



Relaxing music counters heightened consolidation of emotional memory

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ABSTRACT

Emotional events tend to be retained more strongly than other everyday occurrences, a phenomenon partially regulated by the neuromodulatory effects of arousal. Two experiments demonstrated the use of relaxing music as a means of reducing arousal levels, thereby challenging heightened long-term recall of an emotional story. In Experiment 1, participants ($N = 84$) viewed a slideshow, during which they listened to either an emotional or neutral narration, and were exposed to relaxing or no music. Retention was tested 1 week later via a forced choice recognition test. Retention for both the emotional content (Phase 2 of the story) and material presented immediately after the emotional content (Phase 3) was enhanced, when compared with retention for the neutral story. Relaxing music prevented the enhancement for material presented after the emotional content (Phase 3). Experiment 2 ($N = 159$) provided further support to the neuromodulatory effect of music by post-event presentation of both relaxing music and non-relaxing auditory stimuli (arousing music/background sound). Free recall of the story was assessed immediately afterwards and 1 week later. Relaxing music significantly reduced recall of the emotional story (Phase 2). The findings provide further insight into the capacity of relaxing music to attenuate the strength of emotional memory, offering support for the therapeutic use of music for such purposes.

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1. Introduction

Compared to everyday occurrences, memories of emotional events have been described as more vivid, distinct and robust to forgetting (Davidson, Cook, & Glisky, 2006; Heuer & Reisberg, 1990; Reisberg & Hertel, 2004; Windmann & Kutas, 2001). Emphasis of potential threats and other significant stimuli is generally adaptive (McGaugh, 2000), but can also be detrimental to mental health. This is apparent in individuals suffering from the symptoms of Post Traumatic Stress Disorder (PTSD), where heightened retention of unwanted emotional material is a key symptom of this condition (Herman, 1992). Efforts to challenge heightened retention of unwanted emotional material are therefore of considerable clinical significance.

While the underlying cause(s) of heightened emotional memory is still debated (Levine & Pizarro, 2004), there is now substantial evidence that emotional arousal acts a 'neuromodulator' of memory encoding or consolidation (Cahill & McGaugh, 1995; Liu, Graham, & Zorawski, 2008). An emotional event or stimulus that is significant and of influential capacity activates the Sympathetic Nervous System (SNS), which subsequently triggers the release of arousal hormones (such as cortisol, noradrenaline, and adrenaline) into the bloodstream, which then enhance memory by increasing

noradrenergic activation within the amygdala (McGaugh, 1989; McGaugh, 2004). In a pioneering study by Cahill and McGaugh (1995), participants were presented with a slideshow of 11 images accompanied by narratives of either an emotional or neutral story. Both conditions contained identical images with closely matched storylines. Arousal was manipulated by varying the accompanying narrative in the middle phase of the story ('Phase 2'), where the emotional content was introduced. Subjective reports of arousal and long-term retention of the story were consistently higher among those who viewed the emotional, as compared to neutral, story (Arntz, de Groot, & Kindt, 2005; Cahill & McGaugh, 1995; Hamann & Canli, 2004; Quevedo et al., 2003). Furthermore, this discrepancy was most prominent during Phase 2 of the story. The consistency of images between conditions in this design excludes the possibility that differences in recall were due to variations to the intrinsic visual elements of the slides rather than narrative-induced changes in arousal (Christianson & Loftus, 1987; Heuer & Reisberg, 1990).

The facilitation of memory in these studies is typically attributed to increased emotional arousal which is intrinsic to the material being remembered (i.e., the emotional content of the story). However, the neuromodulatory process can extend beyond the initial formation of memory, in that arousal influences memory consolidation as well as memory encoding. For instance, intermediate doses of arousal hormones (adrenaline or noradrenaline) administered to young chicks up to 30 min after learning have been shown to

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enhance memory when tested several hours later (Crowe, Ng, & Gibbs, 1990; Gold & Van Buskirk, 1975). Emotionally arousing music has also been found to enhance long-term retention of a word list when presented 20 min after learning (Judde & Rickard, 2010). These findings suggest that the strength of a memory trace can be modulated by either exogenous or endogenous means of arousal presented during or after the learning phase (McGaugh, 2000).

Importantly, the neuromodulatory process is bidirectional, implying that while increased arousal levels can enhance memory strength, reduced arousal levels can also attenuate recall (Cahill, Prins, Weber & McGaugh, 1994; Pitman et al., 2002). Cahill et al. (1994) demonstrated that enhanced recall among participants who viewed an emotionally arousing story can be prevented by the administration of the noradrenergic antagonist, propranolol. As this study eliminated the sedative influence of the drug as a contributing factor, the finding suggests that sources extrinsic to the emotional event or stimuli can reduce emotionally induced arousal and the enhanced memory that normally accompanies it. Recent studies (Pitman et al., 2002; Vaiva et al., 2003) have further explored the therapeutic application of propranolol among the clinical population. Participants who were administered the drug tended to display fewer PTSD symptoms and later PTSD diagnoses in subsequent follow ups, when compared to those administered the placebo. While these studies support the potential of the therapeutic use of propranolol to reduce retention of unwanted emotional material and even the onset and severity of PTSD, pharmaceutical approaches have been contentious. Some have argued, for instance, that using a drug to erase or blunt unwanted emotional material may interfere with the normal process of emotional recovery, or falsify a true understanding and perception of reality (Dossey, 2006). While arousal-reducing music is also subject to such criticism, there is likely to be less community resistance to using music interventions in this context, perhaps because music is already part of everyday life for most people, whereas pharmaceutical manipulation of cognitive processes is not.

