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Enhancing Memory the Easy Way:

Effects of non-conscious emotional imagery on memory performance

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Word Count:

Abstract: 249

Main Body: 7913

ABSTRACT

Researchers have devised and tested numerous strategies to enhance memory performance. These mnemonic tools often require effort, motivation, and practice from the individual seeking improved memory. Emotion appears to enhance memory effortlessly, however: Stimuli that provoke emotional reactions are remembered better than neutral stimuli. Still, the presence of an emotional stimulus can detract from the often mundane information we would like to remember. This study investigated a possible solution to this problem by examining effects of non-conscious emotional stimuli (subliminal facial expressions) on memory for neutral stimuli (a list of words). I recruited 100 undergraduate students (83 women) and randomly assigned each to one of five subliminal facial expression conditions ($n = 20$ each): fearful, angry, happy, neutral, and none. Each participant was exposed to a facial expression before being shown a word they were instructed to attend to. Memory for the words was tested on the day of the experiment and one day later. Those exposed to emotional expressions (fearful, angry, happy) recalled and recognised more words than did other participants. The largest effect was found for memory tested on Day 1 for participants in the fearful faces condition. Moreover, only participants in the happy faces condition showed improved memory over the 24-hr delay. Hence, the non-conscious emotional stimuli appeared to enhance memory performance without distracting from, or dominating, the to-be-remembered list of words. This study therefore offers an answer to the question of how one might enhance memory performance in a way that requires no conscious effort.

Keywords: non-conscious; subliminal; facial expressions; emotion; memory

A fundamental problem in human psychology is how to improve memory, particularly for the often boring and mundane information we are obliged to learn. To this end, numerous methods, tricks, and artifices have been used and investigated, both informally and empirically. Many of these mnemonic devices rely on greater elaboration of the to-be-remembered information. For example, the *depth of processing* technique (Craik & Lockhart, 1972) is based on the notion that durability of a memory requires greater semantic involvement. Thus, individuals using this technique ask questions, form associations, and try to personally relate to the to-be-remembered information (Chang, 2017; Eysenck, 2014). Another popular strategy, the *method of loci*, requires the individual to create an image of a space in their mind and place images which represent the to-be-remembered information at particular locations within that space (Bower, 1970). The individual then mentally travels through the space when they wish to retrieve a particular memory (Ashoori & Moghadam, 2015; Dresler et al., 2017).

Although these mnemonic devices are frequently employed with notable success, their implementation requires effort, motivation, and no small amount of training and practice. Hence, many people are disinclined to use them, and the search continues for a method of enhancing memory performance with minimal investment of time, energy, and cognitive effort.

A large literature describes ways in which adding emotional stimuli to an environment can effortlessly and efficiently enhance memory for elements of that environment (Brown & Kulik, 1977; LaBar & Cabeza, 2006; McGaugh, 2018; Talmi, 2013). Numerous empirical studies demonstrate that emotionally-valenced stimuli (e.g., an image of a pointed gun or smiling face) are remembered more confidently in terms of their vividness and detail than more mundane or neutral stimuli (such as a geometric shape or an expressionless face; Ekman & Davidson, 1994; Kensinger & Kark, 2018; Tulving, 2016). This heightened-memory effect is achieved by increased arousal at the time of memory encoding, as well as increased attentional and cognitive resources given to the to-be-remembered emotional stimuli (Garrison & Schmeichel, 2018; McGaugh, 2018). Some studies have found a particularly heightened effect of emotion after delays of at least 24 hours (Ritchey, Montchal, Yonelinas, & Ranganath, 2015; Sharot & Yonelinas, 2008). One mechanism purported to account for this phenomenon is the impact of emotion on rehearsal processes: The presence of emotion makes it more likely such stimuli is rehearsed, strengthening memory traces over time (Kensinger & Kark, 2018; McGaugh, 2015; Yonelinas & Ritchey, 2015).

For the purposes of general memory improvement, however, the problem with using emotion as a mnemonic tool is that the stimulus used to induce the emotion often detracts from other stimuli in the environment – the often boring and mundane stimuli that we would like to remember better (Garrison & Schmeichel, 2018; Preciado, Munneke, & Theeuwes, 2017). The outcome of this is that the non-emotional information that needs to be learnt becomes distorted or forgotten owing to individuals' focus and attention being dominated by the emotional stimuli (Dolcos, Iordan, & Dolcos, 2011; Tyng, Amin, Saad, & Malik, 2017; Xie & Zhang, 2017).

The current study tests a possible solution to the way in which emotion dominates and detracts from information surrounding it. Specifically, I investigated the effects on memory performance of presenting non-conscious emotional stimuli (i.e., stimuli the individual is subjectively unaware of), rather than conscious emotional stimuli (i.e., the kinds of stimuli used in the research mentioned above), at the time of neutral information encoding. The proposal here is that such a context allows the emotional nature of the enhancing stimuli to be retained while doing away with its conscious, distracting components.

Previous research investigating the influence of non-conscious stimuli on memory performance have focused on verbal subliminal exposure. Here, the term *subliminal* refers to stimuli presented below the threshold of conscious sensory awareness (Reingold & Merikle, 1988). Hence, studies using verbal forms of such stimuli present positive affirmatory words or auditory messages rapidly before presenting the to-be-remembered information. Typically, however, these studies find little-to-no enhancing effects on memory performance (Greenwald, Spangenberg, Pratkanis, & Eskenazi, 1991; Krendl, Ambady, & Kensinger, 2015; Russell, Rowe, & Smouse, 1991). One way to account for these negative results is that verbal content may rely heavily on conscious semantic processing, and that subliminal verbal messages may thus remain largely undetected and unprocessed (LeDoux, 1998; Meneguzzo, Tsakiris, Schioth, Stein, & Brooks, 2014).

Murphy and Zajonc (1993) suggest that images are a better source for non-conscious exposure methodologies as their meanings and emotional content are more easily extracted at thresholds below conscious awareness. However, no studies to my knowledge have investigated the effects of non-conscious emotional imagery on memory for subsequently-presented neutral information, despite research demonstrating that such stimuli can affect cognitive processes such

as attention and arousal, both of which are important building blocks of memory (Kensinger & Kark, M, 2018; McGaugh, 2018; Murphy & Zajonc, 1993; Prochnow et al., 2013).

Research investigating the effects of non-conscious emotional imagery typically use emotional facial expressions (see Axelrod, Bar, & Rees, 2015; Tamietto & De Gelder, 2010 for a review). Some studies have found effects on cognition and behaviour for facial expressions that are positively valenced and communicate safety or reward (e.g., a smiling face), whereas others have found effects for those that are negatively valenced and communicate threat (e.g., an angry or a fearful face; Davis et al., 2011; Winkielman, Berridge, & Wilbarger, 2005). For instance, Sweeny, Grabowecky, Suzuki, and Paller (2009) found that surprised faces that were paired with subliminal happy faces were rated as more positive and were remembered better one day later compared to when they were paired with fearful or neutral subliminal faces. The non-conscious presentation of angry faces has also been observed to orientate attention toward a consciously presented target (Öhman & Mineka, 2001), while the presentation of non-conscious fearful faces has been shown to increase arousal and facilitate response timing (Carlson & Reinke, 2008).

The current study's novelty is thus that it investigated effects of non-conscious emotional imagery (emotional facial expressions) on memory for subsequently-presented neutral information (non-valenced words). I tested the hypothesis that memory for words presented subsequent to subliminal emotional faces will be remembered better than words presented subsequent to subliminal neutral faces or no subliminal stimuli. Furthermore, I aimed to identify, which if any, of two facial expression categories (negative threatening or positively rewarding) produced the biggest memory-enhancing effects. Based on findings reported by Sweeny et al. (2009), I made the tentative prediction that positively rewarding stimuli will produce the best delayed memory outcomes after 24 hours.

Methods

Design and Setting

This experimental study featured a single-factor repeated-measure design, with five levels. These five levels were categorised along three dimensions related to the subliminal stimuli: negative threatening (stimuli were either fearful or angry facial expressions); positive rewarding (stimuli were smiling facial expressions); and control conditions (stimuli were either neutral facial expressions or entirely absent). Hence, each participant was randomly assigned to one of five conditions: Fear, Anger, Happy, Neutral, or None. Outcome measures were

immediate recall and recognition, as well as one-day delayed recall and recognition, of a list of neutral words.

