Play for Performance: Using Computer Games to Improve Motivation and Test-Taking Performance

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ABSTRACT

The importance of testing, especially certification and high-stakes testing, has increased substantially over the past decade. Building on the "serious gaming" literature and the psychology "priming" literature, we developed a computer game designed to improve test-taking performance using psychological priming. The game primed the concept of achievement to increase an individual's expectation of success and motivation. Our results show that individuals who took a test immediately after playing the game significantly outperformed those who played a placebo computer game designed to have no effect. The effect size was medium (0.63). We believe that these results have important implications for information system education, including improving individual test-taking performance, identifying ways to develop information systems topic-specific games, and the need for more research to better understand how and why such games influence performance.

Keywords: Proficiency testing

1. INTRODUCTION

With the increased use of tests in academia, especially certification exams and high-stakes tests such as the SAT and ACT (Linn, Baker, and Betebenner, 2002), it is increasingly important to ensure that students perform at their best in test situations. Individual test-taking behavior is affected by both ability and motivation (Deci et al., 1991). Most prior research has focused on improving students' abilities, so we chose to examine the other, less studied, component influencing performance: motivation (Custers et al., 2010; Radel et al., 2010).

How can we increase a student's motivation to perform? Much research has focused on using computer games as a way to engage students and motivate them in learning (Gunasekaran, Ronald, and Dennis, 2002; Ricci, Salas, and Cannon-Bowers, 1996; Susi, Johannesson, and Backlund, 2007). These games, often called serious games, are used for purposes other than pure entertainment (Susi, Johannesson, and Backlund, 2007). Serious games enable educators to provide an engaging learning environment in which students can experience situations that were previously impractical due to cost, time, or safety. Serious games are used in a variety of education contexts, including information systems education (Ben-Zv, 2007; Léger, 2006; Seethamraju, 2011). Much of the research on serious games has focused on facilitating learning outcomes (Amory, 2007; Kiili, 2005). This research has highlighted benefits from playing serious games, such as an increased ability to mentally rotate objects and improved spatial reasoning (Cherney, 2008; Subrahmanyam and Greenfield, 1994).

Our study investigated the use of a simple serious game designed to improve test-taking performance by increasing motivation. Motivational theories contend that motivation is a function of the importance of a goal and the expectation of attaining it (Deci et al., 1991). Most students understand the importance of doing well on tests, especially certification and other high-stakes tests; fewer students expect to attain that goal (i.e., actually do well). Thus if we increase a student's expectation of success, we may increase their motivation and ultimately their performance.

In this study, we use the psychological technique of priming, which involves the activation of mental representations to affect an individual's subsequent mood, attitudes, goals, or behavior (Bargh and Chartrand, 2000). We developed a simple computer game designed to prime the concept of "achievement" to improve the performance by increasing an individual's subconscious expectation of success (Bargh et al., 2001). There is considerable evidence that priming can influence individual behavior (Bargh and Chartrand, 1999), but we are aware of no studies that delivered priming via a computer game in an attempt to improve test-taking performance.

We hypothesize that achievement priming delivered through a computer game will enhance test-taking performance. A key point that differentiates this study from previous studies examining the use of serious games in education is the purpose for which the computer game is used. Most prior games have focused on improving students' abilities. Our game strives to subconsciously increase a student's motivation to achieve, which should improve his or her performance. While the student is aware of the game, he or she is unaware that priming has increased the activation of a goal to achieve. (Bargh et al., 2001).

We begin by summarizing prior research on test-taking and the use of priming to increase motivation, before explaining how achievement priming could increase test-taking performance. We then present our game and the methods we used to test our hypotheses. Next, we present the results, then discuss them and draw implication for research and practice.

2. PRIOR THEORY

2.1 Test-taking

Test-taking performance is a joint function of motivation and cognitive ability (Chan et al., 1997). Factors such as coaching for the test, motivation prior to the test, and positive perceptions about the test have a positive influence on student performance on tests (Chan et al., 1997; Powers and Rock, 1999). Motivation and attitude of test-takers have been found to greatly influence test-taking performance (Arvey et al., 1990; Ricci, Salas, and Cannon-Bowers, 1996). Individual motivation towards an activity is a function of the individual's perception of the importance of that activity and the expectancy of success (Wigfield and Eccles, 1994). Our goal is to influence a student's mindset so that he or she has a greater expectancy of success. Prior research suggests it is possible to subtly manipulate a student's expectation of success prior to test-taking, although this specific study found no effect on test-taking performance, as we discuss below (Custers et al., 2010; Radel et al., 2010).

