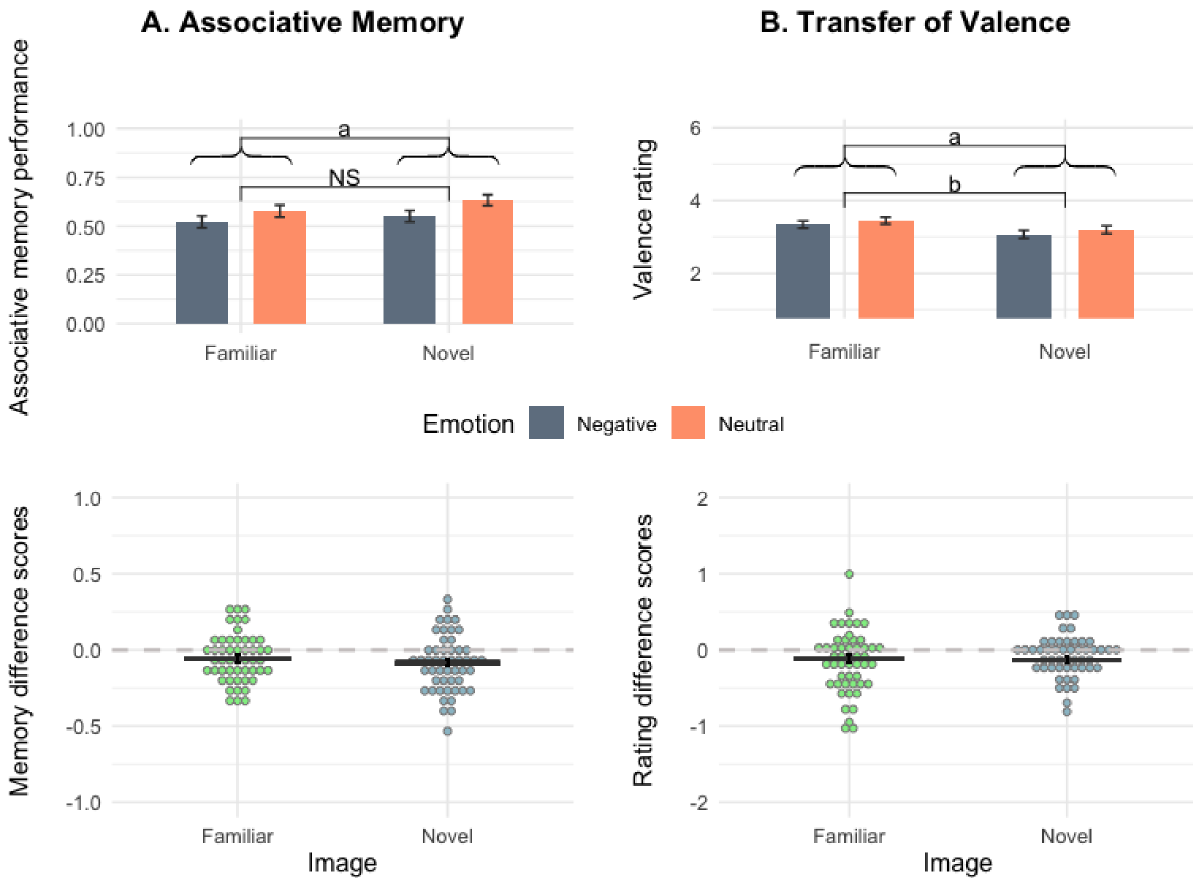
Performance in Experiment 1



Note. Panel A shows the mean associative memory performance for negative and neutral pairings of first and second order CS (error bars show standard errors). Panel B shows the mean valence ratings for negative and neutral pairings of first and second order CS (error bars show standard errors). Difference scores (negative-neutral) for associative memory performance and transfer of valence are shown below (error bars show standard errors; horizontal lines show mean difference).

