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EMPIRICAL RESEARCH

Scaring Them into Learning!? Using a Snake Screen to Enhance the Knowledge Transfer Effectiveness of a Web Interface

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ABSTRACT

It seems that surprise events have the potential to turn short-term memories into long-term memories, an unusual phenomenon that may have limited but interesting applications in learning tasks. This surprise-enhanced cognition phenomenon is theoretically modeled based on the notion that many human mental traits have evolved through natural selection; a mathematical analysis building on Price's covariance theorem is employed in this modeling effort. Additionally, the phenomenon is discussed in the context of an online learning task, based on a study involving 186 student participants. A simulated threat was incorporated into a human–computer interface with the goal of increasing the interface's knowledge-transfer effectiveness. The participants were asked to review Web-based learning modules and subsequently take a test on what they had learned. Data from six learning modules in two experimental conditions were contrasted. In the treatment condition, a Web-based screen with a snake in attack position was used to surprise the participants; the snake screen was absent in the control condition. As predicted, the participants in the treatment condition did significantly better in the test for the modules immediately before and after the snake screen than the participants in the control condition. These findings are extrapolated to classroom applications in general. Ethical considerations are also discussed.

Subject Areas: Evolutionary Psychology, Flashbulb Memorization, Human–Computer Interaction, Online Learning, and Web Interface Design.

INTRODUCTION

Can surprise events enhance knowledge-transfer effectiveness in the classroom? The study reported in this article aims at answering this question for online classes. The study also opens the door for the possibility that surprise can be used more broadly in face-to-face classroom contexts as well. These conclusions are presented and discussed in the context of a unique experiment involving 186 undergraduate university students.

Knowledge transfer is defined, for purposes of this study, in the same way as it was defined by Kock and Davison (2003). That is, knowledge transfer is defined

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as the transfer of mental schemas that can be used to process information, where information can be represented as facts (e.g., today is sunny) and knowledge can be represented as production rules (e.g., if today is sunny, then the probability of rain is low)—see Kock and Davison (2003) for more examples. It is assumed here that the task of teaching a university course involves a great deal of instructor–student and student–student knowledge transfer.

The phenomenon coined flashbulb memorization has puzzled researchers for years (Brown & Kulik, 1977; Edery-Halpern & Nachson, 2004). This phenomenon is associated with the observation that surprise events enhance the memorization of contextual information associated with those events. The enhancement involves memories of contextual information acquired shortly (e.g., a few minutes) before and after the surprise event, in what could be called a surprise zone. Those memories, which can be seen as short-term memories when they are acquired, seem to automatically be turned into long-term memories by the surprise event. This is an unusual phenomenon that short-circuits the often long and time-consuming process of turning short-term memories into long-term memories involved in most types of learning (Anderson, 1983; Baddeley, 1986; Schacter, 2001).

The essence of the flashbulb memorization phenomenon can be illustrated through a simple example. Let us consider a person who is reading a book in a park and suddenly sees a snake near him. He is startled by that event and subsequently leaves the area. According to the flashbulb memorization notion, that person will have better memories associated with his surroundings (e.g., vegetation and terrain) around the time of the snake appearance than a person who was not surprised. Moreover, he will also remember the parts of the book that he was reading better than someone who was not surprised.

In other words, contextual memories, even those unrelated to the snake itself, seem to be enhanced by the surprise event. Moreover, memories associated with contextual information before and after the surprise event are enhanced. This is one of the unusual aspects of the phenomenon, because it appears to violate the laws of physics. An event in the future, that is the surprise event, appears to affect an event that happened in the past, namely, the acquisition of memories before the surprise event. As will be seen later, this unusual aspect of the phenomenon is not because of it violating the laws of physics but rather because of the fact that short-term memories are not erased immediately after they are acquired (Kotulak, 1997; Schacter, 2001).

Based on the discussion above, it is reasonable to believe that a surprise event can be created through a human–computer interface with the goal of enhancing knowledge-transfer effectiveness. One could conceivably improve the communication of certain pieces of knowledge by having surprise events near them. This could take place in an online learning task, where knowledge is communicated through Web pages and the surprise is elicited through a Web page showing the photograph of a snake in attack position.

This would, of course, be useful from a practical perspective if the communication effectiveness associated with pieces of knowledge outside the surprise zone was not negatively affected. Otherwise, the negative effect could offset the positive effect and lead to an overall decrease in knowledge-transfer effectiveness.

This article makes two contributions to the online learning and human–computer interaction literature. First, it provides a theoretical basis on which human–computer interfaces can be designed to elicit surprise, with the goal of enhancing knowledge-transfer effectiveness. Second, the article discusses the results of a Web-based experiment in which a snake screen is used to significantly enhance knowledge-transfer effectiveness in the surprise zone, with no observable negative effects outside the surprise zone.

