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The Effect of Emotion on Associative and Item Memory

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by

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ABSTRACT

Numerous studies to date have demonstrated superior memory for emotional compared to neutral stimuli (Kensinger & Corkin, 2004; Bennion et al., 2013). This finding, although relatively stable across the item memory literature, becomes less consistent when examined in tasks measuring memory for associative or source information (Chiu et al., 2013). For this reason, the present study set out to examine how emotional content (negative, positive and neutral word pairs) influences memory in two distinct associative and item recognition tasks: associative identification (AI), associative reinstatement (AR), paired-item recognition, and single-item recognition. In measuring the influence of emotion on associations using an explicit (AI) and implicit (AR) recognition task, our study provides evidence suggesting that the emotion-enhancement (or arousal-dependent amygdala activation) typically observed in the item literature may actually be working against the process of binding (Murray & Kensinger, 2014; Mather, 2007). Additionally, in measuring the influence of emotion in two different item recognition tasks, we also find that presentation of items during encoding and test maybe vital to this effect.

Keywords

Memory, Associative Recognition, Emotion, Item Recognition, Retention Interval

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Introduction

Personal memory for events with strong emotional overtones (i.e., graduating university, getting married, and having children) are believed to be able to stand the test of time, particularly when compared with other non-affective autobiographical events (i.e., what one had for lunch two days ago). Researchers studying this particular improvement in human memory suggest that emotional content, especially when put into the context of our own lives, holds a particular salience against our everyday, mundane experiences. This salience, then, is believed to produce an increase in attention to the emotional information which, as a result, goes through in-depth encoding. However, over the last decade or so, studies exploring the effect of emotion on simple, single-item recognition and recall tasks have demonstrated a similar effect of affect on memory. That is, people have been found to show better memory for events or items that are rated high on valence and arousal (Kensinger & Corkin, 2004; Bennion et al., 2013). For example, a study testing participant recognition for 2507 words that varied in emotion found that memory for both positive and negative stimuli was superior to neutral (Adelman & Estes, 2013). Similarly, in their study of pictures varying in levels of arousal and pleasantness, Bradley, Greenwald, Petry, and Lang (1992) found that participants' performance on a free-recall task was influenced by the dimensions of emotionality, with arousal having the most effect.

In response to these findings, researchers began to propose possible mechanisms behind this emotion-enhanced memory for autobiographically irrelevant information. More specifically, since emotion is thought to be composed of two separate dimensions of arousal (i.e. how exciting the stimulus is) and valence (i.e. whether the stimulus is positive or negative), there remains to be a debate as to whether one or other is of more importance to this observed effect. A review by McGauth (2004) discusses animal studies that demonstrate how the release of stress hormones, such as cortisol, in response to an arousing experience influences memory consolidation via the modulation of amygdala activity. Moreover, McGauth (2004) suggests that basolateral amygdala activation, as a result of emotional arousal, modulates memory consolidation through projections to other brain regions (such as the caudate nucleus, hippocampus, and nucleus accumbens) and is what plays a major role in the long-term memory enhancement we observe. However, other researchers argue that it is not merely arousal that plays a role in this effect of emotion, but rather that valence influences memory as well. Indeed, Kensinger (2009) argues that negative valence, in particular, increases memory for perceptual details of a stimulus. Therefore, it maybe both or one of these mechanisms that influences the affect-dependent recognition and recall observed in numerous single-item memory studies. Still, amongst this growing body of literature on emotion-enhanced memory remains a small subgroup of inconclusive findings on how valence and arousal influences relational and associative information (Chiu, Dolcos, Gonsalves, & Cohen, 2013).

Relational or associative memory differs from single-item recognition or recall as it requires an individual to effectively bind and encode multiple pieces of information together. That is, instead of remembering an event or item as previously experienced, one would have to remember two or more pieces of stimuli as having previously occurred in the presence of the other. This requirement, therefore, makes the test of associative memory more effortful as memory for each individual item in a pairing cannot aid in discriminating which pair is old or new. However, studies demonstrate that factors influencing memory for items often effect memory for associations in a similar way. In particular, researchers have shown that greater concreteness of the to-be-remembered words increases both item and associative recognition, suggesting that if items are more memorable (i.e., participants are able to picture them), this will also influence how participants are able to pair similar items and form associations (Hockley, 1994). Nevertheless, it is also important to note the studied differences between item and associative memory as well. For example, researchers have demonstrated that the time course for (or time required to retrieve) associative information is longer than the time needed to retrieve item information (Gronlund & Ratcliff, 1989). Along the same lines, Hockley (1992) discusses how single item memory may face increased vulnerability to interference and decay in comparison to associative memory (but see Weeks, Humphreys, & Hockley, 2007, for a different interpretation of these results). Additionally, other studies also demonstrate how word frequency, which has been shown to enhance item recognition, does not influence associative recognition in the same way (Hockley, 1994).

It is for this reason that a recent review paper written by Chiu et al. (2013) is of particular interest. Their work outlines the inconsistency among studies examining emotion and different kinds of associative recognition and recall, and consequently leaves open the question on the effects of affect for associative memory. One example in the review, a study by Guillet and Arndt (2009), examined the effects of taboo versus neutral words presented with an unrelated or peripheral neutral word, and found that peripheral neutral words were better recalled when the pairings incorporated a “prohibited” word. Similarly, a study using neutral nouns which were paired with emotional and neutral adjectives found that participants were better able to recall the pairs which incorporated an emotional word (Hertel & Parks, 2002). To the contrary, Peirce and Kensinger (2011), using an associative recognition task where participants were to remember paired emotional and neutral words, found that negative words actually impaired recognition over a short-delay of 15 minutes. With a period of one week between the study and test, however, participants were found to better identify negative studied pairs in comparison to neutral. Finally, another study examining the effect of emotion on both associative and item recognition reports the existence of emotion enhanced memory for single stimuli but fail to find similar results among paired stimuli (Naveh-Benjamin, Maddox, Jones, Old, & Kilb, 2012).

Possible explanations for the lack of emotional-enhanced memory observed for associative information are proposed by Murray and Kensinger (2014). In particular, their neuroimaging study demonstrates a negative correlation between the activation of the left amygdala, and the frontal and hippocampal areas during the integration of negative word pairs. Therefore, with much research suggesting the important role played by the hippocampus in learning or integrating associations in particular, it maybe that emotion enhanced amygdala activation actually impairs or eliminates the commonly seen item-memory-enhancement for associative material via a disruption in initial hippocampal processing, integration, and consolidation (Murray & Kensinger, 2014; Mattfield & Stark, 2015). Still, it is further possible that this inconsistency is simply proof of separate integrative and retrieval neural processes for emotional and neutral information. Moreover, some studies argue that the integration and recognition of neutral stimuli largely occur in the prefrontal cortex and medial temporal lobe, while emotion pairings are learned and remembered via the visual cortex (Murray & Kensinger, 2014).

Nevertheless, the absence of emotion-enhanced memory for associative information in some studies may have a more basic explanation. That is, dual process theory suggests that memory via the individual processes of recollection (a more effortful type of memory) and familiarity (a feeling of oldness accompanying stimuli) would not work similarly between item and associative recognition (Cohen & Moscovitch, 2007). As mentioned earlier, the test of associations, particularly with associative recognition, often requires more effort than a test of single item recognition as familiarity of items cannot aid in the identification of which pair is old or new. Therefore, the standard associative recognition (or associative identification) task could be argued as testing an explicit form of memory rather than the implicit or subtle feelings of familiarity that often aid single item recognition tests (Cohen & Moscovitch, 2007). As a result, the present study set out to expand the literature above and examined the effect of emotion on associative recognition using two distinct tasks. In doing so, we hoped to provide more insight on the relationship between item and associative memory, and whether affect is a factor that influences them in a similar way.

