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Money enhances memory consolidation – But only for boring material

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ABSTRACT

Money's ability to enhance memory has received increased attention in recent research. However, previous studies have not directly addressed the time-dependent nature of monetary effects on memory, which are suggested to exist by research in cognitive neuroscience, and the possible detrimental effects of monetary rewards on learning interesting material, as indicated by studies in motivational psychology. By utilizing a trivia question paradigm, the current study incorporated these perspectives and examined the effect of monetary rewards on immediate and delayed memory performance for answers to uninteresting and interesting questions. Results showed that monetary rewards promote memory performance only after a delay. In addition, the memory enhancement effect of monetary rewards was only observed for uninteresting questions. These results are consistent with both the hippocampus-dependent memory consolidation model of reward learning and previous findings documenting the ineffectiveness of monetary rewards on tasks that have intrinsic value.

1. Introduction

An old but still central question of both experimental research and educational practice is how learning and retention can be promoted. One factor that has recently attracted increased amounts of attention is monetary reward. Imagine that you reached the one million dollar question on the TV show *Who Wants to be a Millionaire*; it is unlikely that you will ever forget the answer to that question. If you read the same question in a textbook, however, you might forget the answer after a few days. Indeed, recent research has shown that monetary incentives can enhance memory (e.g., Adcock, Thangavel, Whitfield-Gabrieli, Knutson, & Gabrieli, 2006; Shigemune et al., 2010; Thornton et al., 2007; see also Knutson & Adcock, 2005), even in incidental learning situations (e.g., Wittmann et al., 2005; see also Wittmann, Schiltz, Boehler, & Duzel, 2008). Money's ability to improve memory has received considerable attention due to new neurological findings indicating that the hippocampal memory system and the mesolimbic reward system form a functional loop (Lisman & Grace, 2005; Rossato, Bevilaqua, Izquierdo, Medina, & Cammarota, 2009). Specifically, these studies suggest that monetary reward promotes memory consolidation by activating the mesolimbic reward system, which increases dopamine release in the hippocampal memory system (Duzel, Bunzeck, Guitart-Masip, & Duzel, 2010). Although growing evidence for this effect has been proffered, two critical issues remain unresolved.

First, hippocampus-dependent memory consolidation is presumed to require an extended period of time to complete (Hamann, 2001; McGaugh, 2000), suggesting that the effects of money on memory should manifest only after some time has elapsed. Indeed, such time-dependent effects of memory enhancement are well known in studies of emotional effects on memory, which also assumes hippocampus-dependent memory consolidation (see Kleinsmith & Kaplan, 1963; Sharot & Phelps, 2004; Sharot & Yonelinas, 2008). Nevertheless, little research has been

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conducted to systematically investigate the consequences of monetary rewards on memory at different time points; immediately after encoding as well as after a delay.

Second and more intriguingly, research in motivational psychology has repeatedly revealed that monetary rewards can undermine task engagement, especially for interesting tasks (for reviews, Deci, Koestner, & Ryan, 1999; Ryan, Mims, & Koestner, 1983), because these rewards may crowd out the intrinsic value inherent in interesting tasks (Deci & Ryan, 1985). This "undermining effect" raises the interesting possibility that the proposed consolidation effects of money on memory performance may be observed only for uninteresting materials, because monetary rewards may interfere with learning process for interesting materials. Previous studies on reward and memory, however, utilized materials that were not meaningful to participants (for an exception in a prospective memory task, see Brandimonte, Ferrante, Bianco, & Villani, 2010), making it difficult to test this possibility.

Given these considerations proffered by research in both neuroscience and motivational psychology, the current study was designed to examine the hypotheses that (1) monetary rewards promote delayed, but not immediate, memory performance, and (2) monetary rewards only enhance memory for uninteresting materials. Participants completed a quiz in which they attempted to answer trivia questions with or without monetary incentives, and their memory was tested in surprise immediate and delayed memory tests. The trivia question paradigm used herein was composed of both interesting and uninteresting materials (Kang et al., 2009), which enabled the comparison of memory performance for interesting and uninteresting items.

2. Method

2.1. Participants and design

Forty-five undergraduate students (mean age = 23.1 years) were randomly assigned to a money or no-money condition.

2.2. Materials and procedure

The stimuli were 44 trivia questions, taken from Kang et al. (2009), Nelson and Narens (1980), and other resources, to which answers are typically not known (e.g., "What is the only planet in the solar system that rotates clockwise?", "What is the national flower of Spain?"). Half of the questions were used in an immediate memory test, and the other half were used in a delayed memory test. Note that we used different questions for the immediate and delayed memory tests in order to prevent possible confounding effects of test repetition (Roediger & Karpicke, 2006). The questions used in the immediate and delayed tests were counterbalanced across participants.

In the (incidental) learning session, participants were randomly presented with each trivia question on a computer screen at the rate of 10 s per question, and were asked to provide an answer. The correct answer was subsequently displayed for 4 s, regardless of whether participants answered correctly or not. Before the learning session, participants in the money condition were instructed that they would receive 0.25 Euros for each question answered correctly. No mention was made in either condition that there would be a later memory test. To keep participants committed to the task, we included 34 filler questions that were easy to answer.

After the learning phase, participants worked on a filler task for 10 min and then completed the surprise immediate memory test. Participants were presented with trivia questions at the rate of 10 s per question in random order, and asked to recall the correct answers. The delayed memory test took place 1 week after the experiment; the procedure was the same as that used for the immediate memory test. No mention of the delayed memory test was made in advance; participants were simply scheduled to return a week later for an unrelated purpose. No monetary reward was promised or provided for either test.

3. Results

One participant expected to be tested later; this individual was omitted from the following analyses. Recall rates were calculated for each participant after excluding the questions answered correctly in the learning session (overall correct answer rate = .07). Effect sizes were calculated based on generalized eta squared statistics (η_G^2; Olejnik & Algina, 2003).

3.1. Time-dependent effects of money on memory

Average correct recall rates as a function of monetary reward and time interval are presented in Fig. 1. As expected, participants in the money condition showed only a small advantage in recall performance in the immediate memory test ($M = .78$ for no-money, and $M = .82$ for money conditions), whereas the effect of monetary reward was larger in the delayed memory test ($M = .42$ for no-money, and $M = .53$ for money conditions). A 2 (Money: money vs. no-money) × 2 (Time Interval: immediate test vs. delayed test) analysis of variance (ANOVA) revealed significant main effects of Money, $F(1, 42) = 4.89$, $p < .05$,

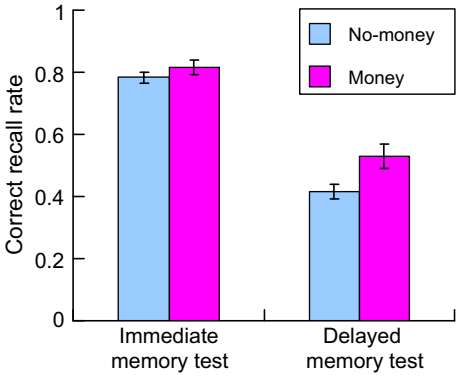

Fig. 1. Correct recall rates as a function of monetary reward and time interval. Error bars represent standard errors of the means.