THE EVOLUTION OF SURPRISE-ENHANCED COGNITION

Price (1970) has shown that for any trait to evolve through selection in a population of individuals it must satisfy equation (1), where w_i is a measure of the fitness of an individual i in the population, usually the number of surviving offspring of the individual, and z_i is a quantitative measure of the any phenotypic trait that has a genetic basis. That is, the covariance between fitness and trait measure must be greater than zero for any trait (morphological, physiological, or mental) to evolve through selection. Examples of traits that could be measured through z_i are height, bone resistance to fracture, and desire for high-calorie foods (e.g., fatty or sweet foods).

$$\mathrm{Cov}(w_i, z_i) > 0. \tag{1}$$

In spite of its apparent simplicity, equation (1) is widely considered to be one of the most important contributions to the mathematical foundations of evolutionary thinking (Frank, 1995; Henrich, 2004; McElreath & Boyd, 2007; Rice, 2004). The equation has been broadly used in a range of areas associated with evolutionary thinking, from the understanding of the evolution of morphological traits in nonhuman organisms (Frank, 1995; Rice, 2004) to the understanding of the evolution of mental traits in humans (Henrich, 2004; McElreath & Boyd, 2007). The latter area, the understanding of the evolution of human mental traits, is the main focus area of the emerging field of evolutionary psychology (Barkow, Cosmides, & Tooby, 1992; Buss, 1999).

Generally, when one wants to build theoretical models of evolution of traits, including mental traits in humans, the relationship between fitness (w_i) and trait measure (z_i) is expressed in the form of a linear equation with regression coefficients (Rice, 2004; McElreath & Boyd, 2007). In this case, the linear equation incorporates hypothesized intervening effects that are relevant for the theory-building effort being conducted (Henrich, 2004; McElreath & Boyd, 2007).

Intervening effects that are relevant for this study are represented in equation (2) through the quantitative variables s_i and p_i, where s_i is a measure of survival success of an individual, such as the age of the individual at the time of death, and p_i is the probability that the individual will be involved during his or her lifetime in a certain number of situations in which he or she will be surprised and in which the surprise will be of an unpleasant nature. The reason for the inclusion of s_i in equation (2) is that unpleasant surprise situations have likely been often associated with survival threats in our evolutionary past (Boaz & Almquist, 2001; Schützwohl, 1998). Examples are near falls from high altitudes, attacks by large predators, and encounters with other dangerous animals (e.g., venomous snakes and spiders).

$$w_i = \alpha_i + \beta_{ws} \times \beta_{sp} \times \beta_{pz} \times z_i + \varepsilon_i. \tag{2}$$

In equation (2), the alpha term refers to the baseline fitness in the population of individuals indexed by i. The beta terms represent the coefficients of regression of w_i on s_i, s_i on p_i, and p_i on z_i, respectively, from left to right. Subindices are not represented in the beta terms to avoid excessive notation complexity. The epsilon term represents the uncorrelated error in the equation.

Combining equations (1) and (2) and applying basic covariance and regression properties (Rice, 2004; Mueller, 1996) lead to equation (3). This equation expresses the fundamental requirement for evolution of the trait measured by z_i in terms of three coefficients of regression and V_z, which is the variance of the trait measured by z_i in the population of individuals indexed by i.

$$\begin{aligned} \mathrm{Cov}(w_i, z_i) > 0 &\Rightarrow \mathrm{Cov}(\alpha_i, z_i) + \beta_{ws} \times \beta_{sp} \times \beta_{pz} \times V_z + \mathrm{Cov}(\varepsilon_i, z_i) \\ &> 0 \Rightarrow 0 + \beta_{ws} \times \beta_{sp} \times \beta_{pz} \times V_z + 0 \\ &> 0 \Rightarrow \beta_{ws} \times \beta_{sp} \times \beta_{pz} \times V_z > 0 \end{aligned} \tag{3}$$

The coefficient of regression of w_i on s_i is always positive because individuals must be alive to procreate and care for offspring, and thus survival success influences fitness in a positive way (Hartl & Clark, 2007; Smith, 1998). The coefficient of regression of s_i on p_i, on the other hand, is always negative because unpleasant surprise situations were likely to be often associated with survival threats in our evolutionary past (Boaz & Almquist, 2001; Schützwohl, 1998), and thus the probability of experiencing a certain number of unpleasant surprise situations influences survival success in a negative way.

Given that V_z is the square of the standard deviation of z_i, it is always nonnegative. Therefore, the coefficient of regression of p_i on z_i must be negative (i.e., $\beta_{pz} < 0$), meaning that the mental trait measured by z_i must influence an individual's probability of experiencing unpleasant surprise situations in a negative way. This is roughly equivalent to saying that the trait measure and the probability of experiencing unpleasant surprise situations must be inversely correlated for that trait to have evolved among our human ancestors though selection and thus must be found today among most modern humans.

Valuable insights into the lives of and dangers faced by our human ancestors can be obtained from studies of nonurban societies today (Boaz & Almquist, 2001), especially in nonurban areas where access to medical care is precarious. Some of these studies (Hung, 2004; Shine & Koenig, 2001) suggest that unpleasant surprise events in our evolutionary past such as encounters with venomous snakes were likely to be often fatal, but probably not always so. As such, they posed strong selection pressure for mental traits that could reduce their probability, which could have led to the rapid evolution of those traits and the fixation or near fixation of their related genotypes (see, e.g., Hartl & Clark, 2007) among our ancestors. The fixation of a genotype, related to a particular trait, occurs when the genes coding for the trait spread to all of the individuals in a population, where the population may comprise all of the individuals of a particular species.

