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**The Facilitation of Memory  
Performance in Emotional  
Contexts**

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## **The Facilitation of Memory Performance in Emotional Contexts**

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### **Abstract**

Any context can be characterised as pleasant, unpleasant or neutral in emotional valence based on a dimensional approach to emotion. Memory performance in such contexts is demanded on everyday basis. This study served the investigation of whether neutral emotional contexts facilitate stronger original encoding and later better memory performance in terms of recall of words previously presented on IAPS selected images as emotional contexts. In addition, finger skin temperature (FST) measurements were obtained to test whether FST is increased during encoding in emotionally pleasant and neutral contexts comparing to unpleasant contexts. The participation of 35 volunteers (24 women and 11 men), with a mean age of 27 years of age ( $N = 33$ ) and an age range of 21 - 45 years, offered the evidence of long-term memory recall for neutral words presented in neutral contexts to be greater in number ( $M = 7.22$ ,  $SD = 2.459$ ) when comparing to long-term memory recall for neutral words presented in both pleasant ( $M = 5.91$ ,  $SD = 2.305$ ) and unpleasant ( $M = 5.5$ ,  $SD = 2.769$ ) contexts. There was no physiological differentiation in FST during encoding in pleasant, unpleasant and neutral contexts. Mean FST during pleasant, unpleasant and neutral contexts do not differ significantly ( $\chi^2(2, 35) = 2.457$ ,  $p > .05$ ). The results show that the slope of FST [ $F(2, 68) = .109$ ,  $p > .05$ ] and linear regression of FST [ $F(2, 68) = .808$ ,  $p > .05$ ] do not develop significantly different during pleasant, unpleasant and neutral contexts.

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## **Introduction**

In understanding how the phenomena of emotion and memory relate in humans, it is of great relevance to consider the contributions of, firstly, emotional material (content) and, secondly, the context in which this material occurs. Researchers generally accept that emotional real-life events or laboratory stimuli as items for remembrance are typically better remembered than neutral events. Memory encoding and consolidation studies have demonstrated that emotional stimuli are better recalled than neutral stimuli (Cahill et al., 1996; Canli et al., 1999; Hamann et al., 1999).

Research studies using recall or recognition of emotionally neutral stimuli embedded in emotionally positive, negative and neutral contexts, demonstrated that the neutral stimuli embedded in emotionally positive or negative contexts were better retrieved than those embedded in emotionally neutral contexts. Brierley et al. (2007) found that recognition memory for neutral words presented in a negative emotional context were recognised and recalled more frequently than neutral words presented in a neutral emotional context. Erk et al. (2003) examined the effect of emotional context on subsequent memory performance by presenting neutral words paired with unrelated images, positive, negative or neutral in emotion, and then assessing free recall of the presented words. In their functional imaging study, scanning data obtained only during encoding. Their findings indicated an enhancement of memory for words presented in positive, but not negative, contexts.

There has been only one study (Erk et al., 2003) that examined the recall of neutral words in positive, negative and neutral pictorial contexts and this investigation served to offer evidence regarding the memory performance for emotionally neutral words encoded in emotionally pleasant, unpleasant and neutral in valence pictorial contexts through successful recall and finger skin temperature measurements, when recall had no emotional context information.

## **Experimental Investigation**

### *Participants*

There were 35 volunteers (24 women and 11 men), with a mean age of 27 years of age (N=33) and an age range of 21 - 45 years. The majority were PhD (44.4%) Masters students (27.8%) and there was a preference to write with their right hand (88.6%). Only 7 participants were English native speakers (19.4%). None of the participants was with known medical, neurological, or psychiatric illness, and was not under any prescribed medication, and 57% (N=35) had consumed caffeine within 6 hours of arrival at the experimental setting.

### *Design*

This experiment was concerned with the within-participants effects of the emotional context at encoding on memory performance in a free recall task, and on finger skin temperature (FST). Emotional context at encoding had three forms: (1) pleasant emotional context, (2) unpleasant emotional context and (3) neutral emotional context, all consisting of rated IAPS (Lang et al., 2005) pictures for the motivational

basic parameters of emotion of (1) hedonic valence and (2) arousal. Memory recall performance for each context was measured as the mean number of words correctly recalled during a free recall task. Five different statistical models were tested for best describing the FST data. That is, during all three emotional contexts FST variation in degrees Celsius was described by the calculation of the representations of measurements: (1) mean, (2) slope, (3) linear regression, (4) ratio of context slope to baseline Slope, and (5) ratio of context linear regression to baseline linear regression.

### *Apparatus*

Stimuli were presented on a desktop computer screen using the Superlab 4.0 presentation software (SuperLab Pro 4.0, Cedrus Corporation, San Pedro, California, United States of America). The FST changes were recorded with the Biopac Lab System (BSL PRO 3.7.3., Galota, California, United States of America) with the MP35 Data Acquisition Unit using a thermistor to detect and measure small variations in temperature.