Research has also focused on understanding test-taker's motivation level during the test and the degree of concentration while taking it (Arvey et al., 1990; Burke, Normand, and Raju, 1987). However, there is limited research on understanding whether performing various activities or tasks immediately prior to taking a test can influence test performance.

2.2 Increasing motivation with priming

Priming refers to the activation of internal mental representations in order to influence subsequent behavior (Bargh and Chartrand, 2000). Segal and Cofer (1960) first coined the term "priming" to refer to a phenomenon where participants exposed to words in one task were more likely to use those words in subsequent tasks (Cofer, 1967). Priming research has shown that is possible to influence human behavior by planting a concept in the mind that activates the mental representations that drive the desired behavior (Bargh, 2002; Fazio et al., 1986; Solomon et al., 1998).

Researchers generally deliver primes in one of two ways: subliminal ("below threshold") and supraliminal ("above threshold"). Subliminal priming involves brief presentation of a stimulus (usually a half a second or less) followed by a mask that covers the stimulus (Bargh and Chartrand, 2000). With subliminal priming, the participant is not consciously aware of the stimulus. With supraliminal priming, the participant is consciously aware of the stimulus but is not aware of the intent behind it. Subliminal and supraliminal priming share a common theme: the participant is unaware that the stimulus is activating internal mental representations (Bargh and Chartrand, 2000). In this study, we used supraliminal priming.

Priming delivered using words (called semantic priming) is one of the many ways individuals can be primed. It works by activating semantic networks within the brain (Rissman, Eliassen, and Blumstein, 2003). The brain is organized into networks based on the associations one makes during prior experiences (Martin and Chao, 2001). These experiences form semantic networks, which develop as we interact with the world (Martin, 2007). When an individual hears or reads a word, the brain automatically attempts to connect the word to its semantic networks; this process is subconscious. As the brain finds matching semantic networks, they are activated in working memory, ready for subsequent use.

Priming words activate the set of concepts in semantic networks associated with the priming words, not just the words themselves (Kutas and Hillyard, 1984). For example, priming the word "popcorn" is likely to activate semantic networks associated with eating and semantic networks associated with movies because most people know that people often eat popcorn in movie theaters. Thus if we prime the word popcorn and then ask individuals to name celebrities, they would be more likely to name movie stars than music stars because the semantic network associated with movies is active in their working memory and the semantic network associated with music is not.

Researchers have found that goals can be primed subconsciously (outside of awareness) and run to completion (Bargh et al., 2001). In one such experiment, researchers used a word search puzzle to prime the concept of achievement (Bargh et al., 2001). In this study, individuals received either priming semantically related to achievement (i.e., "compete, win, succeed") or neutral words (i.e., "ranch, carpet, shampoo"). Investigators found that the individuals primed with "achievement" performed better in subsequent tasks than individuals exposed to the neutral prime (Bargh et al., 2001). The investigators believed that the prime activated an automatic goal pursuit of achievement, which led to high performance on the subsequent tasks (Bargh et al., 2001).

Early work on priming showed that the longer a person was exposed to a prime, the longer the priming effect would last (Bargh and Chartrand, 2000). For example, priming for 5 minutes produces a priming effect that may last 30 minutes (Bargh et al., 2001). The more priming words an individual sees, the greater the observed priming effect (Srull and Wyer, 1979).

Much of the research on test-taking has focused on the activation of mental representations of stereotypes or anxiety that serve to hinder performance (Steele and Aronson, 1995). We believe that it is possible to use achievement priming to change a student's mindset in a positive way prior to taking a test. By subconsciously inducing an achievement mindset, students will have a greater subconscious expectancy of success and therefore greater motivation to perform (Steel and Aronson, 1995; Bargh, Chen, and Burrows, 1996). This increased motivation will lead to better performance even if students are not consciously aware of the effect (Arvey et al., 1990; Meyer and Sørensen, 2009; Radel, et al., 2010).

Radel et al. (2010) primed subjects for autonomous motivation or controlled motivation by using priming words interspersed in a slideshow prior to a test. Autonomous priming included words such as interested, desire, willing, and free while controlled priming included words such as obligation, constraint, forced, and ought. They found that there was no mean difference in test performance due to priming but that students who were low in mindfulness performed better with the autonomous motivation priming. This shows that it is possible to affect test-taking motivation and that motivation can influence test performance. However, because this study did not include a control treatment with neutral or placebo priming, it is unclear whether autonomous motivation priming improves performance, or controlled motivation priming impairs performance.