In their study of associative recognition, Cohen and Moscovitch (2007) demonstrate how a short response deadline and speeded recognition impairs performance on the task of associative identification, as expected, while leaving performance on a second task (i.e., associative reinstatement) unaffected. In doing so they provided evidence to support their proposal, based on the dual processes theory of recognition, that associative identification relies on only the process of recollection (which requires time) while associative reinstatement is able to utilize both processes of recollection and familiarity when completing a recognition task, and thus allows for better performance. Therefore, by differing only in test instructions and probe types, both tasks provide different measures of memory for associations. The standard associative recognition task, referred to as *associative identification* (AI or the explicit task) by Cohen and Moscovitch (2007), utilizes two distinct test probes: intact and rearranged pairs. This task requires participants to identify each pair as *old* (or previously seen) or *new* and, as both intact and rearranged test pairs consist of studied words, memory for the individual words cannot aid in the discrimination between the two. Therefore, this associative recognition task requires a more explicit memory for the association between paired words. *Associative reinstatement* (AR or the implicit task), however, is formatted slightly differently and is argued to be a measure of implicit memory for associative information. This procedure includes four different test pair probes: intact, rearranged, old-new, and new-new, and requires that participants indicate whether or not each test pair consists of two old words. In examining both the old test probes, Cohen and Moscovitch (2007) argue, we should see superior memory performance for intact compared to rearranged pairs as the words in the intact pairs are in the identical condition (or pair) they were during study (Tulving & Thompson, 1973) and therefore allows associative information to make a contribution. As a result, this task is suggested to be sensitive to subtle memory for the associations, making it comparable to item recognition.

In addition to the two types of associative recognition tests, the present study also included a single item recognition task, along with a paired item recognition analysis within one of our existing tasks. That is, while our single item recognition task examined memory for words presented individually in a separately constructed test, the paired item recognition analysis was conducted using two of the test probes within our AR task. In their work, Cohen and Moscovitch (2007) demonstrate how recognition for rearranged pairs relies solely on item memory (as both words are old but the pairing is new) and would thus be an effective measure of paired item recognition when compared against new-new probes, where both the words and pairings are novel. In including these two measures of item recognition, we attempt to replicate the results observed in the item literature using the single item test while also exploring the influence of emotion on paired item recognition. Nonetheless, it is important to note that in our experiment the test of single items follows of a study phase in which words are presented and encoded in pairs. This distinction enables it to act as a total replication of the previously discussed single-item memory literature, where all items are encoded and tested individually. Additionally, with no studies to our knowledge examining the differences between the two kinds of item memory, our study will serve as a first look into this as well.

The final purpose of our study was to re-evaluate the role that delay has on the effects observed in our recognition tasks, both individually and in comparison to each other. That is, with no previous studies examining the effect of delay on associative reinstatement in comparison to associative identification, or paired-item recognition in comparison to single-item recognition, our research provides a first look into such analyses.

Furthermore, by incorporating a delay task, our study adds an additional layer to our analysis of affect. As previously mentioned, Peirce and Kensinger (2011) found that additional time between study and test actually produced a beneficial effect of negative valence on associative memory. Similarly, Sharot and Phelps (2004) found that recognition for peripherally presented arousing words was higher than neutral words specifically after a 24 hour delay. In addition to these, numerous single item studies suggest the important role that time for consolidation plays in memory. For example, a study examining recognition for emotional or neutral facial features (i.e., sad eyes, smiling mouth) found that memory for emotional features improved over a 24 hour delay (Gupta & Srinivasan, 2009). It has been argued that a longer period between study and test, often in the case of 24 hours or a period of sleep in between, gives newly formed memories the opportunity to go through systems consolidation (Ribot, 1882). This form of memory strengthening is believed to occur by the reorganization of hippocampal stored short-term memories into other brain regions such as the neocortex (Squire & Alvarez, 1995). However, since to our knowledge no one has studied the effect of emotion on both associative memory tasks for a retention interval of longer than 24 hours, our study examined recognition at a one week delay.

Method

Participants

In the present study, approved by the Wilfrid Laurier University Research Ethics Board, a total of 48 participants were tested, 7 of which were excluded when they failed to show up for their delay test scheduled a week later. Of the remaining 41 participants, 16 completed an associative reinstatement task and 25 completed the associative identification and item recognition tasks. Our participant group was composed of 7 male and 34 female undergraduate students at Wilfrid Laurier University ranging in age from 18 to 30 (M= 21.1, SD =). Participants attained through our Departmental Research Participant Pool system received compensation of 0.5 credits per session toward their introductory psychology course (for a total of 1.0 credits) while participants from the general student population and recruited through the paid pool were provided monetary compensation ($8 per session) for their time (for a total of $16). All participants provided written consent prior to partaking in the study.

Stimuli and Apparatus

The current experiment studying recognition incorporated both a study phase and test phase. All programs (both study and tests) were created using SuperLab 4.5 software (Cedrus Corp.) and controlled stimulus presentation and response recording. Participants completed the computer tasks on AMD A6, 3.59 GHz desktops paired with Philips 17” LCD screens.

The 168 words (56 negative, 56 positive, 56 neutral) utilized in the study and test programs were selected from Bradley and Lang’s (1999) Affective Norms for English Words (ANEW) database (Appendix). This database, composed of 1034 nouns, verbs and adjectives, contains ratings on various dimensions including arousal and valence for each item. The dimensions of arousal and valence are rated on a 1-9 scale with higher scores in arousal indicating increased levels of arousal. However, in considering valence, words falling in the upper half of the 1-9 range were interpreted to be increasingly positive while the words falling in the lower half of the range are decreasingly negative. The affective words chosen for our study were rated high on arousal (negative ranging from 6.05 to 8.17 with a mean of 6.67, and positive ranging from 5.59 to 8.10 with a mean of 6.87) while the neutral words rated low to average (neutral ranging from 2.65 to 4.48 with a mean of 3.81). Additionally, the words used were rated relatively extreme on their respective scales of valence (negative ranging from 1.25 to 2.5 with a mean of 2.03, and positive ranging from 7.55 to 8.32 with a mean of 7.78) or fell in midrange (neutral ranging from 4.00 to 4.95 with a mean of 4.58).

Procedure

In constructing the study task, a total of 168 words were selected from the ANEW. This was done simply by selecting 56 words that were rated highest on negative and positive valence and arousal, and 56 that fell midrange on the scale for neutral. From this group, only 42 words per valence would be used to construct study pairs, while the remaining words (14 per valence) were later used as the "new" words in constructing the tests. Finally, a few extra words (4 per valence for a total of 12) were also chosen from the ANEW to include in buffer pairs.

Once selected, the words were used to produce three counterbalanced study lists where each negative, positive, and neutral word was randomly selected and paired with a word of the same valence (i.e., negative-negative, positive-positive, neutral-neutral pairs). This allowed for different kinds of pairings for each study list. One study list contained a total of 69 words pairs; the first and last three of which were buffer pairs and excluded during test to avoid primacy and recency effects. Subsequently, we created a type of associative recognition (reinstatement and identification) and item test to correspond with each of the three study lists.

