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EFFECTS OF FEEDBACK STIMULUS IN FEAR CONDITIONED WITH ESCAPABLE AND INESCAPABLE SHOCKS IN RATS

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We have studied the effect of feedback on escape-avoidance training as an immunization against learned helplessness created by inescapable and unpredictable schoks. In the first phase of the experiment, the rats were trained with predictable and controllable stimuli. The animals that achieved the criterium (level press in 80% of the trials during the last 10 trials with and RF-2 reinforcement schedule) were assigned at ramdom to one of the five groups to perform helplessness training: one predictable and controllable (Group E), three unpredictable and uncontrollable (Group I, Group I-S1 with stimulus feedback in all trials, and Group I-S2 with stimulus feedback in 50% of trials), and the control group (Group C). In the test phase, all groups were trained in predictable and controllable events (lever press RF-2). The groups E and I-S2 showed no differences in latency of response, but there were differences between these two groups and the others. Group I showed the most latency of response and difference from the other groups. These results suggest that the effect of fedback at 50% more effectively modulates the effects of helplessness produced by unpreditable and inescapable shocks.

El efecto de los estímulos feedback en el miedo condicionado con descargas escapables e inescapables en ratas. Se ha estudiado el efecto del feedback sobre el entrenamiento de escape-evitación como forma de inmunizar contra la indefensión aprendida generada por exposición a descargas inescapables e impredecibles. En la primera fase del experimento, las ratas fueron entranadas con estímulos predecibles y controlables. Los animales que alcanzaron el criterio (presión de la palanca en el 80% de los ensayos durante los últimos 10 ensayos, con un programa de refuerzo RF-2) fueron asignados aleatoriamente a cada uno de los cinco grupos para recibir entrenamiento en indefensión: un grupo predecible y controlable (Grupo E), tres grupos impredecibles e incontrolables (Grupo I, Grupo I-S1 con estímulo feedback en todos los ensayos y grupo I-S2 con estímulo feedback en el 50% de los ensayos), y el grupo control (Grupo C). En la fase de prueba, todos los grupos fueron entrenados en sucesos predecibles y controlables (presión de palanca RF-2). Los grupos E y I-S2 mostraron significativamente menor latencia de respuesta que el resto de los grupos, pero no diferían entre sí. El grupo I mostró significativamente mayor latencia de respuesta que el resto de los grupos. Estos datos sugieren que el efecto del feedback al 50% modula de forma más efectiva los efectos de la indefensión producida por las descargas impredecibles e inescapables.

Animals wich receive prior inescapable shocks generally take longer to escape shock in subsequent shock escape tasks than animals which have first received either escapable or no shocks.

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Learned helplessness theory proposed that the retarded learning often observed after exposure to uncontrollable shock is due to the subject's learning that their responses and the reinforcement are unrelated (Maier and Seligman, 1976). This effect obtained employing exposure to uncontrollable events have been termed «interference effects» (Weis, 1971). Learned helplessness theory holds that the interference effect arises because subjects learn that shock termination is independent of their responding (Maier and Seligman, 1976). This learning may then generalize to other situations involving shock, where it is presumed to decrease motivation to escape and decrease ability to associate responses and outcomes.

Several alternative theories have been proposed to account for these interference effects. More recent hypotheses, attribute the differential effects of inescapable and escapable shock to their anxiety. This interpretation are based on the premise that inescapable shock is more fear-inducing than is escapable shock (Warren, Rosellini and Maier, 1989).

The notion that learning about the relationship between behavior and outcomes may affect the acquisition of later operant responses suggests a means to prevent «immunize against» the interference effect of exposure to inescapable shock (Troisi, Bersh, Stromberg and Mauro, 1991).

