THE QUARTERLY JOURNAL OF EXPERIMENTAL PSYCHOLOGY, 1996, *49B* (3), 270–283

A Behavioural Preparation for the Study of Human Pavlovian Conditioning

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Conditioned suppression is a useful technique for assessing whether subjects have learned a CS–US association, but it is difficult to use in humans because of the need for an aversive US. The purpose of this research was to develop a non-aversive procedure that would produce suppression. Subjects learned to press the space bar of a computer as part of a video game, but they had to stop pressing whenever a visual US appeared, or they would lose points. In Experiment 1, we used an A+/B− discrimination design: The US always followed Stimulus A and never followed Stimulus B. Although no information about the existence of CSs was given to the subjects, suppression ratio results showed a discrimination learning curve—that is, subjects learned to suppress responding in anticipation of the US when Stimulus A was present but not during the presentations of Stimulus B. Experiment 2 explored the potential of this preparation by using two different instruction sets and assessing post-experimental judgements of CS A and CS B in addition to suppression ratios. The results of these experiments suggest that conditioned suppression can be reliably and conveniently used in the human laboratory, providing a bridge between experiments on animal conditioning and experiments on human judgements of causality.

A general assuption in Pavlovian research is that common associative processes can explain both animal and human learning. However, the majority of the data available are based on non-human animals. There are no obvious theoretical reasons for this strong preference for the use of animal subjects. Instead, the relatively small number of human experiments seems to be due to the lack of convenient behavioural preparations for use with humans.

The traditional techniques used in human Pavlovian research, such as electrodermal conditioning (e.g. Hinchy, Lovibond, & Ter-Horst, 1995), have not become popular because they are expensive, complicated, and sometimes ethically problematic. Some researchers have tried to solve the methodological problem in human research by focus-

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Support for this research was provided by Grant PB91–0288 from Dirección General de Investigación Científica y Técnica (Spain). We are grateful to Angel Baquedano and Ralph Miller for helpful comments and suggestions on a previous draft. We also would like to thank Abraham Arias, Martha Escobar, and Oskar Pineño for running the subjects of Experiment 1, and Mirko Gerolin for assistance in writing the computer program.

ing on the idea that studies of human judgements of causality can be viewed as analogues of animal conditioning (e.g. Allan, 1993; Shanks & Dickinson, 1987; Wasserman, 1990a). The basic idea underlying this approach is that what an animal learns during the pairings of the conditioned stimulus (CS) and the unconditioned stimulus (US) in Pavlovian conditioning is very similar to what a human learns during the pairings of a cause and an effect during causal learning. In a typical study in the causal learning tradition, the subject learns a relationship between the CS or potential cause (e.g. a fictitious allergen) and the US or potential effect (e.g. a fictitious allergy), and this learning is usually assessed through the subject's verbal judgement of the degree to which the target CS is the cause of the US or effect (e.g. Wasserman, 1990b). The use of causal judgements as a tool to explore associative learning in humans is becoming very popular because assessing them is much simpler than assessing autonomic conditioning.

Although we agree with the overall assumption that causal judgement studies with humans may be viewed as analogues of Pavlovian conditioning, we think that the analogy would be more straightforward if behavioural rather than judgemental responses were used to assess conditioning in humans. Verbal judgements are known to be influenced by many variables in addition to the critical ones under study. For example, very slight differences in the wording of the test questions or in the names used for the fictitious causes and effects in verbal causal preparations substantially influence the results (Matute, Arcediano, & Miller, 1996). In our view, behavioural responses are more direct and perhaps more ecologically valid estimates of whether subjects have learned the CS–US relationship. Therefore, our goal was to develop a simple preparation in which behavioural responses could be used to assess whether human subjects have learned an association between a potential cause (CS) and a potential effect (US).

One of the most common techniques used to assess Pavlovian conditioning in animals is conditioned suppression (Estes & Skinner, 1941). In one variant of this technique, called on-line conditioned suppression, subjects are reinforced with food or water for barpressing while, at random intervals, they are exposed to a CS (e.g. light) that signals a US (usually a footshock). The footshock US induces *unconditioned* suppression of barpressing (i.e. rats stop barpressing during and briefly after the footshock). When the subjects learn that the CS will be followed by the footshock US, *conditioned* suppression is evidenced in that subjects also stop barpressing when the innocuous CS is presented. Presumably, at some level they anticipate the US and, as a consequence, the suppression response that initially accompanied the US is now also given in the presence of the CS. This technique is common in animal research because it offers a reliable and convenient means for the study of Pavlovian conditioning.