As mentioned earlier, associative reinstatement tests (AR) are composed of four different kinds of pairs: intact, rearranged, old-new and new. Both intact and rearranged test pairs are constructed using old words (or words included in the study) with intact pairs being presented exactly as seen in study and rearranged pairs consisting of two old words that are rearranged to form a new pairing. New-old pairs, however, are composed of a studied word and a non-studied word while new pairs consist of two non-studied words.

During the construction of an AR test for one study list, 12 studied pairs (4 per valence) were randomly selected to act as intact, 12 to be rearranged to form the rearranged probes, 6 to be used alongside 12 of the 42 new words to construct old-new probes, and finally 24 of the remaining 42 new words were randomly chosen to form the new test probes. Once completed, the task included a total of 50 test trials; the first two of which were constructed using the buffer pairs in the study list and included as practice trials. These were not analyzed. Among the remaining 48 trials, 16 were negative, 16 positive and 16 neutral. Furthermore, since our experiment tested participants at two time points (immediately after study and one week later) this process of constructing an AR test was done twice for each study list to produce an immediate and delayed test. This produced a total of 6 AR tests for the three study lists.

Associative identification (AI) tests were constructed similarly but in combination with an item recognition task. Since AI tests use only two test probes (intact and rearranged), 12 studied pairs were randomly selected and used as described earlier for each probe. Then, by randomly selecting a few (10.5 to be exact) of the remaining pairs, 21 (7 of each valence) old words were used in combination with 21 from the list of 42 new words to construct the item recognition task. Therefore, we produced an AI task with 44 test trials, the first two being practice trials made from buffer pairs. Among the remaining, 14 were negative, 14 positive and 14 neutral. Similarly, our item recognition task was made up of 44 test trials, the first two being practice. Again, this was done twice for each study list allowing for the creation of an immediate and delayed test. Furthermore, since the participants completing the AI task would also complete the item recognition test, the order in which the tasks were administered was counterbalanced across participants.

Participants in our study were tested in individual cubicles. Upon first entering the lab, participants were asked to read and sign a consent form. The experiment then commenced with the study phase in session one. During the study, participants viewed instructions on what they were required to do during the presentation of 69 word pairs (i.e., "associate the pairs and study them together"). Word pairs in the study list were viewed one at a time for 4 s each, at the center of screen in size 60, Times New Roman, black font. After completing this portion, participants moved onto their first recognition task. Each participant was randomly pre-assigned to complete the associative reinstatement or associative identification task; the latter of which was paired with a single-item recognition task. During each of these tasks, they were instructed to press the "d" or "k" key, each of which corresponded to whether a pair was "new" or "old". The response keys pairings were counterbalanced across AI, AR, and item tests. In the AI task, an old pair would simply be one that consisted of two words paired exactly as is during study, while a new pair would consist of previously studied words that were rearranged to form a new pairing. In the AR task, however, since participants are asked to pay attention to individual words rather than the pairing, an old pair would be one that consisted of two previously studied words (these probes would be both rearranged and intact) while a new pair would be one consisting of one or two new words (these probes would be both the new-old and new-new). Again, the distinction in the instructions for this task is what allowed us to also utilize the AR task's rearranged and new-new pairs to examine paired item recognition as well. That is, similar to the AR task itself, rearranged pairs within the test of paired item recognition would prompt a response of "old", as both words were previously studied, while new-new pairs, which consist of both novel words, would need to be correctly identified as "new". Finally, for the separate single item recognition task an "old" response would simply indicate a previously studied word while a "new" response referred to novel words not in the study list. Participants initiated each test list by pressing either response key when they were ready to do so. The presentation of each test list was subject-paced, with the next test probe appearing immediately after a response. Upon completing their assigned tasks and before leaving the lab, participants were reminded about their second session scheduled for the following week.

When returning for session two a week later, participants were asked to complete the second, delayed task that was constructed for their study list. Afterward, they were awarded their compensation, debriefed and the study purposes were discussed in detail.

Results

Overview

In analyzing the item recognition and associative identification task, we utilized the methods of corrected recognition and signal detection theory. Corrected recognition is calculated by subtracting false alarms (or the proportion of times the subject identifies a new item or pair as "old") from hit rates (the proportion of times the subject correctly identifies an old item or pair as "old"). Similarly, in signal detection theory estimates of *d'* (the measure of the distance between the means of the old and new stimulus distributions) were derived from the hit rates and false alarms for each test condition. However, any hit rate or false alarm score of 1 or 0 in the latter calculation is adjusted to 0.98 or 0.02 respectively. In combination with a score of discrimination performance, signal detection theory also produces a criterion score measuring the liberalness of participants to answer "old" to a given word or pair. In other words, an increasing criterion value represents a decrease in liberalness to respond "old".

Given that both corrected recognition and signal detection theory measure discrimination performance and generally revealed a similar pattern of results for our study, we report only our *d'* analysis for the AI and single item tests with one, rare exception. Table 1 outlines these *d'* and criterion scores, along with the hits and false alarm rates, for both the AI and single-item recognition task.

Turning to our associative reinstatement task, our first objective was to ensure that the task was working as expected. This involved examining the intact against rearranged hit rates (collapsed across valence). Table 2 outlines the hits and false alarms for each probe type in our AR task. Given that this test was constructed on the belief that memory for intact pairs (where both associative and item information are reinforced) should be superior to memory for rearranged pairs (where only item information is reinforced), we first calculated two *d'* scores: one using intact hits and new-new false alarms, and another using rearranged hits and new-new false alarms (all of which were first averaged across valence and session). Only after our one-way ANOVA revealed a significant effect of test probe type, $F(1,15) = 10.36$, $p < 0.006$, *partial* $\eta^2 = 0.13$, with better recognition for intact compared to rearranged pairs, did we commence our analysis of emotion and delay.

In examining the influence of affect in the AR task we calculated *d'* scores while also looking at the differences between intact and rearranged hit rates (Table 3). To obtain the appropriate *d'* scores for our AR valence analysis, we first calculated *d'* using our rearranged hit rates and new-new false alarms. These scores were then subtracted from *d'* calculated for intact hit rates and new-new false alarms (Table 2 & 3). Since, in this task, rearranged recognition relies on item memory (as the pairings are new) and intact hit rates rely both on item and associative memory, this method allowed us to isolate and study the effect of associative memory alone (see Cohen & Moscovitch, 2007 for a similar procedure). The second way we examined our AR data was by simply calculating the difference between the intact and rearranged hit rates. Table 2 presents the two *d'* scores mentioned above (intact/new-new and rearranged/new-new), while the final, analysed *d'* and differences scores are outlined in Table 3.

Finally turning to our paired item recognition task, as mentioned earlier, we used rearranged hits and new-new false alarm rates to calculate *d'* scores per valence and session. That is, as rearranged pairs in our AR task rely on memory for the single items, and new-new pairs relies on participant ability to make a correct rejection as both words are novel, we made use of these two probes to examine paired item recognition. These *d'* scores and their corresponding criterion values are also summarized in Table 2.

The first set of analyses discussed will look at the effect of the retention interval on each task separately before discussing two mixed-model ANOVAs where we compare the effect of our within-subjects factor of delay (Session 1 vs. Session 2) across the two sets of tests (paired-item vs. single-item, and AI vs. AR) (Table 4). Following this, we examine each test individually. Included in each set of analyses is a look at the effect of emotion, by session, and an overview of any interaction effects observed in a 2X3 ANOVA with the two within-subject factors of delay (Session 1 vs. Session 2) and valence (negative vs. positive vs. neutral). Table 5 provides a complete summary of observed effects among all four tasks.

