Learned helplessness: Effects of response requirement and interval between treatment and testing

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Abstract

Three experiments investigated learned helplessness in rats manipulating response requirements, shock duration, and intervals between treatment and testing. In Experiment 1, rats previously exposed to uncontrollable or no shocks were tested under one of four different contingencies of negative reinforcement: FR 1 or FR 2 escape contingency for running, and FR1 escape contingency for jumping (differing for the maximum shock duration of 10 s or 30 s). The results showed that the uncontrollable shocks produced a clear operant learning deficit (learned helplessness effect) only when the animals were tested under the jumping FR 1 escape contingency with 10-s max shock duration. Experiment 2 isolated of the effects of uncontrollability from shock exposure per se and showed that the escape deficit observed using the FR 1 escape jumping response (10-s shock duration) was produced by the uncontrollability of shock. Experiment 3 showed that using the FR 1 jumping escape contingency in the test, the learned helplessness effect was observed one, 14 or 28 days after treatment. These results suggest that running may not be an appropriate test for learned helplessness, and that many diverging results found in the literature might be accounted for by the confounding effects of respondent and operant contingencies present when running is required of rats.

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Keywords: Learned helplessness; Response requirement; Time course

For 3 decades, learned helplessness has been used as an animal model for depression. Many experiments have shown that animals exposed to uncontrollable shocks often show signs – both neurological and behavioural – similar to human depression (Colotla, 1979; Overmier and LoLordo, 1998; Seligman, 1975; Willner, 1984, 1991). For instance, helpless animals have lower levels of serotonin and noradrenalin, as has been reported with depressed patients (Weiss, 1968; Weiss et al., 1981, 1970). The learned-helplessness model has also been used to test the effects of antidepressants (Willner, 1991; Gambarana et al., 2001). On the behavioural side, helpless animals usually show motivational deficits (it takes them longer to initiate escape or avoidance responding) and cognitive deficits (even when they start responding, their behaviour may not be as sensitive to environmental contingencies as the behaviour of control animals). This second feature, reduced sensitivity to reinforcement, may be related to the functional analysis of depression proposed by Ferster (1973). Learned helplessness also has been proposed as a model of the post-traumatic stress disorder (PTSD) (Foa et al., 1992) and anxiety (Maier and Watkins, 1998, 2005).

On the behavioural level, learned helplessness may be defined as a difficulty to learn a new operant response after being exposed to uncontrollable aversive stimuli. Experiments conducted to investigate this phenomenon usually comprise two phases. In the first phase (treatment), one group of subjects is exposed to an escape contingency: An aversive stimulus is presented – usually electric shock – and the emission of a specified response (Willner, 1991; Gambarana et al., 2001). On the behavioural side, helpless animals usually show motivational deficits (it takes them longer to initiate escape or avoidance responding) and cognitive deficits (even when they start responding, their behaviour may not be as sensitive to environmental contingencies as the behaviour of control animals). This second feature, reduced sensitivity to reinforcement, may be related to the functional analysis of depression proposed by Ferster (1973). Learned helplessness also has been proposed as a model of the post-traumatic stress disorder (PTSD) (Foa et al., 1992) and anxiety (Maier and Watkins, 1998, 2005).

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(Maier and Seligman, 1976). The usual interpretation of this effect is that animals learn that there is no relationship between their responses and environmental changes, and this impairs the subsequent identification of the dependency relation implicit in operant contingencies (Maier and Seligman, 1976).

Although this interference phenomenon has been reported on several occasions with different species (see Peterson et al., 1993, for a review), some questions still need to be addressed. When a running response is required, demanding a single response in a shuttlebox may be sufficient to produce helplessness in dogs. When rats are used as subjects, however, a fixed-ratio (FR) 2 contingency (running forth and back) is required so that a differential effect of treatment can be observed (Maier et al., 1973). Although these results have been replicated systematically, some unanswered theoretical questions remain. If learned helplessness is the interference in an operant learning process, why does it fail to occur when a single response is required?