Recently, there has been a great deal of research done on the prophylactic mechanisms that reduce conditioned fear. For example, account researches have used different techniques, such as the presentation of predictable stimuli (Jackson and Minor, 1988; Vicente, Ferrandiz y Pardo, 1991); immunization phases prior to inescapable shocks (Ferrandiz, 1989; Ferrandiz and Pardo, 1991; Troisi, Bersh, Stomberg and Mauro, 1991); certain drugs (Drugan, Ryan, Minor and Maier, 1984; Fansenlow and Helmestetter, 1988; Maier, 1990); application of feedback stimuli (Warren, Rossellini and Maier, 1989), etc.

What seems clear is that feedback applied contingent to the subject's response has a beneficial effect after an inescapable shock, and/or feedback applied after an inescapable shock (Galvani and Twitty, 1978; Jackson et al., 1988; Minor, Traumer, Lee and Dess, 1990; Rescorla and Lolordo, 1965). Although the theoretical interpretations of this subject are various, they all agree on the influence of feedback in reducing conditioned fear resulting from an inescapable shock. The differences between the escapable and inescapable groups seem due to the presence vs. absense of feedback rather than to the variable control «per se».

Weis (1971) attributed differences found between the rats exposed to escapable shock, and the ones exposed to inescapable shocks, to the fact that the former exert some behavioral control over the shock which generated «relevant feedback». These propioceptive stimuli acquired fear-inhibiting properties because of their association with shock termination, and safety periods. The «relevant feedback» hypothesis has been studied by numerous authors. Mineka, Cook and Miller (1984) proved that a short signal presented after each inescapable shock mitigated the conditioned fear to electric shock, and as a result the subjects behaved approximately like the ones exposed to escapable shock (Jackson and Minor, 1988; Minor, 1990). The feedback hypothesis is very close to the theories that explain the effects of uncontrollability in terms of fear or anxiety.

Minor et al. (1990) presented a signal a few seconds before the end of the inescapable shock, and found that the subjects behaved like the control group which was not exposed to the shock. Fear reduction was a result of the presence of an external stimulus that later acquires fear inhibiting properties, because it signals to the subjects a following resting period and therefore mitigates anxiety.

Maier and Keith (1987) and Mineka et al. (1984) give a different explanation. They propose that the presentation of a stimulus immediately after an inescapable shock serves as a distractor, which interrupts the information about the independence between responding and the shock termination, therefore subjects do not suffer the learned helplessness effect. This hypothesis, which we call «distractor hypothesis» has been discussed nevertheless by numerous authors, such as Minor et al. (1990). Maier (1989) also suggested that the presentation of a stimulus after an inescapable shock alters the subject's attention and interferes with associative skills. Whichever stimulus associated with an inescapable shock would benefit rather than interfere with associative skills.

Another explanation of learned helplessness is the «conditioned innattention hypothesis». According to Lubow, Wainner and Shur (1981) organisms learned that events without a predictive relation turn out to be irrelevant. In the first phase of learned helplessness, the subjects' responses to the uncontrollable stimuli become irrelevant, and therefoe they stop giving responses in the later tasks phase. Lubow (1989) proposed that any event correlated with an inescapable shock can mitigate the learned helplessness effect. Animals exposed to a feedback stimulus shortly after an inescapable shock respond like animals exposed to escapable shocks because they keep paying attention to the feedback stimulus.

Overmier (1988) proposed the «modulator analysis hypothesis» as an explanation for inhibition. The exposure to unsignaled and inescapable shocks generates a baseline of intense chronic fear that causes subsequent performance deficits. From this point of view, any added variable during the pre-treatment reduces the intensity of fear, and serves as an effective modulator of the helplessness effects. This explanation is closely linked to the relevant feedback hypothesis.

On the other hand, there is the «neurochemical hypothesis». According to this hypothesis, feedback prevents neurotransmitter deficits that affect later learning processes (Volpicelli, Ulm and Alternor, 1984; Weis, 1971).