Retention Interval

Table 4 outlines *d'* and the corresponding criterion scores, per session, for our 4 separate analyses. To examine the effect of delay on both our AI and single-item tasks, we first averaged the hit rates and false alarms per session (across emotion) and then utilized these averages to calculate a single *d'* score for each session. One-way ANOVAs comparing these scores found a significant effect of our within-subject variable of session on discrimination performance for both our AI, $F(1,24) = 32.32$, $p < 0.001$, *partial* $\eta^2 = 0.574$, and single-item task, $F(1,24) = 4.59$, $p = 0.043$, *partial* $\eta^2 = 0.161$. Therefore, the large differences between the means express significantly better performance for the immediate test versus the delay, AI: $M^{S_1} = 1.58$, $M^{S_2} = 0.54$ and ITEM: $M^{S_1} = 1.32$, $M^{S_2} = 0.71$.

Similarly, in the one-way ANOVA for our AR task (using *d'* scores calculated from averaged old-new and new-new false alarms, and averaged intact and rearranged hit rates), we observed superior recognition immediately after study in comparison to the delayed test, $F(1,15) = 9.088$, $p = 0.009$, *partial* $\eta^2 = 0.377$ (Table 3). Additionally, our ANOVA looking at paired-item recognition within our AR task, where *d'* scores were calculated using rearranged hit rates (which were averaged across valence) and new-new false alarms (averaged across valence), also disclosed a significant effect of delay, $F(1,15) = 8.664$, $p = 0.01$, *partial* $\eta^2 = 0.366$. It appears, then, that our findings suggest that we may be observing a significant rate of decay and/or poor consolidation over the one week retention interval (Born & Wilhelm, 2012). In conducting a mixed-model ANOVA on the between-subjects factor of item task type (single item, paired item) and within-subject factor of session (Session 1 vs. Session 2), we attempted to examine whether the interval influenced both item recognition tests similarly. Indeed, a non-significant interaction between session and task type suggests exactly this, $F(1,39) = 0.797$, $p = 0.377$, *partial* $\eta^2 = 0.020$. That is, the decrease in discrimination performance appears to occur equally across both of our item recognition tests (Figure 1). Additionally, this analysis found a main effect of session, $F(1,39) = 12.99$, $p = 0.001$, *partial* $\eta^2 = 0.250$ and no significant effect of our between-subjects variable of task, $F(1,39) = 2.24$, $p = 0.143$, *partial* $\eta^2 = 0.054$. To a similar extent, the mixed model analysis examining between subjects variable of associative task (associative identification, associative reinstatement) and session (Session 1 vs. Session 2) produced a non-significant interaction, $F(1,39) = 1.69$, $p = 0.201$, *partial* $\eta^2 = 0.042$. However, a main effect of session and task type was observed, $F(1,39) = 34.829$, $p < 0.001$, *partial* $\eta^2 = 0.472$ and $F(1,39) = 6.27$, $p = 0.017$, *partial* $\eta^2 = 0.138$ respectively.

Single-item Recognition

Turning to our main variable of emotion (negative vs. positive vs. neutral) in Session 1 of our single item recognition task, a one-way ANOVA on our *d'* scores found a significant effect of affect on memory, $F(2,48) = 6.245$, $p = 0.004$, *partial* $\eta^2 = 0.206$ (Table 1). Paired t-tests revealed that this difference existed between both the negative - neutral, and positive - neutral valences with significantly better discrimination performance for neutral items overall, $t(24) = -3.915$, $p = 0.001$ and $t(24) = 2.319$, $p = 0.029$ respectively. Interestingly, no such differences were observed between negative - positive valences, $t(24) = 0.914$, $p = 0.370$. These results, generally falling in disagreement with much of the emotion-memory item literature, may be the effect of the differential demands of our encoding and recognition tasks.

In analysing *d'* for our delayed-session two, item recognition task we observed an effect of emotion that approached significance, $F(2,48) = 3.166$, $p = 0.051$, *partial* $\eta^2 = 0.117$ (Table 1). Nevertheless, since our corrected recognition data for the same test produced a standard significant effect, $F(2,48) = 4.055$, $p = 0.024$, *partial* $\eta^2 = 0.145$, we decided to explore it further. Paired t-tests on these scores revealed that this effect is now indicative of superior memory for negative over positive items, $t(24) = -2.771$, $p = 0.011$, with no differences between neutral - positive, or negative - neutral items, $t(24) = 1.86$, $p = 0.075$, and $t(24) = 0.857$, $p = 0.400$ respectively. This finding, falling somewhat more in line with what we see in some of the item recognition literature, suggests superior retention over the delay for negative stimuli in comparison to positive (Kensinger, 2009).

Finally, in a 2X3 ANOVA of within-subject factors of delay (Session 1 vs. Session 2) and valence (negative vs. positive vs. neutral) we observed a significant effect of valence, $F(2,48) = 5.542$, $p = 0.007$, *partial* $\eta^2 = 0.169$, and session, $F(1,24) = 4.881$, $p = 0.037$, *partial* $\eta^2 = 0.188$, as well as an interaction effect, $F(2,48) = 3.494$, $p = 0.038$, *partial* $\eta^2 = 0.127$. Group means in this analysis suggest that discrimination performance for negative words, in particular, showed a smaller decline over the delay period when compared to neutral and positive words (Figure 2). Additionally, mean criterion scores observed in this task suggest a tendency for increased conservativeness to respond old to neutral words, with more liberal responses being elicited by negative words (Table 2).

Associative Identification (Explicit Measure)

In examining the emotional influence (negative vs. positive vs. neutral) in Session 1 of our associative identification task, our one-way ANOVA only revealed a marginal, non-significant effect of valence, $F(2,48) = 2.566$, $p = 0.087$, *partial* $\eta^2 = 0.097$. Observation of group means in this dataset suggests superior discrimination performance for positive pairs with the most impairment occurring among negative word pairs (Table 1). Interestingly, it is Session 2 of our AI task where we observe a significant effect of valence, $F(2,48) = 3.58$, $p = 0.036$, *partial* $\eta^2 = 0.130$. A further look into this effect via paired t-tests demonstrated that the difference in valence exists between neutral - negative pairs with neutral affect resulting in significantly better performance following the delay, $t(24) = -3.252$, $p = 0.003$. It is also interesting to note the marginal trend approaching significance between negative - positive valences, where positive pairs also appear to enhance memory retention, $t(24) = 1.735$. $p = 0.096$. These delay-performance results provide modest support for a few of the studies suggesting impairment in memory for associations due to negative emotion (Maden, Caplan, Lau, & Fujiwa, 2012).

Lastly, a 2X3 ANOVA including within subjects factors of delay (Session 1 vs. Session 2) and valence (negative vs. positive vs. neutral) on our AI dataset revealed a significant effect of session, $F(1,24) = 33.274$, $p < 0.001$, *partial* $\eta^2 = 0.581$, and valence, $F(2,48) = 3.657$, $p = 0.033$, *partial* $\eta^2 = 0.132$, but no interaction for our explicit measure, $F(2,48) = 2.136$, $p = 0.129$, *partial* $\eta^2 = 0.082$. Also, similar to our single-item task, mean criterion scores observed in this test suggest a pattern of increased conservativeness to respond old to neutral associations, with the most liberal responses resulting from negative pairs (Table 2).