It is important to note that evolution of quantitative traits normally leads to a reduction of trait variance in species' populations, but not to the complete elimination of trait variance (Smith, 1998; Wilson, 2000). Therefore, one should still observe some variance in connection with virtually any trait measure among modern humans. Among the key reasons for this are that traits are the result of complex interactions between many genes and environmental factors and that evolution itself is often affected by a stochastic process known as genetic drift that may prevent the fixation of genotypes that code for fitness-enhancing traits (Smith, 1998; Rice, 2004; Wilson, 2000).

A search for candidate traits that satisfy the condition $\beta_{pz} < 0$ leads almost inevitably to enhanced cognition around the close temporal vicinity (i.e., a few minutes before and after) of unpleasant surprise events for three key reasons. The first reason is that unpleasant surprise events often occur in a given context, in which there are specific contextual markers; for instance, dangerous animals live in ecological niches with characteristic types of terrain and vegetation (Boaz & Almquist, 2001; Wilson, 2000), which our ancestors likely entered within a few minutes of an encounter with those animals (Boaz & Almquist, 2001; Hung, 2004; Wilson, 2000). The second reason is that enhanced memorization of contextual markers for unpleasant surprises, and their mental association with the related unpleasant surprise events, was likely very important for the avoidance of those events in the future (Edery-Halpern & Nachson, 2004; Schützwohl, 1998). Without enhanced memorization of markers for unpleasant surprise events, our ancestors would likely face the unpleasant surprises over and over again, being ill equipped to avoid them, and thus die in higher quantities than if they possessed the mental trait associated with enhanced memorization of markers. The third reason is that the survival threats likely associated with unpleasant surprises in our evolutionary past were not always fatal; otherwise, mental traits that helped our ancestors to avoid those events would not have evolved, because all individuals involved in the events would have died and thus failed to pass on their genes to the next generations (Hartl & Clark, 2007; Smith, 1998).

Let us consider a mental trait whose measure (z_i) is the level of enhanced cognition in connection with contextual information within the close temporal vicinity of unpleasant surprise events (i.e., within what are referred to in this article as surprise zones). Based on the discussion above, it can be concluded that this trait satisfies Price's (1970) covariance inequality shown in equation (1), the fundamental requirement for the evolution of any trait through selection. Therefore, it can also be concluded that this trait could have evolved through selection. That is, the trait would first have appeared through genetic mutation in one single individual among our human ancestors and then would have spread to other individuals over successive generations because of the survival advantage that it conferred, following the process initially described in a formal way by Darwin (1859).

Because the surprise-enhanced cognition trait discussed above refers to a mental association of facts, such as the occurrence of an event and the presence of environmental markers, one can conclude that it refers to knowledge and not only information—as defined earlier following Kock and Davison (2003). This leads to the expectation that surprise events in situations in which individuals are learning, or acquiring knowledge about a particular subject, would enhance that learning within the surprise zones associated with those events. The empirical study discussed in this article is one initial step in the direction of clarifying and qualifying this connection between unpleasant surprise events and enhanced knowledge transfer.

THE HYPOTHESES OF THIS STUDY

The preceding mathematical discussion is consistent with the empirical results obtained by evolutionary psychologists who examined the relationship between surprise and cognition (Schützwohl & Borgstedt, 2005; Schützwohl & Reisenzein, 1999). Those empirical results generally suggest that surprise enhances cognition, as predicted by the mathematical model. Also, as pointed out by Schützwohl (1998), surprise responses are largely instinctive and associated with involuntary body reactions. Among those are distinctive facial expressions, reflex body movements, and the skin response leading to goose bumps (see also Meyer, Reisenzein, & Schützwohl, 1997).

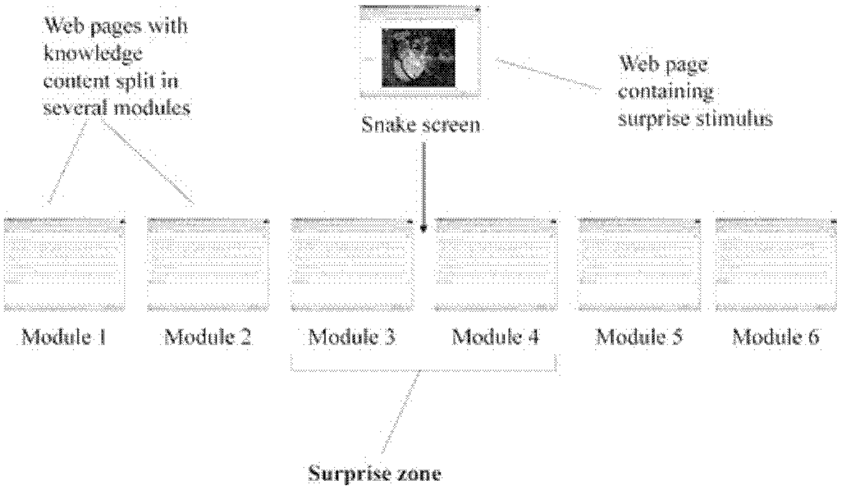
Instinctive responses can be explained in many ways and are often believed to have a strong evolutionary basis (Schützwohl, 1998). One of the main fields of inquiry that explain human behavioral phenomena from an evolutionary perspective is that of evolutionary psychology (Barkow et al., 1992; Buss, 1999). The explanations build on genetically induced behavioral responses that would have been evolutionarily adaptive for our hominid ancestors and that would have been passed on to us through our genes, leading to observable behavioral responses today in analogous situations.

