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Transfer of Conditioning in Stress-Induced Analgesia

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OLIVERIO, A., C. CASTELLANO AND F. PAVONE. *Transfer of conditioning of stress-induced analgesia.* PHARMACOL BIOCHEM BEHAV 25(1) 181–183, 1986.—Classical conditioning of stress-induced analgesia (SIA) resulted in higher tail flick latencies in BALB/c mice. Transfer of classical conditioning of SIA was evident when the same repetition rate (pulsed light or pulsed tone) characterized stimuli in different sensory modalities. This finding is discussed in terms of opioid production and of generalization of emotional reactions.

Stress-induced analgesia Classical conditioning Transfer Mice

TRANSFER of learning is a particular type of generalization based on the attachement of old responses to new stimuli. Transfer to a subsequent task is a decreasing function of the difference between the original and new stimuli [2,10].

Transfer of responding has been assessed within different learning tasks [11] or within the same task. In the latter case a positive transfer between stimuli in different sensory modalities was evident within avoidance conditioning when stimuli of the same repetition rate (pulsed light or pulsed tone) were employed [6,7]. These findings indicated that the brain is able to decode different stimuli which share a common element.

It has previously been demonstrated that stress-induced analgesia may undergo to naloxone-reversible classical conditioning [3,8]. However, while there are a number of studies on transfer processes within instrumental learning and discrimination [4,6], there is no evidence that classical conditioning involving autonomic or central peptidergic mechanisms may undergo to transfer. This latter point could be of particular interest since it might explain a number of generalized responses within emotional behavior. Therefore in the present study we decided to assess if analgesic responses elicited by a given conditioned stimulus may also be evoked by other conditioned stimuli, e.g., undergo to transfer. Our findings indicate that transfer was evident when acoustic or visual stimuli were characterized by the same repetition rate (pulsed light or pulsed tone), as previously demonstrated for discriminative learning.

METHOD

The testing apparatus consisted of a white plastic box (20×10 cm) with a grid floor, through which an inescapable 5 sec continuous footshock (1.5 mA) could be administered. Classical conditioning was based on the footshock as unconditioned stimulus (US), preceded and overlapped by a 6 sec conditioned stimulus (CS). The CS were: continuous light (10 W); pulsed light (10 W pulsed at 3 cps); continuous tone (30 dB, 3000 cps); pulsed tone (30 dB, 3000 cps pulsed at 3 cps). Different groups of 8 mice were subjected to 5 consecutive sessions (sessions 1–4: 1 hr; session 5: 1/2 hr) in the apparatus.

The occurrence of transfer of conditioning of stress-induced analgesia between stimuli in different sensory modalities, was investigated by using an experimental procedure involving three different types of schedules, followed by a test for tail-flick analgesia (see Table 1).

1. In order to assess the effect of a given stimulus, mice were exposed during 5 sessions to a visual or an acoustic stimulus, namely a continuous (L) or pulsed (pL) light, or continuous (T) or pulsed (pT) tone (control groups).

2. In order to assess the effect of different conditioned stimuli in producing classically conditioned tail-flick analgesia, mice were subjected to four classical conditioning sessions in which the Cs were L, pL, T or pT respectively; on day 5 the animals were subjected to the Cs only (conditioned groups).

3. In order to assess transfer of classically conditioned tail-flick analgesia, mice were given four conditioned sessions (as in group 2); on day 5 transfer to a CS in a different sensory modality was carried out (transfer groups).

In addition another group was kept in the apparatus for five consecutive days in absence of stimuli.

Transfer of conditioning of stress-induced analgesia was assessed by comparing the performance of a group of mice conditioned with a pulsed CS (sessions 1–4) and shifted during session 5 to a pulsed stimulus in a different sensory modality (pL+s to pT; pT+s to pL), to the performance of another group of mice conditioned with a pulsed stimulus (sessions 1–4) but shifted during session 5 to a continuous stimulus (pL+s to T; pT+s to L). The amount of transfer

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TABLE 1

TYPES OF SCHEDULES DURING SESSIONS 1–5 AND TAIL-FLICK LATENCIES (TFL) MEASURED FOLLOWING SESSION FIVE

A. Control Groups			B. Conditioned Groups			C. Transfer Groups		
Sessions			Sessions			Sessions		
1–4	5	TFL ± SE	1–4	5	TFL ± SE	1–4	5	TFL ± SE
L	L	8.2 ± 0.4	L + s	L	21.7 ± 2.3	L + s	T	7.9 ± 0.6
pL	pL	11.1 ± 1.4	pL + s	pL	24.0 ± 0.7	pL + s	pT	16.4 ± 1.8
T	T	11.3 ± 1.0	T + s	T	25.5 ± 2.3	T + s	L	9.7 ± 1.1
pT	pT	9.7 ± 1.3	pT + s	pT	25.0 ± 1.8	pT + s	pL	24.5 ± 2.6
						pL + s	T	10.6 ± 0.6
						pT + s	L	8.3 ± 1.2

ANOVA showed no significant differences ($p>0.05$) among the four (column A) control, $F(3, 28) = 1.582$, and among the four (column B) conditioned, $F(3.28) = 0.736$, groups. Taken in the whole the TFL of the four classically conditioned groups were significantly different from those of the four control groups, $F(7, 56) = 22.575$ $p<0.001$. The Duncan multiple range test showed that TFL of each group of mice subjected to classical conditioning with different CS were significantly higher than those evident in the corresponding control group ($p<0.001$).

