Computers in Human Behavior 25 (2009) 402–406

Contents lists available at ScienceDirect

Computers in Human Behavior

journal homepage: www.elsevier.com/locate/comphumbeh

Learning in virtual environments: Some discrepancies between laboratory- and Internet-based research on associative learning

Miguel A. Vadillo *, Helena Matute

Departamento de Psicología, Universidad de Deusto, Apartado 1, 48080 Bilbao, Spain

ARTICLE INFO

Article history:
Available online 6 November 2008

Keywords:
Internet
Associative learning
E-learning

ABSTRACT

Some published reports have emphasized the similarities between Internet and laboratory research on associative learning processes. However, few of them, if any, studied systematic divergences between both types of research methodologies. In the present experiment, we investigated these divergences using an experimental preparation for the study of associative learning. The results show that discrimination and discrimination-reversal can be obtained both in laboratory and Internet experiments. However, the learning rate was clearly better in the laboratory than in the Internet condition. This result suggests that associative learning experiments performed over the Internet should provide participants with extensive training to assure that asymptotic performance is achieved.

1. Introduction

One of the most important methodological innovations in the area of experimental psychology has been the recent development of Internet-based research (Birnbaum, 2000; Gosling, Vazire, Srivastava, & John, 2004; Kraut et al., 2004; Reips, 2001, 2002). This methodology allows the researcher to perform an experiment over the Internet and, therefore, gain access to larger and more representative samples. Many reports have investigated the advantages and disadvantages of this type of research and have contrasted its results with those observed under traditional laboratory conditions. Most of these studies have emphasized the similarities between the results observed in Internet samples and those observed in the laboratory either by replicating one effect already studied in the laboratory or by simultaneously conducting a single experiment both in the laboratory and over the Internet (e.g., Birnbaum & Wakcher, 2002; Buchanan & Smith, 1999; McGraw, Tew, & Williams, 2000; Steyvers, Tenenbaum, Wagenmakers, & Blum, 2003). In general, these studies support the hypothesis that the results are similar in both locations and that the Internet introduces only a little noise in the data that can be overcome by the access to larger samples.

Quite surprisingly, this new methodology has not received equal attention in all research areas. Whereas it is being widely used in areas such as personality research, health psychology, or education, fewer studies have been conducted in basic psychological research, in which researchers are more reluctant to lose control over the experimental conditions. For instance, in spite of the growing interest in the role associative learning processes in diverse phenomena such as categorization (e.g., Gluck & Bower, 1988; Kruschke & Johansen, 1999), causal induction (e.g., Allan, 1993; Shanks, 2007), probabilistic reasoning (e.g., Cobos, Almaraz, & García-Madruga, 2003) or even group biases (e.g., Van Rooy, Van Overwalle, Vanhoomissen, Labiouse, & French, 2003) the use of Internet-based methods is still infrequent or even inexistent in this research area. As a means to encourage the use this novel research tool, we have conducted a series of experiments to test the validity of a set of experimental preparations for the study of basic, associative learning processes over the Internet.

In associative learning experiments, participants are exposed to a series of cue-outcome pairings and, after enough training has been provided, their knowledge of these cue-outcome relations is assessed by several means. In so-called judgmental tasks, participants' knowledge about the cue-outcome relation is assessed by means of a subjective judgment of the relation between the cue and the outcome. For example, after some cue-outcome pairings, participants can be asked to rate the likelihood of the occurrence of the outcome given the presence of the cue in an scale ranging from 0 to 10. In behavioral tasks, however, the participants' learning is inferred from their performance in the task, instead of relying on subjective judgments. For example, participants can be exposed to a video-game in which they can earn points by performing some response just before a particular outcome occurs; the number of responses in the presence of a cue would then be a measure of the perceived relation between the cue and the to-be-predicted outcome (for a more detailed information about both types of associative learning tasks, see Matute, Vadillo, & Bárcena, 2007). In our experiments, we have observed that the results of Internet experiments closely resemble those of the laboratory with both judgmental and behavioral tasks.

* Corresponding author. Fax: +34 94 4139089.
E-mail address: mvadillo@fice.deusto.es (M.A. Vadillo).

0747-5632/$ - see front matter © 2008 Elsevier Ltd. All rights reserved.
doi:10.1016/j.chb.2008.08.009

For instance, Vadillo, Miller, and Matute (2005); see also Vadillo & Matute, 2007), studied the effect of the question wording on the participants' assessment of a cue-outcome relationship in a judgmental task and found consistent results in the laboratory and over the Internet. Similarly, Matute, Vadillo, Vegas, and Blanco (2007) studied the illusion-of-control effect in a judgmental task in which participants were first allowed to try to control an (actually uncontrollable) outcome by performing a response and were later asked to rate their perceived degree of control. As discussed by the authors, the results were similar in the Internet sample and in a control laboratory sample. In a different series of experiments, we focused on the study of cue-interaction effects, in which learning of a cue-outcome relation is affected by training of other cues with the same outcome, using a behavioral task. Again, the results were similar in the laboratory and Internet samples (Vadillo, Bárcena, & Matute, 2006). Apart from these few research reports published by our research team, we are aware of no other research on associative learning processes that has used Internet-based research methods.