Following the mathematical analysis, it would arguably have been evolutionarily adaptive for our hominid ancestors to have enhanced memories of contextual information (e.g., vegetation and terrain type) immediately before and after a surprise encounter with an animal that could harm them. An example of such a surprise encounter would have been one with a venomous snake or spider or a large predator. The reason why enhanced memorization of contextual information in these events would have been evolutionarily adaptive is that such animals usually live in habitats characterized by specific elements such as vegetation, rock formations, and terrain type (Boaz & Almquist, 2001). A hominid ancestor would arguably enter and leave one such niche a short time (e.g., a few minutes) before and after a surprise encounter.

This enhanced cognition phenomenon can be exploited in the design of human–computer interaction interfaces for knowledge transfer. Assuming that knowledge is communicated through discrete content modules implemented through Web pages, a surprise-eliciting Web page should cause the enhanced memorization of content within a Web-based surprise zone. That surprise zone would include the Web pages before and after the surprise-eliciting Web page. The surprise-eliciting stimulus could be a screen showing a snake in attack position, with a snake-like hissing background noise added for realism.

For the sake of simplification, let us assume a human–computer interface with six knowledge-bearing modules, as given in Figure 1. Modules 3 and 4 are the ones immediately before and after a snake screen, and each module is viewed on a computer screen in sequence. Using snakes is particularly meaningful in this context, especially given the likely evolutionary basis of the

Figure 1: Web pages with knowledge content and the surprise zone.



surprise-induced cognition enhancement phenomenon explored here. The reason is that there is strong evidence that snakes coevolved with human ancestors, including early primate ancestors, in what some have referred to as an evolutionary arms race between species (Boaz & Almquist, 2001; Isbell, 2006).

Let us also assume that two groups of individuals can be compared. One group, referred to here as the treatment group, would be surprised with the Web page showing a snake. The other group, called here the control group, would go through the six modules without being surprised by any snake screen. The previous discussion on enhanced memorization of content within a surprise zone leads us to hypotheses H1 and H2 below.

H1: The knowledge-transfer effectiveness for module 3 will be significantly higher in the treatment (surprise) than in the control (no surprise) condition.

H2: The knowledge-transfer effectiveness for module 4 will be significantly higher in the treatment (surprise) than in the control (no surprise) condition.

It is reasonable to conclude that the positive effects predicted in hypotheses H1 and H2 would be useful for designers of human–computer interfaces if they were not accompanied by negative effects outside the surprise zone. That is, the practical potential of the phenomenon would be significantly decreased if the snake screen caused so much distraction that individuals would do worse in terms of learning the content in modules 5 and 6, for example.

From an evolutionary psychological perspective, however, there is no reason to hypothesize that there will be decreased memorization of contextual information outside the surprise zone. That is, there is no reason to expect that it would have been evolutionary adaptive for hominid ancestors to have reduced cognitive resources allocated to events outside the surprise zone.

One could argue that our brain would tend to mentally rehearse a surprise event after it occurred (Greenberg, 2005), which could impair the memorization of contextual information after the surprise zone. Although there is evidence that such mental rehearsal does indeed take place, the research literature on the topic suggests that rehearsal starts after a significant amount of time has passed since the surprise event first occurred (Otani et al., 2005). That time lag is generally in the order of days.

In the human–computer interface analog considered here, the discussion above leads us to hypothesis H3, enunciated below.

H3: The knowledge-transfer effectiveness for modules 1, 2, 5, and 6 will not present significant differences in the treatment (surprise) condition and the control (no surprise) condition.

In other words, hypothesis H3 incorporates the prediction that the enhancement in knowledge-transfer effectiveness within the surprise zone (i.e., modules 3 and 4) will have no negative effect on knowledge transfer effectiveness outside the surprise zone. As such, this hypothesis complements hypotheses H1 and H2 in a way that allows us to test the practicality of the phenomenon from a human–computer interface design perspective in computer-mediated learning contexts.

RESEARCH METHOD

A Web-based knowledge-transfer experiment was conducted with 186 student participants at a university. Two experimental conditions were used. A Web-based screen with a snake picture in attack position, with a snake hissing background noise, was used to create a simulated threat in the treatment condition. The screen was shown for 10 seconds in between modules 3 and 4, as indicated in Figure 1. The simulated threat was absent in the control condition.

Institutional review board approval was obtained prior to the experiment being carried out. The participants were randomly assigned to the two conditions, with approximately half of the 186 participants being in each of the conditions. Their ages ranged from 18 to 48 years, with a mean age of 24 years. Approximately 53% of the participants were females. They were distributed as follows in terms of their student status at the university: sophomore (6.45%), junior (43.55%), senior (41.94%), and graduate (8.06%).

In both conditions, the participants were asked to review learning modules about "Incoterms," presented to them as Web pages with written content. The term "Incoterms" is an abbreviation for "International Commercial Terms" and refers to a body of standard terminology published by the International Chamber of Commerce. The terminology is employed in international trade contracts.