Associative Reinstatement (Implicit Measure)

Among our implicit measure of associative memory, where we examined both differences scores (differences between intact and rearranged hit rates) and *d'* scores, we observed no effect of valence, $F(2,30) = 0.834$, $p = 0.444$, *partial* $\eta^2 = 0.053$ and $F(2,30) =$

1.439, $p = 0.253$, *partial* $\eta^2 = 0.088$ respectively (Table 2). Similarly, difference and *d*' scores of Session 2 found no emotional influence, $F(2,30) = 0.460$, $p = 0.636$, *partial* $\eta^2 = 0.03$ and $F(2,30) = 0.487$, $p = 0.619$, *partial* $\eta^2 = 0.031$ respectively. With our difference and *d'* scores two-way analyses, including within-subject factors of delay (Session 1 vs. Session 2) and valence (negative vs. positive vs. neutral), also demonstrating no effects of emotion, $F(2,30) = 1.00$, $p = 0.380$, *partial* $\eta^2 = 0.063$ and $F(2,30) = 1.414$, $p = 0.259$, *partial* $\eta^2 = 0.086$ respectively , session, $F(1,15) = 0.259$, $p = 0.618$, *partial* $\eta^2 = 0.017$ and $F(1,15) = 0.203$, $p = 0.659$, *partial* $\eta^2 = 0.013$ respectively, or an interaction, $F(2,30) = 0.222$, $p = 0.802$, *partial* $\eta^2 = 0.015$ and $F(2,30) = 0.263$, $p = 0.771$, *partial* $\eta^2 = 0.017$ respectively, we feel that it is the task's sensitivity to implicit memory for associations that is playing a role in eliminating any of the affective enhancement or impairment observed in our AI task.

Paired-item Recognition

Finally, in examining paired item recognition within our AR task, both one-way ANOVAs revealed no effect of valence in Session 1, $F(2,30) = 0.515$, $p = 0.603$, *partial* $\eta^2 = 0.03$, and Session 2, $F(2,30) = 0.131$, $p = 0.878$, *partial* $\eta^2 = 0.009$. Similarly, the two-way analysis including within-subject factors of delay (Session 1 vs. Session 2) and valence (negative vs. positive vs. neutral) revealed no effect of valence, $F(2,30) = 0.403$, $p = 0.67$, *partial* $\eta^2 = 0.026$, or an interaction, $F(2,30) = 0.022$, $p = 0.978$, *partial* $\eta^2 = 0.001$, but produced an expected drop in performance across the two sessions $F(1,15) = 9.48$, $p = 0.008$, *partial* $\eta^2 = 0.387$. However, in examining mean criterion scores, we can see that a pattern in which increased conservativeness to respond old to neutral items remains (Table 2).

Discussion

This study set out to examine the effect of emotion on memory for associations. By measuring recognition performance for pure word pairs using two distinct associative recognition tasks (associative reinstatement and associative identification) we were able to look at the influence of affect on both implicit and explicit types of associative memory. Moreover, as associative reinstatement utilizes four test probes (i.e., intact, rearranged, old-new, and new-new) and measures participants recognition for individual words within the pair (rather than specific pairings as in associative identification), we were able to evaluate how indirect or subtle memory for associations assisted in discrimination. Additionally, by incorporating both a single and paired item recognition test, and an immediate versus delayed test one week later (Session 1 vs Session 2), our study allowed us to compare effects and examine them at a later time point. The findings observed in the present study informs the emotion-memory literature on various novel aspects of valence in relation to associative memory, as well as raises a few additional questions on the topic.

Retention Interval Effects

First and foremost, our overall analyses examining recognition differences between Session 1 and Session 2 for all four tests (single item, AI, AR, and paired item) suggest a high rate of forgetting over the one week delay. Previously, researchers have suggested that time provided between study and test, particularly periods including sleep, allows for new memories or learned information to go through a process of consolidation whereby they move into long-term memory systems (Ribot, 1882; Squire & Alvarez, 1995). Nevertheless, many recent studies advise that not all newly encoded material receive this benefit (Born & Wilhelm, 2012). Indeed, it is proposed that memory consolidation during sleep is selective to explicit training in motor tasks and information that is relevant to future plans (Robertson, Pascual-Leone, & Press, 2004; Wilhelm et al., 2011). Additionally, knowledge of future retrieval expectancy also appears to have an effect on sleep related memory enhancements (Fisher & Born, 2009). Therefore, with our study looking at an incidental memory tests at Session 2, it maybe that the paired-words studied in our experiment did not meet the requirements for sleep consolidation (Born & Wilhelm, 2012). Still, given our delay period of one week, it is very possible that the sleep dependent consolidation often observed in many memory studies (Ribot, 1882) could have taken place over the first 24 hours or so, and were later followed by forgetting or decay of the studied information.

In addition to the effects of delay on each individual task, our first mixed model analysis examining delay between the two item tasks suggests that a one week interval between study and test influences recognition in a similar way. Comparable effects were observed in our mixed-model ANOVA examining the effect of delay in our two associative recognition tasks, suggesting that they, too, are susceptible to the same types of decay. These finding are of particular interest as it stands against researchers proposing that implicit memories tend to show a greater preservation over retention intervals (Tamayo & Frensch, 2007). Nonetheless, with larger standard errors and observable differences in decay across task (Table 4), more research would be required before conclusions can be drawn on this analysis.

Influence of Emotion on Immediate Test

In considering the results of our single-item recognition task, the effect of valence produced in Session 1 raises some interesting ideas as to what role encoding stimuli in pairs may play in attenuating the emotion-enhanced item memory observed in numerous other studies (Kensinger & Corkin, 2004). Moreover, with participants doing significantly better in discriminating between old and new neutral words when compared to negative words, it is possible that negative stimuli may rely more heavily on contextual information. In other words, based on the dual processes theory of recognition memory which suggests that two distinct processes of familiarity and recollection work together during retrieval (Atkinson & Juola, 1974; Jacoby, 1991), it could be that the impairment we see for negative stimuli in the immediate test of item recognition is actually the result of impairment in the process of recollection (Cohen & Moscovitch, 2007). As the individual items tested in this session were initially encoded in pairs, with participants specifically instructed to associate the two words together, our single item recognition task may have hindered the ability of individuals to effectively put to use the process of recollection (which may rely on contextual information). Indeed, with much research suggesting that emotion-enhanced memory is the result of attention narrowing and better within-subject binding (i.e. better binding between contextual information such as location of stimuli), it may be that rearranging the presentation of words during encoding and study differentially influenced our results (Long, Danoff, & Kahana, 2015). Interestingly however, in turning to our paired-item recognition task, we find no such effect of valence on discrimination performance. Therefore, it is possible that by actually presenting our items in pairs (a form closer to the encoded state), albeit rearranged or new pairs, we somehow allow the process of recollection to work indirectly in this test. More specifically, it maybe that seeing two words presented in a new pairing allows participants to identify the pairing as new, and therefore retrieve the initial pairing or association formed with each word during encoding. This process would then allow participants increased access to their studied information. Although more research is required to confirm this hypothesis, our results do provide evidence to support that single-item and paired-item recognition are distinct measures of item memory, and may provide differential reflections of the effects of affect.