In a series of two experiments using subliminal priming, Custers et al. (2010) had subjects receive subliminal priming in which success words (similar to those we used such as win, honor, award, masterful) were flashed on the screen for 30 ms prior to taking a test. They found that expectations of success increased in the success priming conditions, but there was no effect on performance. In a third experiment, Custers et al. (2010) had subjects perform a pre-task and randomly receive feedback about their performance, and while this affected perceptions, it did not affect performance. This series of experiments shows that priming can influence expectations of success, but not performance, which may be due to the use of subliminal priming, which is often weaker than supraliminal priming.

Ciani and Sheldon (2010) conducted three experiments using an anagram test that had subjects write either the letter "A" or the letter "F" on each page of their test answer sheet to prime success or failure. Participants were not informed of the meaning of the letters, but the intent was to prime the concept of a grade of "A" or a grade of "F." In all three experiments, students writing an "A" outperformed students writing an "F." Two experiments included a third treatment in which students wrote a meaningless letter "J," designed to simulate neutral placebo priming. In one experiment, students writing "A" outperformed students writing a "J," while in the other they did not. This study shows it is possible to prime students during a test, but the effects of positive priming (i.e., writing the letter "A") may or may not have significant effects compared to a placebo priming. This study is very suggestive that priming during test-taking can affect performance, but it presents mixed results on whether simple priming such as writing a letter can improve performance relative to placebo priming.

Taken together, we believe these studies suggest that priming can affect the expectation of success and motivation, which may or may not affect test performance, depending upon the nature of the priming. Subtle priming (e.g., subliminal or writing a letter) may have only limited effects. A priming game that delivers supraliminal priming over a longer period of time is more likely to have a stronger effect than subliminal priming or writing one letter (Bargh and Chartrand, 2000). Therefore, we believe that achievement priming is likely to improve test-taking performance.

2.3 Serious games for priming motivation

The extent of user engagement in computer games triggered the development of games for educational purposes (Wolfe and Crookall, 1998). Computer-based gaming is defined as a "rule-governed, goal-focused, microcomputer-driven activity incorporating principles of gaming and computer-assisted instruction" (Driskell and Dwyer, 1984). Such games have also been found to improve collaboration, problem solving, and decision-making skills of people. While these games enhance knowledge acquisition and retention, a major issue for recent research has been the motivational influence of computer games (Green and Bavelier, 2003).

Woodrow Wilson Institute's Serious Games Initiative first used the term "serious games" in 2002 when it established a connection between the computer gaming industry and the educational gaming community (Susi, Johannesson, and Backlund, 2007). Since then, serious computer gaming has been incorporated in various areas, such as public policy, health sciences, education, and strategic communication (Susi, Johannesson, and Backlund, 2007). Since the early 2000s, when Prensky (2003) first coined the term "game-based learning," developers have designed educational games based on various theories and models to improve student engagement and learning (Kearney, 2007).

Recent research has identified computer-based serious gaming as an enhancer of educational learning, motivation, knowledge retention, and performance on cognitive ability tests (Garris, Ahlers, and Driskell, 2002; Green and Bavelier, 2003; Randel et al., 1992; Ricci, Salas, and Cannon-Bowers, 1996). Research in cognitive psychology suggests that if these computer games are based on learning and instructional theories, they may improve test-taking performance (Meyer and Sørensen, 2009). Such serious games can not only improve the motivation levels of students for taking a test, but can also improve their overall cognition, which results in better test performance (Cherney, 2008; Subrahmanyam and Greenfield, 1994).

We hypothesized that playing a computer word game designed to prime the concept of achievement prior to taking a test will increase a student's expectation of success, which will in turn increase motivation to succeed and ultimately, test-taking performance. Many tests, including all of the high stakes tests such as the SAT, attempt to assess a student's cognitive ability using both verbal and quantitative reasoning. Verbal reasoning often assesses an individual's vocabulary, grammar, and reading comprehension, while quantitative reasoning assesses an individual's basic arithmetic, algebra, and geometry. We do not expect there to be a differential effect of the game on verbal or quantitative achievement because increasing the expectation of success should affect performance on both verbal and quantitative performance equally. We hypothesize that when subjects play an engaging priming game of sufficient duration prior to taking a test, test-taking performance will be improved on both verbal and quantitative testing. Therefore:

H1a: Playing a computer word game delivering achievement priming will increase performance on a subsequent verbal cognitive ability test.