The participants were asked to take a test covering the Incoterms in the six modules that they had just reviewed. The goal of the test was to assess the knowledge-transfer effectiveness for each module, that is, how much the participants learned about each module. The test contained three multiple-choice questions per module; each question had four choices, of which only one was correct.

Each module was reviewed by the participants during a set time interval, which was the same for all participants. Each module was approximately 265 words in length and was reviewed by the participants for 2.35 minutes. The reason for the use of these numbers (i.e., 265 words and 2.35 minutes) is that they have been proposed in past research to approach the optimal communication unit size toward which individuals gravitate in technology-mediated business communication contexts (Kock & Davison, 2003).

Both parametric and nonparametric comparisons of means tests were used to assess the statistical significance of the differences in the participants' test scores between conditions. These two types of tests were used together for the sake of completeness, as recommended by Siegel and Castellan (1998). Additionally, interaction and control tests were conducted with demographic variables to assess whether those variables either: (a) interacted with the condition variable, thus affecting test scores, or (b) influenced the effect of the condition variable on test scores when included in a modified comparison of means test as covariates. Three demographic variables were used: gender, age, and scholastic status (e.g., freshman, sophomore, junior, etc.).

DATA ANALYSIS RESULTS

Figure 2 shows a summary of the results obtained through the experiment. The top part of the figure shows the percentage differences between the mean scores

Figure 2: Summary of results.

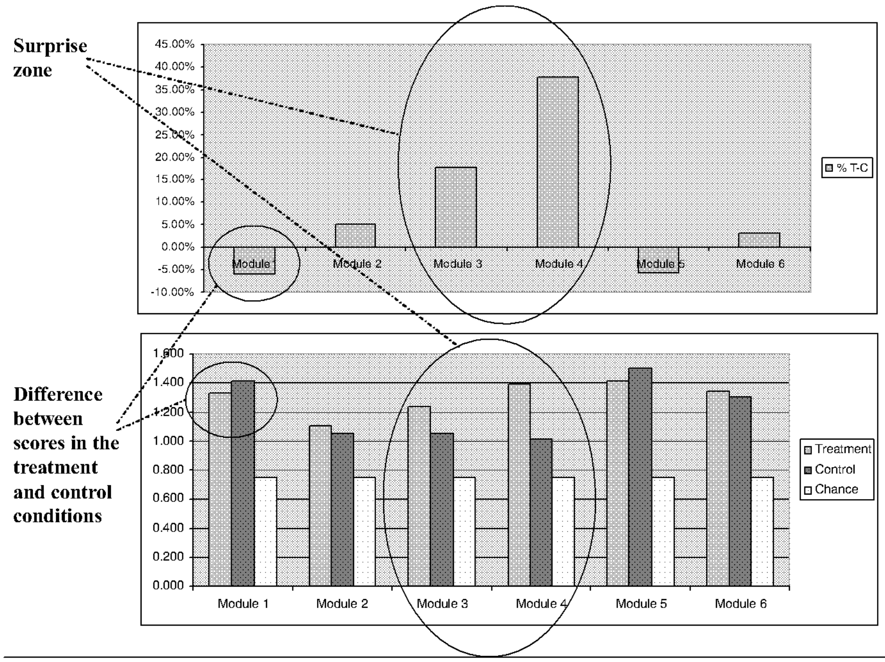


Table 1: Comparison of means tests.

Module	t	p (t)	z	p (z)
1	.62	.27	.63	.26
2	.40	.35	.60	.27
3	1.63	.05	1.60	.05
4	3.03	.001	2.92	.002
5	.73	.23	.90	.18
6	.31	.38	.02	.49

Notes: t = statistic from independent samples t test; z = statistic from Mann-Whitney U test; p = chance probability associated with statistic.

obtained by participants in the treatment and control conditions. That is, the magnitude of each of the bars at the top of the figure has been calculated through the following formula: $(M_t(m) - M_c(m))/M_c(m)$, where $M_t(m)$ is the mean test score in the treatment condition for learning module m, and $M_c(m)$ is the mean test score in the control condition for learning module m. The bottom part of the figure shows the mean scores obtained by participants in both conditions as well as the scores that the participants would have obtained by chance. The chance scores would likely have been the ones obtained by the participants if their learning had been significantly impaired for any of the modules; this could have happened because of distraction, for example.

Table 1 summarizes the results of several comparisons of means tests using both parametric and nonparametric techniques. The tests compare the means obtained for the treatment and control conditions associated with each of the modules. For each module, a parametric, independent samples t test and a nonparametric Mann-Whitney U test were conducted (Hair, Anderson, & Tatham, 1987; Rosenthal & Rosnow, 1991). Each test yielded a statistic—t or z statistic, respectively—for which chance probabilities (i.e., p values) are shown. Even though the data generally satisfied the criteria for the use of parametric tests (e.g., acceptable sample size and multivariate normality), both parametric and nonparametric tests were conducted for completeness and to add to the robustness to the data analysis (Siegel & Castellan, 1998; Sommer & Sommer, 1991; Stinchcombe, 1968). The rows for which chance probabilities were statistically significant are shaded.

As predicted, the participants in the treatment condition did significantly better in the modules within the surprise zone, namely, modules 3 and 4, than the participants in the control condition. The difference between the means for module 3 was approximately 18%. This difference was found to be significant in the two comparisons of means tests, namely, the independent samples t test ($p = .05$) and the Mann-Whitney U test ($p = .05$). The difference between the means for module 4 was found to be approximately 38% and significant in both the independent samples t test ($p = .001$) and the Mann-Whitney U test ($p = .002$).