I chose to use two different negative threat stimuli because there is contention in the literature about whether angry and fearful faces are part of a single 'negative threatening' category of expression. Even though they both communicate threat, they appear to have different effects on attention, arousal, and brain activation (Fox et al., 2000; Hedger, Adams, & Garner, 2014; Whalen et al., 2001).

I chose to use two control conditions to test whether the emotional nature of the subliminal stimuli, rather than simply the presentation of subliminal faces, accounted for any positive results.

Participants completed initial study procedures in the ACSENT laboratory of the University of Cape Town (UCT) Department of Psychology. They completed an online memory test one day after laboratory procedures.

Participants

I recruited 103 undergraduate students by convenience sampling, using the UCT Department of Psychology's Student Research Participation Programme (SRPP; see Appendix A). Eligibility criteria specified that participants (a) be aged between 18 and 26 years, (b) have no current prescription for psychotropic medication, (c) have no neurological disease or history of head trauma with loss of consciousness, and (d) have no diagnosis of an affective disorder, as characterized by the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5; American Psychiatric Association, 2013).

This latter criterion was enforced strictly because clinical levels of depression and anxiety appear to affect both memory performance and emotional experience, as well as relations between them (Garrison & Schmeichel, 2018; Shi, Gao, & Zhou, 2014). Depression can bias cognition and memory recall toward negative events, and anxiety can exert an attentional bias toward threatening information (Eysenck, Derakshan, Santos, & Calvo, 2007; Yiend, 2016). Moreover, individuals with moderate-to-high anxiety levels are better at detecting threat even when it is rendered non-conscious, indicating a bias occurring at early stages of the attentional process (Mogg, Bradley, & Williams, 1995). Non-clinical anxiety levels were further investigated in the current study as a possible confound.

The datasets of three participants were excluded from the final analysis owing to them reporting conscious awareness of the subliminal stimuli. Hence, the final sample comprised 100 participants (83 women; age $M = 20.51$, $SD = 1.36$). However, G*Power software (Faul, Erdfelder, Buchner, & Lang, 2009) calculated that a sample size of 125 would deliver sufficient statistical power to detect the effects under consideration. This calculation was based on an ANOVA repeated-measures, between-groups analysis, with statistical parameters set at a small-moderate effect size of Cohen's $f = .25$, power $(1 - \beta) = .80$, and $\alpha = .05$.

Materials

All materials were presented to participants electronically (i.e., on a computer screen) except for the paper-and-pencil subjective image awareness questionnaire.

Self-report measures.

Sociodemographic questionnaire. This study-specific questionnaire (Appendix B) gathered biographical information (viz., age, sex).

Mood scale. The *Self-Assessment Manikin* (SAM; Lang, 2005; Appendix C) measured participants' subjective emotional levels during the experiment to determine whether the experimental conditions had an effect on conscious subjective emotional levels. SAM is an imagery-based 9-point Likert-type scale that is used frequently in emotion research (Bynion & Feldner, 2017; Gläscher & Adolphs, 2003). On the SAM-Pleasure scale, respondents rate how sad or happy they feel; values near to 1 indicate sad, near to 5 indicate neutral, and near to 9 indicate happy. On the SAM-Arousal scale, respondents rate how aroused they feel; values near to 1 indicate not aroused, near to 5 indicate neutral, and near to 9 indicate very aroused.

The SAM displays high levels of internal consistency and reliability (Bradley & Lang, 1994; Morris, 1995). Furthermore, because it is a language-free measure, it has been used successfully within many different countries, including South Africa (Bradley, Greenwald, Petry, & Lang, 1992; Bynion & Feldner, 2017; Yao, Joubert, & Davis, 2016).

Subjective anxiety. The *Spielberger State-Trait Anxiety Inventory* (STAI; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983; Appendix E) assessed participants' general as well as in-the-moment anxiety levels. Form Y-1 of the instrument consists of 20 items that measure state anxiety, whereas Form Y-2 consists of 20 items that measure trait anxiety. All items are answered using a 4-point Likert-type scale, with response options ranging from "not at all" to "very much" (Y-1) or "almost never" to "almost always" (Y-2). Higher scores indicate higher

anxiety levels (Spielberger et al., 1983). The instrument has a high degree of internal consistency and test-retest reliability (Speilberger & Vagg, 1984). It is also used regularly in South African research (Du Plooy, Thomas, Henry, Human, & Jacobs, 2014; Rieckert & Möller, 2000; Spangenberg & Campbell, 1999).

Subjective image awareness questionnaire. This questionnaire, based on one used by Brooks et al. (2012), was used to check if the participants had any conscious awareness of the subliminal stimuli presented during the encoding task (see Appendix F). If participants said they had seen something, they were asked to judge, using a 5-point Likert-type scale, how confident they were about having seen something, and to then write down what they think they saw. Cheesman and Merikle (1986) suggest subliminal stimuli are those that fall below the subjective threshold of consciousness. Hence, if the participants reported any subjective awareness of the facial expressions, these images could not be regarded as subliminal stimuli for them, and their data were excluded from the final analyses.

Encoding task stimuli.

Subliminal emotional stimuli. I used images from the *Radboud Faces Database* (RaFD; Langner et al., 2010). The RaFD comprises 67 faces, including those of Caucasian Dutch adults ($n = 39$) and children ($n = 19$) and Moroccan Dutch men ($n = 19$). The expressions shown on the faces are based on prototypes from the Action Coding System (Ekman, Friesen, & Hager, 2002). This dataset has been validated in terms of ratings of attractiveness and intensity and of expression genuineness, judgment, and valence (Langner et al., 2010). The faces used here ($n = 100$) were divided into five categories, with 20 faces (50% male) comprising each category. The sample consisted of 15 Caucasian Dutch adults (9 women), one Caucasian Dutch female child, and four Moroccan Dutch men. All faces were looking forward, featured on a white background, and matched on technical aspects including lighting, facial landmarks, background, colour, and clothing.

To control for lower-level aspects of the facial expressions as well as gender and attractiveness, I used the same 20 identities for each of the conditions. Thus, each participant was exposed to the same 20 face identities, differing only by emotional expression for each subliminal stimulus condition.

Word list. I selected 60 words from the Medical Research Council's Psycholinguistic Database (http://websites.psychology.uwa.edu.au/MRCDataBase/uwa_mrc.htm). Words were

matched on number of letters (between 5 and 10), number of syllables (between 1 and 3), and meaningfulness (Colorado and Paivo Norms < 700). Twenty words formed the target list (i.e., were presented at the encoding phase), while the remaining 40 were used as foils during the Day 1 and Day 2 recognition tests (20 words per day; see Appendix D).

Procedure

On Day 1, each participant (within a group of 2-10 participants) completed study procedures in the research laboratory. Each of the 10 computers in the laboratory ran the procedures using E-Prime software (Psychology Software Tools, 2016, Pittsburgh, Pennsylvania).

Each condition's stimuli were loaded onto two non-adjacent computers. After entering the laboratory, participants were told to freely choose a computer. To ensure that there would be an equal number of participants per condition, toward the end of the study participants were directed to sit at a computer running a particular condition. On Day 2, all participants were sent an email containing a link to an online memory test.

Day 1. Upon entering the laboratory, the participant was seated at a booth containing a desktop computer. The participant's eyes were approximately 60cm away from the computer screen. The group was told they would be viewing a list of words and would then complete some questionnaires. Based on Davis et al. (2011), the cover story given to participants was that the study was investigating the effects of words on completing questionnaires. I did not mention that memory for the words would be tested -- this minimized confounds related to performance anxiety or differential use of memory rehearsal procedures. Participants were also told they might be exposed to emotional images during the experiment, but they were not told these would appear during the memory encoding task. Withholding this information sought to ensure that the emotional stimuli did not have placebo effects, which is a concern in research investigating effects of subliminal stimuli (Takahashi, 2007). Finally, participants were instructed that if they wished to continue with the study, they should sign the consent forms (Appendix G) and press the spacebar on their keyboard. No participant withdrew at this point.

After pressing the spacebar, participants were prompted to complete the sociodemographic questionnaire. At completion, they were instructed to press the spacebar again when they were ready to start the experiment. The experiment itself began with the SAM scales appearing on the screen. Participants were instructed to use the SAM to indicate how they felt in

the moment. After completing the SAM, they were told that a list of words would be presented to them one by one and that they should pay attention to these words. Thereafter, the encoding task featuring the subliminal stimuli was presented (see Figure 1).