Our goal was to adapt this preparation to the human laboratory to make it as similar as possible to that used with animal subjects. However, many pilot experiments conducted in our laboratory suggested that USs that were sufficiently "mild" to be ethically acceptable in human research (e.g. loud noise of up to 112 dB A scale; electric shock with subjects setting the intensity level) were not effective in causing unconditioned suppression beyond the first few trials. Other attempts to use conditioned suppression techniques with human subjects have been made in the past (e.g. Di Giusto, Di Giusto, & King, 1974) but then abandoned, presumably because of the ethical problems involved in exposing human subjects to a US that would consistently cause unconditioned suppression over a series of trials.

An interesting behavioural alternative that used an ethically acceptable US was developed long ago by Ivanov-Smolensky (1927). He instructed children to squeeze a ball every time an innocuous US (a piece of chocolate) was visible. The ball was connected to an apparatus that could measure reaction time as well as the magnitude (i.e. force) of the response. The interesting aspect of the procedure was that after a series of trials, this response transferred to a CS (a bell) that was paired with the US. Ivanov-Smolensky reported simple excitatory conditioning, as well as generalization, discrimination, extinction, and several other phenomena using this instructed-US preparation with children. More recently, Perruchet (1985) has also developed a procedure that uses an instructed US (either visual stimulation or an airpuff) with adult humans and keypress reaction time as the dependent variable. Although we were not successful at obtaining sensitive results with direct adaptations of the instructed procedure to simple computer-based tasks, a combination of the instructed procedure and the conditioned suppression preparation used in animal research yielded what we think is a very sensitive and convenient preparation. Thus, the preparation that we describe below, like the procedures described by Ivanov-Smolensky (1927) and Perruchet (1985), uses an instructed US that is not biologically significant but is ethically acceptable in human research. Our US was a visual stimulus that suppressed responding through prior explicit instructions telling the subjects to stop responding when they saw the US. Our critical question was whether subjects would learn to anticipate the US and would show this learning through conditioned suppression to a CS that predicted the US.

For this purpose, we used a simple A+/B− discrimination procedure in which Stimulus A was always followed by the US, and Stimulus B was never followed by the US. In Experiment 1, subjects were not given any information concerning the existence of these stimuli. We expected that subjects would learn to anticipate the US in the presence of A but not in the presence of B, and our primary interest was whether this learning would be manifested through conditioned suppression. In Experiment 2 we explored whether adding instructions concerning the significance of the conditioned stimuli would affect learning, and we also explored the correspondence between our behavioural data and the more traditional causal judgement measurements.

EXPERIMENT 1

Method

Subjects and Apparatus

Sixteen undergraduate non-psychology students volunteered for the study. Subjects were run individually, using a personal computer, in a room measuring about 2 × 2 m. The experimenter stayed in the room with the subject during the pre-training phase and until the subject understood the instructions for the Pavlovian phase. After that, the experimenter stayed in an adjacent room.

Dependent Variable

The dependent variable was a suppression ratio, which is the conventional dependent variable in animal conditioned suppression studies and is computed as $X/(X+Y)$, where X is the number of barpresses during the CS, and Y is the number of barpresses in a period of time that is identical to the duration of the CS and that immediately precedes the presentation of the CS. A suppression ratio of 0 indicates that conditioned suppression to the CS was complete. By contrast, if the CS does not affect behaviour, the number of responses during the CS and that during the period of time immediately preceding the CS are identical; therefore, the resultant suppression ratio is 0.5 and indicates that conditioning has not taken place.

Procedure

Pre-training. Subjects first completed a pre-training phase. The purpose of this phase was to teach each subject to barpress consistently using the space bar of the computer keyboard. No CSs or USs were presented at this stage. A translation of the instructions used for this phase reads as follows:

> *Your task is to prevent Martians from landing. Every half-second one new Martian will try to land. In order to destroy them, you must use your laser-gun (the space bar) before they can see you—that is, just before you can see them. But do not shoot too early, because you only have one shot per Martian. At the end of this phase, we will tell you the percentage of Martians that you have killed. THE PLANET DEPENDS ON YOU!! DO NOT ALLOW THEM TO LAND!!*