A second question relates to the observation that the phenomenon seems to be short lived. Maier (2001) observed that learned helplessness often disappeared 48 h after treatment; only when re-exposed to the stimuli paired with electric shocks during treatment did the animals show effects of uncontrollable shocks after longer periods of time. Learned helplessness can be more durable (effects demonstrated 168 h after the treatment) if the apparatus used in both phases is the same, but the effects disappear after 48 h if the test environment is different than that used in the treatment session (Maier et al., 1995). If helplessness is in fact learned, why should it be weakened by the passage of time? By definition, learning is a long-lasting change in behaviour. The need to re-expose subjects to stimuli paired with shocks suggests that other processes are involved besides the impossibility to control the environment.

The answers to these questions may have important implications for understanding the processes involved, as well as for the use of such procedures as an animal model of psychopathology. First, since learned helplessness is defined as interference with operant learning, it is important that the test procedure allows for a precise assessment of operant control. Secondly, the question of whether learned helplessness decreases with time is particularly important when one considers it as an animal model of depression and PTSD. In the case of PTSD, for example, a person may suffer the effects of a single traumatic experience years after it had occurred. Maier’s result showing that re-exposure to conditioned stimuli maintains helplessness may shed some light on this issue, but does not explain all cases.

Previous experiments in our laboratory suggest that the response topography required in the test may not be the only critical variable to obtain helplessness in rats. The maximum shock duration used in the test may also play an important role (Hunziker, 1992). The present study attempted to investigate learned helplessness generality across response topographies with different and test shock duration. Along three experiments we investigated different test procedures on which uncontrollable shocks produce (1) interference on the acquisition of responses under an FR 1 contingency, and (2) a long-lasting effect without the need to re-expose subjects to the conditioned stimuli.

1. Experiment 1

As mentioned above, rats fail to show learned helplessness when a single escape response (FR 1) is required during test. The present experiment compared the effects of uncontrollable shocks on the subsequent learning of two different responses (running and jumping) with different ratio requirements (FR 1 and FR 2) and maximum shock duration.

1.1. Materials and methods

1.1.1. Subjects

Sixty-four 3-month-old naïve male albino Wistar rats were housed individually, with water and food freely available. The experiment was carried out during the light phase of a 12-h light/12-h dark cycle.

1.1.2. Equipment

Three experimental chambers were used: Two square chambers and one rectangular one (shuttlebox). The square chambers, made of aluminum and plexiglass, were 21.5 cm long, 21.5 cm wide and 21 cm high. These chambers were connected to two Lehing Valey 113–33 electric shock generators and a scrambler, which delivered shocks through the grid floor. The grid floor of each of the experimental chambers was constructed of stainless steel rods 0.3 cm in diameter and spaced 1.3 cm apart.

The shuttlebox was 50 cm long, 15.5 cm wide and 20 cm high. It consisted of two compartments of equal size, separated by an acrylic wall. In this centre wall, there was a 7.5-cm-high and 6-cm-wide rectangular opening. Its base could be place either at grid floor level or at 8 cm above the grid floor. When the opening base was placed at grid floor level, the rat could run from one compartment to the other to escape the shock; when the opening was 8 cm above the grid floor, the rat had to jump from one side to another. Each compartment had an independent grid floor, which was depressed by the animal’s weight. When this happened, a microswitch was activated, registering the animal’s presence in that compartment. Two cylinder metal rods (similar to those on the floor) were located at the base of the opening that separated the compartments. The shuttlebox was connected to a BRS Foringer 901 electric shock generator and a scrambler, which delivered shocks to the grid floor and the metal rods at the base of the opening. The three experimental chambers were housed in light- and sound-attenuating boxes equipped with a fan for ventilation and masking noise. Sessions were run by a PC computer, with a software especially developed for this experiment.

1.1.3. Procedure

The subjects were divided into eight groups (n = 8). In the first session, four groups were exposed to one session of uncontrollable shocks (uncontrollable groups - U) and the remaining four remained in their home cages (naïve groups - N). During this session, subjects were exposed to 60 electric shocks in the square...
chambers, each 10 s in duration, with an intensity of 1.0 mA and an average 60-s interval between them (min = 10 s, max = 110 s). The subjects had no control over any aspect of the shocks.