H1b: Playing a computer word game delivering achievement priming will increase performance on a subsequent quantitative cognitive ability test.

3. METHOD

3.1 The game

Our computer game utilized an achievement prime designed to improve performance on subsequent tasks (Bargh et al., 2001). We used a Scrambled Sentence Test, in which participants develop a four-word newspaper headline from a set of five words (Srull and Wyer, 1979). The Scrambled Sentence Test is a priming technique that has been used extensively over the last decade to deliver semantic priming (Bargh, Chen, and Burrows, 1996; Chartrand and Bargh, 1996; Simpson et al., 1989).

Figure 1 shows a screenshot of the Web-based version of the computer word game. The computer game presented a set of five words, from which a participant could choose four words to create a newspaper headline. As seen in the screenshot, each of the five words presented on the screen had a “Select” button to the left. The “Select” buttons were oriented next to the words in order to create engagement between the participant and the list of words. After thinking about the formation of a four-word sentence from the list of five words, the participant selected four words using the select button. If the participant was not satisfied with the selection, he or she could cancel the selection using the “Clear Selection” button and think about the four-word sentence formation again. After a participant was satisfied with his or her choice of four words, he or she clicked a submit button, and the game presented a new set of five words.

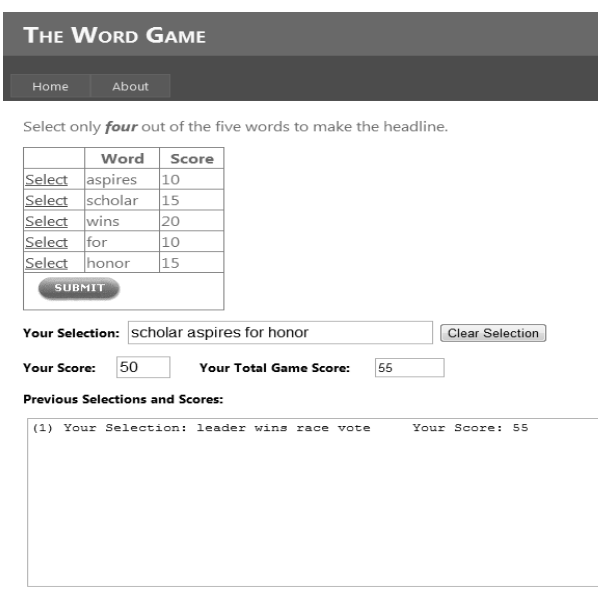

Figure 1. Screenshot of the priming word game

In our game, points were assigned to each of the words, and participants attempted to maximize their point score. With each submission, participants could view their score for the current submission as well as the cumulative score for all the submissions in the game. We assigned the most points to the words designed to induce priming to encourage participants to focus on them. We instructed participants that the headlines had to make sense grammatically but could be silly (e.g., “genius millionaire wins game” or “millionaire wins genius game” but not “wins game genius millionaire”). However, the game did not validate each headline to ensure that the rules of grammar were followed. Even if the headline was not grammatically correct, the game would still prime the participants as long as they read the words.

At least two words in each set of five words (often three or four words) was an achievement-oriented word based on words used in an achievement-activation priming experiment (Bargh et al., 2001). These words include win, leader, strive, aspire, scholar, genius, award, and honor. The words in the game were assessed using the Affective Norms of English Words (ANEW) database (Bradley and Lang, 1999). The ANEW database contains thousands of words that have been rated on arousal and valence. Arousal describes the level of an individual’s emotional activation, varying from calm to aroused (Lang, 1995). Valence describes the amount of individual attraction towards an object, ranging from attraction and pleasure to aversion and displeasure (Lang, 1995). In the ANEW database, arousal is rated on a scale from 1 (low arousal) to 9 (high arousal), as is valence from 1 (negative) to 9 (positive). For the achievement-oriented priming computer game, we would ideally want words that are high in arousal and have a positive valence. The achievement-oriented computer game words had high arousal ($M = 5.73$, $S.D. = 0.98$) and positive valence scores ($M = 7.22$, $S.D. = 0.93$).

