

EFFECTS OF AVERSIVE CLASSICAL CONDITIONING ON HABITUATION OF UNCONDITIONED SKIN CONDUCTANCE RESPONSE

José L. Marcos
Universidad de La Coruña

Effects of Aversive Classical Conditioning on Habituation of Unconditioned Skin Conductance Response. The purpose of this experiment was to investigate the effect of classical conditioning on the amplitude of the unconditioned response (UR). The conditioned stimulus (CS) was a 340 Hz tone, and the unconditioned stimulus (US) consisted of a white noise with an intensity of 105 dBs. Twenty five subjects were presented with 20 trials of delayed conditioning, with an interval between the CS and the US of 0.5 seconds (s) . A further 25 subjects received the same number of presentations of both stimuli, but in an explicitly randomized order. The dependent variable was the amplitude of the skin conductance response (SCR) elicited by the US on each trial. The results showed that the amplitude of the SCR decreased throughout the acquisition trials in both groups. However, a greater decrease in SCR was observed in the conditioning group. It can be concluded, therefore, that aversive classical conditioning facilitates the habituation of the unconditioned SCR.

El propósito de este experimento era investigar el efecto del condicionamiento clásico sobre la amplitud de la respuesta incondicionada (RI). El estímulo condicionado (EC) era un tono de 340 Hz y como estímulo incondicionado (EI) fue utilizado un ruido blanco con una intensidad de 105 dBs. Veinticinco sujetos recibieron 20 ensayos de condicionamiento diferido, con un intervalo entre el EC y el EI de 0.5 segundos. Otros veinticinco sujetos recibieron el mismo número de presentaciones de ambos estímulos, pero de un modo explícitamente no-correlacionado. La variable dependiente era la amplitud de la respuesta electrodérmica de conductancia suscitada por el EI en cada uno de los ensayos. La amplitud de la respuesta electrodérmica de conductancia disminuyó a lo largo de los ensayos de adquisición en los dos grupos. Sin embargo se constató una mayor disminución de la respuesta electrodérmica en el grupo de condicionamiento. Se concluye, por tanto, que el condicionamiento clásico aversivo incrementa la habituación de la respuesta electrodérmica incondicionada.

Traditionally, the study of the parameters, operations and mechanisms of classical con-

ditioning has been carried out considering the conditioned response (CR) separately and by regarding it as the optimum way of measuring the behavioral manifestation of conditioning. There are fundamentally two theories which have attempted to explain the nature of this response. The theory of the

Correspondencia: José L. Marcos
Departamento de Psicología
Campus de Elviña, s/n. Universidad de La Coruña
15071 La Coruña (Spain)
E-mail: jlmarc@udc.es

“substitution of stimuli” is based on the close similarity which is frequently observed between the CR and the UR. The association between the CS and the US produces a transference of the eliciting capacity of the US to the CS, with the result that the latter ends up provoking the same reflex reaction as the US (Jenkins and Moore, 1973). On the other hand, the CR does not always resemble the UR (Wasserman, 1973), but instead seems to be a “preparatory reaction” from the organism in order to receive the US (Jenkins, Barrera, Ireland, and Woodside, 1978). This preparatory characteristic becomes even more evident in the phenomenon of «compensatory responses», which is seen in some pharmacological conditioning in animals (Siegel, 1990). In such cases, the CR moves in an opposite direction to the UR, compensating for the homeostatic unbalance produced by the administration of the US.

Siegel (1975) has postulated that when drugs are used as the US, the CR very frequently exhibits an opposing nature to the UR. When both responses are superimposed (as occurs in the usual circumstances of the administration of the drugs), the CR reduces the impact of the drug’s UR, considerably decreasing its effect. As far back as 1937, Subkov and Zilov reported that dogs who were repeatedly given epinephrine (each injection caused tachycardia) exhibited a CR of bradycardia. Subsequent research has suggested that the characteristics of the pharmacological CR greatly depend on the nature and mechanism of the effect of the drug (Eikelboom & Stewart, 1982; Paletta & Wagner, 1986; Siegel, 1989).

