Using Surprise in Human-Computer Interfaces to Enhance Knowledge Communication Effectiveness

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Abstract

A study with 186 subjects is described in which a simulated threat was incorporated into a human-computer interface with the goal of increasing the interface's knowledge communication effectiveness. The subjects were asked to review Web-based learning modules about International Commercial Terms (Incoterms), and subsequently take a test on what they had learned. Data from 6 learning modules in 2 experimental conditions were contrasted. In the treatment condition a Web-based screen with a snake in attack position was used to surprise the subjects; the snake screen was absent in the control condition. As predicted, the subjects in the treatment condition did significantly better in the test for the modules immediately before and after the snake screen than the subjects in the control condition; approximately 18 and 38 percent better, respectively.

1. Introduction

The phenomenon coined flashbulb memorization has puzzled researchers for years [1], [2]. The 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.

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, 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.

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 communication 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 photo 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 were not negatively affected. Otherwise, the negative effect could offset the positive effect, and lead to an overall decrease in knowledge communication effectiveness.

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

2. Research background and hypotheses

As pointed out by Schutzwohl [3], 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 [4]).

Instinctive responses can be explained in many ways, and are often believed to have a strong evolutionary basis [3]. One of the main fields of inquiry that explain human behavioral phenomena from an evolutionary perspective is that of evolutionary psychology [5], [6]. 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.

Arguably it would have been evolutionarily adaptive for our hominid ancestors to have enhanced memories of contextual information (e.g., vegetation, 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 ecological niches characterized by specific elements such as vegetation, rock formations, and terrain type. 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.

The enhanced memorization phenomenon above can be exploited in the design of human-computer interaction interfaces for knowledge communication. 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, and with a snake-like hissing background noise added for realism.

For the sake of simplification, let us assume a human-computer interface with 6 knowledge-bearing modules, as 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.

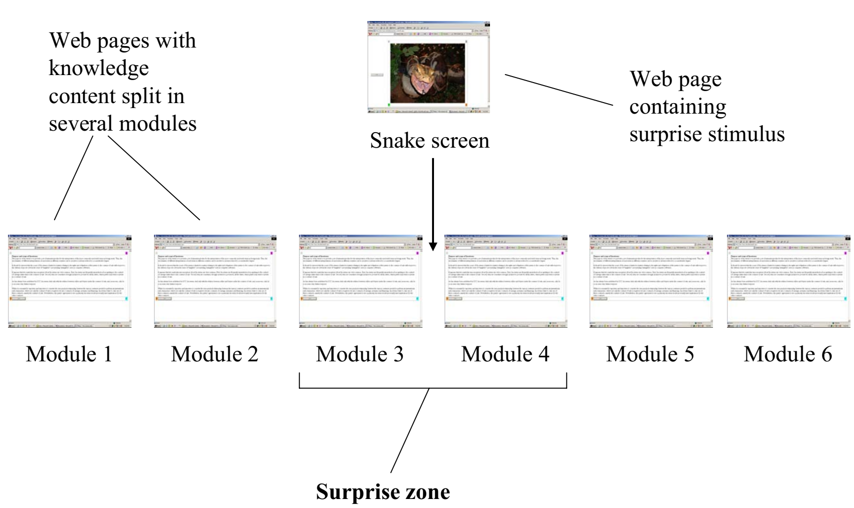
Let us also assume that two groups of individuals can be compared. One group, referred to here as the treatment group, would be surprise with the Web page showing a snake. The other group, called here the control group, would go through the 6 modules without being surprised by any snake screen. The previous discussion on enhanced memorization of content within a surprise zone leads us to hypotheses H1 and H2 below.

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

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

It is reasonable to conclude that the positive effects

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



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 [7], which could impair the memorization of contextual information after the surprise zone. While 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 [8]. That time lag is generally in the order of days.

In the human-computer interface analogue considered here, the conclusion above would lead us to hypothesis H3, enunciated below.

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

In other words, hypothesis H3 incorporates the prediction that the enhancement in knowledge communication effectiveness within the surprise zone (i.e., modules 3 and 4) will have no negative effect on knowledge communication 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.

3. Research method

A Web-based knowledge communication experiment was conducted with 186 student subjects at a university. Two experimental conditions were used. A Web-based screen with a snake picture in attack position, and 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.

The subjects were randomly assigned to the two conditions. Their ages ranged from 18 to 48, with a mean age of 24. Approximately 53% of the subjects 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 subjects 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 subjects were asked to take a test covering the Incoterms in the 6 modules that they had just reviewed. The goal of the test was to assess the knowledge communication effectiveness for each module; that is, how much the subjects learned about each module. The test contained three multiple-choice questions per module; each question had four choices, of which only one was correct. Parametric and nonparametric comparisons of means tests were used to assess the statistical significance of the differences in the subjects’ test scores between conditions.

Each module was reviewed by the subjects during a set time interval, which was the same for all subjects. Each module was approximately 265 words in length, and was reviewed by the subjects 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 business communication contexts [9].

4. Results

Figure 2 shows a summary of the results obtained through the experiment. The top part of the figure shows the differences between mean scores obtained by subjects in the treatment and control conditions. The bottom part of the figure shows the mean scores obtained by subjects in both conditions, as well as the scores that the subjects would have obtained by chance. The chance scores would likely have been the ones obtained by the subjects if they had learned nothing about Incoterms.