### *Stimuli*

The 60 pictures involved in the task were taken from the IAPS (Lang et al., 2005). The choice of 20 pleasant, 20 unpleasant and 20 neutral IAPS pictures was based on their valence and arousal mean for men and women, pleasant; pleasure mean was  $7 \pm .4$  and arousal mean was  $5.8 \pm 1$ , unpleasant; pleasure mean  $2.7 \pm .3$  and arousal mean was  $6.4 \pm 1$ , and neutral; pleasure mean was  $5 \pm .3$  and arousal mean was  $2.9 \pm .5$ . The 60 words neutral in valence, of 3 to 9 letters and of frequency from 1 to 38, were chosen for the experiment from the Siegle list (Siegle, 1994).

### *Procedure*

The participants signed the informed consent to assure that they agreed with the instructions of the researcher and were willing to provide information for investigation under the protection of anonymity. The electrode for the measurement of skin temperature changes was placed on the middle phalanx of the third finger of the non-dominant hand of the participants, so they would be able to write and use the computer mouse freely. Measurements of their FST were taken until the end of the experiment. In addition, if the participants agreed in video and audio recording, the recording started. The experiment started when the participants expressed their readiness to begin.

The experiment comprised 3 parts of the same time period and structure but with different stimuli in each part. Each part had 3 phases: (1) a baseline phase, (2) a learning phase and (3) a free recall phase. The presentation of a blank screen for 2 minutes in the beginning of each part of the experiment was used as a time phase to gather data concerning the participants' finger skin temperature without stimulation named as baseline. The learning phase involved the presentation of 20 IAPS pictures with words on them for 2.26 minutes. A fixation cross of 0.8 seconds preceded the appearance of a picture with a word for 6 seconds. In the recall phase the participants were provided with 4 minutes to recall the previously presented words and answer to 4 questions regarding their experience.

There were 3 learning phases in the experiment all characterised by the valence of the pictures presented. All the pictures in each learning phase were selected to be from the same valence group, sustaining them in this way all pleasant, unpleasant or neutral. The allocation of the pictures with the words was randomised across participants, as was the order of presentation of each experimental part.

## Results

### *Perception of Emotional Context*

At the end of the free recall phase, participants were asked to characterise each presentation as pleasant, unpleasant or neutral. The pictorial backgrounds used to induce the emotionally pleasant, unpleasant and neutral contexts were respectively referred to as pleasant by 60% of the 35 participants, unpleasant by 80%, and neutral by 77%. In terms of emotional intensity, the 35 participants were asked to rate the intensity of the emotional contexts on a 5-ranked scale (0 = not at all, 1 = slightly, 2 = moderately, 3 = very, 4 = extremely). The mean ratings for each induced emotional context were rounded to the nearest number in the above scale showing that both the neutral ( $M = 1.09$ ) and pleasant ( $M = 1.26$ ) context were *slightly* emotional to the participants, and the unpleasant ( $M = 1.94$ ) context was *moderately* emotional to the 35 participants.

### *Memory Recall Performance*

One of the objectives of the study was to investigate whether there is an effect of emotional valence on memory recall performance. Thirty five participants had to recall 60 words in total. Mean rate of total successful word recall was 26 out of 60 words ( $M = 25.77$ ,  $SD = 6.809$ ). The average number of successfully recalled words presented in both pleasant and unpleasant contexts was approximately 8 (pleasant:  $M = 8$ ,  $SD = 2.668$ ; unpleasant:  $M = 7.89$ ,  $SD = 3.132$ ), whereas for words presented in the neutral context the average recall number was approximately 10 ( $M = 9.89$ ,  $SD = 2.867$ ). Using a one-way repeated measures ANOVA, it is observed that the valence of the emotional context at encoding does influence memory recall ( $F(2,68)=9.106$ ;  $p=0<.001$ ,  $\eta^2 = .211$ ). Post hoc comparisons revealed that the total number of successfully recalled words in the neutral context was significantly higher than memory recall in both pleasant ( $p=.002<.01$ ) and unpleasant contexts ( $p=.006<.01$ ).

### *Long-term memory*

In each emotional context 20 words were presented. In order to assess the influence of emotional context on long-term memory, scores of successful word recall was calculated up to the 15<sup>th</sup> word presented. In this way, 34 seconds had passed since the last word to be remembered had been presented. The sample comprised of 32 people, 3 volunteers were not included as data for their memory recall performance were not collected due to technical failure of the presentation software used. Long-term memory recall for neutral words presented in neutral contexts was significantly greater in number ( $M = 7.22$ ,  $SD=2.459$ ) when comparing for long-term memory



recall of neutral words presented in both pleasant ( $M = 5.91$ ,  $SD = 2.305$ ) and unpleasant ( $M = 5.5$ ,  $SD = 2.769$ ) contexts ( $F(2,62)=6.552$ ;  $p=.003<.01$ ,  $\eta^2 = .174$ ).