Martians were represented by ASCII 002 (☻) in graphics mode and were approximately 7 mm in diameter. They appeared at intervals of 0.3 sec on a black background. A space of approximately 14 mm separated each Martian from the previous one. If subject pressed the space bar before a Martian was displayed, an explosion (represented by ASCII 015 [☼] with the same format), rather than a Martian, was displayed. The objective was to have a screen filled with explosions, not with Martians. Only one barpress per Martian was allowed, and it could be made at any time during the 0.3-sec interval. The instruction that responding too early was not desirable was used to emphasize that only one response per Martian was allowed, and to obtain, therefore, a regular rate of responding through the task (as well as to prevent the subjects from holding the space bar pressed down). If more than one press was recorded during the 0.3-sec interval (e.g. if subjects held the space bar pressed down), a Martian rather than an explosion was printed. All this was shown by the experimenter, who performed the first few responses and then passed the keyboard to the subject. The screen was filled when 80 Martians or explosions were visible (10 in each of 8 lines), but no breaks between screens were used. Instead, when the screen was filled, it moved up progressively to make room for new Martians. One hundred Martians were depicted as attempting to land during this phase. The score (percentage of explosions) was shown at the end.

Pavlovian Conditioning. Following pre-training, the training phase was begun. This phase consisted of the critical Pavlovian conditioning, and it was superimposed on the operant task. That is, the CSs and USs were presented during the Martian task. A translation of the instructions used for this phase reads as follows:

> *Now the Martians have developed a powerful anti-laser shield. You must continue using your laser to prevent their landing. BUT BE CAREFUL, because if you shoot your laser-gun when the shield is connected, your shot will reflect back to you, thousands of Martians will land safely immediately,*

and you will not be able to stop that invasion. You will know that the shield is connected when you see a WHITE INTERMITTENT FLASHING on the screen.

Remember, just one shot while the shield is connected (WHITE FLASHING SCREEN) and the Martians will successfully invade!!

The US was a white flashing screen (12 flashes/sec) presented for 0.4 sec if the subject did not respond. But if the subject responded during the US, the flashes remained on for an additional 5-sec period, during which Martians invaded the screen (at a rate of 20, rather than 10, Martians per line, and a between-Martian space of 7 mm). The experimenter used a demonstration variant of the program to show the subject the difference between a short (without punishment) and a long (punishing) US (with no CSs being presented during this demonstration). Following this, the experimenter left the room and the subject started the Pavlovian phase.

Now Martians appeared at 0.2-sec intervals. CSs (A and B) were blue and yellow backgrounds, counterbalanced. CS A was always followed by the US; CS B was never followed by the US. There were 20 trials for each CS. Their distribution was pseudorandom and identical for all subjects, starting with a B trial, and with no more than 3 trials of the same type in succession. CSs duration was 1 sec, but for every fourth A trial and every fourth B trial the CS duration was 3 sec. These 3-sec trials were intended as test trials for which suppression ratios could be calculated. Thus, suppression ratio was recorded for Trials 1, 4, 8, 12, 16, and 20 for each of the two CSs. The background colour remained black during the inter-trial intervals (ITI). The duration of the ITI was pseudorandom, with a range between 5 and 10 sec, and a mean of 7.5 sec.

Results and Discussion

A learning curve for the discrimination task was observed through increased conditioned suppression to A but not to B during the Pavlovian training phase. Figure 1 depicts the learning curve—that is, mean conditioned suppression to CSs A and B on Trials 1, 4, 8, 12, 16, and 20, which were the longer trials that had been inserted for assessment purposes during the discrimination training phase. Suppression to CS B was stronger than suppression to CS A only on Trial 1, which probably reflected the surprise produced by the very first presentation of a CS (i.e. the sequence of trials always started with a B-trial). A 2 (stimulus) × 6 (test trial) ANOVA yielded a main effect for stimulus, $F(1, 15) = 11.93$, $p < .01$, and trial, $F(5, 75) = 4.63$, $p < .001$. The Stimulus × Trial interaction was also significant, $F(5, 75) = 19.14$, $p < .001$, reflecting gradual learning of the A+/B− discrimination. Planned comparisons showed that suppression to A was significantly stronger than suppression to B on Trial 8, $F(1, 15) = 8.88$, $p < .01$, Trial 12, $F(1, 15) = 16.84$, $p < .001$; Trial 16, $F(1, 15) = 21.32$, $p < .001$; and Trial 20, $F(1, 15) = 30.66$, $p < .001$. That is, after 8 training trials with each CS, the suppression ratio showed that subjects had learned to predict the occurrence of the US in the presence of A, as opposed to B.