First, a white fixation cross centered on a black background was presented on the screen for 500 milliseconds (ms). Then, a facial expression (measuring 17 x 27 cm; or no stimuli, in the None condition) was shown for 16.7ms. The choice of this speed was based on three factors: (a) in order to make the stimuli subliminal, speeds of below 30 ms need to be achieved (Murphy & Zajonc, 1993) (b) it is the fastest speed attainable on a monitor with a refresh rate of 60 Hz, and (c) Liddell et al. (2005) used this speed and found it to be effective at eliciting neural responses while remaining undetected by the participants (the latter confirmed by self-report). After each image, a new word from the encoding list (see Appendix D) covering a face was presented for 3000ms. The use of the face acted as a backward mask to prevent conscious awareness of the subliminal stimuli that preceded it (Pessoa, Japee, & Ungerleider, 2005). This encoding task procedure was repeated until each of the 20 target words and emotional faces had been displayed. The order of face and word presentation was randomised to control for order effects.

At the conclusion of the encoding task, a screen appeared asking participants to complete the SAM scale again. After doing so, they were asked to complete the STAI. Aside from its central purpose, this questionnaire also acted as a distractor to ensure participants did not engage in subvocal rehearsal of the word list.

After completing the STAI, participants were given a surprise memory test in which they were asked to recall as many items as they could from the word list. They completed this recall task by typing words into a space provided on the screen. After they had exhausted their free recall, they were told that words were going to appear on the screen, one at a time, and that for each word they should press either '1' for yes (was a part of the encoded list) or '0' for no (was not a part of that list). A new word only appeared after the participant had made a selection for the word currently on the screen. The order of word presentation was once again randomised between participants.

Finally, participants completed the subjective image awareness questionnaire. These procedures took 20-30 minutes to complete.
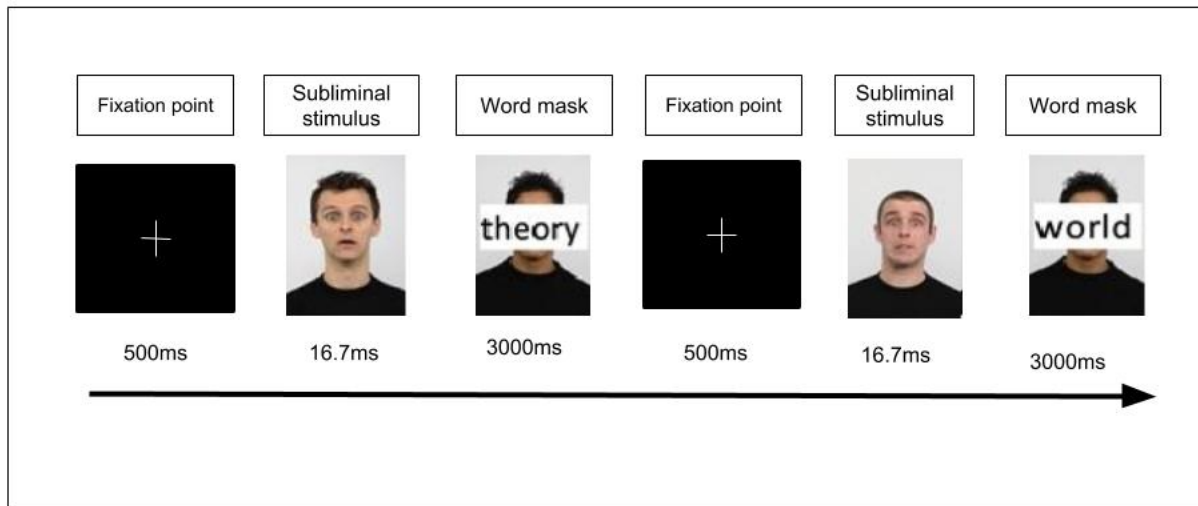
Figure 1. Illustration of an encoding task procedure block. This series (fixation point, subliminal stimulus, word mask) was repeated until all 20 words and emotional stimuli had been shown.

Day Two. Participants were sent a memory test via a link (https://www.surveymonkey.com/r/H2G36KF; see Appendix I) sent by email 24 hours after completion of the laboratory procedures described above. They were instructed to click on the link as soon as they received it. The link took participants to a questionnaire that asked them to recall as many words as they could remember from the encoding task presented the previous day. They completed this recall task by typing words into a space provided on the questionnaire. After exhausting their recall, they were prompted to select a button which took them to the next screen. That screen showed a word list comprising 20 'new' items (i.e., words never seen before) and 20 'old' items (i.e., words from the encoding task they had been shown previously). They were asked to tick the boxes next to the words they remembered from the word list. This questionnaire took 5-10 minutes to complete. Participants were rewarded 2 SRPP points for their participation in the study.

Participants were debriefed via email after they had completed all procedures. The email explained the true nature of the experiment. Ethical approval for the study was granted by the UCT Ethics Review Committee of the Faculty of Humanities, reference number PSY2018-030.

Data Management and Statistical Analyses

Statistical analyses were performed using Microsoft Excel and SPSS (version 25). Datasets were checked thoroughly for any entry errors, missing values, and outliers before analysis commenced. For decisions pertaining to statistical significance, α was set at .05, following convention (Field, 2013).

Inferential analyses proceeded across three distinct stages. First, a series of one-way analyses of variance (ANOVAs) assessed between-condition differences with regard to sociodemographic characteristics (viz., age, sex), SAM scores, and STAI scores. Second, a series of paired-sample *t*-tests assessed within-group changes in SAM scores from pre- to post- word encoding task procedure.

Third, a series of one-way ANOVAs assessed between-condition differences with regard to memory performance (recall and recognition, evaluated separately, on Day 1 and Day 2). Before commencing these analyses, I scored each word of each participant's recall trial on Day 1 and 2 as "correct" or "incorrect." An independent judge made the same ratings on a sample of data from 20 participants, which was comprised of four randomly assigned participants from each condition. Inter-rater reliability revealed 100% agreement ($\kappa = 1.00$, $p < .001$ for recall outcomes on both days). I then derived the following outcome variables:

(1) Recall trials: (a) *hits* (proportion of words generated that were part of the encoded list), (b) *intrusions* (proportion of words generated that were not part of the encoded list); (c) *corrected recall* ([hits – false alarms] / total number of words on the encoded list; following Davis et al., 2011); and (d) *retention* (hits on Day 2 / hits on Day 1).

(2) Recognition trials: *hits* (words correctly identified as part of the encoded list), (b) *false alarms* (words incorrectly identified as being part of the encoded list); and (c) *corrected recognition* ([hits – false alarms] / total number of words on the target list; following Davis et al., 2011)

Recognition accuracy was further analysed using a loglinear signal detection approach for *d'* measures (Snodgrass & Corwin, 1988). This analysis is recommended for data where some participants achieve a 100% hit rate or a 0% false alarm rate, which was the case in the current study. This approach involves adding 0.5 to both the number of hits and false alarms frequencies for each participant, and then dividing each of these frequencies by ($N + 1$), where N is the total number of 'old' or 'new' items (Stanislaw & Todorov, 1999).

Games-Howell post-hoc tests analysed directionality of significant recall and recognition results. I chose to use this post-hoc procedure because some of the memory performance outcomes were relatively skewed. The Games-Howell procedure is conservative (i.e., it offers good power and control against Type I error) and is recommended for data that are not normally distributed (Field, 2013; Shingala & Rajyaguru, 2015). All of the other assumptions underlying parametric statistical tests were upheld, unless otherwise stated.

Results

Sample Characteristics

Table 1 summarises the sample's characteristics with regard to age, sex, time between Day 1 and Day 2 memory testing, self-reported state and trait anxiety and subjective emotion ratings. Analyses detected no between-condition differences with regard to any of those variables. Hence, none of those variables were considered as possible confounds or covariates in subsequent analyses.

