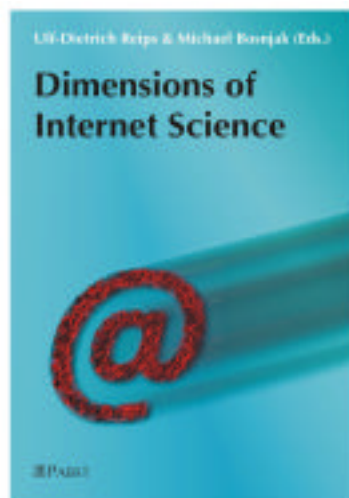


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CGI Versus JavaScript: A Web Experiment on the Reversed Hindsight Bias

Stefan Schwarz¹ and Ulf-Dietrich Reips²

Introduction

In recent years doing experimental research in the World Wide Web has become more and more popular. Many researchers use JavaScript - a compact, cross platform, object-based scripting language that can be applied to create interactive Web pages - to run online studies. Although many Web browsers do not or only partially support JavaScript, it is a widely used technology in Online Research (Musch & Reips, 2000). Reasons for the use of JavaScript are the ease with which this scripting language can be learned and its effectiveness in creating interactive elements on Web pages (e.g., Janetzko, 1999, p. 109). However, the naivity regarding its compatibility often results in a number of problems, e.g., *drop out* in online studies. JavaScript may create anger and frustration in participants, if they cannot access parts of an online study or if error messages appear on the screen. In some types of online studies these problems can lead to methodological artifacts. Investigation of the existence and impact of such problems in Internet Science was one of the two main goals in conducting this research.

We conducted a Web experiment to address the issue of drop out problems when applying JavaScript. A JavaScript condition was compared to a condition without JavaScript. In this control condition, all functions were realized with CGI (common gateway interface) programs. CGI programs are server-side applications or scripts for processing user data and returning dynamic replies. Importantly, their performance does not depend upon the Web browser being used by a participant.

To answer the question whether a JavaScript version of a Web study would result in more or less drop out than a CGI version, we conducted a Web experiment on an established phenomenon in cognitive psychology:

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The hindsight bias. This bias, also referred to as the knew-it-all-along-effect, occurs when outcomes seem more inevitable in hindsight than they did in foresight. Since Fischhoff (1975) started doing research on the hindsight bias, many studies have been conducted on this phenomenon and it appears to be very robust (Hawkins & Hastie, 1990). Considering its robustness this bias seemed to be the ideal theoretical platform for our technical question. As a second objective we wanted to know more about the conditions under which the hindsight bias is eliminated or even reversed. Some researchers found a reversal of the hindsight bias if the outcome information was very surprising (Mazursky & Ofir, 1990; Ofir & Mazursky, 1997). Under this condition participants showed an “I could not have expected this to happen” reaction instead of an “I knew it all along” reaction. Recently, Stahlberg, Sczesny, and Schwarz (1999) reported a reversed hindsight bias when participants learned about a self-threatening outcome and hypothesized that motivational factors like self-protection might play a role in moderating the hindsight bias. Regarding these different explanations for the same phenomenon we wondered whether the reversal of the hindsight bias is due to the surprise or the self-threat of an outcome. Consequently we designed an experiment with stimulus material that varied in terms of the surprise of an outcome information (surprising vs. not surprising) as well as in terms of its self-threat (self-threatening vs. not self-threatening) and let the experiment run on the WWW in two technical versions (JavaScript vs. CGI). For a better understanding of the following description of the Web experiment we first give a theoretical introduction into the two different fields of research: The use of JavaScript in Web experiments and the reversal of the hindsight bias. After that we will report the Web experiment, which combined both fields of research in one experimental design.

Theoretical Background

1. Technical Question: Consequences of Using JavaScript in Web Experiments

Web Experiments

Web experiments have been conducted since 1995 (Musch & Reips, 2000). They provide researchers with a number of advantages (Reips, 2000), such as

1. easy access to a demographically and culturally diverse participant population, including participants from unique and previously inaccessible target populations;
2. bringing the experiment to the participant instead of the opposite;
3. high statistical power by enabling access to large samples;
4. the direct assessment of motivational confounding³; and
5. cost savings of lab space, person-hours, equipment, and administration.