Twenty-four hours later, each animal previously exposed to uncontrollable shock was arbitrarily paired with one that received no shock, compounding four pairs of U and N groups (n = 8). All of them were exposed to a test session in the shuttle-box where they received 30 electric shocks (1.0 mA of intensity, average 60 s between shocks). Each pair was tested under one of the four different contingencies of negative reinforcement. Two pairs of groups were tested for running. For one of them, the escape running contingency was FR 1 during all the session: if the animals ran from one compartment to the other when an electric shock was present, shock was terminated and an interval between shocks was initiated. For the other pair, the schedule in the first five trials was FR 1. In the remaining 25 trials, the schedule was changed to an FR 2 running contingency: two responses were required for shock termination, i.e., the animals had to run towards the other compartment and then return to the compartment where they initially were. In both running contingencies, if the escape response was not emitted, the shock was automatically interrupted after 30 s from its onset.

The remaining two pairs were tested under an FR1 contingency for jumping: with shock onset, if the animals jumped a single time from one compartment of the shuttlebox to the other, shock was terminated and an interval between shocks was initiated. If the jumping response was not emitted, shock was automatically interrupted after 30 s, for one pair of groups, and after 10 s for the other. So, the only difference between these pairs tested under an FR 1 contingency for jumping was the maximum shock duration.

In all tests, the time between the shock onset and shock offset was defined as response latency.

1.2. Results

Fig. 1 shows response latencies, grouped in blocks of five trials, in the four different test conditions for both uncontrollable and naïve groups. The upper panels show results from the running condition (FR1 on the left and FR2 on the right); the lower panels show results from the jumping condition (30-s shock duration on the left and 10 s on the right). Under the FR1 running condition, both uncontrollable and naïve groups had low response latencies (less than 5 s) throughout the session. It is important to note that these latencies were low since the first block of trials, with no systematic differences observed between groups. Under the FR2 running condition the uncontrollable and the naïve animals differed from each other: mean response latencies were higher for the animals previously exposed to uncontrollable shocks, increasing throughout the session (around 10 s at the first FR2 block and 20 s at the last block). Conversely, latencies for the naïve group remained relatively constant (around 5 s). An analysis of variance indicated reliable effects of shock treatment [F(1,14) = 4.715 p < 0.05], blocks of trials [F(5,70) = 2.381, p < 0.05], and trial × treatment interaction [F(5,70) = 3.148, p < 0.05]. In the jumping with 30-s...
shock condition, response latencies for both naïve and uncontrollable animals were initially high and decreased throughout the session, but they were higher for the uncontrollable animals in comparison to the naïve animals \(F_{\text{group}(1,14)} = 4.547, p < 0.05; F_{\text{trial}(5,70)} = 5.876, p < 0.01\). In the jumping with 10 s shock condition, response latencies for the uncontrollable group remained virtually constant at approximately 10 s throughout the session, while response latencies of naïve animals decreased systematically \(F_{\text{group}(1,14)} = 27.219, p < 0.01; F_{\text{trial}(5,70)} = 19.540, p < 0.01; F_{\text{trialXgroup}(5,70)} = 11.876, p < 0.01\).

1.3. Discussion

The results observed here show clearly that the effects of uncontrollable shocks on subsequent learning depend to a great extent on the response required during test. When running was required under FR1, response latencies were low during all session. In contrast, when jumping was required under FR1, latencies were initially high and decreased for both controllable and uncontrollable groups, but to a lower extent for the uncontrollable group. These data may suggest that different behavioural processes may be at play in each of these situations.

