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The effects of non-contingent extrinsic and intrinsic rewards on memory consolidation

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Abstract

Emotional and arousing treatments given shortly after learning enhance delayed memory retrieval in animal and human studies. Positive affect and reward induced prior to a variety of cognitive tasks enhance performance, but their ability to affect memory consolidation has not been investigated before. Therefore, we investigated the effects of a small, non-contingent, intrinsic or extrinsic reward on delayed memory retrieval. Participants ($n = 108$) studied and recalled a list of 30 affectively neutral, imageable nouns. Experimental groups were then given either an intrinsic reward (e.g., praise) or an extrinsic reward (e.g., $1). After a one-week delay, participants' retrieval performance for the word list was significantly better in the extrinsic reward groups, whether the reward was expected or not, than in controls. Those who received the intrinsic reward performed somewhat better than controls, but the difference was not significant. Thus, at least some forms of arousal and reward, even when semantically unrelated to the learned material, can effectively modulate memory consolidation. These types of treatments might be useful for the development of new memory intervention strategies.

Keywords: Memory consolidation; Reward; Positive affect; Long-term memory; Emotion; Memory modulation; Arousal

1. Introduction

Each day people experience, learn, and recall events while in some affective or emotional state. Under these conditions, some occurrences are remembered better than others. Thus, it seems reasonable to believe that there should exist mechanisms to differentiate the events that are more important than others such that the important experiences are then remembered better than those of lesser importance. Studies suggest that one such mechanism is emotional or arousing content; events that are emotional or arousing are often better remembered than those lacking in such content (McGaugh, 2000). The selection process for permanent storage in memory is believed to occur after the initial moment of learning (Squire, 1987), during the stages of memory storage that occur over time (cf. Deutsch & Deutsch, 1966; McGaugh & Gold, 1989; Müller & Pilzecker, 1900). Evidence shows that modulation in the memory storage process can occur after the original experience (cf. Gold & van Buskirk, 1975; McGaugh, 1966; Squire, 1986), enhancing long-term but not immediate retrieval (e.g., Nielson & Jensen, 1994; Nielson, Radtke, & Jensen, 1996; Nielson, Yee, & Erickson, 2005; Revelle & Loftus, 1992; Walker, 1958), likely because the memory consolidation process is believed to take considerable time—perhaps 30 min, or even hours or days (Revelle & Loftus, 1992; Torras-Garcia, Portell-Cortes, Costa-Miserachs, & Morgado-Bernal, 1997; Walker, 1958).

Studies specifically examining the effects of arousal and emotion on the memory consolidation process in

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humans are as yet few. Although a number of studies have examined memory modulation via arousal or affective techniques, these have predominantly administered modulatory treatments such as glucose prior to learning or task performance, thereby potentially affecting encoding or consolidation (e.g., Cahill & McGaugh, 1995; Mohanty & Flint, 2001). In contrast, a few studies have more directly mirrored rodent studies, administering treatments after learning, during the consolidation interval. Nielson and Jensen (1994) investigated the effects of moderate muscle tension-induced arousal after learning on later memory retrieval in both older and younger adults. The older participants were either healthy and not taking any medications, hypertensives taking a calcium channel blocker or an angiotensin-converting enzyme inhibitor, or hypertensives taking a β-adrenergic receptor antagonist ("beta-blockers"). The results indicated that the induction of muscle tension shortly after exposure to target words embedded in paragraphs increased heart rate, and enhanced delayed recall and recognition of the words for all participant groups, except those older subjects taking β-blockers. β-blockers inhibit physiological response to arousal and emotion. Nielson et al. (1996) used this muscle tension procedure in a within-subject design and demonstrated that arousal induced during the initial consolidation or retrieval intervals after learning enhanced delayed (30 min) retrieval over either non-arousal or arousal during encoding conditions. A more recent study also showed that an emotional arousal source, a video of oral surgery, shown after learning an unrelated word list, significantly enhanced delayed retrieval of the words (Nielson, Yee, & Erickson, 2002; Nielson et al., 2005). These studies suggest that hormones and neuromodulators play a significant role in memory storage. Enhanced levels of catecholamine stress hormones (e.g., Gold, 1986; McGaugh, 2000; Nielson & Jensen, 1994) and/or glucose (e.g., Parent, Varnhagen, & Gold, 1999; Parsons & Gold, 1992) can specifically affect memory storage processes. Although most arousal occurs during the emotional event, arousal or emotional events occurring shortly after a learning event can also influence memory storage processes (e.g., McGaugh, 2000; Nielson & Jensen, 1994; Nielson et al., 1996). Indeed it was recently reported that such arousal manipulations are effective even when delayed 30 min after learning (Powless et al., 2003). The studies have thus far focused on physiological or negative arousal stimuli. Another potentially effective technique is the use of reward.

It has long been believed that certain rewards can enhance the learning or retention of a cognitive task, such as when future performance on a maze or Skinner box task is enhanced by giving appetitive rewards to animals upon completion of a run (e.g., Burns, Kinney, & Criddle, 2000). One consequence of this approach, the positive affect generated by the reward, could influence learning or retention in much the same way that arousal and emotion are thought to do so. Indeed, positive affect is also associated with a catecholamine response, in this case likely dopamine that is comparable to the catecholamine release produced during other types of arousal (e.g., Ashby, Isen, & Turken, 1999; Bozarth, 1991; Phillips, 1984).

A variety of human studies have shown that mild positive affect, such as that associated with everyday experiences or receiving a small gift, experienced prior to a task can improve cognitive performance, such as creative problem solving (e.g., Estrada, Young, & Isen, 1994; Greene & Noice, 1988; Isen, Daubman, & Nowicki, 1987; Isen, Johnson, Mertz, & Robinson, 1985) and recall of neutral and positive material (e.g., Isen, Shalker, Clark, & Karp, 1978; Nasby & Yando, 1982). It can also alter decision-making strategies (Carnevale & Isen, 1986; Estrada, Isen, & Young, 1997; Isen & Geva, 1987; Isen, Nygren, & Ashby, 1988). Such a reward, given before the task, could alter performance in a number of ways, including by enhancing motivation, attention, learning, mood congruence, etc. (e.g., Ashby et al., 1999; Revelle & Loftus, 1992; Walker, 1958). An after learning procedure, such as that used in memory modulation studies, has not been employed but would be a better test of whether a reward can alter memory consolidation. If positive arousal sources are effective, the applications of such an approach as a memory enhancement technique would be much more palatable for a variety of contexts than some of the previously used techniques. Thus, the purpose of the present study was to bring these two literatures together by evaluating the effects of a small, non-contingent reward given after learning on delayed memory retrieval. Both an extrinsic reward, such as a small gift, and an intrinsic reward, an experience that is itself rewarding (e.g., praise, Snelders, Dirk, & Lea, 1996), were investigated. Immediate word retrieval, measured prior to giving the reward, was not expected to differ between groups. However, it was hypothesized that both extrinsically and intrinsically induced positive affect, given shortly after learning, would enhance recall and recognition of words from a list learned a week earlier.

2. Method

2.1. Participants

The sample, participants completing both testing sessions, consisted of 108 undergraduates enrolled in Introductory Psychology (94 females, 14 males; mean age = 19.14, $SD = 1.2$), each of whom received course credit for participating. Assignment to experimental groups was quasi-random, determined by the session for which each individual enrolled. Participants who failed