Figure 4

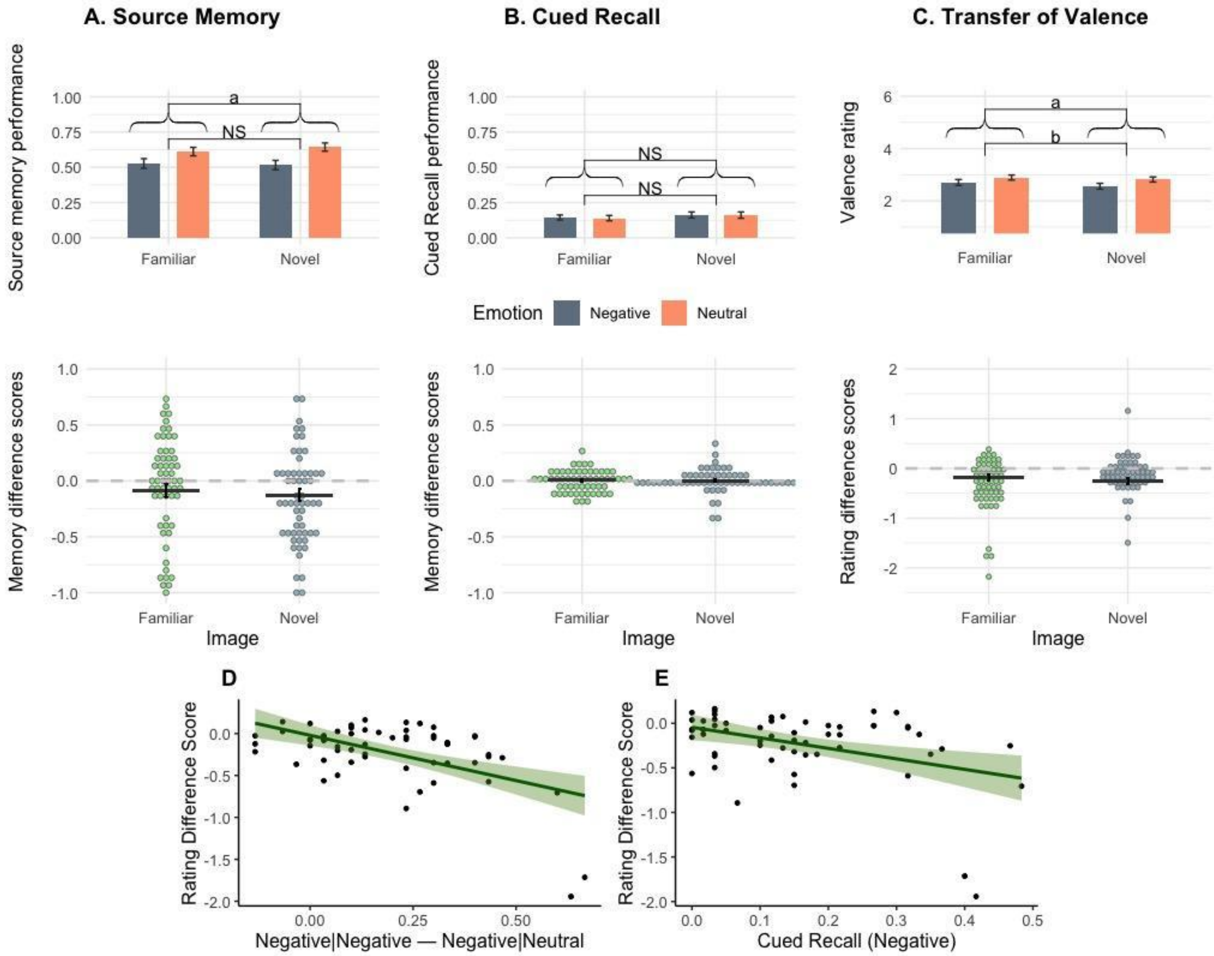
Performance in Experiment 2



Note. Panel A shows the mean associative memory performance for negative and neutral pairings of familiar and novel CS (error bars show standard errors). Panel B shows the mean valence ratings for negative and neutral pairings of familiar and novel CS (error bars show standard errors). Difference scores (negative-neutral) for associative memory performance and transfer of valence are shown below (error bars show standard errors; horizontal lines show mean difference). A lowercase “a” denotes the presence of a main effect of image type whereas a lowercase “b” denotes the presence of a main effect of emotion.

Figure 5

Performance in Experiment 3



Note. Panel A shows the mean source memory performance for negative and neutral pairings of familiar and novel CS (error bars show standard errors). Panel B shows the mean cued recall performance for negative and neutral pairings of familiar and novel CS (error bars show standard errors). Panel C shows the mean valence ratings for negative and neutral pairings of familiar and novel CS (error bars show standard errors). Difference scores (negative-neutral) for source memory performance and transfer of valence are shown below (error bars show standard errors; horizontal lines show mean difference scores). A lowercase "a" denotes the presence of a main effect of image type whereas a lowercase "b" denotes the presence of a main effect of emotion.

Panel D shows the Pearson correlation between rating difference scores (i.e., transfer of valence) and the difference in how likely participants were to choose negative when the source was in fact negative as opposed to neutral. Panel E shows the Pearson correlation between rating difference scores and participants' cued recall performance in the negative condition. Note that these correlations were significant using both Pearson and Spearman correlational analyses, the latter of which is robust to extreme observations.