While there are also disadvantages of using the Web experimental method, such as reduced experimental control, dependence on computers and network technology, limited personal interaction between experimenter and participant, and higher drop out rates, a careful analysis shows that the advantages of using this experimental method by far outweigh the disadvantages (Reips, 2000). Despite the reduced experimental control, it has been shown that the validity of Web experiments is high (Krantz & Dalal, 2000).

One method often used in Web experiments, as well as on Web pages in general, is the programming language called "JavaScript". The hypotheses we wanted to test with this Web experiment are whether technical problems created by such a client-side programming language (1) will result in higher drop out rates, and (2) will have a qualitative effect on the results of the experiment.

JavaScript and Online Research

In its early days JavaScript was called LiveScript, and later renamed by its inventing company Netscape to suggest a relationship to Java, the platform independent programming language developed by Sun. By now, version 1, which was only supported by Netscape Navigator 2, has evolved to version 1.3. Version 1.4 is in preparation. Every version created new incompatibilities with Web browsers (www.hotwired.com/webmonkey/browserkit/). Table 1 shows which Web browsers became incompatible at what stage of

³ Motivational confounding is related to the agreeableness of participation in experiments. Levels of a participant's motivation to engage in the experimental task or task difficulty might be confounded with levels of the independent variable. However, in traditional laboratory settings those participants who are in the less motivating or more difficult condition usually will not indicate so by leaving the situation. For reasons such as fear of losing course credit or politeness towards the experimenter they will stay and finish the experiment, thereby possibly contaminating the data. In Web experiments a differential drop out rate in experimental between-subjects conditions would indicate such a motivational confounding. This information can then be used to address issues such as task difficulty or task attractiveness, for example by introducing control conditions.

Table 1: Compatibility of Web Browsers and Versions of JavaScript

JavaScript Version	Web browsers becoming incompatible at this stage
1.0	Netscape 1.1, Explorer 1 & 2, AOL browser, Lynx, Arena, Opera < 3.5, Amiga browsers, and Atari browsers
1.1	Netscape 2, Explorer 3 partially
1.2	Netscape 3, Explorer 3
1.3	Netscape < 4.5, Explorer 4

JavaScript development. In most cases, an incompatible Web-Browser version remains incompatible with higher JavaScript versions as well.

In addition to incompatibility of one's Web browser, turning off JavaScript in the browser options leads to inaccessibility of JavaScript based online studies.

Why do we need to study the influence of JavaScript on drop out rates? Missing or turned off JavaScript compatibility can have disastrous consequences for Online Research projects. This is particularly abundant whenever JavaScript functions interact with other factors that have an influence on motivation for participation or drop out. Participation may be low, drop out rates may be high, and participants' behavior may be systematically biased. Indications for possible drop out problems from use of JavaScript can be seen in data coming from many studies conducted online. For example, a study on Internet addiction is currently conducted by a group of scientists at the department for Educational and Health Psychology, Humboldt University, Berlin (PSILab, www.internetsucht.de). Using a personality measure with five sub-scales, the team tries to determine risk factors for showing "Internet addiction" behavior. Based on a pilot study conducted with more than 14,000 WWW-recruited participants, the Humboldt group estimates the prevalence of "Internet addiction" at about 3%. Within this online survey about Internet addiction, JavaScripts of version 1.0 are installed on two of 29 Web pages. These scripts are provided to help participants with otherwise quite difficult arithmetics on these Web pages. Now, if the "Internet addicted" 1.) tend to use more current versions of Web browsers and do turn on JavaScript more often (a reasonable guess, as they use the Internet more often and frequently are

“power users”) and 2.) show a higher motivation to continue with participation in the study, as its topic affects them, then these JavaScripts might lead to a selective drop out of less “Internet addicted” persons. Consequently, the incidence of “Internet addiction” might be overestimated.

Data support the notion that such effects of JavaScript shouldn't be taken lightly. While the drop out rate is below 1% of the total sample in almost all of the other 29 survey Web pages in the Internet addiction study, it is more than 4% on each of the two Web pages with JavaScript (André Hahn⁴, personal communication, 10-22-99; the two pages are the 6th and 7th page of the survey). This means that 8.9% of the complete sample (1261 of 14208 participants) drops out of the survey at this point. Even if one doesn't count the start and information pages (12879 persons requested the first page containing a question), the rate is 9.8%!