Moving onto the associative memory tasks, it appears that much like Naveh-Benjamin et al. (2012), we observed no effect of valence in our associative identification task immediately after study. It is suggested that as emotional stimuli draws in more attention, less cognitive resources are allocated to integrating the two pieces of stimuli together leading to poorer memory for the association (Naveh-Benjamin et al., 2012). Therefore, any of the emotion-dependent memory enhancements commonly reported in the item literature may have very well been eliminated when adding a task of integration between items during encoding in our associative identification task. Interestingly enough, this lack of emotional influence immediately after study was not altered in our second, implicit task of associative memory. Indeed, our AR task also found no significant effect of emotion on memory for associations during Session 1. These results may very well be best accounted for by a few brain imaging studies exploring the neural basis of emotion and integration. That is, emotion-enhanced amygdala activation during encoding may interfere with hippocampal processing and integration, and therefore reduce the advantage in memory often observed for emotional stimuli (Mather, 2007; Mattfield & Stark, 2015).

Emotion, Delay, and Interactions

In examining the influence of emotion at the delay test, we see that the effect of valence in our single-item recognition task persists, but has now shifted to indicate better discrimination performance for negative versus positive items. Instead of representing an increase in memory, however, a significant interaction between session and valence in our task demonstrates a reduction in loss over retention for negative items (Figure 2). Indeed, Sharot and Phelps (2004) similarly report that recognition for peripherally presented negative, arousing words stayed the same over a 24 hour delay while neutral word recognition dropped. Therefore, negative words, in particular, may actually experience a slower rate in forgetting (Sharot & Phelps, 2004). Nonetheless, it is interesting to note that even though performance for neutral words did not differ significantly from positive and negative items in the delay task, we still observed a relatively large drop in performance means for neutral items from the immediate to delay task (Figure 2). Therefore, the interaction further supports the idea of negative items showing greater resistance to forgetting when compared against neutral and positive single words. Additionally, these results are interesting as they provide support for a few studies which argue that valence, and not only arousal, plays a role in this emotional enhancement that we observe in item memory. More specifically, with researchers suggesting that negative valence in particular allows for increased memory of perceptual details of a stimulus (Kensinger & Corkin, 2003; Kensinger, 2009), it is not surprising that the enhancement at the delay task was observed for negative and not positive words.

Examining the results of our paired-item recognition test, we continue to demonstrate no effect of valence in Session 2, as well as no interaction effects between valence and delay. Once again, this discrepancy in results between the two item tests suggests that single-item and paired-item recognition may utilize the processes involved in recognition memory (i.e., recollection and familiarity) differently.

Turning attention to our associative recognition tasks at delay, we find a significant effect of valence in our AI task between neutral - negative word pairs, with the former valence showing better memory. Again, discrimination performance means demonstrate a greater loss over the retention for negative pairs rather than a gain in memory for neutral pairs (Table 1). Such results provide support for the idea that an impairment may exist in the integrative processes employed as a result of negative valence (Mather, 2007). With researchers suggesting the typical resistance to decay observed in associative memory over a delay period, it is arguable that the problem lies not in the retention of encoded associations but rather in the forming of associations itself (Weeks et al., 2007). In accordance, Mather (2007) discusses an arousal-impairs-binding-hypothesis and suggests that high levels of arousal or stress interferes with hippocampal and prefrontal activity and disrupts binding between items. Therefore, it is very possible that we would observe greater loss in explicit memory for these negative associations over the one week period due to weaker integration or binding between words.

Finally, in considering the influence of valence at delay in our implicit associative memory task, we continue to see no effect. It appears, then, that by taking into consideration more subtle memory for associations, we eliminate the detrimental effects of emotion observed in the AI explicit task all the while remaining unable to replicate the emotional enhancement typically found in the item literature. In other words, by enabling participants to utilize both processes of familiarity and recollection in this task, we see that memory performance is not as impaired by affect and arousal. However, in finding no beneficial effect of emotion, we have further support for the idea that it is indeed the process of integrating two items together that eliminates the advantage commonly provided by valence and arousal in the item literature (Kensinger & Corkin, 2004, Adelman & Estes, 2013). These results are important in that they provide support for the AR task as a differential measure of associative memory and act as further evidence for this amygdala-hippocampus trade-off that may have been observed in studies examining emotion and associative memory (Mather, 2007; Murray & Kensinger, 2014).

It appears, then, that the present study provides evidence for differential influences of emotion on our various paradigms. However, factors that should be taken into consideration when evaluating these effects are our small sample sizes. Due to both time constraints and resources available, the number of participants tested for each of our tasks was limited. Additionally, by incorporating a single-item test in which words were encoded in pairs rather than as single-words, the task of comparing or replicating the effects observed in the item-memory literature is further complicated. Future studies examining the influence of emotion on associative and item recognition should attempt to overcome such limitations. Additionally, with a few studies advocating an effect of taboo words on recall tests of associations (Guillet & Arndt, 2009; Maden et al., 2012), it would be interesting to further examine this in the two associative recognition paradigms presented here.

Nevertheless, by incorporating two distinct item and associative memory tests, the present study serves as evidence for the existence of differential effects of emotion in the various measures. Moreover, by examining the influence of affect in both single-item and paired-item recognition, in addition to an explicit and implicit measure of associative memory, our study reveals how changes in the presentation of items during test, or changes in the demands of an associative recognition task can work to attenuate or eliminate the influence of valence. Additionally, in finding a disadvantageous influence of negative valence in our AI delay task and a reversed effect in our single-item recognition delay test, we provide further evidence to suggest the differential processes involved in these two measures. More specifically, these results support the idea that arousal and/or affect-dependent amygdala activation, which typically aids single-item memory, may in fact interfere with hippocampal and prefrontal activity and disrupt the forming of association between items (Mather, 2007; Murray & Kensinger, 2014).

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Table 1.
Mean hit rates, false alarm rates, *d'* scores, criterion, and the corresponding standard error per valence (negative, positive, neutral) and session (Session 1, Session 2) in AI and single-item recognition tasks.

	Associative Identification				Single-item Recognition			
	Intact (Hits)	Rearranged (FA)	*d'*	c	Old (Hits)	New (FA)	*d'*	c
	Session 1							
Negative	0.68 (0.04)	0.26 (0.05)	1.48 (0.19)	0.12 (0.14)	0.66 (0.06)	0.32 (0.05)	1.13 (0.32)	0.02 (0.13)
Positive	0.74 (0.05)	0.17 (0.05)	2.05 (0.24)	0.19 (0.17)	0.67 (0.06)	0.26 (0.05)	1.35 (0.31)	0.14 (0.13)
Neutral	0.63 (0.05)	0.17 (0.04)	1.63 (0.23)	0.37 (0.13)	0.66 (0.05)	0.15 (0.05)	1.89 (0.31)	0.39 (0.14)
	Session 2							
Negative	0.45 (0.04)	0.35 (0.05)	0.27 (0.16)	0.31 (0.15)	0.67 (0.05)	0.34 (0.03)	1.04 (0.13)	-0.02 (0.12)
Positive	0.47 (0.05)	0.27 (0.05)	0.66 (0.22)	0.43 (0.13)	0.58 (0.06)	0.46 (0.05)	0.45 (0.18)	-0.06 (0.15)
Neutral	0.46 (0.05)	0.22 (0.05)	0.87 (0.14)	0.56 (0.14)	0.48 (0.06)	0.21 (0.04)	0.99 (0.20)	0.55 (0.16)

Table 2.
Mean hit rates and false alarm rates for each test probe with corresponding standard error per valence (negative, positive, neutral) and session (Session 1, Session 2) in the AR recognition tasks. Also included are *d'* and criterion scores calculated for intact hits and new-new false alarms, and rearranged hits and new-new false alarms.