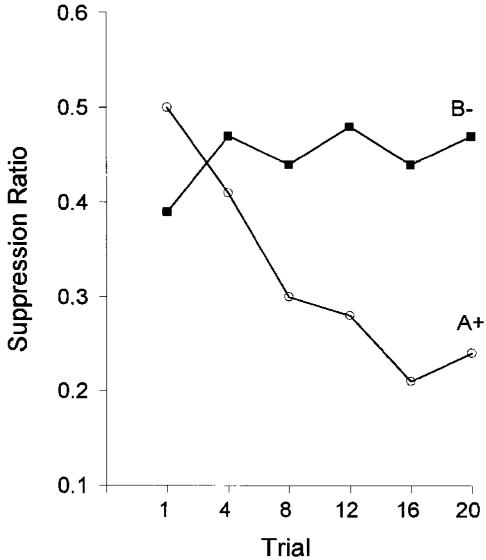

FIG. 1. Discrimination learning curve for Stimuli A+ and B− during the Pavlovian phase of Experiment 1, which was run individually and in which no instructions on the existence of CSs were given. The dependent variable was mean suppression ratio; thus, a lower value represents stronger conditioning.

EXPERIMENT 2

Experiment 1 showed that students who were trained individually learned to discriminate between the stimulus that predicted the US and the one that did not, as evidenced through a conditioned suppression learning curve. Experiment 2 was designed to replicate and extend those results in several ways. First, in order to increase the potential of this preparation, we thought it important to replicate the results in a group setting rather than in the individual setting used in Experiment 1. Second, in order to explore the correspondence between our behavioural data and more traditional judgemental measures of associative learning in humans, in Experiment 2, in addition to suppression ratios, we also assessed the subjects' judgements of CS A and CS B once the Pavlovian phase was completed. Finally, we explored the effect of different instruction sets. That is, although Experiment 1 showed that learning took place even though subjects had not been warned of the existence of CSs and their potential relation to the US, it is possible that more explicit instructions would make the task work better. Thus, in Experiment 2, half of the subjects (uninstructed group) received instructions that were identical to the instructions used in Experiment 1 (i.e. uninstructed with respect to CSs), and the other half of the subjects received explicit instructions concerning the CSs (instructed group).

Method

Subjects and Apparatus

Forty non-psychology undergraduate students volunteered for the study. None of them had participated in Experiment 1. Subjects were randomly assigned in equal numbers to the instructed and the uninstructed group. The study was run in a group setting in a large laboratory containing 70 personal computers. Subjects were separated from each other by about 1 m, and each subject was exposed to a different experimental condition (and counterbalancing of stimuli) from the two subjects sitting next to him or her. Data from one subject from group instructed were eliminated from the study due to equipment failure.

Procedure

Pre-training. The pre-training phase was identical to that in Experiment 1, except for the changes required to adapt it to the group setting used in this experiment. After subjects had read the instructions, one of the experimenters explained them while performing the pre-training task on a computer connected to a large screen that could be seen by all subjects. Once the experimenter had completed this phase, any questions were answered aloud, so that all subjects would have the same information. Finally, each subject completed pre-training, which finished with a screen showing the percentage of Martians that subject had destroyed. Questions were allowed at this point, but none were asked.

Pavlovian Conditioning. Subjects were then asked to go on to the next screen, read it carefully, and wait until all subjects had read it. This screen contained the instructions for the Pavlovian phase, and subjects were told to pay no attention to their neighbours' instructions, because each of them was being instructed to do a different thing. Subjects in the uninstructed group received the same instructions as those used in the Pavlovian phase in Experiment 1 (i.e. no instructions about the CSs). Subjects in the instructed group received the same instructions, but with the following paragraph inserted between the first and second paragraphs:

> *Some INDICATORS will help you predict when the shield is about to be connected, but there will also be some false cues. If you learn to distinguish between the correct and the false indicators, you will always be able to avoid the shield. Otherwise, each time the Martians connect the shield, you will be shooting, and they will invade you.*

Once subjects had read the instructions, the experimenter performed a variant of the program in which only two trials, containing one US each but no CSs, were shown. As in pre-training, the experimenter's screen could be seen by all subjects. The purpose of this demonstration was to show subjects the difference between a large (punishing) and a short (non-punishing) US (white flash). Because subjects had been warned that there were many different instructions, the experimenter explained that only the aspects common to all instructions were being explained during this demonstration and asked subjects to make sure they understood any additional details provided by their own instructional screen. No questions were asked at this stage. After all subjects said they had understood their own instructions, the experimenter told them the password that was needed to begin the experiment. This password was needed so that no one could start the experiment before the demonstration was finished. The critical Pavlovian training and testing was identical to that in Experiment 1.