Focusing on this last perspective, we could direct our attention to the hypothesis suggesting that organisms exposed to inescapable shocks exhibit profound hypoalgesia dificits, contrary to the results shown by control and escapable groups (Stuckey, Marra, Minor and Insel, 1989); therefore, the feedback groups would show hyperalgesia. The groups exposed to inescapable shocks showed profound hypoalgesia and gave no avoidance responses to the aversive stimulus during the second phase of the experiment.

The present study has been devised, in the first place, to explore the existence of significant differences between escapable and inescapable groups; in the second place, to explore whether feedback mitigates the inescapable shock effects and subsequently will reduce the amount of conditioned fear, causing the subjects to respond as the escapable groups; in the third place, whether there are significant differences between the two feedback groups and which of the two had a better performance. We have also proposed a hypothesis that better explains the beneficial effects of feedback.

One of the problems found in this kind of experiment is what measures should be chosen for the learned helplessness deficit: the absence of any response, number of responses in later learning trials, escape latencies, etc. Escapable latencies were selected to measure the effects generated by uncontrollability rather than by unpredictibility and because slow scape response reflect a lack of conviction concerning the response/reinforcer contingent.

Method

Subjects

Twenty five male Wistar rats (Charles River) of 90 days of age at the beginning of the experiment, were obtained from Interfauna Ibérica, S.A. (Barcelona). The animals were housed in individual cages, with free access to food and water, in a colony room maintanined at constant temperature (21_1 °C), and 12:12-hr light/dark cycle.

Apparatus

The experiment was performed in eight identical (280x233x310 mm) operant conditioning Skinner boxes (Letica LE-836). The opposite wal and the top of the chambers were made of transparent plexiglass, one front wall was of opaque plastic and the other of modular aluminum plates. The metal one had one lever placed on the right side at 8 cm from the top, and a central food disposer. The floor consisted of 20.4 mm diameter stainless steel rods connected in groups of 6 in order to deliver the scrambler shocks. The grid floor was connected to a shock generator (LE 100-26) computer-controlled designed to produce a direct current of between 0-3.5 mA. The boxes were placed in sound-attenuating enclosure containing an exhaust fan which generated a white noise of 62 dB SPL at 24 V. During the experiment, the boxes were constantly illuminated by a 6 V regulable fluorescent light. An 80 dB 1250 Hz tone was delivered from a speaker located at the top (Oscilatore Sweep IX, Nuova Electronica). The 24 V white light in the Skinner box served as a feedback signal after the shock termination. Experimental events were automatically controlled by a computer.

Procedure

The experiment was divided into three phases: a) Predictable and controllable responses training phase; b) Learned helplessness training phase; b) Predictable and controllable training phase.

a) Predictable and controllable responses training phase: Rats were placed in the boxes 10 min prior to the begenning of the trials to allow them to explore the environment freely. They were exposed to a 5 sec tone followed by a 5 sec silent period. Subsequently, a 1 mA shock was applied to the grid floor during a maximun of 30 sec. rats could escape by pressing the lever according to a FR-2 schedule. Shock terminated automatically if the appropiate operant response was not met within 30 sec of shock onset.

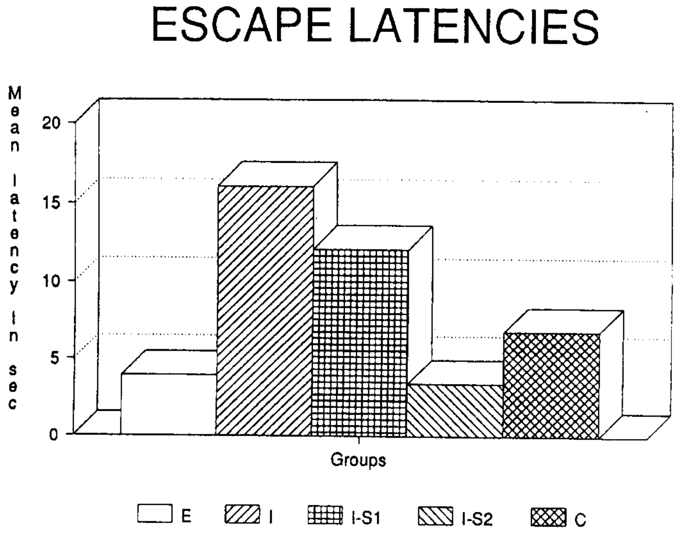
Rats performed a total of 80 trials presented on a random 51 sec mean-time.