3.2 Participants

Sixty-one freshman and sophomores from an introductory business course participated in the study and received extra credit. The average age was 19.4 years, and 44 percent were male. Thirty-five participants received the achievement prime, while 26 received the placebo prime.

3.3 Task

The participants worked on a cognitive ability test. The questions on the test were drawn from a set of practice SAT tests. The questions were a mix of both quantitative and verbal reasoning questions. There were 21 quantitative reasoning questions comprised of numbers and operations, geometry, algebra, and statistics and probability. There were 28 verbal reasoning questions comprised of sentence completion and critical reading.

3.4 Treatments

There were two treatments: the achievement-prime computer game described above and the placebo computer game. Participants were randomly assigned to one treatment. We designed the placebo version of the game to have no effect, using words from prior research including worker, break, room, bench, dirt, and table. For this version, we would ideally want words that are moderate in both arousal and valence. The placebo computer game words were moderate in arousal (M = 4.44, S.D. = 0.75) and moderate in valence (M = 4.89, S.D. = 0.59). There were significant differences between the sets of words used in the two versions of the game for both arousal (t(248) = 13.19, p < .001) and valence (t(298) = 25.74, p < .001).

3.5 Measures

There were six measures. The first measure was performance on the quantitative reasoning test. The second measure was performance on the verbal reasoning test. Consistent with SAT scoring, participants received one point for each correct answer, zero points for skipping a question, and lost .25 points for incorrectly answering a question.

The remaining four measures came from a questionnaire each participant completed at the end of the session. The instrument assessed the "ease of use" and "enjoyment" of the computer game. The ease-of-use construct contained three items, with a Cronbach's alpha of .72. A sample ease-of-use item is: "The computer game was easy to learn." The enjoyment construct had four items, with a Cronbach's alpha of .90. A sample enjoyment item is: "The computer game was interesting."

The other two measures were self-reported GPA and gender, used as controls. Gender may be an important factor because men often have greater computer knowledge than women (He and Freeman, 2010). Self-reported GPA is a reasonable proxy for actual GPA (Kuncel, Credé, and Thomas, 2005).

3.6 Procedures

Participants began by playing one of the priming games; all participants received either the achievement or placebo prime. Participants played the priming game for eight minutes or until they completed 30 sets of priming words. Approximately 80 percent of the participants were still working on the priming game at the end of the eight minutes. Participants then worked on the cognitive ability test for 30 minutes. They then completed the questionnaire. The participants were debriefed, and the session concluded.

4. RESULTS

4.1 Test performance

All statistical analyses were completed in SPSS PASW Statistics 18.0 using a repeated-measures GLM. A summary of the means and standard deviations is provided in Table 1. Table 2 shows the statistical results for test performance. The omnibus hypothesis is supported. Participants in the achievement-prime treatment performed significantly better than participants in the placebo-prime treatment (F(1, 57) = 5.60, p = .021). There are no statistical significant differences in the effectiveness of the priming game on the quantitative reasoning or verbal reasoning questions (F(1, 57) = 0.09, p = .767). Hypotheses 1a and 1b are both supported: participants performed significantly better on verbal reasoning and quantitative reasoning test questions following the achievement- priming game compared to the placebo-priming game. The effect size was "medium," with Cohen's d = .63.

As an aside, we note that participants scored higher on the verbal reasoning questions than the quantitative reasoning questions. Self-reported GPA was not significantly related to overall test performance (F(1, 57) = 2.64, p = .110), although it was significant for verbal reasoning questions (t(57)=2.14, p=.037). There were no significant differences in GPA between the two treatments (achievement prime mean= 3.66, placebo mean= 3.67, t(59)=0.13, p=.895). Participants' gender was significantly related to test performance with males scoring significantly higher than females (quantitative reasoning: males=12.08, females=10.72; verbal reasoning: males= 12.14, females=10.01; F(1, 57) = 4.29, p = .043). There were no significant differences in gender between the two treatments (achievement prime mean= 44% male, placebo mean= 41% male, t(59)=0.29, p=.772). Likewise, the effect of priming did not have a different effect on males versus females (F(1, 57) = 0.93, p = .340).

4.2 Student perceptions

No significant differences were observed between the achievement-prime computer game and placebo game for ease of use (F(1, 57) = 0.05, p = .827) or enjoyment (F(1, 57) = 0.10, p = .751). Additionally, we note that no significant differences due to gender were observed for ease of use (F(1,57) = 0.65, p = .425) or enjoyment (F(1, 57) = .0.48, p = .491).