Judgemental Tests. The judgemental tests occurred with no interruption after subjects had completed the latest Pavlovian trial. The following instruction was then shown on a black background:

> *We will soon show you your score, but first we would like to know if you have been able to distinguish what the different colours indicated. That is, which ones warned you that the shield was about to be connected and which ones were false cues. For this purpose we need to ask you a couple of questions. Press <ENTER> to continue.*

When subjects pressed the "enter" key, the background colour changed to either the A or the B colour (counterbalanced for order), and the following question was printed in the middle of the screen:

> *To what degree do you think that this colour was an indicator that the shield was about to be connected? (Please give a number between 0 [none] and 9 [very high])*

After subjects had responded to this question, the screen changed to the other colour (A or B), and the same question was asked again. Finally, the next screen showed the percentage of Martians the subject had destroyed, and subjects were carefully debriefed, with special emphasis on the difference between the instructed and the uninstructed conditions, which might have resulted in different degrees of task difficulty for different subjects.

Results and Discussion

The results of this experiment replicated those of Experiment 1 in a group rather than an individual setting. Additionally, they showed that the instructed condition was even more effective than the uninstructed one in producing a faster and more pronounced discrimination, although good performance was also observed under the uninstructed condition that replicated Experiment 1. Finally, the post-experimental judgemental questions reflected the same pattern of results as the behavioural data. That is, group instructed was superior to group uninstructed, but both groups showed very good discrimination through their judgements of CSs A and B.

Behavioural Data. Figure 2 depicts the conditioned suppression discrimination learning curves for group uninstructed (left panel) and group instructed (right panel). Inspection of Figure 2 reveals that both groups showed good discrimination learning but also that the discrimination was faster and more pronounced in group instructed compared to group uninstructed. Consistent with this, a 2 (group) × 2 (stimulus) × 6 (test trial) ANOVA yielded a main effect for stimulus, $F(1, 37) = 35.03$, $p < .001$, and trial, $F(5, 185) = 5.37$, $p < .001$, and no main effect for group, $p > .5$. The Group × Trial, Group × Stimulus, Stimulus × Trial, and Group × Stimulus × Trial interactions—$F(5, 185) = 2.44$, $p < .05$; $F(1, 37) = 0.8$, $p > .1$; $F(5, 185) = 21.74$, $p < .001$; $F(5, 185) = 2.18$, $p = .05$, respectively—indicated that both groups learned progressively to discriminate between A and B, and that the discrimination learning was faster and more pronounced in the instructed group compared to the uninstructed group. Planned comparisons showed that suppression to A differed significantly from suppression to B as early as in Trial 4 for group instructed, $F(1, 37) = 14.42$, $p < .001$, but not for group

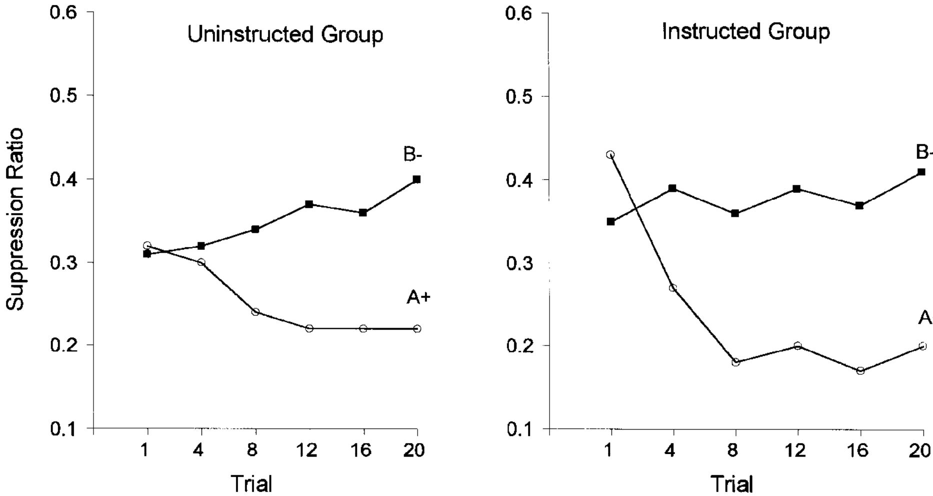

FIG. 2. Discrimination learning curves for Stimuli A+ and B− during the Pavlovian phase of Experiment 2, which was run in a group setting. Group uninstructed (left panel) received the instructions used in Experiment 1. Group instructed (right panel) was given instructions on the existence of CSs. The dependent variable was mean suppression ratio; thus, a lower value represents stronger conditioning.

uninstructed, $p > .1$, in which the discrimination was significant after Trial 8, $F(1, 37) = 11.74$, $p < .01$. Thus, group uninstructed replicated the discrimination learning observed in Experiment 1, and group instructed enhanced those results.