The SOP model proposed by Wagner (Donegan and Wagner, 1987; Wagner, 1981; Wagner and Brandon, 1990; Wagner and Donegan, 1989) seeks to unify previous points of view, by attempting to explain when the CR will resemble the UR and when it will be opposed. The SOP model describes the UR as biphasic and assumes that the CR nor-

mally reflects the second component of the UR. When the behavioral manifestations of these components are antagonistic, the CR shows itself to be opposite to the UR, producing a decrease in the magnitude of the this UR (conditioned diminution) when presented with the CS-US sequence (Fanselow, 1980; Fanselow and Baackes, 1982; Paletta and Wagner, 1986; etc.). Paletta y Wagner (1986) suggested that the relationship between CR and UR hypothesized by SOP was exemplified in the case of conditioned activity changes produced with injection of morphine as the US. In effect, these authors pointed out that the initial sedation produced by morphine is likely to be followed by a period of hyperactivity and they demonstrated in companion experiments that the conditioned response mimicked the secondary response to morphine (hyperactivity).

However, in other cases, depending on the nature of the UR, the two behavioral components of the UR can be complementary rather than antagonistic (Grau, 1987; Thompson et al., 1984). In these cases, given that both components are of the same sign, the secondary component corresponding to the CR will be added to the two components of the UR, thereby exhibiting a greater magnitude. Studying eyeblink conditioning in the rabbit, Thompson et al. (1984) have shown that the US affects the eyeblink UR through both a relatively direct pathway and a relatively indirect pathway. Both the direct and indirect paths are engaged by the UR: electrical stimulation in appropriate parts of either pathway produces an eyeblink. However there are several lines of evidence indicating that the CR is driven by the indirect pathway. The most unambiguous evidence is that, if an animal is trained to give a conditioned eyeblink response to a CS, lesions in this pathway eliminate the CR and make reacquisition impossible while sparing the UR component that is generated through the direct path.

Problems with predictions based on SOP arise for unconditioned responses that do not have a biphasic characteristic. Such is the case with electrodermal conditioning. The experiments carried out with this preparation by Baxter (1966), Kimmel (1967) and Kimmel and Pennypacker (described in Kimmel, 1966) seem to confirm a deteriorative effect of conditioning on the amplitude of the UR. However, these experiments contain serious methodological faults, such as the fact that the initial reaction to the US may be different in the experimental groups. Consequently, this research does not allow the conditioning effects to be separated from the potential effects of habituation, since relative habituation is inversely related to the intensity of the stimulus (Davis and Wagner, 1968; Groves and Thompson, 1970). Moreover, other parallel research has not been able to reproduce these findings (Grings and Schell, 1971).

The purpose of the present study was to clarify the effect of associative learning on the magnitude of the UR, while explicitly controlling for the possible interference of the process of habituation.

Methods

Subjects

Subjects were 50 undergraduate volunteers, aged 21-30. All received class credit for their participation in the experiment. An additional 26 subjects were rejected for giving SCRs in response to white noise US which went beyond the limits of 0.2 and 0.8 micro-mhos. The inclusion of this criterion in the selection of the sample complies with the aim of obtaining a sample homogeneous in its initial reactivity to the US.

Variables and Design

Subjects were assigned randomly to one of two experimental groups. The indepen-

dent variables were (1) *Learning*, with two levels (associative and non-associative) and (2) *Trials*, with 20 levels. The dependent variable was the amplitude of the SCR elicited by the US on each trial. The *awareness of the CS/US relationship* was controlled by informing the subjects about the CS/US contingency (associative group) and the non-contingency (non-associative group).

The experiment was designed according to a 2 (learning) x 20 (trials) factorial model, with repeated measures on the last factor. The learning factor refers to the presentation of CS-US, either in temporal contiguity (associative) or explicitly uncorrelated (non-associative). The trials factor is determined by the 20 presentations of the CS and US.

Stimulus, Materials and Apparatus

The CS consisted of a 340 Hz tone with an intensity of 65 dB, produced by a Med Associates precision signals generator (ANL). A white noise generator produced loud-noise US with an intensity of 105 dBs, through headphones.

Skin conductance was recorded on a Biopack MP100WS through a constant .5 V bridge (Lykken & Venables, 1971). SCRs were recorded from Beckman silver-silver chloride electrodes filled with isotonic electrode paste (Grass EC33) and attached with adhesive collars to the medial phalanges of the second and third fingers of the subject's right hand.

Stimulus durations for the tone (0.5 s) and for the white noise US (0.4 s) were controlled by Electronic Developments Tachistoscope timers. Intervals between the trials varied randomly between 25 s and 35 s.

Procedure

The experiment consisted of four parts.