The fact that learned helplessness depends on the test requirement has previously been pointed out by other researchers (Maier et al., 1973; Seligman and Beagley, 1975). The failure to obtain helplessness with a single running response has been attributed to the assumption that an FR1 contingency is too “easy,” resulting in a floor effect, with effective responding occurring early in the test. The proposed solution was to make responding more difficult by increasing reinforcement intermittency. Under an FR2 contingency for running, significant differences between uncontrollable and naïve animals were obtained, indicating learned helplessness. However, various experiments that reported learned helplessness using an FR2 contingency for running failed to analyze an interesting effect: response latencies of naïve animals did not indicate learning, i.e., mean latencies of the naïve animals either did not decrease (see Alloy and Bersh, 1979; Freda and Klein, 1976, experiment 3; Jackson et al., 1978, experiments 1A, 1B and 3; Maier and Testa, 1975; Seligman et al., 1975, experiment 2) or even increased throughout the session (e.g., Freda and Klein, 1976, experiment 1; Jackson et al., 1978, experiment 1A). By definition, if response latencies were not reduced when responses terminated shocks, these latencies could not be taken as evidence of operant (escape) learning. Therefore, it appears likely that these studies were not investigating the effect of uncontrollable shocks on operant learning, as defined by the learned helplessness effect.

Our FR 1 results replicated previous reports Maier et al. (1973). When presented with electric shocks on the grid floor, rats are very likely to run, a response that can be viewed as unconditioned or elicited. We observed the same. Because of this floor effect, it is hard to pinpoint the exact moment when control by the operant contingency becomes more pronounced (if ever). This respondent/operant interaction is possibly the reason why running under FR1 may not be an adequate test of operant learning when used in studies on learned helplessness.

Under FR 2, response latencies were higher for the uncontrollable group, which may suggest that previous experience with uncontrollable shocks impairs learning an operant task. However, response latencies remained constant for naïve subjects, which is contrary to what should be expected if an operant learning process was actually taking place. In this case, another respondent/operant interaction may have been superimposed to the previous one and may be responsible for this odd result. Due to an association between the compartment and the onset of electric shocks, the compartment itself may have acquired conditioned aversive properties. Under FR 2, to terminate shocks the animals had to cross over to the other compartment and then return to the very compartment where they were receiving shocks in the first place. So, a competing control of responding was established: one operant (by shock termination) and one respondent (by S–S associations). Because the association between compartment and shock onset makes the animals more likely to run away from it, they became more and more reluctant to return, which caused response latencies to increase. Once again, this contingency may not be adequate to demonstrate a clear operant control.

It is worth mentioning that these results are consistent with previous experiments that used running in the test (both under FR1 and FR2), despite some procedural differences during treatment, mainly the way shocks were administered and the restrictions on moving. In previous experiments that used FR2 (for example, Maier and Testa, 1975), shocks were administered to the rats’ tail inside a container that restricted movement. In our experiment, shocks were administered through the grid floor, and the animals were free to move inside the chamber. These differences have at least two implications. First, there is less similarity between treatment and test when treatment shocks are administered to the tail and test shocks are administered through the grid floor. Second, the experience of uncontrollability is likely to be stronger when the animal is allowed to move freely in the chamber, since these animals are likely to emit many responses, none of which is followed systematically by shock termination, whereas animals confined in container can emit only a limited number of responses. These differences may establish different S–S and R–S relationships. However, as the main result was replicated here, these diverse relationships may not be relevant to the phenomenon.

When jumping was required in the test, the other hand, naïve groups showed clear signs of learning. Response latencies were high in the initial trials and decreased with additional testing, with responding becoming more likely with each successful trial, a typical pattern of escape learning. Moreover, there was a clear difference between groups: it took uncontrollable animals significantly longer to terminate shocks when compared to naïve animals, an indication that previous experience with uncontrollable shocks impairs learning in an unambiguous operant task.

In addition, by limiting the opportunity to respond (as a consequence of reducing the time during which the response can occur), the performance of uncontrollable and naïve animals became even more differentiated. With shock duration set at 30 s, although latencies of uncontrollable animals were undoubtedly higher than those of naïve animals – which attests for the effect
of uncontrollable shocks —, there was a clear indication of learning in both groups. This procedure made escape learning more difficult, but did not prevent it. The stronger interference effect on escape learning was observed with shock duration set at 10 s. Under this contingency, uncontrollable animals did not show any evidence of learning: response latency was high, and even when the animals eventually emitted the required response, it did not become more likely on the following trials. So, among the procedures tested here, the arrangement that required the response of jumping with shock duration set at 10 s max seems to be the best to analyze an interference of previous uncontrollable shocks on escape learning. It is important to note that, in addition to providing a more valid measure of learned helplessness, this shorter parameter for shock also has the additional advantage of providing a more ethical treatment to the animals, since shock duration is reduced to third of its original value.