Also consistent with theoretical predictions, knowledge-transfer effectiveness does not seem to have been significantly affected for the modules outside the surprise zone. The differences between the treatment and the control condition means for modules 1, 2, 5, and 6 were found to be statistically insignificant. In percentage terms, those differences were found to be approximately 5% or less, with chance probabilities of 18% or higher.

The broad quantitative analysis technique of generalized linear modeling and the more specialized technique of analysis of covariance (Hair et al., 1987; Rosenthal & Rosnow, 1991) were used in the interaction and control tests, in which the demographic variables gender, age, and scholastic status were included as possible moderating variables and covariates. The results of these interaction and control tests were all statistically insignificant. This means that the demographic variables did not significantly interact with the condition variable or influence the effect of the condition variable on test scores when included in a modified comparison of means test as covariates. Or, in other words, the effects indicated by the t test and Mann-Whitney U test seem to hold regardless of gender, age, and scholastic status.

DISCUSSION

The results of this study provide support for all of the three hypotheses and thus generally support the theoretical evolutionary psychological model of surprise-enhanced cognition presented earlier. The hypotheses can be restated in mathematical terms as follows, where, as mentioned before, $M_t(m)$ is the mean test score in the treatment condition for learning module m, and $M_c(m)$ is the mean test score in the control condition for learning module m.

H1: $M_t(3) - M_c(3) > 0$.

H2: $M_t(4) - M_c(4) > 0$.

H3: $\forall m \in X : M_t(m) - M_c(m) = 0; \text{where } X = \{1, 2, 5, 6\}$.

The knowledge transfer effectiveness for modules 3 and 4 were found to be significantly higher in the treatment (surprise) condition than in the control (no surprise) condition, supporting hypotheses H1 and H2. Consistent with hypothesis H3, the knowledge transfer effectiveness for modules 1, 2, 5, and 6 did not present significant differences in the treatment (surprise) condition and the control (no surprise) condition.

Arguably, the study reported here is the first to evaluate the use of surprise in human–computer interfaces with the goal of enhancing knowledge-transfer effectiveness in Web-based learning tasks. This is an important area of future research because of the extensive use of Web-based learning in many professional areas.

The results of this study suggest that surprise, in the form of a computer-simulated venomous snake attack, can be incorporated into the design of interfaces and significantly enhance knowledge-transfer effectiveness within surprise zones. Those zones are temporally adjacent to the surprise event and occurring a few minutes before and after it. Moreover, the results of this study suggest that the enhancement achieved in a surprise zone is not accompanied by a negative effect outside that surprise zone.

This study cannot alone be used as a basis for the unmistakable conclusion that surprise events do turn short-term memories into long-term memories. Nevertheless, consistent with previous studies addressing the flashbulb memorization phenomenon (Brown & Kulik, 1977; Edery-Halpern & Nachson, 2004), the results of this study do suggest an effect that is fairly consistent with short-term memories being turned into long-term memories by a cognitive response to surprise. The limitation of this study in this respect is that the knowledge-transfer test questions were answered very soon after the surprise event. A more comprehensive test, which is suggested for future research, should include an evaluation of the strength of memories well after the experiment—for example, days or months after it.

Surprise elements cannot be incorporated in computer–human interfaces indiscriminately, but undoubtedly there are many areas in which similar applications can be found. One interesting area is that of training on the use of interfaces in emergencies. Because emergencies are usually exceptions, those elements of interfaces that are used in emergencies are not used often. This may lead interface operator to forget how to effectively use those elements without constant training. An alternative is to use surprise events to train users on those emergency interface elements because surprise appears to create long-term memories that can last many years.

For example, human–computer interfaces can be designed to train airline pilots on aspects of the operation of an airplane. Those pilots may be induced to better memorize certain pieces of knowledge that are critical to the operation of the airplane in an emergency situation through the use of Web-based modules that incorporate surprise zones. The results of this study suggest that the pilots' learning effectiveness in connection with other modules outside the surprise zones would not be negatively affected, which makes this type of application attractive from a computer-mediated training perspective.

This study also provides partial support for a related but broader notion, associated with the flashbulb memorization phenomenon (Brown & Kulik, 1977; Edery-Halpern & Nachson, 2004), which may have wide-ranging applications in both online and face-to-face classroom settings. Although this would have to be tested through further research, it is reasonable to assume that surprise of any kind used in the classroom can lead to increased knowledge-transfer effectiveness. If a professor does something unexpected in the classroom, for example, or an unexpected element is added to a Web site containing class material, this could have a positive effect on knowledge-transfer effectiveness. However, much more research is needed to ascertain whether this is likely to be the case for surprise events in general and whether the degree of surprise elicited by different events is significantly related to knowledge-transfer effectiveness.

It is interesting to note that, from a pedagogical perspective, the approach to learning improvement discussed here differs significantly from those based on most of the existing influential theories of learning and cognition such as Soar (Laird, Newell, & Rosenbloom, 1987), minimalist theory (Carroll, 1998), and andragogy theory (Knowles, 1984). In fact, the approach to learning improvement discussed here could potentially lead to a new theory of pedagogy because it points at learning processes that are different from and sometimes contradictory with existing theories.