- a) Phase of adaptation to the experimental situation: Once the apparatus had been connected and the electrodes had been attached, subjects were told that the purpose of the experiment was to measure consistency over time in response patterns to blasts of white noise. To be more specific, subjects in the associative learning group were told about the CS-US contingency and were informed that after hearing a tone, they would experience a blast of white noise of high intensity. Subjects of the non-associative learning group were informed that the two stimuli would be administered randomly and without any type of association. Then a demonstration trial took place. This was done with the intention that they should feel calm and relaxed, so that their level of activation should decrease and would therefore not affect the subsequent electrodermal reading. The SCR was recorded for 3 or 4 minutes until it stabilized.
- b) Phase of habituation of the orienting reflex (OR) elicited by the stimulus to be conditioned: The aim was to eliminate the possible OR produced by the stimulus that was going to be conditioned (tone), by means of its repeated presentation. And thus the aim was to avoid possible interference with the UR in the first few trials.
- c) Acquisition phase: Twenty trials were carried out in this phase. In the associative learning group, the CS was followed by the US (*delayed conditioning*). The non-associative learning group received the same number of presentations of these stimuli, but they were uncorrelated and there was an average interval of 15 s between each stimulus.

In order to detect the CR in the associative learning group it would be necessary to include CS-alone trials (i.e., trials without the US). An important methodological objection to using CS-alone test trials is that in the paired arrangement these CS-alone test trials constitute a change from paired CS-US trials in a way that is not reflected in the unpaired (control) condition. The greater responding to the CS-alone test trials in the paired (experimental) condition may be due to reinstatement of the orienting response rather than "true" conditioning. In the present research, the use of a brief CS-US interval with presumed overlapping conditioned and unconditioned responses precludes direct assessment of the CR. For these reasons, acquisition of the CR was not measured but, was simply assumed to progress normally across the 20 CS-US trials.

Dependent Variable

SCR was defined as the maximum deflection occurring 1 - 4 s after US onset and was measured in micro-mhos. The unconditioned SCRs obtained in the acquisition phase were only considered in the later analysis.

Results

Prior to other types of analysis, the values of the amplitude of the first UR of both groups were compared, to determine whether the two groups were homogeneous in their initial reactivity. A rejection region of $p < .05$ was adopted. The Student *t* - Test ($p = .1282$) indicated the absence of a significant difference between the groups.

For reasons discussed by Venables and Christie (1980), SCR amplitude was logarithmically transformed to normalize the distributions prior to analysis. Previously, to avoid a value of 0 log, as well as the log of amplitudes lower than 1 micromho (which

would be negative), I is conventionally added to all SCRs amplitude scores. Thus, the data are expressed in terms of $\log(I + SCR \text{ amplitude})$. These amplitude data were then range corrected by dividing each response by the maximum response for each subject (Lykken, 1972). The obtained values represent the electrodermal change in relation to the maximum value of this subject, allowing us to compare the electrodermal values across subjects, independent of their initial reactivity to the US. The obtained values ranged between 0 and 1. In order to avoid operating with such small values, the resulting values were multiplied by 1000.

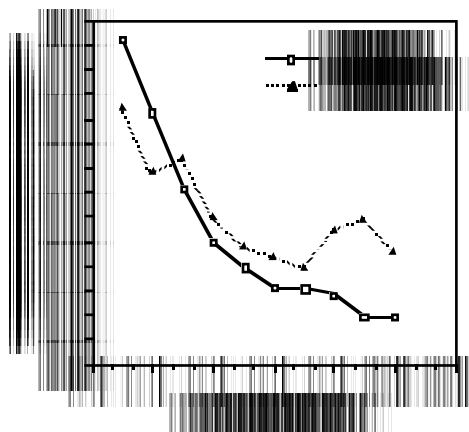


Figure 1. Evolution of the amplitude of the SCRs over the 20 presentations of the US in the associative learning group (paired CS/US) and in the non-associative learning group (unpaired CS/US).

The factors included in the analysis were *learning* (associative vs. non-associative) and *trials*. Because the sphericity assumption of repeated measurement ANOVAs is likely to be violated by the present type of data, Greenhouse-Geisser probability levels were used when testing effects involving the trials factor (Kirk, 1968). The nominal degrees of freedom are stated together with the epsilon correction factor (Jennings, 1987) yielded by the statistical software SUPERANOVA.

SCR data from the associative and non-associative groups was subjected to a 2 x 20 (groups x trials) ANOVA with repeated measures on the trials. A significant effect of the learning factor on the amplitude of the unconditioned SCRs was not found: $F(1) = 1.058, p > .05$. The effect of the trials was highly significant: $F(19) = 26.958, p = .0001$. The interaction of the learning factor with the trials also turned out to be significant: $F(19) = 4.155, p = .0001, e = 0.412$.