We compared the mean ratings of the achievement priming game to the neutral value of 3.00 for both perception scales. We found that the students perceived the game to be significantly greater than neutral for ease of use (t(35) = 4.13, p < .001) and no different than neutral for enjoyment (t(35) = 1.43, p = .162).

	Achievement Prime		Placebo Prime	
Measures	**Mean**	**Std**	**Mean**	**Std**
Quantitative Reasoning	12.24	3.33	10.10	3.50
Verbal Reasoning	12.50	6.91	9.91	5.03
Ease of Use	3.64	0.96	3.58	0.86
Enjoyment	2.74	1.00	2.64	1.17

Table 1. Means and Standard Deviations

Factor	F-statistic	p-value
Achievement Priming	5.60	.021
GPA	2.64	.110
Gender	4.29	.043
Question Type	4.60	.036
Priming x Question Type	0.09	.767
GPA x Question Type	7.75	.033
Gender x Question Type	0.93	.340

Table 2. Results of statistical analyses for test performance (using both quantitative reasoning and verbal reasoning questions)

5. DISCUSSION

Our study provides evidence that playing a computer word game designed to prime achievement improves performance on subsequent test performance. We found that individuals who played an achievement computer game had significantly better quantitative and verbal reasoning performance on an SAT-style test than individuals playing a placebo game designed to have no effect. The effect size is "moderate," with a Cohen's d of .63, which Cohen describes as visible to the naked eye (Cohen, 1988).

We believe the achievement computer game activated a subconscious motivation towards "high performance." Motivation towards an activity is comprised of the individual's belief of the importance of that activity and the individual's expectancy of success (Wigfield and Eccles, 1994). We believe the game subconsciously influenced the individual's expectancy of success by activating networks semantically related to "achievement," which in turn created a more achievement-oriented mindset. Past research shows that priming can affect expectations of success in test-taking (Custers et al., 2010), although expectations may not translate into better performance. One important difference between our study and the Custers et al. (2010) study that found no difference was the type of priming used. Custers et al. (2010) used very short-duration subliminal priming (30 ms), which has a mixed history of success, while we used much longer priming, in which subjects were actively engaged with the priming words.

We believe the computer game enhanced individual performance by helping participants reach their individual best cognitive performance. The findings illustrate that serious games can influence test-taking performance of individuals. This study suffers from the usual limitations of experimental research. We studied a small set of participants (61 students) performing a short-duration task (a 30-minute test) that was not linked to their normal course activities. Despite these limitations, we believe that these results have several theoretical and practical implications.

5.1 Implications for research

This study theorizes that priming influences test performance, and the results indicate a significant and meaningful effect. However, we have no direct measures to understand the exact mechanism by which priming works. We theorized priming works by activating subconscious motivation (through the expectancy of success). Future research should investigate the exact mechanism by which priming works. Although self-reported methods like surveys or interviews are commonly used in behavioral studies, these would likely not be appropriate because priming works subconsciously, so participants should not be consciously aware of priming's effects (Bargh et al., 2001). If we asked participants, they should not report any increased expectation of success or increased motivation. If they did report such increases, then the effects would not be subconscious—the effects would be conscious. Researchers could explore the possibility of using the tools of cognitive neuroscience such as EEG or fMRI, which can examine the corresponding neural activation that forms the basis of priming-induced subconscious behavior.

Previous research has examined how motivation before a test affects test performance (Higgins, Rholes, and Jones, 1977; Radel et al., 2010). This study contributes to the literature by introducing the effect of priming on test-taking performance improvement. Future research can explore the relationship between priming and motivation. Researchers can focus on finding out if priming helps improve the underlying motivation to perform well on the test.

This study examined the effect of priming on an SAT test. We believe that there is nothing unique about the SAT test. If priming affects a general-ability test such as the SAT, then it is likely to also affect performance on subject-specific tests, such as certification exams focused on specific skill sets or tests in academic courses. Of course, this calls for more research on the effects of priming for these specific subjects. Future research also could explore the effect of such computer-based priming games on other standardized tests, such as the certification exams. Students around the globe whose first language is not English take English-ability tests like the TOEFL or IELTS if they wish to pursue their education in countries where English is the first language. Researchers can focus on understanding the effect of priming delivered through a word-based computer game, such as the one used in this study, on the performance of students who take such English-ability tests.