Table 1
Sample Characteristics (N = 100)

	Condition									
Measure	Fear (n = 20)	Anger (n = 20)	Happy (n = 20)	Neutral (n = 20)	None (n = 20)	F/χ^2	df	p	ESE	95% CI
Age (years)	20.55 (1.28)	20.30 (1.72)	20.35 (1.81)	20.65 (.59)	20.70 (1.13)	0.33	4,95	.854	.01	[20.24, 20.78]
95% CI	[19.95, 21.15]	[19.50, 21.10]	[19.50, 21.20]	[20.38, 20.92]	[20.17, 21.33]					
Sex (M:F)	5:15	3:17	4:16	3:17	2:18	1.84	4	.765	.14	----
Testing interval (hours)[a]	25.76 (1.01)	26. 03 (1.29)	25. 84 (1.19)	25.97 (1.12)	26. 05 (1.02)	0.25	4,95	.912	.01	[25.71, 25.15]
95% CI	[25.29, 26.24]	[25.43, 26.64]	[25.28, 26.40]	[25.44, 26.50]	[25.57, 26.53]					
STAI										
Form Y-1 (*M, SD*)	40.80 (10.86)	43.70 (9.83)	37.40 (11.92)	41.95 (14.61)	36.90 (11.31)	1.23	4,95	.303	.05	[37.79, 42.51]
95% CI	[35.72, 45.88]	[39.10, 48.30]	[31.82, 42.98]	[35.11, 48.79]	[31.61, 42,19]					
Form Y-2 (*M, SD*)	46.60 (12.45)	48.05 (11.874)	39.30 (10.07)	44.65 (15.30)	46.35 (11.78)	1.50	4,95	.208	.06	[42.50, 47.48]
95% CI	[40.77, 52.43]	[42.49, 53.61]	[34.59, 44.01]	[37.49, 51.81]	[40.83, 51.87]					
SAM-Pleasure										
Before	6.10 (1.25)	6.40 (1.43)	6.35 (1.57)	6.15 (1.57)	6.85 (.875)	0.95	4,95	.438	.04	[6.10, 6.64]
After	5.65 (1.27)	5.65 (1.53)	6.10 (1.48)	5.85 (1.57)	6.65 (.93)	1.84	4,95	.127	.07	[3.41, 4.19]
Difference	-0.45 (.83)	-0.75 (.85)	-0.25 (.85)	-0.30 (.73)	-0.20 (.62)	1.62	4,95	.176	.06	[0.23, 0.55]
95% CI	[-0.84, -0.06]	[-1.15, -.35]	[-0.65, 0.15]	[-0.64, 0.04]	[-0.49, 0.09]					
SAM-Arousal										
Before	3.65 (2.16)	3.80 (1.99)	3.65 (2.08)	4.25 (1.89)	3.65 (1.81)	0.34	4,95	.850	.01	[5.70, 6.26]
After	3.90 (2.32)	3.60 (1.85)	4.05 (2.50)	4.30 (1.87)	3.80 (1.61)	0.33	4,95	.858	.01	[5.53, 4.33]
Difference	0.25 (.79)	-0.20 (1.40)	0.40 (1.35)	0.05 (.76)	0.15 (1.04)	0.84	4,95	.505	.03	[-0.35, 0.09]
95% CI	[-0.12, 0.62]	[-0.85, 0.45]	[-0.23, 1.03]	[-0.31, 0.41]	[-0.34, 0.64]					

Note. For the variables: Age, Testing interval, SAM-Pleasure, SAM-Arousal and STAI, data presented are means with standard deviations in parentheses. Depending on whether the measure was categorical or continuous, the test statistic F or χ^2 is provided.
[a]Time between Day 1 (laboratory administration) and Day 2 (online administration) memory testing.
CI = confidence interval; ESE = effect size estimate (η_p^2 for one-way ANOVAs, or Cramer's *V* for chi-squared tests of contingency); STAI = State-Trait Anxiety Inventory (Form Y-1 = State form; Form Y-2 = Trait form); SAM = Self-Assessment Manikin.
All listed *p*-values are two-tailed.

Within-Group Comparisons of Subjective Mood Ratings

Analyses detected only two significant results: changes in SAM-Pleasure ratings in the Fear and Anger conditions from pre- to post- word encoding procedure. Participants in those conditions reported significantly decreased (i.e., more sad, less happy) mood after being exposed to stimuli compared to before exposure). Each of these significant results was associated with a medium-to-large effect size estimate (see Table 2).

Table 2

Difference in Subjective Mood Ratings from Pre- to Post-Encoding Procedure (N = 100)

| | SAM-Pleasure | | | | | | | SAM-Arousal | | | | | | |
| | Before | | After | | | | | Before | | After | | | | |
Condition[a]	M (SD)	95% CI	M (SD)	95% CI	t	p	ESE	M (SD)	95% CI	M (SD)	95% CI	t	p	ESE
Fear	6.10 (1.25)	[5.51, 6.69]	5.65 (1.27)	[5.06, 6.24]	-2.43	.025*	-0.36	3.65 (2.16)	[2.64, 4.66]	3.90 (2.32)	[2.82, 4.98]	1.42	.171	0.11
Anger	6.40 (1.43)	[5.73, 7.07]	5.65 (1.53)	[4.94, 6.37]	-3.94	.001**	-0.50	3.80 (1.99)	[2.87, 4.73]	3.60 (1.85)	[2.74, 4.46]	-0.64	.530	-0.10
Happy	6.35 (1.57)	[5.62, 7.08]	6.10 (1.48)	[5.41, 6.79]	-1.31	.204	-0.16	3.65 (2.08)	[2.67, 4.63]	4.05 (2.50)	[2.88, 5.22]	1.32	.202	0.17
Neutral	6.15 (1.57)	[5.42, 6.88]	5.85 (1.57)	[5.12, 6.58]	-1.83	.083	-0.19	4.25 (1.89)	[[3.37, 5.13]	4.30 (1.87)	[3.43, 5.17]	0.30	.772	0.03
None	6.85 (.875)	[6.44, 7.26]	6.65 (.93)	[6.21, 7.09]	-1.45	.163	-0.22	3.65 (1.81)	[2.80, 4.50]	3.80 (1.61)	[3.05, 4.55]	0.65	.527	0.09

Note. n = 20 per condition. CI = confidence interval; SAM = Self-Assessment Manikin; ESE = effect size estimate (a calculation of Cohen's *d* that involves taking the correlation between measures into account (Dunlap, Cortina, Vaslow, & Burke, 1996).

*p < .05. **p < .01. All listed *p*-values are two-tailed.

Between-Group Comparisons of Memory Performance

 Recall Day 1. As Table 3 shows, analyses detected two significant between-condition differences: For hits, and for corrected recall. Post-hoc pairwise comparisons revealed that (a) regarding hits, participants in the Fear condition performed significantly better than those in the Happy, Neutral, and None conditions, all ps = .003, and (b) regarding corrected recall, participants in the Fear condition performed significantly better than those in the Happy, Neutral, and None conditions, p = .014, .003, and .019, respectively. Each of these significant results was associated with small effect size estimates.

 Recall Day 2. As Table 3 shows, analyses again detected two significant between-condition differences. Again, these were for hits and for corrected recall. Post-hoc pairwise comparisons revealed that: (a) regarding hits, participants in the Fear condition performed significantly better than those Neutral and None conditions, p = .006 and .038, respectively, and (b) regarding corrected recall, participants in the Fear condition performed significantly better than those in the Neutral and None conditions, p = .001 and .031, respectively, and participants in the Anger condition performed significantly better than those in the Neutral condition, p = .045. Each of these significant results was associated with small effect size estimates.

 Retention across days. Initially, the omnibus F statistic was statistically significant overall (p = .039). However, because of a violation of the homogeneity of variance assumption, I had to employ a Welch correction, and this resulted in the statistic no longer meeting the threshold for statistical significance (see Table 3). Descriptive statistics suggested that participants in the Happy condition had the best retention scores and were the only ones whose recall memory performance improved on Day 2 (see Figure 2).