In the Internet addiction study, JavaScripts of the most compatible version (1.0) were used. An even higher drop out rate can be expected with newer versions of JavaScript. Apart from the methodological problems it should be taken into account that technical problems during a study may leave participants frustrated or otherwise emotionally stressed. Every means should be taken to keep such experiences at a minimum. One of the goals in conducting this Web experiment was providing the scientific community with some data as a basis for choice between different ways of conducting Online Research.

2. Theoretical Question: What is the (Reversed) Hindsight Bias?

The Hindsight Bias

The hindsight bias (or knew-it-all-along effect) is the tendency of people to falsely believe that they would have predicted the outcome of an event, once the outcome is known. In hindsight people report that the marriage of a chummy couple had to end in divorce, that a certain football match had to result in the victory of the winning team, or that a given opinion poll had to produce this and no other result. It was Fischhoff and his collaborators (Fischhoff, 1975; Fischhoff & Beyth, 1975) who first investigated the phenomenon that people consider events predictable or even inevitable once they have occurred. Since then, a lot of studies on the hindsight bias have been reported (for an overview see Hawkins & Hastie, 1990). In sum,

⁴ We would like to thank André Hahn (andre.hahn@pixelpark.com) for providing us with data from his study.

they showed that the hindsight bias is a very robust phenomenon that cannot easily be suppressed. Even if the participants were carefully informed about the phenomenon or asked to try not to fall prey to this bias they were unable to ignore the outcome information (Fischhoff, 1975, 1977). In a meta-analysis of 128 hindsight bias studies, Christensen-Szalanski and Willham (1991) found just six studies without a significant effect. Although there is a rich literature on hindsight distortions, the underlying mechanisms are not yet fully understood. Three main approaches to explain the hindsight bias are discussed (for a detailed overview see Stahlberg & Maass, 1998):

- The motivational approach (e.g., the assumption that people are motivated to make others believe that their predictions were close to the actual outcome in an attempt to maintain a high level of public self-esteem);
- The memory impairment approach (e.g., the assumption that the outcome information impairs the memory for the previous judgement by either altering or erasing the existing memory traces or by rendering them less accessible);
- The biased reconstruction approach (e.g., the assumption that the major source of the hindsight bias is a deliberate judgment process that operates only at the response generation stage).

The Reversed Hindsight Bias

Several authors report a reversal of the hindsight bias effect for outcomes that are perceived to be highly unlikely (e.g., Mazursky & Ofir, 1990; Ofir & Mazursky, 1997). If the participants learn about such a surprising outcome they show an "I could not have expected this to happen" reaction instead of an "I knew it all along" reaction. For example, Mazursky and Ofir (1990) found a reversed hindsight bias when participants had to recall their prior expectations of the quality of suction hooks after they had learned the surprising outcome that the suction hooks could carry a 15-lb weight (in a pre-test the participants had judged the quality of the suction hooks as low). The data of a study by Stahlberg, Sczesny and Schwarz (1999) support the hypothesis that not only surprising outcomes but also outcomes that appear to be self-threatening can reduce or even reverse hindsight bias effects. Their participants read a short account of an interaction between a man and a woman who met in a bar. Some participants learned that the man raped the woman on their way home from the bar, others received no

outcome information. As a dependent variable participants in the no outcome information group had to judge the likelihood of the female protagonist being raped. Participants in the rape outcome information group had to estimate the likelihood of a rape as if they did not know the outcome of the story. While male participants showed no hindsight bias at all, female participants showed a significant reversed hindsight bias. The authors suggest motivational reasons for the reversal of the hindsight bias because women are likely to personally feel more self-threatened by a rape scenario than men are. For women the rape outcome information is expected to have self-threatening implications because they have a higher likelihood of being a potential victim of such a crime than men have.

Method

The Web experiment we conducted combined the two different fields of research in one experimental design. To answer the question whether JavaScript causes a higher drop out than a traditional CGI version of a Web experiment, we created two identical versions of Web pages for an experiment on the reversed hindsight bias. We then put external JavaScripts of version 1.1⁵ in one of the two sets – the lowest version of JavaScript that allowed for programming of necessary functions. For example, functions managed by these scripts were:

- Randomized distribution of participants to the experimental conditions;
- Passing on a user specific identification number from Web page to Web page.