It should be noted, however, that although the statistical results of group uninstructed replicated those of Experiment 1, the shape of the learning curve suggests some differences, particularly during the early trials. These differences should probably be attributed to the individual versus group setting, which was the only difference between Experiment 1 and the uninstructed group in this experiment (with the individual setting used in Experiment 1 involving a greater experimenter–subject interaction during the pre-training and instructional stages, as well as fewer distractions and a greater personal involvement on the part of the subject during the actual experiment).

Judgemental Data. Figure 3 depicts subjects' post-experimental judgements of CSs A and B. As can be seen in Figure 3, the judgemental data reflected the same pattern of results as the behavioural data. That is, both the uninstructed and instructed groups showed very good discrimination through their post-experimental judgements of A and B, although this discrimination was better in the instructed group. This was confirmed by a 2 (group) × 2 (stimulus) ANOVA conducted on subjects' judgements. This yielded a main effect for stimulus, $F(1, 37) = 113.05$, $p < .001$, no main effect for group, $F(1, 37) = 0.2$, $p > .5$, and a significant Group × Stimulus interaction, $F(1, 37) = 4.26$, $p < .05$. This suggests that although the difference between the post-experimental judgement of A and that of B was more pronounced in group instructed than in group uninstructed, both groups discriminated very well between A and B in their verbal ratings—$F(1, 37) =$

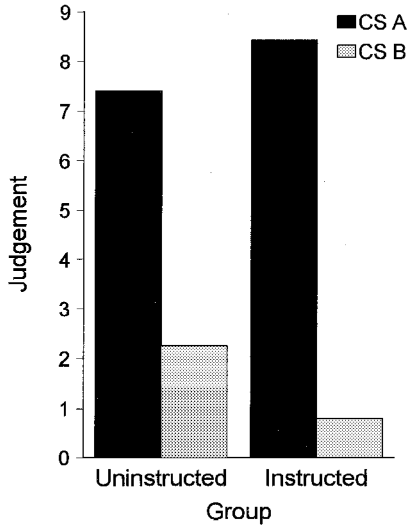

FIG. 3. Post-experimental judgements of CSs A and B under the uninstructed and instructed conditions used in Experiment 2. Judgements were given in a 0–9 scale and represent the degree to which subject expected the US to occur after the CS.

37.67, $p < .001$ for the uninstructed group; $F(1, 37) = 78.59$, $p < .001$ for the instructed group.

GENERAL DISCUSSION

The results of Experiment 1 indicated that even though subjects had not been told that CSs would be presented, they learned progressively to discriminate between the two CSs, anticipating the US in the presence of CS A and not in the presence of CS B. Most importantly, this learning was evidenced behaviourally through conditioned suppression. Experiment 2 further explored the potential of this preparation by replicating the results of Experiment 1 in a group setting and by showing that even better discrimination can be obtained if explicit instructions on the existence of CSs are used. Additionally, Experiment 2 showed a very high correspondence between our behavioural data and more traditional causal judgement assessment procedures. This provided a reliable and very convenient methodology for the study of human conditioning, which can also be used to assess human causal judgements.

On the other hand, our observation of similar behavioural and judgemental patterns of results could be interpreted as suggesting that the development of a behavioural preparation was an unnecessary complication over already established causal judgement assessment tools. However, there are at least two arguments against such conclusion. First, under the very simple A+/B− discrimination procedure that we used, the similar patterns of results yielded by the behavioural and the judgemental data is not surprising. Under more complex designs, as mentioned in the introduction, causal judgement studies are influenced by many variables in addition to the critical ones under study. For example, the specific wording of the assessment question frequently influences the results in those studies (see, e.g., Matute et al., 1996). Additionally, and at a more theoretical level, many researchers have argued that independent and dissociable learning systems may be responsible for verbal and performance data. If this were true, data from experiments using verbal reports as the dependent variable would provide evidence for a learning system that is not necessarily the same as that involved in conditioning phenomena. Although this is very controversial (see Shanks & St. John, 1994, for a review), that being the case, the development of a behavioural preparation to be used with humans becomes potentially significant.