Associative Reinstatement

	Test Probes [a]				Intact/New-New [b]		Rearranged/ New-New [c]	
	Intact (Hits)	Rearranged (Hits)	Old-New (FA)	New-New (FA)	*d'*	c	*d'*	c
	Session 1							
Negative	0.73 (0.07)	0.58 (0.09)	0.39 (0.06)	0.25 (0.07)	1.75 (0.46)	0.07 (0.17)	1.28 (0.36)	0.30 (0.28)
Positive	0.67 (0.06)	0.53 (0.10)	0.28 (0.06)	0.17 (0.07)	1.88 (0.33)	0.39 (0.20)	1.41 (0.45)	0.62 (0.24)
Neutral	0.67 (0.07)	0.42 (0.09)	0.27 (0.08)	0.13 (0.06)	2.09 (0.34)	0.45 (0.19)	1.11 (0.38)	0.94 (0.21)
	Session 2							
Negative	0.55 (0.07)	0.48 (0.08)	0.38 (0.08)	0.45 (0.08)	0.39 (0.43)	0.02 (0.17)	0.17 (0.28)	0.13 (0.26)
Positive	0.66 (0.06)	0.52 (0.08)	0.47 (0.08)	0.44 (0.07)	0.72 (0.25)	-0.15 (0.19)	0.21 (0.29)	0.11 (0.25)
Neutral	0.44 (0.05)	0.27 (0.06)	0.22 (0.04)	0.23 (0.04)	0.64 (0.16)	0.53 (0.14)	0.00 (0.28)	0.85 (0.15)

Note.
[b]*d'* for rearranged hits and new-new false alarms were subtracted from the *d'* for intact hits and new-new false alarms to produce the analyzed scores in Table 3.
[c]*d'* for rearranged hits and new-new false alarms were the scores examined for the paired-item recognition test.

Table 3.
Mean *d'* scores, criterion, difference scores and the corresponding standard errors in AR recognition task per valence (negative, positive, neutral) and session (Session 1, Session 2).

	Associative Reinstatement		
	d' [a]	Criterion [b]	Difference Score [c]
	Session 1		
Negative	0.47 (0.46)	-0.23 (0.23)	0.16 (0.11)
Positive	0.47 (0.36)	-0.23 (0.18)	0.14 (0.09)
Neutral	0.98 (0.36)	-0.49 (0.18)	0.25 (0.10)
	Session 2		
Negative	0.21 (0.40)	-0.11 (0.20)	0.06 (0.11)
Positive	0.51 (0.21)	-0.26 (0.11)	0.14 (0.06)
Neutral	0.64 (0.28)	-0.32 (0.14)	0.17 (0.07)

Note.
[a]*d'* scores for our AR analysis were calculated by first producing a *d'* score using our rearranged hit rates and new-new false alarms. These scores were then subtracted from *d'* scores calculated for intact hit rates and new-new false alarms (See Table 2 for the two *d'* scores used).
[b] Criterion scores indicated here are also derived in the same manner discussed above.
[c]Differences scores were calculated by subtracting rearranged hits from intact hits (See Table 2 for hit rates).

Table 4.
Mean *d'* scores, criterion, and the corresponding standard errors for AI, AR, single-item, and paired-item recognition tests per session (collapsed across valence).

	Associative Identification [a]		Associative Reinstatement [b]		Single-item Recognition [c]		Paired-item Recognition [d]	
	d'	Criterion	*d`*	Criterion	*d'*	Criterion	*d'*	Criterion
Session 1	1.58 (0.16)	0.22 (0.11)	1.02 (0.20)	0.26 (0.13)	1.32 (0.28)	0.17 (0.10)	1.18 (0.33)	0.58 (0.20)
Session 2	0.54 (0.10)	0.39 (0.11)	0.36 (0.08)	0.23 (0.11)	0.71 (0.07)	0.14 (0.11)	0.16 (0.08)	0.31 (0.13)

Note.

[a]AI scores were calculated by first averaging intact hits and rearranged false alarms across all three valences in each session. These averages were then used to calculate single *d'* and criterion scores per session.

[b]AR scores were calculated by first averaging intact/rearranged hits and old-new/new false alarms across all three valences in each session. These averages were then used to calculate single *d'* and criterion scores per session

[c]Single-item scores were calculated by first averaging old hits and new false alarms across all three valences in each session. These averages were then used to calculate single *d'* and criterion scores per session.

[d]Paired-item scores were calculated using rearranged probe hits (averaged across valence) and new-new probe false alarms (averaged across valence) within the AR task.

Table 5.
Summary of observed effects in associative identification, associative reinstatement, single-item and paired-item recognition tasks.

Item Recognition	**Associative Recognition**
Single – Item - Effect of delay in overall analysis. ▪ *Session 1 Recognition > Session 2 Recognition* - Significant effect of emotion in Session 1. ▪ *Neutral words > Negative words* ▪ *Neutral words > Positive words* - Significant effect of emotion in Session 2. ▪ *Negative words > Positive words* - Significant interaction between session (Session 1, Session 2) and valence (Negative, Neutral, Positive).	Associative Identification - Effect of delay in overall analysis. ▪ *Session 1 Recognition > Session 2 Recognition* - No effect of emotion in Session 1. - Significant effect of emotion in Session 2. ▪ *Neutral pairs > Negative pairs* - No interaction between session (Session 1, Session 2) and valence (Negative, Neutral, Positive).
Paired – Item - Effect of delay in overall analysis. ▪ *Session 1 Recognition > Session 2 Recognition* - No effect of emotion in Session 1 or 2. - No interaction between session (Session 1, Session 2) and valence (Negative, Neutral, Positive).	Associative Reinstatement - Effect of delay in overall analysis. ▪ *Session 1 Recognition > Session 2 Recognition* - No effect of emotion in Session 1 or 2. - No interaction between session (Session 1, Session 2) and valence (Negative, Neutral, Positive).