Transfer of conditioning was evident only in those groups in which different stimuli characterized by the same repetition rate (pL or pT) were used (Column C). On the contrary no transfer was evident between continuous light (L) and continuous tone (T) and vice versa (see the Results section).

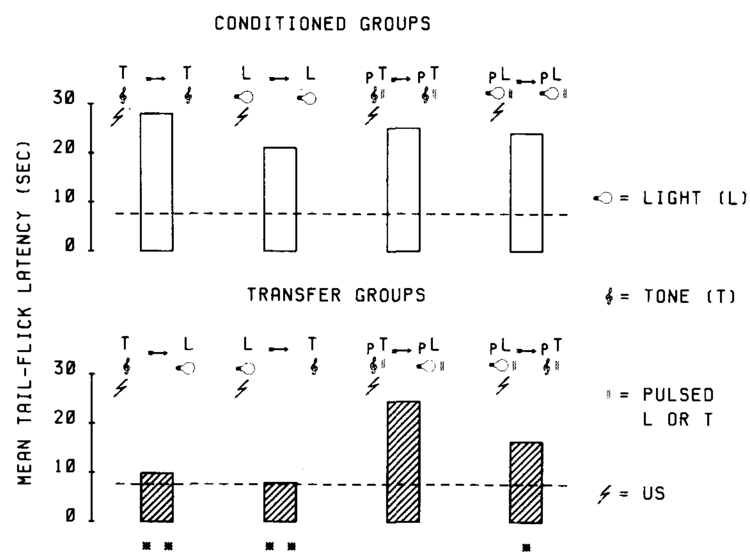

FIG. 1. Mean tail-flick latencies of different groups of mice subjected to classical conditioning (conditioned groups) or to transfer of conditioning (transfer groups). The symbols above the columns indicate the schedule adopted: the first symbol refers to the CS and US stimuli used in sessions 1–4; the second symbol refers to the CS used during session 5, which was followed by the tail-flick test. The broken line refers to the mean tail-flick latency of a group of mice kept for five sessions in the apparatus in absence of CS and US. The asterisks indicate that the performance of a given transfer group was significantly different (**$p<0.001$; *$p<0.01$) in relation to the conditioned group represented above.

was determined by using the formula of Murdock [5]. A scale correction was operated by subtracting the baseline performance of the groups of mice tested in absence of stimuli.

The analgesic responses of the mice were tested in a tail-flick test, immediately after the fifth session. In this test a beam of intense light is focused on the tip of the mouse tail. A timer is automatically started when the light is turned on and stopped when the tail is flicked in response; this also turns off the light.

One hundred and twenty male mice (25–30 g) belonging to the BALB/c strain were used. Mice were maintained in groups of 8 in clear plastic pens, with food and water available ad lib until testing.

The results were statistically evaluated by ANOVA (1-way) and Duncan multiple range tests.

RESULTS

Mice subjected to five sessions in the apparatus in presence of the visual or the acoustic stimuli only (control groups) showed tail-flick latencies (TFL) similar to those evident in mice kept in the apparatus in absence of stimuli (TFL=7.6±0.7).

As far as conditioned groups are considered, analgesia was evident in all animals following the fifth training session (Table 1 and Fig. 1). Mice conditioned with the pulsed tone or pulsed light CS showed transfer of responding to pulsed light or pulsed tone respectively (Fig. 1). The percentage of transfer in animals shifted from a pulsed light to a pulsed tone was 48.7%. The difference between the TFL of this group and those of mice shifted from pulsed light to steady tone was significant at the 0.01 percent level. As far as the transfer from pulsed tone to pulsed light is concerned, the percentage of transfer was 93.1%. The difference between the TFL of this group and those of mice shifted from pulsed tone to steady light was significant at the 0.001 percent level.

It must be noted that mice conditioned with a continuous light or tone were characterized by low TFL when they were shifted (session 5) to a continuous tone or light respectively.

DISCUSSION

Our findings indicate that mice conditioned to stress-induced analgesia presented a clear transfer of responding between a pulsed light or a pulsed tone (and vice versa) characterized by the same repetition rate. In contrast, no transfer of responding was evident between non pulsed stimuli differing in sensory modalities.

Previous experiments indicated that stress-induced analgesia undergoes to naloxone-reversible classical conditioning [8], suggesting that the endorphinergic system, which is activated by stress [1,3], may also be activated by stimuli associated to past experience. The present findings suggest that non-specific neural structures may be responsible for the representation of the temporal patterns common to different pulsed stimuli eliciting stress-induced analgesia. This suggests that a number of emotional reactions modulated by endorphins [1,9] may undergo generalization, and that stress-induced overproduction of opioids may also be elicited by related stimuli or situations [1].

Our results also indicate that the neural or neuroendocrinological systems implicated in emotionality may respond to transfer. Thus stress reactions may follow to the same generalization and transfer processes which were shown to characterize other behavioral patterns not related to emotionality.

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