The theoretical model called Soar (Laird et al., 1987), for example, argues that learning occurs at a constant rate, which is inconsistent with the discontinuity in cognition caused by surprise. Minimalist theory (Carroll, 1998) emphasizes practice-based learning in the context of self-contained learning modules, whereas the surprise-enhanced cognition phenomenon discussed here seems to apply to learning that is not practice based. The Incoterms learned in the study discussed here are used by international business brokers, a professional category to which the vast majority of the participants in the study did not belong. Andragogy theory (Knowles, 1984) places a great deal of importance on the participation of the learners in the design of the learning process; the surprise-enhanced cognition phenomenon discussed here seems to apply to learning where this is not the case. No input from the participants in the study discussed here was used in the design of the learning task.

At least two influential theories of learning and cognition, however, incorporate ideas that are somewhat related to the surprise-enhanced cognition phenomenon discussed here. These are symbol systems theory (Salomon, 1979) and the genetic epistemology model (Piaget, 1970). Symbol systems theory (Salomon, 1979) focuses on the medium used for instruction, which in online learning is, to a large extent, defined by the computer interface used for instruction. The surprise-enhanced cognition phenomenon discussed here suggests that the incorporation of surprising elements into the computer interface used for online learning can improve that learning. The genetic epistemology model (Piaget, 1970) has as its basis an evolutionary model in which different development stages in children can be traced back to different evolutionary stages in humans. That is, like the surprise-enhanced cognition phenomenon discussed here, Piaget's (1970) theoretical model also has a human evolutionary basis.

CONCLUSION

The theoretical analysis, discussion, and study reported here suggest that surprise events have the potential to lead to enhanced cognition, apparently turning short-term memories into long-term memories. The study reported here was arguably the first of its kind and points at the existence of an unusual phenomenon that may have limited but interesting applications in learning tasks. The context of the study was an online learning task and involved 186 university student participants. A simulated threat was incorporated into a human–computer interface with the goal of increasing the interface's knowledge-transfer effectiveness.

In this study, the participants were asked to review six Web-based learning modules and subsequently take a test on what they had learned. Data from the learning modules in two experimental conditions were contrasted. In the treatment condition, a Web-based screen with a snake in attack position was used to surprise the participants. In the control condition, the snake screen was absent. As predicted based on an evolutionary theoretical model, the participants in the treatment condition did significantly better in the test for the modules immediately before and after the snake screen than the participants in the control condition. In the treatment condition, the performance enhancements in the test were 18% and 38%, for the modules before and after the snake screen, respectively.

As with many investigations on novel aspects of human–computer interface design, this study suggests a number of interesting questions that can be answered through additional research. One such question is whether the enhancement in knowledge-transfer effectiveness caused by surprise is maintained if the same surprise stimulus is used more than once in a given learning task. One would expect some deterioration of the effect due to desensitization to the surprise stimulus (Lazarus & Abramovitz, 2004; Powell, 2004). That is, one would expect that the same surprise event will lead to decreasing enhancements in knowledge transfer each time it is used because the individuals subjected to the surprise event will become increasingly desensitized to it.

A related question is whether enhancement in knowledge-transfer effectiveness can be maintained through the use of different surprise stimuli. This seems intuitive but needs to be tested using a variety of related and unrelated stimuli, a task that is likely to require the design and execution of several related research projects.

Yet another question that arises is whether the knowledge-transfer effectiveness enhancement effect can be made stronger through the use of more realistic surprise events and to what extent. One would expect that this is possible based on the theoretical discussion presented earlier as well as on media naturalness theory (Kock, 2005; Kock, Verville, & Garza, 2007; Simon, 2006).

Perhaps, one of the main contributions of this study is the demonstration that evolutionary psychological theorizing can be used as a basis on which interesting online learning and human–computer interaction hypotheses can be generated and tested. Evolutionary psychological predictions of phenomena can be rather counterintuitive, which is one of the characteristics that make those predictions hold a great deal of promise in future research.

REFERENCES

Anderson, J. R. (1983). *Architecture of cognition*. Cambridge, MA: Harvard University Press.

Baddeley, A. D. (1986). *Working memory*. Oxford, UK: Oxford University Press.

Barkow, J. H., Cosmides, L., & Tooby, J. (Eds.). (1992). *The adapted mind: Evolutionary psychology and the generation of culture*. New York: Oxford University Press.

Boaz, N. T., & Almquist, A. J. (2001). *Biological anthropology: A synthetic approach to human evolution*. Upper Saddle River, NJ: Prentice Hall.

Brown, R., & Kulik, J. (1977). Flashbulb memories. *Cognition, 5*(1), 73–99.

Buss, D. M. (1999). *Evolutionary psychology: The new science of the mind*. Needham Heights, MA: Allyn & Bacon.

Carroll, J. M. (1998). *Minimalism beyond the Nurnberg Funnel*. Cambridge, MA: MIT Press.

Darwin, C. R. (1859). *On the origin of species by means of natural selection, or the preservation of favoured races in the struggle for life*. London: John Murray.

Edery-Halpern, G., & Nachson, I. (2004). Distinctiveness in flashbulb memory: Comparative analysis of five terrorist attacks. *Memory, 12*(2), 147–157.