*Emotional Context Finger and Skin Temperature*

Five different models were statistically tested for significant differences in FST during emotional contexts. The results show that mean FST during pleasant, unpleasant and neutral contexts do not differ significantly ( $\chi^2(2, 35) = 2.457, p > .05$ ). The slope of FST during pleasant, unpleasant and neutral contexts do not differ significantly ( $F(2, 68) = .109, p > .05$ ). The linear regression of FST during pleasant, unpleasant and neutral contexts do not differ significantly,  $F(2, 68) = .808, p > .05$ . The FST slope ratio of context to baseline during pleasant, unpleasant and neutral contexts do not differ significantly ( $\chi^2(2, 34) = 4.412, p > .05$ ). The FST linear regression ratio of context to ratio during pleasant, unpleasant and neutral contexts do not differ significantly ( $\chi^2(2, 34) = .1824, p > .05$ ).

*Memory Recall and Finger Skin Temperature*

The results show that mean FST during pleasant, unpleasant and neutral recall time do not differ significantly ( $\chi^2(2, 35) = 4.514, p > .05$ ). The slope of FST during pleasant, unpleasant and neutral recall time do not differ significantly ( $\chi^2(2, 35) = .686, p > .05$ ). The results show that the linear regression of FST during pleasant, unpleasant and neutral contexts do not differ significantly ( $\chi^2(2, 35) = .972, p > .05$ ).

**Discussion**

The memory mechanisms of attention, working memory, long-term memory and retrieval have been shown to enhance memory for emotional information relative to neutral information as the greater the existence of early information processing resources, elaboration on rehearsal, consolidation and presence of retrieval cues the greater the possibility to enhance memory for emotional information relative to neutral information (for a review see Levine & Edelman, 2009). In this particular study, the aim was to provide empirical evidence on the facilitation of memory performance for neutral words encoded in emotionally pleasant, unpleasant and neutral pictorial contexts and if FST measurements can provide a physiological basis of this performance.

At least 60% of the 35 volunteers perceived the induced emotional contexts as it was intended. The volunteers perceived both neutral and pleasant induced contexts as slightly emotional, whereas the unpleasant context as moderately emotional, on a scale from 0 to 4. Their self-reports come in line with the statistical analysis of FST during emotional contexts, as no statistically significant difference was detected in terms of arousal. This can be explained from the selection of the pictures as those used for the pleasant and unpleasant contexts were of similar arousal ratings (moderate to very arousing according to the IAPS ratings) and those selected to induce the neutral context were slightly arousing.

Both total memory recall performance and long-term memory were found to be enhanced when neutral words were presented in a neutral context, characterised by moderately pleasant IAPS pictures, comparing to slightly pleasant IAPS pictures in the unpleasant context and to very pleasant IAPS pictures in the pleasant context. The single existing study (Erk et al., 2003) that has provided evidence for memory

performance in pictorial emotional contexts showed that emotionally pleasant contexts favoured subsequent memory performance comparing to emotionally unpleasant contexts. The experimental design though was different as both emotional contexts were presented continuously with a break of 6 seconds whereas in this study each emotional context was induced with the appearance of appropriately selected IAPS images for each context lasting for 2.26 minutes and then followed by 4 minutes of recall break. It was commented by Erk et al. (2003) that before using their experimental design in one of their pilot studies their participants could not engage their feelings to an induced emotional context, in contrast to this study where at least 60% of the participants perceived the induced emotional context as intended.

The differentiation of memory recall in terms of valence has been investigated extensively with functional neuroimaging methods for emotional material rather than emotional context. LaBar and Cabeza (2006) comment that the memory enhancement provided by arousal seems to engage similar brain systems for positive and negative valence. Studies by Cahill et al. (1996) and Hammann et al. (1999) highlighted with empirical evidence the role of amygdala for the subsequent memory of emotionally arousing events. Declarative memory retention conferred by emotional valence in the absence of high arousal results from semantic and strategic processes without the involvement of the amygdala (LaBar and Cabeza, 2006).

It has been showed that encoding context can enhance memory when is reinstated at retrieval (Cutler & Penrod, 1988). In this study no retrieval cues were provided and people performed better after learning in a neutral context. This comes in contrast with the findings by Levine et al. (2007) as they have demonstrated that neutral words were recognised and recalled more frequently when presented in an emotionally negative context than in a neutral one. In addition, neutral words embedded in emotional sentences were remembered better when the embedded word was positioned in front of the emotional target words, compared to after them, providing explanation of their results due to classical conditioning. In this experimental design neutral words appeared in the middle of emotional pictures simultaneously, and the emotional context was induced through pictures.

It has been shown in this study that in the absence of high arousal memory performance in terms of immediate recall and long-term memory does not differ between neutral words presented in either pleasant or unpleasant contexts, and it is significantly greater for those presented in a neutral context but with a small effect size which is indicative of further collecting data to increase the sample size as it was limited to 35 volunteers so we can talk with validity and reliability about the significance of the results.

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