The learning criteria was met if the rats performed at least 80% of the operant response during the last 10 trials. Only 65% reached this criteria.

b) Learned helplessness training phase: The rats were assigned randomly to groups of 5 subjects each (n=5): Group E (escapable shock); three yoked groups: Group I (inescapable shock); Group I-S1 (inescapable shock followed by a feedback stimulus (a 24 V white light was presented for 10 sec in 100% of the trials); Group I-S2 (inescapable shock followed by a feedback stimulus (a 24 V

Figure 1

Mean lever press FR-2 escape latencies for groups previously given escapable shock (E), inescapable shock followed by a stimulus in 100% of the trials (I-S1), inescapable shock followed by a stimulus in 50% of the trials (I-S2), control group (C).



white light was presented for 10 sec in 50% of the trials); and a Group C (control group).

All the subjects were allowed to explore the box freely for 10 min prior to the beginning of the trials. All groups performed a total of 80 trials presented on a random 51 sec mean-time.

That day, groups I, I-S1 and I-S2 performed the learned helplessness training. Group I was exposed to 80 1 mA inescapable shocks of 10 sec duration; Group I-S1 was exposed to 80 1 mA inescapable shocks of 10 sec duration followed by a 24 V white light feedback signal per trial; Group I-S2 was exposed to 80 1 mA inescapable shocks of 10 sec duration followed by a 24 V white light feedback signal in 50% of the trials. The selection of the trials with feedback stimulus was randomly. In the trials without stimulus feedback, the intertrial interval was iniciated when the footshock finished. In the trials with feedback stimulus the intertrial interval was iniciated when the light of feedback stimulus finished.

During this phase, Group E was exposed to 80, 1 mA escapable shocks of 10 sec maximun duration if rats did not escape, and the Group C (control group) stayed in the box the same amount of time as the rest of the groups without any treatment.

c) Test phase. Subjects were tested for escape-avoidance performance. That is, they were placed in the boxes 10 min prior to the beginning of the trials to allow them to explore the environment freely. They were exposed to a 5 sec tone followed by a 5 sec silent period. Subsequently, a 1 mA shock was applied to the grid floor during a maximun of 30 sec. The rats could avoidance the footshock by pressing the lever during the 5 sec of tone and the 5 sec of silent period according to a FR-2 schedule or escape during the shock period by pressing the lever according to a FR-2 schedule. Shock terminated automatically if the appropiate operant response was not met within 30 sec of shock onset.

Rats performed a total of 80 trials presented on a random 51 sec mean-time.

Latency response periods were registered here. If rats did avoidance, the latency resposte registered was 0 sec.

The boxes were cleaned with water and soap after each animal experimental sesion in the three phases.

Data was statistically analyzed by repeated measures ANOVA (BMDP 2V program). The multiple comparison Scheffé method was utilized. The statistical significance criterion was p<.05.

Results

Figure 1 shows the mean values of the latency responses in the diferent groups.

The results show that groups differ significantly in the latency response mean time (F (4,1995) = 2.81, p<.05).

Table I shows the multiple comparison results calculated between the mean values of each pair of groups. There we can see that group E and group I-S2 behaved in a similar way but differently than the rest (they show shorter latency responses). On the contrary, group I differs from all the rest (it shows longer latency escape responses). Group C differs from groups I and I-S2, and group I-S1 differs only from group I (it had a shorter escape latency).