Table 3

Recall Memory Performance: Descriptive statistics and between-condition comparisons for each experimental day (N = 100)

Measure[a]	Fear (n = 20)	Anger (n = 20)	Happy (n = 20)	Neutral (n = 20)	None (n = 20)	F	p	η^2	95% CI
Day 1									
Hits	.40 (.10)	.37 (.13)	.28 (.10)	.26 (.12)	.26 (.12)	6.56	< .001***	.22	[.29, .34]
95% CI	[.35, .44]	[.30, .42]	[.23, .32]	[.20, .32]	[.20, .32]				
Intrusions	.04 (.05)	.06 (.08)	.03 (.03)	.06 (.06)	.04 (.05)	1.66	.167	.07	[.03, .05]
95% CI	[.01, .06]	[.02, .09]	[.01, .04]	[.03, .09]	[.01, .06]				
Corrected Recall[a]	.36 (.11)	.31 (.16)	.25 (.10)	.20 (.15)	.22 (.16)	4.61	.002**	.16	[.24, .30]
95% CI	[.31, .41]	[.23, .38]	[.20, .30]	[.13, .27]	[.15, .30]				
Day 2									
Hits	.38 (.13)	.35 (.17)	.32 (.12)	.24 (.11)	.26 (.13)	4.23	.003**	.15	[.28, .34]
95% CI	[.32, .43]	[.27, .43]	[.27, .37]	[.19, .29]	[.19, .32]				
Intrusions	.03 (.04)	.05 (.06)	.06 (.06)	.07 (.06)	.05 (.05)	1.53	.201	.06	[.04, .06]
95% CI	[.01, .05]	[.02, .08]	[.03, .08]	[.04, .10]	[.02, .07]				
Corrected Recall[a]	.35 (.14)	.31 (.18)	.27 (.14)	.17 (.11)	.21 (.14)	4.98	.001**	.17	[.23, .29]
95% CI	[.28, .41]	[.22, .39]	[.20, .33]	[.11, .22]	[.14, .27]				
Retention[b,c]	0.95 (.23)	1.01 (0.54)	1.39 (0.96)	0.94 (0.23)	0.97 (0.11)	0.99	.425	.10	[.95, 1.16]
95% CI	[0.85, 1.06]	[0.75, 1.26]	[0.94, 1.84]	[0.84, 1.06]	[0.92, 1.03]				

Note. Means are presented, with standard deviations in parentheses and 95% confidence intervals in square brackets below. Mean values for Hits and Intrusions represent proportion correctly and incorrectly recalled, respectively. For each between-group comparison, *df* = (4, 95) unless otherwise stated.

CI = confidence interval.

[a]Calculated as (Hits – False Alarms) / (total number of target words).

[b]Calculated as (Hits on Day 2) / (Hits on Day 1).

[c]Levene's test of homogeneity of variance was significant, and therefore I used the Welch correction to calculate *F*, with adjusted *df* = 4, 43.63.

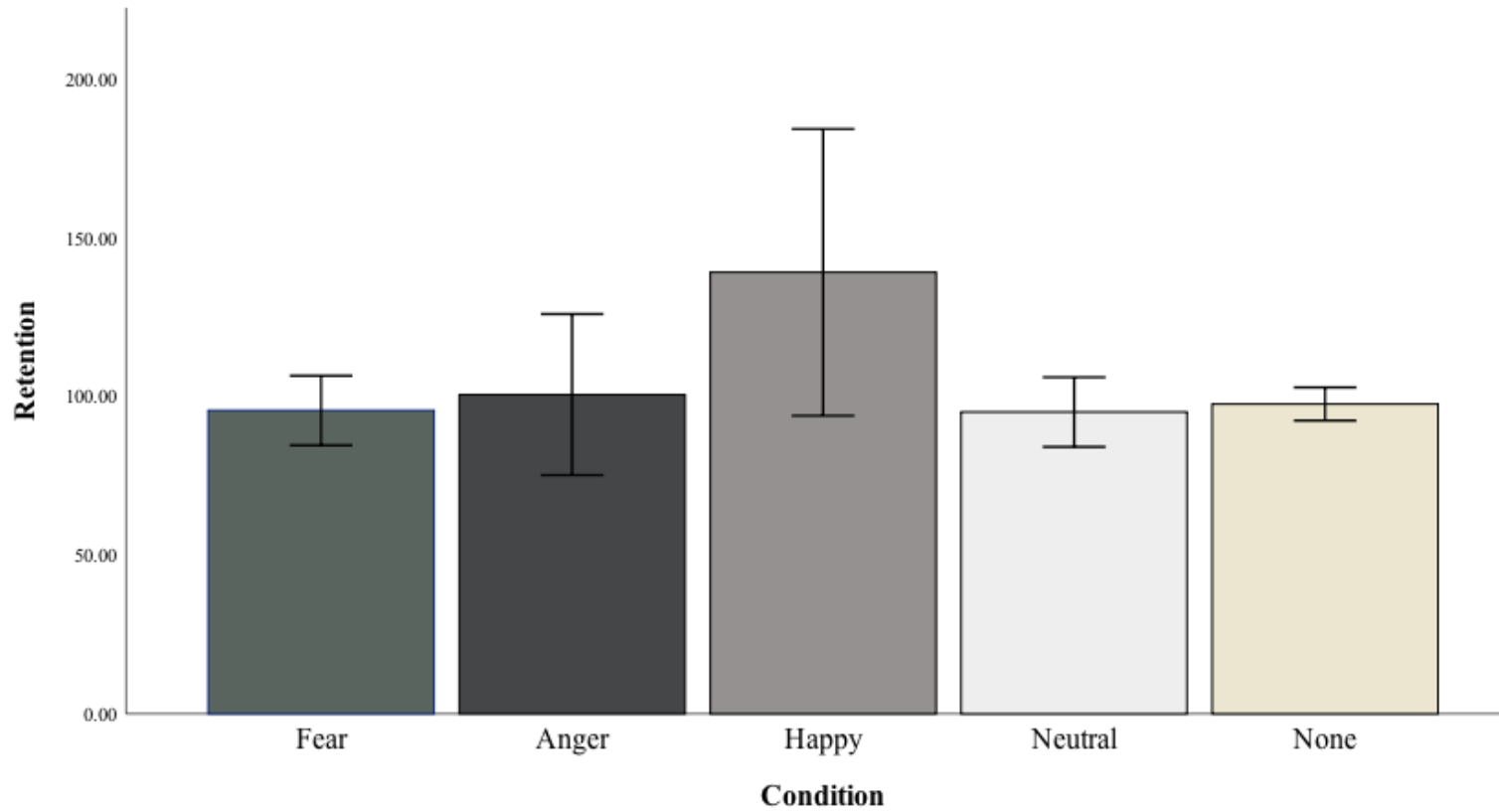*p* < .05. **p* < .01. ***p* < .001. All listed *p*-values are two-tailed.

Figure 2. Retention outcomes for the five subliminal conditions. Error bars represent 95% confidence intervals.

Recognition Day 1. As Table 4 shows, analysis detected three significant between-condition differences: For hits, corrected recall, and d'. Post-hoc pairwise comparisons revealed that (a) regarding hits, participants in the Fear condition performed significantly better than those in the None condition, $p = .013$, and participants in the Anger condition performed significantly better than those in the Neutral and None conditions, $p = .045$ and .001, respectively, (b) regarding corrected recognition, participants in the Fear condition performed significantly better than those in the Neutral and None conditions, $p = .039$ and .046, respectively, and (c) regarding d', participants in the Fear condition performed significantly better than those in the Neutral and None conditions, $p = .044$ and .015, respectively. Each of these significant results was associated with small effect size estimates.

Recognition Day 2. As Table 4 shows, the omnibus F statistic was statistically significant for hits. However, post-hoc pairwise comparisons detected no significant between-condition differences. There was nevertheless a trend toward significance ($p = <.10$) for (a) the Anger condition compared to the Neutral and None conditions, $p = .064$ and .076, respectively and (b) the Happy condition compared to the Neutral and None conditions, $p = .077$ and .090, respectively. Further, descriptive statistics revealed that participants in the Happy condition had the highest memory scores on all Day 2 recognition measures, and once again were the only ones whose recognition memory improved on Day 2.