Discussion

Contrary to what was expected, no significant differences appear in the amplitude of the SCR between the associative and non-associative learning groups. Two interrelated reasons appear to explain this result: the first is the range corrected transformation of the amplitude of SCRs; this transformation converts the values of absolute amplitude into values of relative amplitude. The second reason is the different temporal pattern exhibited by the amplitude of the SCRs in both groups, which causes a compensation of the initial values with the final values, producing nonsignificant differences between the values of both groups.

The deteriorative effect of the CS-US trials on the amplitude of the UR is consistent with the results obtained by Baxter (1966), Kimble & Ost (1961), Kimmel (1967), Kimmel & Pennypacker (described in Kimmel, 1966) and Morrow (1966). This effect appears in the two groups, which could be interpreted as the result of a non-associative process of habituation to the UR.

However, the purpose of this work was to find out whether the process of classical conditioning affected the magnitude of the UR. Concerning this point, the interaction of the type of learning with the conditioning trials reveals that the effect of the conditioning trials on the amplitude of the UR is

modulated by the associated or non-associated presentation of the CS and US. This phenomenon is easily confirmed by observing the tendency followed by the amplitude of the URs in each group. This result permits the assertion that, in addition to a process of habituation, a process of associative learning is involved in the reduction of the amplitude of the UR, at least in these kinds of preparations of SCR aversive conditioning. Moreover, the tendency of the magnitude of the UR to decrease throughout the acquisition trials in an opposite direction to the standard learning curve adds more arguments to this interpretation. In effect, as the conditioning increases, the magnitude of the UR decreases to the same proportion, which seems to indicate an opposition between the CR and the UR.

It is widely recognized that a signaled US is generally less effective than a unsignaled US, for it produces a weaker UR (Donegan, 1981; Wagner & Donegan, 1989) and, therefore, is more likely to result in habituation (Davis & Wagner, 1968; Groves & Thompson, 1970).

In this experiment, subjects of the associative learning group were explicitly told that the US would immediately follow the termination of the CS; on the contrary, subjects of the non-associative learning group were instructed that the two stimuli would appear randomly. However, the two groups did not differ in the amplitude of their first UR. These considerations lead to the conclusion that the deteriorative effect of the CS (signaling stimulus of the US) on the amplitude of the UR in the associative learning group should be attributed to an associative process, rather than to a cognitive or relational learning process.

In general terms, the results of this work are partially consistent with the predictions of Wagner's STM and SOP models (Donegan & Wagner, 1987; Wagner, 1978, 1981; etc.), concerning the associative bases of the habituation of the UR. The monophasic nature of the SCR prevents a complete adaptation of these results to the SOP model and suggests the necessity of additional research in order to determine the mechanisms which are responsible for the conditioned diminution of the UR.

Referencias

- Baxter, R. (1966). Diminution and recovery of the UCR in delayed and trace classical GSR conditioning. *Journal of Experimental Psychology*, 71, 447-451.
- Davis, M., and Wagner, A. R. (1968): Startle responsiveness after habituation to different intensities of tone. *Psychonomic Science*, 12, 337-338.
- Donegan, N. H., and Wagner, A. R. (1987). Conditioned diminution and facilitation of the UR: a sometimes opponent-process interpretation. In I. Gormezano, W. F. Prokasy & R. F. Thompson (Eds.), *Classical conditioning III*. Hillsdale, N.J: Erlbaum.
- Eikelboom, R., and Stewart, J. (1982). Conditioning of drug-induced physiological responses. *Psychological Review*, 89, 507-528.
- Fanselow, M. E. (1980). Conditional and unconditional components of post-shock freezing. *Pavlovian Journal of Biological Science*, 15, 177-182.
- Fanselow, M. E., and Baackes, M. P. (1982). Conditioned fear-induced opiate analgesia on the formalin test: evidence for two aversive motivational systems. *Learning and Motivation*, 13, 200-221.
- Grau, J. W. (1987). The central representation of an aversive event maintains opioid and nonopioid forms of analgesia. *Behavioral Neuroscience*, 101, 272-288.
- Grings, W. W., and Schell, A. M. (1971). Effects of trace versus delay conditioning, interstimulus interval variability, and instructions on