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. Each test yielded a statistic – t or z statistic, respectively – for which chance probabilities (i.e., P values) are shown. The rows for which chance probabilities were statistically significant are shaded.

As predicted, the subjects in the treatment condition did significantly better in the modules within the surprise zone, namely modules 3 and 4, than the subjects in the control condition. The difference between means for Module 3 was approximately 18 percent. 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 means for Module 4 was found to be approximately 38 percent, 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 communication effectiveness does not seem to have been significantly affected for the modules outside the surprise zone. The differences between treatment and 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 percent or less, with chance probabilities of 18 percent or higher.

Figure 2. Summary of results

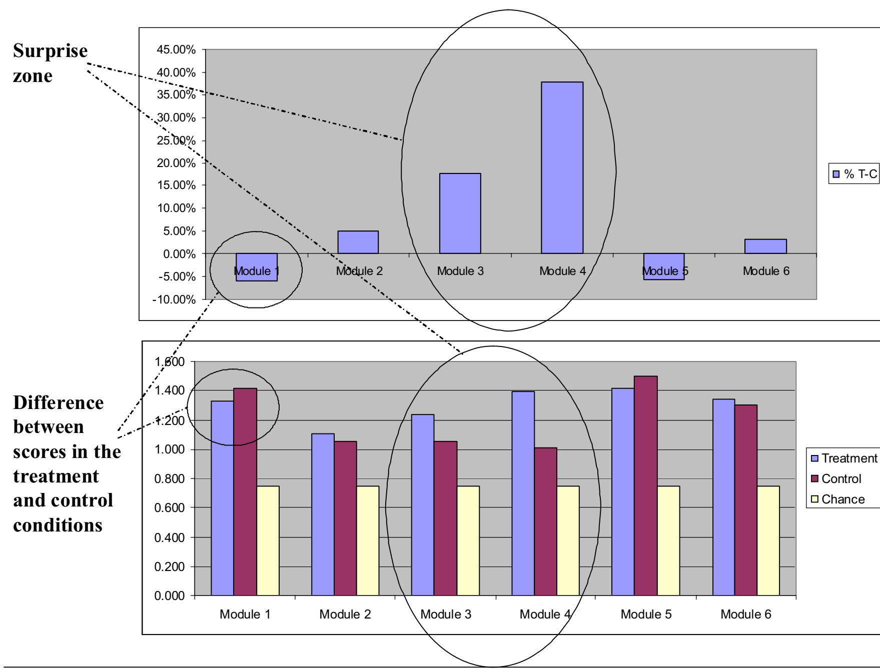


Table 1. Comparison of means tests

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

5. Discussion and conclusion

The results of this study provide support for all of the three hypotheses, and thus generally support the theoretical evolutionary psychological model presented earlier. The knowledge communication effectiveness for modules 3 and 4 were found to be significantly higher in the treatment (surprise) than the control (no surprise) condition, supporting hypotheses H1 and H2. Consistently with hypothesis H3, the knowledge communication effectiveness for modules 1, 2, 5 and 6 did not present significant differences in the treatment (surprise) 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 communication 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 communication 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.

Surprise elements cannot be incorporated in computer-human interfaces indiscriminately, but undoubtedly there are many areas in which similar applications can be found. 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 an computer-mediated training perspective.

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 communication 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.

A related question is whether enhancement in knowledge communication 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 communication 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 based on media naturalness theory [10].

Perhaps one of the main contributions of this study is the demonstration that evolutionary psychology can be used as a basis on which interesting 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 human-computer interaction research.

6. References

[1] Brown, R. & Kulik, J. (1977). Flashbulb Memories. *Cognition*, 5(1), 73-99.

[2] Edery-Halpern, G. & Nachson, I. (2004). Distinctiveness in Flashbulb Memory: Comparative Analysis of Five Terrorist Attacks. *Memory*, 12(2), 147-157.

[3] Schutzwohl, A. (1998). Surprise and Schema Strength. *Journal of Experimental Psychology: Learning, Memory & Cognition*, 24(5), 1182-1199.

[4] Meyer, W.-U., Reisenzein, R. & Schutzwohl, A. (1997). Toward a Process Analysis of Emotions: The Case of Surprise. *Motivation and Emotion*, 21(3), 251-275.

[5] Barkow, J.H., Cosmides, L. & Tooby, J. (Eds) (1992). *The Adapted Mind: Evolutionary Psychology and the Generation of Culture*. New York, NY: Oxford University Press.

[6] Buss, D.M. (1999). *Evolutionary Psychology: The New Science of the Mind*. Needham Heights, MA: Allyn & Bacon.

[7] Greenberg, D. (2005). Flashbulb Memories. *Skeptic*, 11(3), 74-80.

[8] Otani, H., Kusumi, T., Kato, K., Matsuda, K., Kern, R., Widner Jr, R. & Ohta, N. (2005), Remembering a Nuclear Accident in Japan: Did it Trigger Flashbulb Memories? *Memory*, 13(1), 6-20.

[9] Kock, N. and 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.

[10] 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.