The arousal-modulating capacity of music (see Baumgartner, Esslen, & Jancke, 2006; Krumhansl, 1997; Rickard, 2004) presents a plausible non-therapeutic alternative to the use of propranolol in attenuating the strength of unwanted memories. Indeed, relaxing music is often used to alleviate anxiety and stress-induced arousal responses, such as decreases in heart rate, blood pressure and skin conductance levels, in both clinical and non-clinical settings (Hodges, 2010; Knight & Rickard, 2001; Pelletier, 2004). While it has been demonstrated that arousing music can increase emotionally induced arousal and subsequently enhance memory strength (Judde & Rickard, 2010), the neuromodulation theory also implies that relaxing music should also be capable of countering emotionally induced arousal and consolidation of emotional memory. The aim in the reported experiments was to explore whether music can challenge the heightened memory for emotionally arousing material. In Experiment 1, it was hypothesised that in the presence of relaxing music, the heightened retention scores for the emotionally arousing story would be significantly reduced (similar to those for the neutral story). In Experiment 2, it was hypothesised that this effect would also occur when music was presented *after* learning, and would not be generalised to non-relaxing or another auditory non-music condition.

2. Experiment 1

2.1. Method

2.1.1. Participants

Eighty-four individuals (28 male, 60 female) between the ages of 18 and 53 ($M = 26.18$, $SD = 7.95$) participated in this experiment.

Participants were recruited through several channels: online advertisement in University memo, posters displayed around University campuses, through an undergraduate psychology participant pool, and through convenience sampling. Due to the nature of the study, which involved watching a slideshow containing a graphic slide, listening to narration, and possible exposure to music (depending on the condition to which an individual was allocated), the exclusion criteria for participants consisted of the following: (1) no uncorrected serious hearing impairment; (2) no association with (including close friends or family involved in) a traumatic accident; and (3) no prior involvement in a similar experiment running at the university.

Participants were randomly assigned by an online module to one of four conditions: emotionally arousing story with relaxing music, emotionally arousing story without music, neutral story with relaxing music, and neutral story without music. Participants were not informed that they would be completing a memory test in the second session; this was to avoid rehearsal or other cognitive strategies convoluting the anticipated emotional neuromodulation of interest in this study. As an incentive to complete both Sessions 1 and 2 of the study (which were conducted 1 week apart), participants who completed the second session were invited to enter a competition to win luxury cinema tickets for two.

2.1.2. Materials

Memory task: An online version of the paradigm developed by Cahill and McGaugh (1995) was developed, containing 11 slides accompanied by either an arousing or neutral narrative. The slides for both conditions were identical to avoid retention differences due to novelty of visual elements or inherent memorability, rather than variation in arousal effects (Cahill & McGaugh, 1995). Each slide also had a similar narration (storyline) in Phase 1 (slides 1–5) and 3 (slides 9–11) (about a boy visiting his father's workplace) but the narration in Phase 2 (slides 6–8) was different for each condition (emotional – the boy gets hit by a car and was rushed to hospital; neutral – he watches an accident disaster drill in a hospital). The recognition memory test developed by Cahill and McGaugh was used to assess participants' recall of the slideshow. This test consists of 76 forced choice questions (1 correct, 3 distracters), with 5–10 questions on each slide in chronological viewing order.

Assessment of manipulation: Participants' mood and arousal levels were assessed using a five point Likert scale (mood: 1 = very sad, 5 = very happy; arousal: 1 = very calm, 5 = very aroused) prior viewing of the slideshow. A demographic and background questionnaire (gender, last time of stimulant intake (e.g., coffee) was also used to identify potential confounds. Post-slideshow questions (liking of story, perception of emotion intended to be expressed by the story, actual emotion and arousal experienced by the story) were used to verify that the intervention (arousing narratives) achieved the intended effect on emotional and arousal levels (liking: 1 = disliked it very much, 6 = liked it very much; emotion intended/perceived: 1 = very sad, 5 = very happy; arousal: 1 = very calm, 5 = very aroused).

Music: Satie's *Gymnopedie no. 1*, which has been used in previous studies for the purpose of inducing relaxation (Iwanaga, Ikeda, & Iwaki, 1996; Sand & Levin, 1997), was used for the relaxing treatment condition. The suitability of the piece was confirmed by the results from a pilot study conducted on 11 participants, which illustrated its superior relaxing effects compared to four other relaxing musical pieces. To reduce distraction, participants were required to use headphones while watching/listening to the slideshow on the computer. The sound integrity was important as the four testing conditions were visually identical, and relied on the auditory narration and music for differentiated effects.

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