- UCR diminution. *Journal of Experimental Psychology*, 90, 136-140.
- Groves, P. M., and Thompson, R. F. (1970). Habituation: a dual-process theory. *Psychological Review*, 77, 419-450.
- Jenkins, H. M., and Moore, B. R. (1973). The form of the autoshaped response with food or water reinforcers. *Journal of the Experimental Analysis of Behavior*, 20, 163-181.
- Jenkins, H. M., Barrera, F. J., Ireland, C., and Woodside, B. (1978). Signal-centered actions patterns of dogs in appetitive classical conditioning. *Learning and Motivation*, 9, 272-296.
- Jennings, J. R. (1987). Editorial policy on analysis of variance with repeated measures. *Psychophysiology*, 24, 474-475.
- Kimble, G. A., and Ost, J. W. P. (1961). A conditioned inhibitory process in eyelid conditioning. *Journal of Experimental Psychology*, 61, 150-156.
- Kimmel, E. (1967). Judgments of UCS intensity and diminution of the UCR in classical GSR conditioning. *Journal of Experimental Psychology*, 73, 532-543.
- Kimmel, H. D. (1966). Inhibition of the unconditioned response in classical conditioning. *Psychological Review*, 73, 232-240.
- Kirk, R. E. (1968). *Experimental design: Procedures for the behavioral sciences*. Belmont: Brooks/Cole.
- Lykken, D. T. (1972). Range correction applied to heart rate and GSR data. *Psychophysiology*, 4, 437-442.
- Morrow, M. C. (1966). Recovery of conditioned UCR diminution following extinction. *Journal of Experimental Psychology*, 71, 884-888.
- Paletta, M. S., & Wagner, A. R. (1986). Development of context-specific tolerance to morphine: Support for dual-process interpretation. *Behavioral Neuroscience*, 100, 611-623.
- Siegel, S. (1975). Evidence from rats that morphine tolerance is a learned response. *Journal of Comparative and Physiological Psychology*, 89, 498-506.
- Siegel, S. (1989). Pharmacological conditioning and drug effects. In A. J. Goudie & M. W. Emmett-Oglesby (Eds.), *Psychoactive drugs: tolerance and sensitization. Contemporary neuroscience*. Clifton, NJ: Humana Press.
- Siegel, S. (1990). Classical conditioning and opiate tolerance and withdrawal. In D. J. K. Balfour (Ed.), *Psychotropic drugs of abuse. International encyclopedia of pharmacology and therapeutics, Section 130*. Elmsford, NY: Pergamon Press.
- Thompson, R. F., Donegan, N. H., Clark, G. A., Lavond, D. G., Lincoln, J. S., Madden, J., Mamounas, L. A., Mauk, M. D., McCormick, D. A., and Thompson, J. K. (1984). Neural substrates of learning memory: a "multiple-trace" view. In G. Lynch, J. L. McGaugh & N. M. Weinberger (Eds.), *Neurobiology of learning and memory*, (pp. 137-164). New York: The Guilford Press.
- Venables, P. H., and Christie, M. J. (1980). Electrodermal activity. In I. Martin & P. H. Venables (Eds.), *Techniques in psychophysiology*. New York: Wiley.
- Wagner, A. R. (1978). Expectancies and the priming of STM. In S. H. Hulse, H. Fowler & W. K. Honing (Eds.), *Cognitive aspects of animal behavior* (pp.177-209). Hillsdale, NJ: Erlbaum.
- Wagner, A. R. (1981). SOP: a model of automatic memory processing in animal behavior. In N. E. Spear & R. R. Miller (Eds.), *Information processing in animals: memory mechanisms*. Hillsdale, NJ: Erlbaum.
- Wagner, A. R., and Brandon, S. E. (1990). Evolution of a structured connectionist model of Pavlovian conditioning (AESOP). In S. B. Klein & R. R. Mower (Eds.), *Contemporary learning theories*. Hillsdale, N.J: Erlbaum.
- Wagner, A. R., and Donegan, H. S. (1989). Some relationships between a computational model (SOP) and an essential neural circuit for Pavlovian (rabbit eyeblink) conditioning. In R. D. Hawkins & G. H. Bower (Eds.), *The psychology of learning and motivation*. Vol. 22: *Computational models of learning in simple neural systems*. Orlando: Academic Press.
- Wasserman, E. A. (1973). Pavlovian conditioning with heat reinforcement procedures stimulus-directed pecking in chicks. *Science*, 181, 875-877.

Aceptado el 6 de agosto de 1997