In the other set randomization was achieved server-side via CGI. This method has been used for several years in Web experiments run in the Web Experimental Psychology Lab (Reips, 1995). As the dependent variable, we measured the drop out in both versions. drop out is defined as the percentage of “participants” (people requesting the first page of the online study) who at some point do not continue requesting further Web pages that are part of the study (*Answering drop outs or Lurking drop outs* in the terminology used by Bosnjak, this volume). By pressing the *submit buttons* that were present on every page of the Web experiment, the participants triggered the Web server to record their answers in a logfile

⁵ “External” JavaScripts are scripts that are stored outside of the html page, rather than being placed within the source code of a Web page. Our JavaScripts contained the functions “Math.round” and “Array”.

and send the next Web page. We measured the drop out rate through analysis of the logfile. To answer the theoretical question whether not only surprising outcomes but also outcomes that appear to be self-threatening can reduce or even reverse hindsight bias effects, we experimentally manipulated both factors as follows:

Participants were asked to imagine the following scenario: Due to the participant's advice his or her parents went on holiday by car instead of by plane. Depending on the experimental condition the participants either learned that their parents had a serious accident, which caused the death of their father (self-threatening outcome information), that they had a mild accident, which caused a delay of their journey (not self-threatening outcome information) or they got no outcome information (control group). Half of the participants were told that their parent's car was new and secure. The other half learned that it was very old and insecure. The outcome information that the accident had happened due to the breakdown of the brakes was supposed to be surprising in the "new/secure car" condition and not surprising in the "old/insecure car" condition. This experimental design allowed for comparison of the four possible combinations of surprising/not surprising outcome information and self-threatening/not self-threatening outcome information. We expected a reduced or reversed hindsight bias in the surprising/self-threatening outcome condition and a hindsight bias in the not surprising/not self-threatening outcome condition was anticipated. The surprising (not surprising)/not self-threatening (self-threatening) outcome condition was designed to show whether a reduction of the hindsight bias was caused by either surprising or self-threatening events. As a measure of the hindsight bias the control group participants (without outcome information) were asked: "How likely do you think it is that your parents will have an accident with this car?" The participants in the experimental groups (with outcome information) were asked: "Imagine that you do not know the outcome of this scenario. How likely would you have thought that your parents would have an accident with this car?" Subsequently the participants in the experimental groups were asked to rate how surprising and how self-threatening the outcome information appeared to them (on a scale from 1 = "not at all" to 7 = "very much"). These questions served as a manipulation check and were balanced regarding the order of appearance.

Thus, the combination of the technical and the theoretical objectives of our study resulted in a 2 (JavaScript vs. CGI) x 2 (condition of the car: old/insecure vs. new/secure) x 3 (outcome information: accident with serious consequences vs. accident with mild consequences vs. no outcome

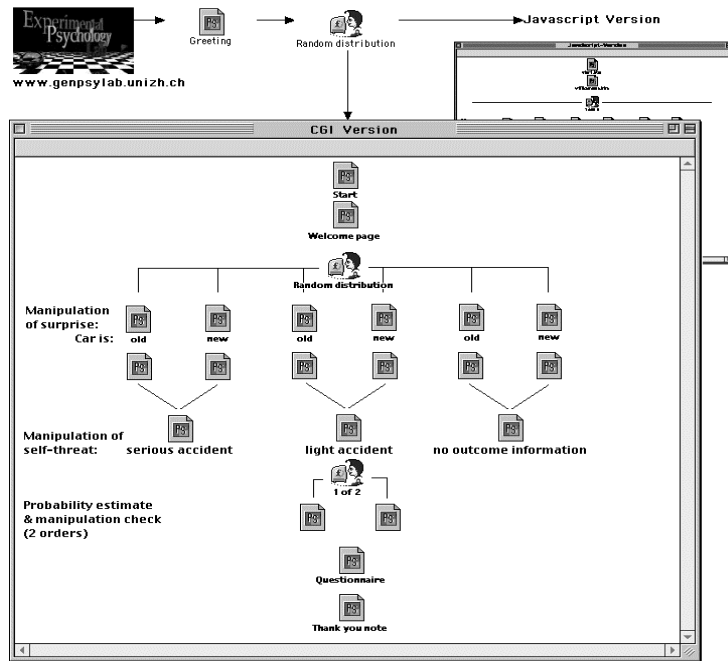


Figure 1. Design and procedure of the Web experiment. Square icons symbolize Web pages, face icons symbolize procedures for random distribution of participants to conditions.

information) between subjects design. Design and procedure of the Web experiment are shown in Figure 1.