These results, taken together, suggest that, just as seems to be the case with dogs, learned helplessness can be observed with rats under an FR1 contingency that isolates the operant part of the task. This evidence is important for the purposes of studying interference on learning by uncontrollability. Considering that one of the most basic learning process is the selection by consequences (Skinner, 1981), it can be very important to demonstrate that uncontrollable shocks produce a change in the sensitivity to consequences. Conversely, if one is interested in measuring other effects of shock uncontrollability that is not the operant learning difficulty, the use of an FR 2 contingency can possibly be very useful as a test.

2. Experiment 2

Results from the previous experiment showed that jumping under FR1 provides a way to assess learned helplessness. However, the effects of uncontrollability were not isolated from the stress that comes from shock exposure per se. The isolation of these effects have been traditionally done with the use of a triadic design, where uncontrollable animals are yoked to controllable ones, which are exposed to electric shocks as well, but have the opportunity to terminate them. Thus, Experiment 2 attempted to investigate whether the same results are obtained with a triadic design when jumping under FR1 is required in the test.

2.1. Method

2.1.1. Subjects

Twenty-four naïve male Wistar rats, 3 months old at the beginning of the experiment, were maintained in the same housing conditions as in Experiment 1.

2.1.2. Equipment

In the treatment phase, two square experimental chambers were used. They were similar to those in Experiment 1, with the following exception. The right wall contained a round opening, 3 cm in diameter, through which the rat could insert any of its body parts. On the other side of the wall, a photo-electric cell was mounted. If the rat inserted any body part at least 1.5 cm deep into the opening, a light beam was interrupted and a response was registered. This response provided the animals in the “controllable” condition with an opportunity to terminate shocks during treatment. All other aspects of the equipment, including the shuttlebox, were the same as in Experiment 1.

2.1.3. Procedure

Rats were divided into three groups (n = 8). One group (C) was exposed to 60 electric shocks in one square chamber (1.0 mA of intensity, 10 s of maximum duration, and an average of 60 s apart from each other). If the animal emitted a response (insertion of any body part at least 1.5 cm deep into the orifice) during an electric shock, shock was terminated immediately. If the animal did not respond during the shock, it terminated automatically after 10 s. Another group (U, or uncontrollable) of animals was yoked to the first in the other chamber, so that electric shocks were initiated and terminated at the same time for the paired animals. Responses by these “uncontrollable” animals were registered, but had no effect over shock termination. A third group of animals (N, or naïve) was not exposed to electric shocks whatsoever.

Twenty-four hours later, all animals were exposed to 30 electric shocks in the shuttlebox (1.0 mA of intensity, and an average of 60 s apart from each other). Again, if the animal emitted a response (jumping from one compartment to the other) during an electric shock, shock was terminated. If the animal did not respond during the shock, it was terminated automatically after 10 s.

2.2. Results

Fig. 2 shows mean response latency (jumping) for the three groups, grouped in blocks of five trials, in the test. Performance in the first block of trials was virtually the same for the three groups, but differences arose as session progressed. Naïve animals (N) showed high initial latencies with a subsequent systematic decrease throughout the test sessions. Similar
performances were observed with animals previously exposed to controllable shocks (C). Conversely, latencies from animals previously exposed to uncontrollable shocks (U) were high throughout the sessions, with no apparent systematic change.

A two-way ANOVA showed an effect of treatment \([F_{\text{group}}(2,21) = 10.700, p < 0.001]\) and trials \([F_{\text{trial}}(5,105) = 8710, p < 0.001]\). Tukey post hoc analyses showed that group U differed from groups C and N \((p < 0.001)\), which were similar to each other.