Discussion

Escape latencies after an inescapable shock were used as motivational deficit measures. Our results show that the group exposed to escapable shocks present shorter latency responses than the groups exposed to inescapable shocks. Nevertheless, the variable of control «per se» is not the only one responsible for the amount of learned helplessness that organisms show in later performace tests. The exteroceptive stimulus presented immediately after the inescapable shocks, that acted as feedback, mitigate the learned helplessness deficits; there are significant differences between these groups and the group exposed to inescapable shock without feedback; the latency responses were shorter in the escapable groups with feedback than in the one without feedback in the third phase (Jackson et al. 1988; Minor et al. 1988).

The most interesting fact in this experiment was examining the mechanisms responsible for making an extero-

Table I

Pair comparisons between mean «latency response» values of each group. The central values indicate the probability (Scheffé) asociated with each comparison (n.s. no significant, p >.10). Group E (escapable shock), Group I (inescapable shock), Group I-S1 (inescapable shock followed by a stimulus in 100% of trials), Group I-S2 (inescapable shock followed by a stimulus in the 50% of trials).

	E	I	I-S1	I-S2	C
I	01		01	01	01
I-S1	01	01		01	01
I-S2	n.s	01	01		01
C	01	01	01	01	

ceptive stimulus, presented after an inescapable shock and reducing the learned helplessness deficits (shorter latencies responses showed in the third phase). A explanation for this is that the feedback stimulus, as well as the escape response, can partially reduce fear of exposure to a shock that otherwise would have continued after the shock termination, due to the fact that the feedback stimulus is an excellent predictor, signaling to the subject that a resting period without a shock will follow; in other words, it acts as a safety signal informing that it can relax for a brief period of time, thereby mitigating the amount of anxiety. As Mineka et al. (1985) propose, feedback stimulus acquires fear-inhibiting properties.

Another alternative briefly exposed in the introduction is the one in which the feedback stimulus acts as a distractor (Maier et al. 1987) interrupting the memory processes and the information about the absence of relationship between responses and shock termination.

The previous explanations are also valid for interpreting part of our data, that is, the differences found between the inescapable group and the two inescapable groups with feedback; however, they are not conclusive when trying to explain the most interesting data of our experiment: the differences between the inescapable groups with feedback. As stated in the introduction, we proposed two groups with feedback; in one of them we applied the feedback stimulus in 100% of the trials, that is, after each shock termination, a signal followed; in the other group, we presented the feedback stimulus in 50% of the trials. According to the previous theories espoused before, the group with feedback in 100% of trials should have performed better than the group with 50% of feedback in the third phase. However, our results are totally different. The escapable group and the inescapable group with 50% of feedback behaved practically the same, without statistically significant differences, these two groups being the ones with shorter latency responses, followed by the control group. One of the posible explanations for this account, is that the feedback stimulus present in 50% of the trials act as a posible reinforcer in an intermitent or partial schedule, signaling a security period to the subject. Therefore, it performs better than the group with feedback in 100% of the trials, due to the fact that in the first group, extinction would be more resistent. Morris (1975) proved that feedback stimuli acquire reinforcement properties.

If we interpreted our data in accordance with the distractor hypothesis, we could say that in the group with 100% of feedback, some habituation to the stimulus feedback should have ocurred; this phenomenon does not occur in the groups with 50% feedback. Therefore, the feedback stimulus in the first groups stops accomplishing its function of interrupting the information about the independence between responding and the shock termination. This does not happen to the second group, and therefore this is the reason why the subjects who received 50% of feedback performed better than the ones with 100%. We could propose the same argument for the conditioned innattention hypothesis.

However, our data rejects the relevant feedback hypotesis, because, according to it, subjects with 100% feedback should have performed better than the ones with 50% feedback, due to the fact that in the second group the feedback stimulus does not strictly act as a «security signal», but it does in the group with 100% feedback.

Finally, we want to stress that our data is closer to the distractor hypothesis and to the conditioned innattention hypothesis.

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