The Web experiment was then linked to the Web Experimental Psychology Lab (Reips, 1995), which receives about 4000 visits a month, 1200 of which are to the German version of the laboratory (Reips, this volume). A demonstration version of our Web experiment is kept in the laboratory's German archive, where the reader may take a look at it. The following results consist of the data of 150 participants (77 males, 73 females). They were randomly drawn from those 286 participants who had finished the experiment. Most of them were employed (64) or students (61). Their mean age was 28.7 years.

Results

We will first present the results concerning the questions of whether JavaScript makes a difference in hindsight probability ratings and whether it causes more or less drop out in Web experiments. Then we will present the results concerning the influence of levels of surprise and levels of self-threat on the (reversed) hindsight bias.

1. Technical Question: Consequences of Using JavaScript in Web Experiments

First of all: It did not matter for the results concerning the hindsight bias question, whether participants were in the JavaScript condition or in the CGI condition. A 2 (JavaScript vs. CGI) \times 2 (surprising vs. not surprising event) \times 3 (outcome information: self-threatening vs. not self-threatening vs. none) ANOVA of the probability ratings revealed neither a significant main effect of the factor "JavaScript vs. CGI" ($F[1,138] = 0.59, p = .44$) nor any

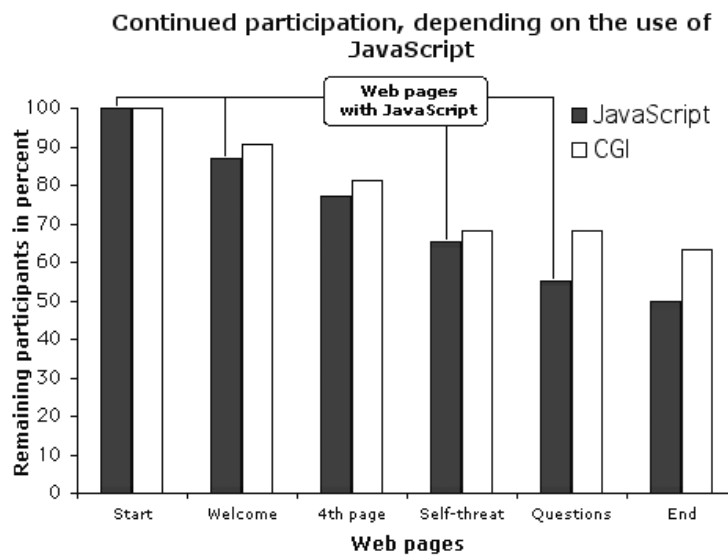


Figure 2. Comparison of CGI and JavaScript version's influence on drop out. Web pages with JavaScripts in the JavaScript condition are marked. In the JavaScript condition continued participation dropped on the last pages.

significant interaction including the factor "JavaScript vs. CGI" (all $F < .83$, all $p > .41$). The analysis of the drop out rate showed a different picture. Overall, the use of JavaScript increased the drop out rate: Only 49.8% of those accessing the start page reached the end page. In contrast, this figure was 63.2% in the CGI version. A χ^2 analysis revealed that this difference in drop out between CGI and JavaScript conditions is statistically significant, $\chi^2(1, N = 490) = 6.13, p_{\text{one-tailed}} < .01$. The first impression of incompatibilities with JavaScript resulting in higher drop out is further supported by the following fact: On the first Web page containing a complex JavaScript there was an immediate reload in at least 5% of cases, but only in 1% of cases in the CGI version. However, a deeper analysis shows only a small fraction of drop out in the JavaScript condition can be attributed directly to the technical problems with JavaScript. Instead of an instant drop in continued participation at the beginning, we observed a continually increasing drop out in the JavaScript condition compared to the CGI condition (see Figure 2).