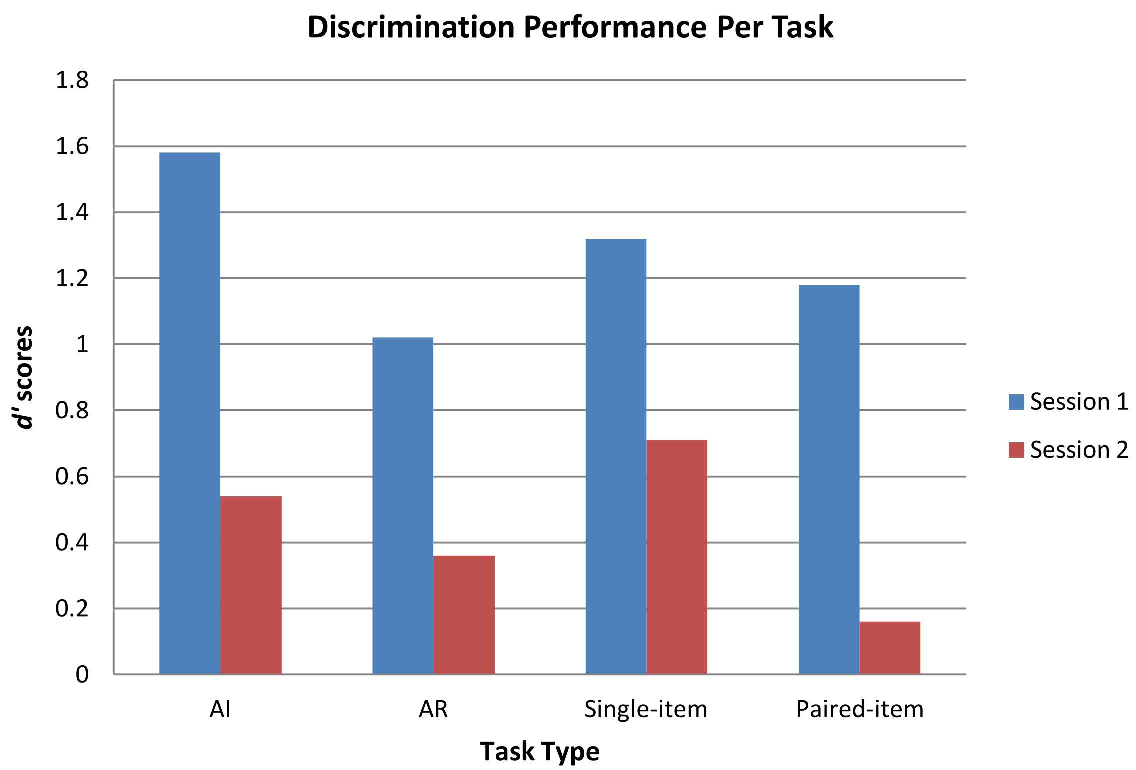

Figure 1.
Discrimination performance (*d*` scores) per session for associative identification, associative reinstatement, and item recognition tasks

Figure 2.
Discrimination performance (*d*` scores) over delay (Session 1, Session 2) per valence (negative, positive, neutral) for single-item recognition task.

Appendix

Stimuli selected from Bradley and Lang's (1999) Affective Norms for English Words (ANEW) database.

Words (NEG)	Val.	Aro.	Words (POS)	Val.	Aro.	Words (NEU)	Val.	Aro.
Accident	2.05	6.26	Admire	7.74	6.11	Absurd	4.26	4.36
Afraid	2.00	6.67	Adventure	7.60	6.98	Aloof	4.90	4.28
Agony	2.43	6.06	Aroused	7.97	6.63	Bandage	4.54	3.90
Ambulance	2.47	7.33	Astonished	6.56	6.58	Bench	4.61	3.59
Anger	2.34	7.63	Birthday	7.84	6.68	Bland	4.10	3.29
Assault	2.03	7.51	Car	7.73	6.24	Blase	4.89	3.94
Bankrupt	2.00	6.21	Cash	8.37	7.37	Board	4.82	3.36
Betray	1.68	7.24	Casino	6.81	6.51	Bus	4.51	3.55
Bomb	2.10	7.15	Christmas	7.80	6.27	Cane	4.00	4.20
Cancer	1.50	6.42	Confident	7.98	6.22	Cellar	4.32	4.39
Crash	2.31	6.95	Couple	7.41	6.39	Coarse	4.55	4.21
Crucify	2.23	6.47	Dazzle	7.29	6.33	Contents	4.89	4.32
Demon	2.11	6.76	Desire	7.69	7.35	Corner	4.36	3.91
Despise	2.03	6.28	Ecstasy	7.98	7.38	Corridor	4.88	3.63
Detest	2.17	6.06	Engaged	8.00	6.77	Curtains	4.83	3.67
Devil	2.21	6.07	Erotic	7.43	7.24	Dark	4.71	4.28
Disaster	1.73	6.33	Excitement	7.50	7.67	Dirt	4.17	3.76
Disloyal	1.93	6.56	Exercise	7.13	6.84	Errand	4.58	3.85
Distressed	1.94	6.40	Fame	7.93	6.55	Excuse	4.05	4.48
Divorce	2.22	6.33	Festive	7.30	6.58	Fur	4.51	4.18
Drown	1.92	6.57	Fireworks	7.55	6.67	Glass	4.75	4.27
Enraged	2.46	7.97	Flirt	7.52	6.91	Habit	4.11	3.95
Fearful	2.25	6.33	Fun	8.37	7.22	Hairdryer	4.84	3.71
Hate	2.12	6.95	Graduate	8.19	7.25	Haphazard	4.02	4.07
Hostage	2.20	6.76	Heart	7.39	6.34	Icebox	4.95	4.17
Humiliate	2.24	6.14	Holiday	7.55	5.59	Indifferent	4.61	3.18
Killer	1.89	6.86	Infatuation	6.73	7.02	Insect	4.07	4.07
Leprosy	2.09	6.29	Intercourse	7.36	7.00	Iron	4.90	3.76
Mad	2.44	6.76	Intimate	7.61	6.98	Kerosene	4.80	4.34
Mutilate	1.82	6.41	Joke	8.10	6.74	Knot	4.64	4.07
Nightmare	1.91	7.59	Joy	8.60	7.22	Lazy	4.38	2.65
Pain	2.13	6.50	Kiss	8.26	7.32	Listless	4.12	4.10
Pollute	1.85	6.08	Laughter	8.45	6.75	Mantel	4.93	3.27
Rabies	1.77	6.10	Leader	7.63	6.27	Metal	4.95	3.79
Rage	2.41	8.17	Love	8.72	6.44	Muddy	4.44	4.13
Rape	1.25	6.81	Lucky	8.17	6.53	Nonchalant	4.74	3.12
Rejected	1.50	6.37	Lust	7.12	6.88	Nonsense	4.61	4.17
Roach	2.35	6.64	Miracle	8.60	7.65	Nun	4.93	2.93
Rude	2.50	6.31	Orgasm	8.32	8.10	Obey	4.52	4.23

Slaughter	1.64	6.77	Outstanding	7.75	6.24	Odd	4.82	4.27
Slave	1.84	6.21	Party	7.86	6.69	Pamphlet	4.79	3.62
Stress	2.09	7.45	Passion	8.03	7.26	Plain	4.39	3.52
Terrible	1.93	6.27	Power	6.54	6.67	Radiator	4.67	4.02
Terrified	1.72	7.86	Promotion	8.20	6.44	Reserved	4.88	3.27
Terrorist	1.69	7.27	Quick	6.64	6.57	Seat	4.95	2.95
Thief	2.13	6.89	Rollercoaster	8.02	8.06	Shadow	4.35	4.30
Torture	1.56	6.10	Romantic	8.32	7.59	Shy	4.64	3.77
Toxic	2.10	6.40	Sex	8.05	7.36	Slush	4.66	3.73
Tragedy	1.78	6.24	Ski jump	7.06	7.06	Solemn	4.32	3.56
Trauma	2.10	6.33	Surprised	7.47	7.47	Square	4.74	3.18
Tumor	2.36	6.51	Talent	7.56	6.27	Stagnant	4.15	3.93
Ulcer	1.78	6.12	Terrific	8.16	6.23	Stuff	4.68	4.02
Unfaithful	2.05	6.20	Thrill	8.05	8.02	Stomach	4.82	3.93
Victim	2.18	6.06	Treasure	8.27	6.75	Stool	4.56	4.00
Violent	2.29	6.89	Triumphant	8.82	6.78	Subdued	4.67	2.90
War	2.08	7.49	Win	8.38	7.72	Thermometer	4.73	3.79

Note. 'Val.' is used as the abbreviation for valence and 'Aro.' for arousal.