Table 4

Recognition Memory Performance: Descriptive statistics and between-condition comparisons for each experimental day (N = 100)

Measure	Group					F	p	η^2	95% CI
	Fear (*n* = 20)	Anger (*n* = 20)	Happy (*n* = 20)	Neutral (*n* = 20)	None (*n* = 20)				
Day 1									
Hits	.87 (.13)	.88 (.10)	.78 (.22)	.71 (.23)	.74 (.11)	3.96	.005**	.14	[.76, .83]
95% CI	[.80, .93]	[.83, .93]	[.68, .88]	[.61, .82]	[.68, .79]				
False Alarms	.09 (.11)	.15 (.09)	.10 (.13)	.15 (.17)	.11 (.06)	1.05	.387	.04	[.10, .14]
95% CI	[.04, .14]	[.10, .19]	[.04, .16]	[.07, .23]	[.08, .13]				
Corrected Recognition[a]	.78 (.18)	.73 (.16)	.68 (.22)	.57 (.26)	.63 (.13)	3.63	.008**	.13	[.64, .72]
95% CI	[.69, .86]	[.66, .80]	[.58, .78]	[.45, .68]	[.57, .69]				
d' (log linear)	2.58 (0.83)	2.28 (0.73)	2.20 (0.86)	1.79 (0.88)	1.84 (.49)	3.59	.009**	.13	[1.98, 2.30]
95% CI	[2.19, 2.97]	[1.94, 2.62]	[1.80, 2.61]	[1.38, 2.20]	[1.61, 2.07]				
Day 2									
Hits	.78 (.19)	.80 (.14)	.80 (.16)	.65 (.18)	.66 (.18)	3.77	.007**	.14	[.70, .77]
95% CI	[.69, .87]	[.73, .86]	[.72, .87]	[.57, .74]	[.57, .74]				
False Alarms	.09 (.11)	.11 (.09)	.09 (.13)	.08 (.17)	.06 (.06)	0.84	.504	.03	[.07, .11]
95% CI	[.05, .13]	[.06, .17]	[.04, .13]	[.04, .13]	[.03, .09]				
Corrected Recognition[a]	.69 (.21)	.68 (.17)	.71 (.17)	.57 (.19)	.60 (.18)	2.19	.075	.09	[.61, .69]
95% CI	[.59, .78]	[.60, .76]	[.63, .79]	[.48, .66]	[.51, .68]				
d' (log linear)	2.23 (.88)	2.17 (.75)	2.31 (.68)	1.84 (.73)	1.92 (.62)	1.54	.198	.06	[1.95, 2.24]
95% CI	[1.82, 2.64]	[1.82, 2.53]	[1.99, 2.62]	[1.50, 2.18]	[1.63, 2.21]				

Note. Means are presented, with standard deviations in parentheses and 95% confidence intervals in square brackets below. Mean values for Hits and False Alarms represent proportion correctly and incorrectly recalled, respectively. For each between-group comparison, $df = (4, 95)$ unless otherwise stated.

CI = confidence interval.

[a]Calculated as (Hits – False Alarms) / (total number of target words).

p < .05. **p** < .01. All listed *p*-values are two-tailed.

Discussion

This study aimed to investigate whether non-conscious emotional images (various types of facial expressions) presented immediately before neutral information (non-valenced words) affects subsequent memory for that information. Embedded within the investigation were two specific aims. I address each aim separately below.

Aim 1: Effects of non-conscious emotional stimuli on memory performance

The main hypothesis tested here was that memory for words presented subsequent to subliminal emotional faces will be remembered better than those presented within two control conditions (subsequent to subliminal neutral faces and no subliminal presentation). This hypothesis was confirmed for most outcome variables.

Analyses of Day 1 data revealed that (a) participants in the Fear condition performed significantly better on recall hits, corrected recall, recognition hits, corrected recognition and *d'* outcomes compared to the two control conditions (Neutral and None) and (b) that participants in the Anger condition performed significantly better on recognition hits compared to those in the two control conditions.

Analyses of Day 2 data revealed that (a) participants in the Fear condition performed significantly better on recall hits and corrected recall than those in the two control conditions, and (b) participants in the Anger condition performed significantly better on corrected recall than those in the Neutral condition. Descriptive statistics revealed that participants in the Happy condition had the highest retention outcomes and were the only ones whose recall memory performance improved on Day 2. In terms of recognition memory outcomes, analyses revealed that participants in the Happy and Anger conditions had a trend toward significance for recognition hits compared to the two control conditions. Moreover, on Day 2, participants in the Happy condition had the highest recognition outcomes overall and were also once again the only ones whose recognition memory improved.

In summary, the current set of analyses revealed that participants in the subliminal emotional conditions (Anger and, especially, Fear) outperformed those in the two control conditions. Furthermore, analyses suggested a trend toward participants in the Happy condition having the best memory improvement after 24-hr delays compared to the two conditions. Thus, these overall findings suggest it was the emotional nature of the facial expressions, rather than merely the presentation of faces per se, that enhanced memory performance.

These results are consistent with research showing that affective stimuli can influence cognitive processes even though the individual is unaware of the presence of the affective stimuli (Axelrod et al., 2015; Poehlman, Dhar, & Bargh, 2016; Zajonc, 1980). They also provide support for the notion that affect is processed early in the information processing stream (see, e.g., (LoBue, Matthews, Harvey, & Stark, 2014; McFadyen et al., 2017; Oliman, Dimberg, & Esteves, 2014), and for studies asserting that the fast-acting primacy of emotion is particularly notable in the case of facial expressions, probably because faces and the expressions they produce constitute a set of biological stimuli to which humans are evolutionarily hardwired to respond to rapidly and automatically (Lapate et al., 2016; Murphy & Zajonc, 1993; Tamietto & De Gelder, 2010) .

Research investigating the influence of non-conscious facial expressions on human physiological systems provides insight into possible mechanisms underlying the memory-enhancing effects of subliminal emotional faces observed in the current study. Such research suggests that an encounter with non-conscious emotional facial stimuli provokes the release of stress hormones and other neurotransmitters, thus increasing general arousal and stimulating activity in brain stem areas and the amygdala (Jacobs & Sack, 2012; Tamietto & De Gelder, 2010; Whalen et al., 1998). It is specifically activity in the amygdala which is believed to be central in accounting for the enhancing effects of emotional arousal on memory (Meneguzzo et al., 2014; Squire & Dede, 2015; Tyng et al., 2017).

Non-conscious facial expressions activate the amygdala via a short and fast-acting thalamic-subcortical route (LeDoux, 1998; Öhman, 2002). Hence, humans can be affected by, and they can respond to, emotional expressions without being aware of the stimulus provoking the action (Esteves, Dimberg, & Öhman, 1994; Méndez-Bértolo et al., 2016). Research has shown a particularly pronounced effect of fearful facial expressions on the amygdala which may be explained by the fact that (a) humans have adapted to have rapid, automatic, and non-conscious responses to threatening stimuli, owing to their survival salience (Baran, Canzog, & Psik, 2016; Kensinger & Corkin, 2003), (b) that brain structure appears to respond most profoundly to ambiguity (Wang et al., 2017; Whalen et al., 2001), and (c) fearful faces are ambiguous because they do not contain the source of threat within them (Davis & Whalen, 2001).

Thus, the observed heightened effect of non-conscious emotion (and particular fearful expressions) on memory in the current study may have been caused by participants gaining the enhancing effects of emotion (through its influence on arousal, attentional, and memory mechanisms in the brain) without being affected by the distracting qualities of consciously processed emotional stimuli.

Furthermore, the observed results might have been due to the fact that the source of experienced emotion remained unknown to the participants in the current study. The affective quality of the non-conscious stimuli may have spilled over onto the consciously perceived words, imbuing them with emotion (Murphy & Zajonc, 1993). Hence, participants might have associated the words with emotional content even though they were unaware of the presentation of affective stimuli (Kan et al., 2011). In this way, the words could have gained extra contextual support from the emotional association, making their retrieval easier upon subsequent testing (Kensinger & Corkin, 2003; Sharot & Phelps, 2004).

Of further potential relevance to the interpretation of the current pattern of data is that participants' subjective mood reports (made via SAM-Pleasure ratings) were significantly lower after viewing the negative threatening stimuli (Anger and Fear conditions). These subjective emotional changes may have occurred because of hard-wired physiological and affective responses to viewing emotional faces, even when the presentation of those faces is non-conscious (Axelrod et al., 2015; Ohman & Soares, 1993). Or, it may be that the participants were mimicking the facial expressions of the subliminal stimuli and it is this which caused the emotional changes (Dimberg, Thunberg, & Elmehed, 2000; Tamietto & de Gelder, 2008). Consistent with the *somatic marker hypothesis* (Damasio, 2010), these emotional changes might have acted as valuable guides for cognitive processes such as memory. The perception of negative emotion may have signalled the presence of a potential threat, and that therefore the events and/or objects occurring in the presence of those emotions were important to remember in case similar instances should arise in future (LeDoux, 1998; Lipp, Kempnich, Jee, & Arnold, 2014). Consequently, the relatively pronounced effect of non-conscious threatening stimuli on subjective emotional ratings may have also contributed to those stimuli having the biggest effect on memory performance, particularly on Day 1.