Taken together, these results seem to show that Internet-based research on associative learning always yields results akin to those observed in the laboratory, therefore suggesting that experimenters can strongly rely on data gathered over the Internet. However, it is still possible that other learning effects are not so easily replicable over the Internet. In order to make a good use of the possibilities offered by Internet-based research, both the similarities and the potential divergences between Internet-based and laboratory-based research should be extensively studied.

In the present experiment we looked for divergent results in the laboratory and the Internet. In associative learning experiments, participants are usually exposed to a large number of trials showing the relationship between cues and outcomes and, only after this training is completed, they are tested for responding to one or more of these cues. Given the extensive training provided to all participants, it is not strange that the results tend to be similar in the laboratory and the Internet samples: Even if participants are paying little attention to the experimental task, they are exposed to so many trials of each type that they certainly do converge to a similar learning asymptote. However, if we paid more attention to the behavior of Internet participants during the early phases of learning, it would not be surprising to find that they learned at a different pace. For instance, given that Internet participants perform the experiment under uncontrolled conditions, they might take part in the experiment while they are involved in other activities that would distract them and reduce the level of attention they pay to the experimental task, which would result in slower learning of the target contingencies. If this were the case, our focus on participants' behavior at the end of training would have prevented us from noting interesting differences in the rate of learning. This can be extremely important for certain experimental studies, given that many interesting effects explainable in terms of associative learning processes, such as illusory correlations and illusions of control, are highly dependent on the learning rate and the number of trials (e.g., Shanks, 1985).

Therefore, in the present experiment we exposed participants to a simple behavioral task and looked at their pace of learning, both in the laboratory and over the Internet. Specifically, we exposed participants to a discrimination problem in which one cue, *X*, was followed by the outcome and another one, *Y*, was not. This task was so easy that participants would probably find no problem in solving it after a few trials. However, one might expect that Internet participants would probably learn more slowly than laboratory participants. Moreover, and in order to increase the number of conditions in which we could contrast Internet and laboratory research, we included a second training phase in which the discrimination was reversed; that is, participants now had to learn that cue *X* was no longer followed by the outcome and that cue *Y* was now followed by the outcome. We expected Internet participants to find more difficulties in learning this discrimination-reversal.

2. Method

2.1. Participants and apparatus

The laboratory sample was composed of 20 undergraduate students from Deusto University who volunteered to take part in the experiment. All these participants performed the experiment in a large computer room, with each computer station placed at least at 1.5 m apart from the adjacent one. The Internet sample was composed of 75 anonymous participants who visited our virtual lab's web page, www.labpsico.com, and volunteered to take part in the experiment. The experimental program was embedded in an HTML document, using JavaScript code to manage the presentation of the stimuli in the screen and to collect participants' responses. All the stimuli were preloaded in memory before participants could start the experiment, so that differences in the connection speed could not influence the pace of the experiment.

2.2. Procedure and design

The experimental task is a JavaScript version of a standard behavioral preparation for the study of human predictive learning that has already been used in several studies (Arcediano, Matute, & Miller, 1997; Arcediano, Ortega, & Matute, 1996; Havermans, Keuker, Lataster, & Jansen, 2005; Lipp & Dal Santo, 2002; Matute & Pineño, 1998). In this task, participants are told that their objective is to prevent the landing of a group of Martians that are trying to invade the earth. When a Martian is just appearing in the screen, the participants can destroy it by firing a gun (pressing the space bar in the computer's keyboard). Given that Martians appear on the screen at a fixed rate of about 4 Martians per second (with slight variations in different computers), this task keeps participants responding regularly at a rate of about 4 responses per second. After providing some pre-training with 150 Martians, so that participants learn to respond regularly, an instructional screen tells participants that the Martians have developed a defense system, a shield that protects them from firings. Participants are told that if they fire the gun when the Martians' shield is activated, more invaders will appear on the screen. The immediate activation of the shield can be predicted by a change in the screen's background color, so that participants can avoid these invasions by ceasing to fire the gun when these signals appear on the screen. Participants, however, are not told which cues signal the activation of the shield. The decay in participants' response during the presentation of the background colors that predict the activation of the shield, relative to the rate of responding before the presentation of those colors, is used as a measure of the participants' learning of the association between the color and the activation of the shield (for a complete description of the task and of the actual instructions, see Arcediano et al., 1996).

After reading the instructions and practicing in the pre-training phase, participants were exposed to two phases of training. In the first phase, one color cue, *X*, was always paired with the Martians' activating the shield, while a second color cue, *Y*, was never followed by that outcome. These two types of trials were presented in pseudorandom order. Thus, participants should learn to discriminate between them. That is, to refrain to respond when *X* was presented and to keep responding when *Y* was presented. Blue and yellow background colors, counterbalanced, served as cues *X* and *Y*. Eight $X \rightarrow$ outcome and eight $Y \rightarrow$ no outcome pairings were pre-