2. Theoretical Question: (Reversed) Hindsight Bias

Manipulation Check: Both the self-threat scores and the surprise scores were subjected to a 2 (JavaScript vs. CGI) \times 2 (surprising vs. not surprising event) \times 2 (outcome information: self-threatening vs. not self-threatening) between subjects ANOVA⁶. As for the probability estimates (see technical question) there was neither a significant main effect of the factor "JavaScript vs. CGI" nor a significant interaction including this factor (all $F < 2$, all $p > .16$). Therefore Table 2 and Table 3 show the collapsed means across the two versions of the experiment for the self-threat scores and the surprise scores as a function of the factors surprise and self-threat. The analysis of the self-threat scores (see Table 2) revealed the expected main effect of self-threat ($F[1,90] = 38.5, p < .000$). Self-threat scores in the self-threatening outcome information condition ($M = 4.8$) were higher than self-threat scores in the not self-threatening outcome information condition ($M = 2.4$). Neither the main effect surprise nor the interaction between surprise and self-threat was significant (both $F_s < 1.2$, both $p > .27$). The analysis of the surprise scores (see Table 3) revealed the expected main effect of surprise ($F[1,88] = 43.8, p < .000$) as well as an (unexpected) main effect of self-threat ($F[1,88] = 5.0, p = .028$). The surprise scores in the surprising event condition ($M = 5.0$) were higher than the surprise scores in the not

⁶ Participants in the control group received no outcome information; therefore they did not get the manipulation check questions.

Table 2: Self-threat Scores as a Function of the Outcome Information

	Surprising outcome	Not surprising outcome	Overall
Self-threatening outcome	4.4	5.2	4.8
Not self-threatening outcome	2.1	2.7	2.4
Overall	3.2	4.0	

surprising event condition ($M = 2.9$). Additionally, the surprise scores in the self-threatening condition ($M = 4.4$) were higher than the surprise scores in the not self-threatening condition ($M = 3.6$). This result shows that we obviously did not succeed in our attempt to independently manipulate both factors surprise and self-threat. This fact should be taken into consideration when interpreting the results. The interaction between surprise and self-threat was not significant ($F[1,88] = 0.28, p = .87$).

(Reversed) *Hindsight Bias*: The probability scores (participants were asked to estimate the probability of an accident) were subjected to a 2 (JavaScript vs. CGI) \times 2 (surprising vs. not surprising event) \times 3 (outcome information: self-threatening vs. not self-threatening vs. none) between subjects ANOVA. As mentioned earlier it made no difference whether the participants were in the JavaScript or CGI version. Therefore Figure 3 shows the collapsed means across the two versions of the experiment for the probability estimates as a function of the factors *surprise* and *self-threat*. The ANOVA revealed a main effect of outcome information ($F[2,138] = 7.5, p =$

Table 3: Surprise Scores as a Function of the Outcome Information

	Surprising outcome	Not surprising outcome	Overall
Self-threatening outcome	5.5	3.2	4.4
Not self-threatening outcome	4.5	2.6	3.6
Overall	5.0	2.9	

.001). Probability scores in the not self-threatening outcome information condition ($M = 25.5\%$) were higher than in the self-threatening outcome information condition ($M = 12.5\%$) and the no outcome information condition ($M = 7.0\%$). The two last mentioned conditions did not differ significantly from each other. Additionally, the analysis revealed a main effect of surprise ($F[1,138] = 4.2, p = .043$). Probability scores in the not surprising event condition ($M = 19.4\%$) were higher than in the surprising event condition ($M = 10.6\%$). The interaction between outcome information and surprise was also significant ($F[2,138] = 3.7, p = .027$).

To find out whether surprising or self-threatening outcomes reverse the hindsight bias we calculated the a-priori contrasts between the probability scores of the four experimental conditions (all combinations of surprising/not surprising and self-threatening/not self-threatening) and the appropriate no outcome information control groups. The only condition which revealed a significant hindsight bias was the not surprising/not self-threatening outcome information condition (38.4% vs. 5.5%, $t [26.63] =$