Aim 2: Effects of negatively threatening versus positively rewarding faces on memory performance

A secondary aim of this study was to investigate which of negatively threatening (fearful or angry) or positively rewarding (happy) subliminal facial expressions produced a bigger effect on memory performance. Analyses revealed that participants in the Fear condition performed significantly better on Day 1 recall hits and corrected recall than participants in the Happy condition. Post-hoc testing revealed no other significant differences between emotional conditions. Nevertheless, overall, participants exposed to the negatively threatening expressions can be distinguished from those exposed to the positively rewarding expressions in that those in the Anger, and more especially the Fear condition, performed significantly better than those in the two control conditions on several measures, whereas the same was not true for those in the Happy condition.

The finding that negative threatening stimuli had the most pronounced effect on memory is thus consistent with separate lines of research showing that (a) negatively arousing emotional stimuli are particularly strongly associated with enhanced memory performance (Dolcos & Cabeza, 2002; Kensinger, 2009; Xie & Zhang, 2017), and (b) non-conscious negatively threatening face stimuli having significant effects on the processing of subsequently presented conscious stimuli in that such stimuli are consistently rated more negatively (Balconi, 2011; Williams, Morris, McGlone, Abbott, & Mattingley, 2004; Yang, Xu, Du, Shi, & Fang, 2011).

I also made the tentative prediction that participants exposed to positively rewarding stimuli will have the best delayed memory outcomes after 24 hours. However, the findings of the current study do not confirm this prediction. Although there were no statistically significant differences between the emotional expression conditions in delayed memory outcomes, participants exposed to the negatively threatening stimuli were the only ones who performed significantly better on delayed memory tests (Day 2 recall memory) than those in the two control conditions. Nevertheless, it is still of interest that participants in the Happy condition had the best retention outcomes overall and were the only ones whose memory improved (measured via correctly recalled and recognised words) on Day 2. Furthermore, even though statistical significance was not reached, there was a trend toward significance for participants in the Happy and Anger conditions in terms of recognition hits on Day 2.

In summary, because post-hoc pairwise comparisons detected no significant differences between negatively threatening and positively rewarding subliminal facial expressions on delayed memory testing, it is difficult to make any conclusive remarks about which of these emotional dimensions has more of an impact on memory storage processes. Nevertheless, these findings are, at least, inconsistent with research showing a pronounced shallower forgetting curve for negatively valenced emotion compared to positively valenced emotion (Bowen, Kark, & Kensinger, 2018; Wang, 2014). They therefore counter the notion that "bad is [always] stronger than good" when it comes to memory storage processes (Baumeister, Bratslavsky, Finkenauer, & Vohs, 2001; Bowen & Kensinger, 2017).

Effects of angry faces and fearful faces on memory performance

As an aside, it is interesting to note that patterns within the current data add to the discussion in the literature about whether angry and fearful faces should be construed as a single negative threatening category. Although post-hoc pairwise comparisons detected no significant difference between the memory performance of participants in the Fear and Anger conditions, participants in the Fear condition scored significantly better than participants in the two control conditions on numerous measures. The same pairwise differences were not observed for participants in the Anger condition, however. This difference in memory performance may be due to the following proposed mechanisms which research studies have observed: (a) pronounced amygdala activity for exposure to fearful compared to angry facial expressions (Calder, 1996; Pishnamazi et al., 2016; Whalen et al., 2001), and (b) exposure to fearful faces prompting heightened processing compared to angry faces, as they do not contain the source of threat within themselves (Davis et al., 2011). Fearful faces signal that the surrounding context needs to be carefully scrutinised if the source of threat is to be found (Becker, 2009; Whalen, 1998). In the current study, this 'surrounding environment' may have been the subsequently presented words, resulting in heightened processing and encoding of these stimuli.

Limitations and Directions for Future Research

Inferences from the current findings must be drawn cautiously as it was the first study of its kind. Moreover, the study was limited by the following methodological limitations. First, the study was statistically underpowered: The sample size was smaller than what power analyses suggested would be required to detect the effects under consideration. Second, I took no physiological measures, and thus can only speculate about the potential neural effects of the

subliminal stimuli. Finally, although the current analyses detected patterns of statistically significant results, the associated effect sizes were relatively small. Hence, here are a few suggestions that future research might implement in order to increase the observed effects: (1) because this study involved a surprise memory test, future research could examine memory performance when participants are informed that their memory will be tested before the encoding task, (2) use of newer methods of rendering imagery non-conscious (such as binocular rivalry and continuous flash suppression (Axelrod et al., 2015; Yang & Blake, 2010) may produce heightened outcomes and effects, and (3) future studies may want to examine memory at longer intervals (such as a week) to gain a clearer picture of which non-conscious emotional facial expressions have the greatest delayed memory performance outcomes.

Summary and Conclusion

This study is the first to investigate the effects of non-conscious emotional imagery on subsequent memory performance for non-emotional stimuli. Findings suggest that negative threatening facial expressions (particularly fearful faces) have the most powerful influence on memory performance overall. Positively rewarding facial expression (smiling faces) show a trend toward memory improvement after 24-hr delayed tests. These results thus offer a way to utilise the memory-enhancing benefits of emotional stimuli, without incurring the costs of its dominating and distracting limitations. Implementing the findings in everyday, practical ways might allow one to increase memory performance for more mundane or neutral information in a way that, unlike more conventional mnemonic devices or strategies, requires little effort or motivation.

Acknowledgements

I would like to express my deepest gratitude and appreciation to the following people:

To my supervisor: Kevin Thomas, for his patience, guidance and clear and precise wisdom.

To Alicia Nortje, for her time and trouble in E-prime tutoring.

To Mark Solms, for his time given over to have 'little chats' with me, providing insight and understanding into the magical world of the non-conscious.

To all of my participants, for their time and contribution to this research.

And lastly, to my family, for their love and kindness.

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Appendix A

SRPP Recruitment Advert

Subject: Get 2 SRPP points by participating in this novel study!

From: Sabina Funk (FNKSAB001@myuct.ac.za).

Hello!

You are invited to take part in a novel research study investigating how certain words impact how we answer questionnaires.

To participate in this study, you need to:

- Be between 18-26 years old
- Not have a current or past neurological injury (e.g., as a result of epilepsy or stroke) or history of head trauma with loss of consciousness
- Not be diagnosed with a depression or anxiety by a professional

If you meet these criteria, you may sign up for the study using the **'Sign-Up' tab** on the SRPP Vula page.

The study will take place in the ACSENT Laboratory (ground floor of the Department of Psychology) through the month of August. Various timeslots have been made available on Vula – you may sign up for any one of them under the 'sign up' tab – the study is called '**Words + questionnaires study'**. Participation will take approximately 45 minutes and will **involve coming into the ACSENT laboratory** for approximately **30 minutes** where you will look at words and answer questionnaires. You will then **complete a very short questionnaire one day later via email** (this should take about 5-10 minutes). You will be awarded **2 SRPP points** for your time.

Please take note of the timeslot you sign up for and come to the ACSENT Laboratory five (5) minutes prior to the starting time.

If you sign up for a timeslot and later find you cannot make the time, please let me know as soon as possible.

If you have any questions, please do not hesitate to contact me at this email address: FNKSAB001@myuct.ac.za

Kind regards

Sabina
UCT Honours Student
Principal Researcher

Appendix B

Sociodemographic Questionnaire
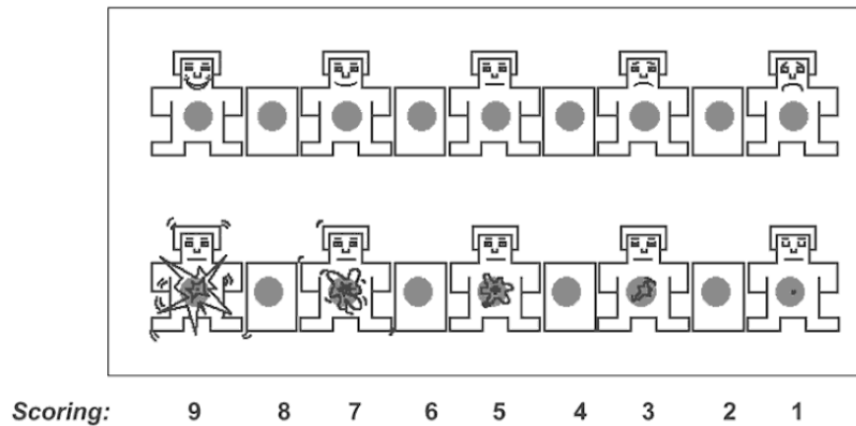
Please answer the following questions:

Sex: _____

Age:_____

Degree registered for at UCT:_____

Level of study (1st/2nd/3rd year, other)_____

Appendix C

Self-Assessment Manikin Scales:

Scoring: 9   8   7   6   5   4   3   2   1

Note that the above image is only a demonstration of what the scale looks like. In the actual study, each SAM figure (SAM-Pleasure and SAM-Arousal) appeared on the screen individually, asking for a rating from 1-9. On the first SAM scale, respondents rate how sad or happy they feel; values near to 1 indicate sad, near to 5 indicate neutral, and near to 9 indicate happy. On the second SAM scale, respondents rate how aroused they feel; values near to 1 indicate not aroused, near to 5 indicate neutral, and near to 9 indicate very aroused.