Related to the debate on dissociable learning systems is the issue of learning without awareness (see Shanks & St. John, 1994, for a recent review). For example, some researchers have argued that although verbal reports cannot occur without the subject's awareness of the contingencies, behavioural responses can occur before the subject is aware of the contingencies or even in the absence of awareness (e.g. Lewicki & Hill, 1989; Reber, 1989). Our use of instructed versus uninstructed conditions could perhaps be interpreted in relation to this problem. The purpose of the present research, however, was to develop a behavioural preparation, and, in our view, it should not be interpreted in relation to the issue of learning without awareness. Although we did observe a very similar pattern of results for the judgemental and the behavioural data, judgements were assessed only after the Pavlovian phase had been completed, and thus our data do not speak to the question of whether conditioned responses (CRs) or awareness occurred first. What our results show is, on the one hand, that explicit instructions favour the development of CRs as well as the subject's awareness and, on the other hand, that instructions are not necessary for CRs and awareness to occur: Subjects receiving no instructions on the existence of CSs also learned to respond differentially to the two CSs and were aware of the contingencies (at least at the end of training).

Our use of a US that is not biologically significant may be viewed as problematic by researchers who focus on the Pavlovian definition of conditioning, according to which the US must be biologically significant. Indeed, although some current accounts of Pavlovian phenomena interpret conditioning as a mechanism for identifying causal relationship between any events, regardless of their nature (e.g. Dickinson, 1980), according to more traditional interpretations we might expect conditioning to occur only in situations where the predicted event is biologically significant (e.g. Pavlov, 1927). However, it should be noted that several traditional Pavlovian procedures involve the use of US surrogates that are not biologically significant (e.g. sensory pre-conditioning and second-order conditioning). Similarly, many accepted applications of Pavlovian research (e.g. systematic desensitization) involve the use of instructed USs (in this case, instructions to relax). Thus, our procedure is consistent with a broader definition of conditioning, according to which organisms learn a relationship between events, regardless of whether they are neutral, as in sensory preconditioning, or biologically significant, as in more traditional forms of conditioning, and this learning is evidenced through a response that is given to a CS that initially did not elicit the response.

It is true, however, that the relationships between these two types of learning (with and without biologically significant USs) have not yet been adequately established. Is it just a matter of different definitions of conditioning, or do these two situations involve different processes? In our view, most instances of conditioning involve two different components: (a) the learning of a relationship between two events (see, e.g., Dickinson, 1980); and (b) the second event almost always being biologically significant (e.g. Pavlov, 1927). The development of a CR to the CS, which is the way in which conditioning is usually assessed, has been regarded as a consequence either of the first (e.g. Dickinson, 1980) or the second (e.g., Pavlov, 1927) component, but investigation of the separate role of each of them, or even of whether those two components can be explained through the same learning process, did not start until very recently. Recent studies suggest that the biological significance of the US could be a source of some of the differences observed between animal conditioning (which generally uses biologically significant USs) and human causal learning research (which uses US surrogates that are biologically neutral). For example, Miller and Matute (in press) reported that several phenomena that had been observed in human causal learning but not in animal conditioning (e.g. backward blocking) could be obtained in animals if they were treated analogously to human subjects in terms of being exposed to biologically neutral rather than biologically significant USs (e.g. through the use of sensory preconditioning). Thus, the question of whether the same process is responsible for the acquisition of associations between neutral events and for the acquisition of biological significance by the CS is an open but empirical one, which, in our view, should be addressed in future research.

With regard to the present research, one implication of this is that phenomena that are relevant with respect to current causal-learning interpretations of conditioning and that were difficult to observe in conditioning research because of the use of biologically significant USs, should be easier to demonstrate using the present biologically neutral behavioural preparation. The other implication is that the role of the biological significance component of conditioning cannot be investigated using the present preparation. On the other hand, if the need to separate the role of both components of conditioning is accepted, the present preparation provides a unique opportunity to study the development of associations between neutral events and the conditioning of behavioural responses that are not mediated by the biological significance of the US. Thus, the suppression observed in the present research should be regarded as an index of whether subjects have learned an association between two events, but not as an index of fear or of the transfer of biological significance to the CS.