2.3. Discussion

These results are consistent with those of Experiment 1. Naïve rats exposed to negative reinforcement of jumping in a shuttlebox under FR1, with maximum shock duration set at 10 s, showed clear signs of escape learning. Also, previous exposure to uncontrollable shocks once again impaired such learning. Experiment 2 added the demonstration that this effect was actually due to shock uncontrollability and not to some non-specific effect of shocks per se: despite the fact that animals from group C received the same duration of shocks and same temporal distributions during treatment as the U animals, learning was impaired only with animals from group U. Thus, the effects obtained with this procedure replicate previous demonstration about the importance of the uncontrollability for the learned helplessness production (Seligman and Maier, 1967). The original result showed here is the learned helplessness effect showed by rats tested under an FR1 escape contingency.

3. Experiment 3

The previous experiments showed that learned helplessness can be obtained with rats under FR 1 on a task that isolated the operant nature of the response. This experiment was designed to assess the effects of the passage of time on learned helplessness, using a clearly operant task. Rats were exposed to a treatment of either uncontrollable electric shocks or no shocks at all. Then they were tested under the escape contingency for jumping either 1, 14, or 28 days after treatment.

3.1. Materials and methods

3.1.1. Subjects

Thirty-two 3-month-old naïve male albino Wistar rats were kept in the same housing conditions as those of Experiment 1.

3.1.2. Equipment

Same as Experiment 1.

3.1.3. Procedure

The subjects were divided into four groups \((n = 7)\). Three groups were exposed to one session of uncontrollable shocks (treatment) and the remaining group (naïve) was kept in its home cages. During treatment, subjects were exposed to 60 electric shocks in square chambers. Electric shocks were 10 s long, with an intensity of 1.0 mA and an average 60-min interval between them \((\text{min} = 10 \text{ s}, \text{max} = 110 \text{ s})\).

All groups (uncontrollable and naïve) were then tested in a contingency of negative reinforcement for jumping in the shuttle box, identical to that in Experiment 1. The interval between treatment with uncontrollable shocks and testing was varied across uncontrollable groups. For the first uncontrollable group, the test was conducted 1 day after treatment (identical to Experiment 1); for the second and third uncontrollable groups, the tests were conducted 14 and 28 days after treatment. During the interval between treatment and test, the animals were maintained in their home cages.

In the test session, 30 electric shocks were delivered (1.0 mA of intensity, 10 s long, average 60 min between shocks). If the animal jumped a single time from one side of the shuttle box to the other when an electric shock was in effect, shock was terminated and an interval between shocks was initiated. In case animals failed to emit a response, a 10-s latency was registered.

3.2. Results

Fig. 3 shows response latency in the FR 1 jumping test for all groups. Shocks were grouped in blocks of five trials by averaging response latencies in each block. There was no effect of trial on response latencies for the groups previously exposed to uncontrollable shocks, while response latencies of naïve subjects decreased systematically. Two-way ANOVA tests were conducted and confirmed these results. There was no significant effect of trial \([F_{\text{trial}}(29,696) = 1.038, p = 0.412]\), but there was a significant between-group difference \([F_{\text{group}}(3,24) = 3.854, p < 0.05]\) and Trial \(\times\) Group Interaction \([F_{\text{trial} \times \text{group}(87,696) = 2.193, p < 0.001}\]. Bonferroni post hoc tests confirmed that naïve animals differed from all the others \((p < 0.05)\).
3.3. Discussion