Frank, S. A. (1995). George Price's contributions to evolutionary genetics. *Journal of Theoretical Biology, 175*(3), 373–388.

Greenberg, D. (2005). Flashbulb memories. *Skeptic, 11*(3), 74–80.

Hair, J. F., Anderson, R. E., & Tatham, R. L. (1987). *Multivariate data analysis.* New York: Macmillan.

Hartl, D. L., & Clark, A. G. (2007). *Principles of population genetics.* Sunderland, MA: Sinauer Associates.

Henrich, J. (2004). Cultural group selection, coevolutionary processes and large-scale cooperation. *Journal of Economic Behavior & Organization, 53*(1), 3–35.

Hung, D. (2004). Taiwan's venomous snakebite: Epidemiological, evolution and geographic differences. *Transactions of the Royal Society of Tropical Medicine and Hygiene, 98*(2), 96–101.

Isbell, L. A. (2006). Snakes as agents of evolutionary change in primate brains. *Journal of Human Evolution, 51*(1), 1–35.

Knowles, M. (1984). *Andragogy in action.* San Francisco: Jossey-Bass.

Kock, N. (2005). Media richness or media naturalness? The evolution of our biological communication apparatus and its influence on our behavior toward e-communication tools. *IEEE Transactions on Professional Communication, 48*(2), 117–130.

Kock, N., & Davison, R. (2003). Can lean media support knowledge sharing? Investigating a hidden advantage of process improvement. *IEEE Transactions on Engineering Management, 50*(2), 151–163.

Kock, N., Verville, J., & Garza, V. (2007). Media naturalness and online learning: Findings supporting both the significant- and no-significant-difference perspectives. *Decision Sciences Journal of Innovative Education, 5*(2), 333–356.

Kotulak, R. (1997). *Inside the brain: Revolutionary discoveries of how the mind works.* Kansas City, KS: Andrews McMeel Publishing.

Laird, J. E., Newell, A., & Rosenbloom, P. S. (1987). Soar: An architecture for general intelligence. *Artificial Intelligence, 33*(1), 1–64.

Lazarus, A. A., & Abramovitz, A. (2004). A multimodal behavioral approach to performance anxiety. *Journal of Clinical Psychology, 60*(8), 831–841.

McElreath, R., & Boyd, R. (2007). *Mathematical models of social evolution: A guide for the perplexed.* Chicago: University of Chicago Press.

Meyer, W.-U., Reisenzein, R., & Schützwohl, A. (1997). Toward a process analysis of emotions: The case of surprise. *Motivation and Emotion, 21*(3), 251–275.

Mueller, R. O. (1996). *Basic principles of structural equation modeling.* New York: Springer.

Otani, H., Kusumi, T., Kato, K., Matsuda, K., Kern, R., Widner R., Jr., & Ohta, N. (2005). Remembering a nuclear accident in Japan: Did it trigger flashbulb memories? *Memory, 13*(1), 6–20.

Piaget, J. (1970). *The science of education and the psychology of the child.* New York: Grossman.

Powell, D. H. (2004). Behavioral treatment of debilitating test anxiety among medical students. *Journal of Clinical Psychology, 60*(8), 853–866.

Price, G. R. (1970). Selection and covariance. *Nature, 227*(1), 520–521.

Rice, S. H. (2004). *Evolutionary theory: Mathematical and conceptual foundations.* Sunderland, MA: Sinauer Associates.

Rosenthal, R., & Rosnow, R. L. (1991). *Essentials of behavioral research: Methods and data analysis.* Boston: McGraw Hill.

Salomon, G. (1979). *Interaction of media, cognition, and learning.* San Francisco: Jossey-Bass.

Schacter, D. L. (2001). *The seven sins of memory: How the mind forgets and remembers.* New York: Houghton Mifflin.

Schützwohl, A. (1998). Surprise and schema strength. *Journal of Experimental Psychology: Learning, Memory & Cognition, 24*(5), 1182–1199.

Schützwohl, A., & Borgstedt, K. (2005). The processing of affectively valenced stimuli: The role of surprise. *Cognition and Emotion, 19*(4), 583–600.

Schützwohl, A., & Reisenzein, R. (1999). Children's and adults' reactions to a schema-discrepant event: A developmental analysis of surprise. *International Journal of Behavioral Development, 23*(1), 37–63.

Shine, R., & Koenig, J. (2001). Snakes in the garden: An analysis of reptiles "rescued" by community-based wildlife careers. *Biological Conservation, 102*(3), 271–283.

Siegel, S., & Castellan, N. J. (1998). *Nonparametric statistics for the behavioral sciences.* Boston: McGraw-Hill.

Simon, A. F. (2006). Computer-mediated communication: Task performance and satisfaction. *Journal of Social Psychology, 146*(3), 349–379.

Smith, J. M. (1998). *Evolutionary genetics.* New York: Oxford University Press.

Sommer, B., & Sommer, R. (1991). *A practical guide to behavioral research.* New York: Oxford University Press.

Stinchcombe, A. L. (1968). *Constructing social theories.* New York: Harcourt Brace.

Wilson, E. O. (2000). *Sociobiology: The new synthesis.* Cambridge, MA: Harvard University Press.

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