Future research could focus on understanding the effect of priming on specific sections of the SAT or specific knowledge sets, such as Cisco or Microsoft certification exams. It is possible that priming could be designed to influence performance on one section of the SAT exam or a specific subject area on a certification exam more or less than another. For example, a priming treatment might be designed to activate the semantic networks associated with mathematics thinking and thus improve the score on the quantitative section more than the score on the verbal section. This could provide further research opportunities to understand how priming affects test-taking.

Our game did not verify the grammatical correctness or semantic correctness of the headlines that participants created nor did it record their headlines. Future research could investigate the strategies that students use and the actual headlines they create to see if the content of the headlines influences the priming they receive and ultimately affects their test-taking performance.

Priming lasts only a short period of time because as an individual works on a task following priming, other concepts begin to push the priming concept out of working memory (Bargh and Chartrand, 2000). There is little research that shows how long supraliminal priming continues to influence behavior, although the effects from a short-duration priming game like ours probably last up to 30 minutes (Bargh et al., 2001). Longer priming with more words likely has a longer impact, but there is some limit beyond which more priming is likely to have little additional effect on how long the priming effect lasts (Srull and Wyer, 1979). More research is needed to better understand how long priming can last, how we can extend the effects of priming, and how to modify tasks to reinforce priming during the execution of the task so that the effects of priming lasts longer.

While this paper focuses on implementation of achievement priming delivered through a scrambled sentence computer game, future research can focus on understanding the effects of other types of priming. Instead of using achievement- oriented words, researchers can explore other types of priming to see the effects on test performance. Also, researchers can explore if priming using words affects performance on certain sections of the test compared to priming using numbers or pictures.

A recent area of interest among researchers is the role of computer games to improve student learning (Vogel et al., 2006). While it is known that computer games can lead to cognitive benefits, incorporating priming tasks into these computer games could help students further improve their learning capabilities. Researchers can focus on understanding if different types of priming delivered through a computer game help students activate certain semantic representations that help them learn concepts quicker and/or better. Students could be asked to undertake different kinds of priming tasks before or during each tutoring session. Their learning performance during these sessions can be compared with their learning during the session when no priming was used. This will open avenues for research in the areas of accelerated learning, advanced tutoring systems, and so on.

5.2. Implications for practice

This study shows that students can significantly improve their test scores by using a computer-based word game prior to taking a test. Students can use such computer-based games prior to taking a test or certification exam. Students can also use such games when they are preparing for an upcoming test. This will not only help them raise their confidence level for the test, but may also help them learn the concepts better.

The applicability of the results in this study can be extended to testing protocols used in educational institutions. While use of such games might not be a regular part of the current testing protocols, incorporating such games into the standard process of high-stakes tests in grade schools could better ensure that students perform at their best. By introducing priming into the test-taking process, educational institutions are likely to see an improved performance on the tests by their students. The percentage improvement in the test score seen in this study is significant and meaningful. With the increasing computerization of various cognitive ability tests, incorporating computer-based priming games into the flow of test-taking activities might not be a difficult task to accomplish.

The results of this study have implications for testing and tutoring software development companies like Kaplan and Educational Testing Service. Such companies can incorporate computer-based priming games into the structure of their test preparation, whether for SAT tests or certification exams. Similar games could also be incorporated into tutoring systems which involve tests at the completion of a certain course. With such priming games as an integral part of the testing or tutoring software, these companies can see significant improvement in the performance of the customers who use their testing or tutoring systems.

Apart from commercial use, students can benefit from such priming-based computer games by incorporating them into their study exercises. Students can use such games before working on any assignments or similar exercises. Students can also use such games in the middle of long study sessions. By incorporating such priming games into the flow of their work activities, students can expect to see significant improvement in not only the time efficiency of their work, but also in the scores obtained on the work.

6. CONCLUSION

In this study, we investigated the effect of achievement priming, delivered through a computer-based word game, on test performance. Participants who played an achievement-priming game performed significantly better than participants who played a placebo-priming game. The Cohen's d effect size was .63, indicating a "medium" effect that Cohen describes as non-trivial or visible to the naked eye (Cohen, 1988). The results of this study open many avenues for research studies that can explore different types of priming conditions and the effect on test performance. Also, educational institutions as well as companies developing tutoring or testing software can use this study to incorporate priming into their tutoring methodology and testing structure. This could help improve student test performance as well as student learning.

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