Another aspect of our procedure also deserves some comment. As previously mentioned, ethical constraints in the use of biologically significant USs with humans prompted us to use a US that was given motivational value through instructions and punishment. In the present experiments, subjects were instructed to stop responding—and were punished if they responded—in the presence of a visual US. Thus, it could be argued that the present research dealt with punishment rather than with Pavlovian conditioning. Note, however, that subjects were not punished for responding during the CS but during the US. Pavlovian learning was evidenced in that subjects progressively suppressed responding, not only in the presence of the US, but also in the presence of the CS that predicted it. Admittedly, this can be interpreted as avoidance learning. However, it is the Pavlovian component (prediction of the US) that we think was in need of a methodological development. Although some studies in the human causal learning tradition had previously used behavioural responses rather than—or in addition to—verbal judgements, to our knowledge the majority of those studies had been concerned with instrumental rather than with Pavlovian conditioning (e.g. Matute, 1995; Shanks & Dickinson, 1991; Wasserman, 1990a;

but see Perruchet, 1985, for a Pavlovian preparation). In our view, the present preparation includes the necessary components for the study of Pavlovian conditioning in humans by allowing simple manipulations of the CS–US contingencies and by making use of a very sensitive dependent variable—suppression ratio—in order to study how behavioural responses are transferred to a CS as a function of such manipulations between CSs and USs. This allows almost any Pavlovian design to be run in human subjects.

As mentioned in the Introduction, more traditional preparations for the study of human Pavlovian conditioning have involved either causal judgements (e.g. Shanks & Dickinson, 1987) or psychophysiological measures (e.g. Hinchy et al., 1995) as dependent variables. The latter offer a non-verbal assessment tool that is probably a more direct estimate of conditioning than is causal judgement, but the former is widely used because it is more convenient and simple. The conditioned suppression preparation that we described is similar to techniques used in animal research and combines the higher reliability of behavioural assessment with the simplicity in application that we think is also important for the development of research.

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Manuscript received 8 August 1995
Accepted revision received 18 March 1996

Une procédure comportementale pour l'étude du conditionnement pavlovien chez l'homme

La suppression conditionnée est une technique utile pour examiner si des sujets ont acquis une association SC-SI (CS-US), mais elle est difficile à utiliser chez l'homme parce qu'elle nécessite l'emploi d'un SI aversif. Le but de cette recherche était de mettre au point une procédure non-aversive induisant la suppression conditionnée. Après avoir appris à appuyer sur la barre d'espacement d'un ordinateur dans le cadre d'un jeu vidéo, les sujets devaient interrompre l'appui chaque fois qu'un SI visuel apparaissait, au risque de perdre des points. Une condition de descrimination A+/B− a été utilisée lors de la première expérience: le SI suivant toujours le stimulus A et jamais le stimulus B. Bien qu'aucune information concernant l'existence des SC n'ait été donnée aux sujets, les rapports de suppression ont révélé une courbe d'apprentissage de la discrimination. En d'autres termes, les sujets apprenaient à supprimer la réponse par anticipation du SI lorsque le stimulus A était présenté, mais pas en cours de présentation du stimulus B. La seconde expérience a exploré le potentiel de cette procédure par l'utilisation de deux instructions différentes et la récolte post-expérimentale des avis au sujet des SC A et B, en plus du calcul du rapport de suppression. Les résultats de ces expériences ont montré que la suppression conditionnée peut être fiablement et aisément utilisée chez l'homme, ce qui permet de jeter un pont entre le conditionnement animal et les jugements de causalité chez le sujet humain.

Una preparción conductual para el estudio del condicionamiento pavloviano en humanos

La supresión condicionada es una útil técnica para evaluar el aprendizaje de asociaciones EC-EI, aunque resulta difícil de aplicar en humanos debido a la necesidad de un EI aversivo. El propósito de esta investigación fue el desarrollo de un procedimiento no aversivo para producir la supresión. Los sujetos aprendían a presionar la barra espaciadora de un ordenador como parte de un videojuego, debiendo suprimir esa respuesta, para no perder puntos, siempre que aparecía un EI visual. En el Experimento 1, se empleó un diseño de discriminación A+/B− : El siempre seguía al estímulo A y nunca al estímulo B. A pesar de que los sujetos no recibían información sobre la existencia del EC, las razones de supresión mostraron una curva de aprendizaje discriminativo; es decir, los sujetos aprendieron a suprimir sus respuestas en anticipación al EI en presencia del estímulo A, pero no en presencia del estímulo B. En el Experimento 2 se analizaron las posibilidades de esta preparción, empleando dos diferentes tipos de instrucciones y evaluando los juicios post-experimento acerca del EC A y del EC B, así como las razones de supresión. Los resultados de estos experimentos indican que la supresión condicionada pueda ser estudiada de forma cómoda y fiable en el laboratorio humano, proporcionando un nexo de unión entre los experimentos de condicionamiento animal y los experimentos sobre juicios de causalidad en humanos.