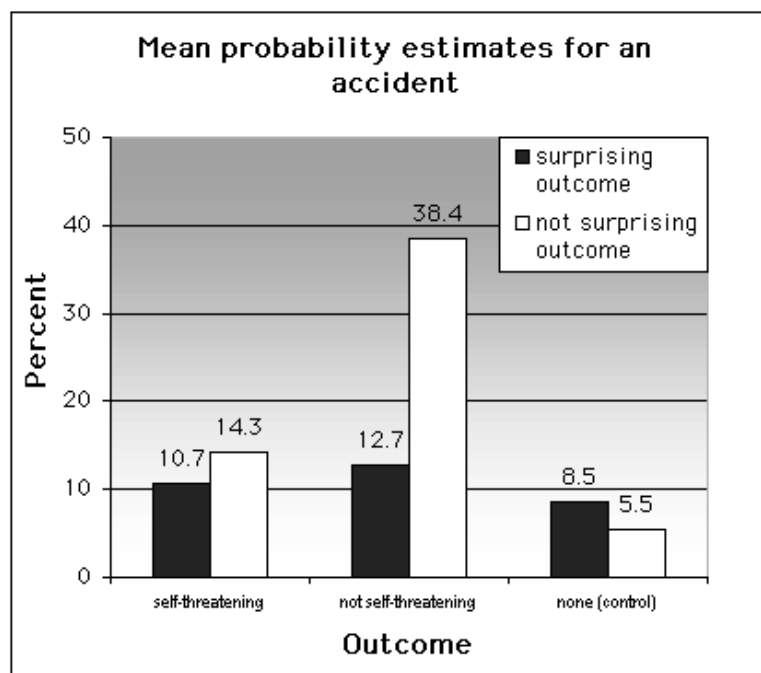


Figure 3. Hypothetical probability estimates as a function of the outcome information.

4.3, $p < .000$). The probability scores of all the other conditions, that either contained a surprising event or a self-threatening outcome information, did not differ significantly from the appropriate no outcome information control group (all $p > .113$). Both surprise and self-threat seemed to be able to eliminate the hindsight bias. But as mentioned before we have to keep in mind that we did not succeed in independently manipulating the self-threat and the surprise of the participants. Level of self-threat had an influence on the reported amount of surprise. The former mentioned main effect of self-threat in the ANOVA of the surprise scores (see manipulation check) shows that the self-threatening outcome information had an influence on the surprise in the not surprising/self-threatening outcome information condition. The results of the following covariance analyses suggest that it is the surprise, which eliminates the hindsight bias in this study. If we control the self-threat scores in the former mentioned $2 \times 2 \times 3$ ANOVA of the probability scores, there is no significant regression of the self-threat ($p = .53$). If we control the surprise scores, the regression of the surprise is still significant ($p = .03$). Additionally, the formerly significant ($p = .04$) main effect of surprise is no longer significant ($p = .66$). The interaction surprise \times outcome information is still marginally significant ($p = .08$). Finally, if we control the surprise scores (regression significant: $p = .02$) and the self-threat scores (regression not significant: $p = .92$), this interaction is no longer significant ($p = .13$). Whereas the results of the covariance analyses confirm the importance of surprising outcomes as the main force to eliminate the hindsight bias, no clear evidence could be found for self-threatening outcome information to eliminate the hindsight bias.

Discussion

Questions that might be bothering scientists using JavaScript in Internet Science are whether the compatibility problems with this scripting language increase drop out, and whether this drop out is systematic. From our results we can confidently advise that it is better to work server-side with CGI, and only use JavaScript if increased drop out is no threat to the research design at hand. It seems wise to be careful in using JavaScript, as we could observe a substantial increase of drop out in the JavaScript version of the Web experiment. We can further conclude from our Web experiment that JavaScript compatibility is not necessarily binary: JavaScripts can simply increase the likelihood of browser failures or system crashes through complex interactions with software and hardware components building up

over time. Such a technical interference would be most detrimental in research designs and research questions with a high susceptibility to drop out. Because participants produced no different probability ratings under JavaScript and CGI conditions despite markedly different drop out rates, we can conclude the following. The Web experimental method was once again confirmed as being quite robust to sampling effects as well as to artifacts stemming from limited control of technical equipment (see also Reips, 1999, 2000).

The results of the present Web experiment also substantiate former findings reported in the hindsight literature that highly surprising outcome information can eliminate or even reverse the hindsight bias (Mazursky & Ofir, 1990; Ofir & Mazursky, 1997). Despite the fact that we did not find clear evidence that self-threatening outcome information could cause the same effect we suggest not to dismiss this possibility. Unfortunately we did not succeed in manipulating surprise and self-threat independently. Very often self-threatening events are likewise surprising, making it difficult to manipulate both factors independently. Future experiments will have to focus this point. Another aspect also concerns the stimulus material. It is doubtful whether participants reading a fictitious story about their parents involved in an accident are really self-threatened by the also fictitious outcome information that their father died as a result of the accident. But how can we really self-threaten participants without violating ethical limits? For Web studies this seems to be a particular problem because it is not feasible to debrief the participants in a face-to-face communication and to dampen possible negative emotional reactions.

Overall, we would like to draw the following conclusion as a practical advice for conducting Web studies: If robust general psychological phenomena such as the hindsight bias are studied, then it does not matter whether the researcher uses CGI or JavaScript. If not, then CGI should be used to minimize drop out.

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