Appendix D

Word Lists

Encoding Word List:	Distractor Word List Day 1:	Distractor Word List Day 2:
World	Owner	Power
Shield	Author	Chance
Belief	Fire	Beggar
Artist	Library	Letter
Excuse	Style	Square
Hotel	Alcohol	Tree
Slipper	Orange	Apple
Butter	School	Oxygen
Dress	Circle	Chief
Freedom	Metal	Fantasy
Journal	Board	Peace
Knowledge	Window	Hostage
Pencil	Earth	Refuge
Safety	sweet	Snake
Sugar	Sickness	Thief
Teacher	Justice	Plain
Factory	Engine	Woman
Acrobat	Dream	Chair
Theory	Pupil	Office
Flower	Garden	Student

Appendix E

State-Trait Anxiety Inventory Questions

Form Y-1

A number of statements that people have used to describe themselves are given below. Read each statement and then indicate which of the four numbers (1,2,3,4) best reflects how you feel right now, that is, **at this moment**. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.

Key:

1- Not at all
2- Somewhat
3- Moderately so
4- Very much so

Questions:

1. I feel calm
2. I feel secure
3. I feel tense
4. I feel strained
5. I feel at ease
6. I feel upset
7. I am presently worrying over possible misfortunes
8. I feel satisfied
9. I feel frightened
10. I feel comfortable
11. I feel self-confident
12. I feel nervous
13. I am jittery
14. I feel indecisive
15. I am relaxed
16. I feel content
17. I am worried
18. I feel confused
19. I feel steady
20. I feel pleasant

Form Y-2

A number of statements that people have used to describe themselves are given below. Read each statement and then indicate which of the four numbers (1,2,3,4) best reflects how you **generally** feel. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe how you feel most of the time best.

Key:

1- Not at all
2- Somewhat
3- Moderately so
4- Very much so

Questions:

21. I feel pleasant
22. I feel nervous and restless
23. I feel satisfied with myself
24. I wish I could be as happy as others seem to be
25. I feel like a failure
26. I feel rested
27. I am 'calm, cool and collected'
28. I feel that difficulties are piling up so that I cannot overcome them
29. I worry too much over something that really doesn't matter
30. I am happy
31. I have disturbing thoughts
32. I lack self-confidence
33. I feel secure
34. I make decisions easily
35. I feel inadequate
36. I am content
37. Some unimportant thought runs through my mind and bothers me
38. I take disappointments so keenly that I can't put them out of my mind
39. I am a steady person
40. I get in a state of tension or turmoil as I think over my recent concerns and interests.

Appendix F

Subjective image awareness questionnaire

Did you notice any images on the screen while the words were presented to you other than an

image of a cross on a black screen and the image of a word covering a person's face? (yes/no)

_____

If yes, how confident are you about this on a scale of 1-5?

(1 – not confident; 2 – somewhat confident; 3 – neutral; 4 – confident; 5 – very confident)

_____

If you think you saw something, please give a brief description of what you think you saw:

Appendix G

Informed Consent Form

CONSENT FORM FOR PARTICIPATION IN PSYCHOLOGICAL STUDY

Dear Participant:

INVITATION TO PARTICIPATE IN STUDY

You are being invited to participate in a study conducted at the University of
Cape Town by an Honours student in the Department of Psychology.

Nature of Study:

The purpose of this study is to investigate how certain words impact how we answer
questionnaires.

Procedure:

If you agree to participate in the study, you will be shown a list of words and then given a
questionnaire to answer. You may also view some images during the study procedures. You will
fill in short questionnaires about demographic information and mood. **One day after the
laboratory procedures, you will complete a short online questionnaire.** The link to the
questionnaire will be sent via email.

Confidentiality

All information obtained for the purposes of this study is anonymous and confidential. Any reports
or publications of the study material will never identify you or any other study participant.

Voluntary Participation

Your participation in this study is completely voluntary. If you do not wish to take part in the study
(or, if at a stage during the study you do not feel comfortable) you are free to leave the venue. Your
decision regarding participation in this study will not affect your grades or academic career.
However, you will not receive your SRPP points.

Possible Risks

Participation holds no risks of social, psychological, or physical harm. Should you feel any distress after completion of the study, Student Wellness Services (0216501017 or lerushda.cheddie@uct.ac.za) are available to you for assistance.

Benefits

If you complete the entire study, including the questionnaire that will be sent to you one day after the experimental session in the ACSENT laboratory, you will be awarded **2 SRPP points**. You can also have the final write-up of the research project emailed to you if you so choose.

Questions

Any questions or concerns regarding the study can be directed to the principal researcher (FNKSAB001@myuct.ac.za). Any other questions such as your rights as a study participant or complaints about the study can be directed to the Research Ethics Committee of the Department of Psychology at the University of Cape Town (Mrs Rosalind Adams – 0216503417 or Rosalind.Adams@uct.ac.za).

CONSENT TO TAKE PART IN STUDY

I have read the above and am satisfied with my understanding of the study and its possible benefits and risks. My questions about the study have been answered. I hereby voluntarily consent to participation in the research study as described.

Name: _____Date: _____

Student number: _____ Course code: _____

Email to be used for questionnaire sent next day: _____

Phone number for reminder of questionnaire: _____

Signed: _____

Appendix H

Debriefing Email

Dear Participant:

The purpose of this email is to debrief you about your recent participation in a study that took place within the UCT Department of Psychology. The study investigated how words impact how we answer questionnaires.

The true aim of the study was to explore how subliminal images (i.e., images presented so quickly that you were not consciously aware of them) affect our ability to remember a set of words. You will remember that we informed you that you might be exposed to some images during the study. Some of you were exposed to subliminal images that were pleasant (smiling faces), some to threatening images (fearful or angry faces), some to neutral images (neutral facial expression), and some of you weren't exposed to any image at all. It was important not to mention the true nature of the experiment (i.e., when the images would be projected, and what the nature of the images would be) as knowing this could have affected the outcome and confounded results. It was also important not to mention that your memory for the words would be tested so as to remove any possible anxiety or memory rehearsal procedures which may have taken place and further confounded results.

If you have any further questions and/or would like to receive the results and conclusions from the study, please write to me at the email address given below.

Thank you for your participation in the study!

Kind regards

Sabina Funk
FNKSAB001@myuct.ac.za

Appendix I

Experimental Stimuli: Day 2 Memory Testing

1. Please answer both questions presented to you. Note you cannot go back once you click 'next'

| NEXT |

2. In the experiment yesterday, some words pasted over a human face were flashed to you on the computer screen. Please type all the words you can remember seeing into the space below, separated by a COMMA:

| NEXT |

3. Below is a list of words. Please select the words you remember seeing flashed to you on the computer screen (the words pasted over the human face at the beginning of the experiment):

- ☐ plain
- ☐ belief
- ☐ oxygen
- ☐ dress
- ☐ student
- ☐ thief
- ☐ chief
- ☐ hostage
- ☐ apple
- ☐ fantasy
- ☐ acrobat
- ☐ tree
- ☐ pencil
- ☐ chance
- ☐ artist
- ☐ power
- ☐ shield
- ☐ woman
- ☐ journal
- ☐ flower

- ☐ chair
- ☐ factory
- ☐ square
- ☐ refuge
- ☐ sugar
- ☐ butter
- ☐ freedom
- ☐ office
- ☐ safety
- ☐ theory
- ☐ teacher
- ☐ slipper
- ☐ letter
- ☐ excuse
- ☐ beggar
- ☐ hotel
- ☐ world
- ☐ knowledge
- ☐ peace
- ☐ snake