The effects of uncontrollable shocks did not dissipate after periods as long as 28 days without any re-exposure to the apparatus. Naive rats learned to emit the response consistently and with decreasing latencies, whereas rats previously exposed to uncontrollable shocks did not show any systematic evidence of learning, regardless of how many days had elapsed between treatment and test. These data contrast with those reported by Maier (2001), who found that, without re-exposure to the apparatus where treatment took place, learned helplessness dissipated after 48 h of treatment. There are two main differences that may account for these diverging results. First, Maier’s rats were confined in tubes and shocks were administered to the tail during treatment, while ours were able to move freely in the experimental chamber and received shocks through the grid floor. As mentioned above, these differences were not relevant in the test conducted 24 h after the treatment, where the results are consistent with those present in the literature on learned helplessness, both for FR1 and FR2. Maier and Watkins (2005) claim that a longer lasting effect is obtained when treatment and test are conducted in the same experimental chamber. In the present experiment, these sessions were conducted in different apparatuses, which might preclude such interpretation. However, even though the apparatuses were different, the fact that shocks were administered to the animal’s paws in both sessions may constitute sufficient similarity. Although this interpretation is possible, it is not thoroughly convincing. If we compare the environmental variables present during treatment and test, the fact that the same aversive stimulus (electric shocks) is used constitutes a greater similarity, and this similarity is present in all the experiments reported here, whether shocks were administered to the tail or to the paws. Thus, if similarity alone was sufficient to produce long-lasting helplessness, the use of electric shocks in both phases would meet this criterion. Nevertheless, this is not observed in experiments that administered shocks to the tail of restrained animals and then tested them under an FR2 escape contingency where the required response was running.

The question of similarity between sessions, as noted by Maier and Watkins, is relevant, but has not been duly investigated yet. To properly identify its relevance, changing the source of electric shocks might not be sufficient. A more adequate approach would be to use different aversive stimuli in each phase. Going even further, other non-aversive stimuli could be used either in the treatment or in the test, in order to investigate whether helplessness is restricted to aversive contexts. As it is technically difficult to use other kinds of aversive stimuli, little has been done in this direction. Yet, some experiments were conducted using appetitive stimuli either in the treatment or in the test, with divergent results: some have reported helplessness (Oakes et al., 1982) while others have failed to provide unequivocal evidence of the effect (Beatty and Maki, 1979). Thus, even if we consider similarity as an important variable for the production and maintenance of helplessness, the existing data do not allow for the conclusion that mere similarity is the only variable responsible for the long-lasting effect observed here.

Other procedural differences may also be relevant to understand the present results. The diversity of responses allowed for in each experimental arrangement (high when the animal is free to move about the chamber and low when the animal is restricted) is one of them. What an animal learns when restricted is likely different from what it learns when allowed to move freely and none of its responses is systematically followed by shock termination. Even though this variable was not manipulated in the present experiment, it is a possible cause for the long-lived effect observed here. Further research is necessary to evaluate this issue. It is worth mentioning, however, that this experimental arrangement is more similar to uncontrollable situations experienced by humans, which are often allowed to emit different responses that have no effect over the aversive stimuli that act upon them. To the extent that learned helplessness has been used as a model of some human psychopathologies, this kind of similarity may be an advantage.

A third variable that should be considered is the requirement for shock termination. While Maier’s rats had to run forth and back in the shuttle box, ours had to jumping only once from one compartment to the other. For reasons discussed earlier, an FR2 contingency of negative reinforcement for running may establish a multitude of controls other than operant selection, while the main control in an FR1 contingency of negative reinforcement for jumping is clearly operant, as seen by the learning curves of naive animals exposed to such a task. The operant nature of the response may be crucial for the establishment of a long-term effect, since other non-associative processes, such as habituation, have a limited duration, weakening with the passage of time.

4. General discussion

Learned helplessness has been defined over the years as the difficulty to learn an operant response due to the previous exposure to uncontrollable shocks. However, in order to demonstrate that past experiences with uncontrollable aversive events interfere with subsequent operant learning, it is necessary to demonstrate that, without such history, learning actually takes place. When measuring response latency (the most common measure of performance under an escape contingency), learning is evidenced by latencies that decrease across trials. Flat curves (unchanging latencies) or increasing latencies cannot be taken as an evidence of learning, since these patterns do not reflect an increasing probability of responding, which is characteristic of operant selection. With that in mind, a review of the literature on learned helplessness reveals that, in many experiments, latencies of naive animals remained unchanged throughout the whole session, while in others, latencies increased (e.g., Freda and Klein, 1976, experiment 1; Jackson et al., 1978, experiment 1A). Although, in many of these studies, statistically significant differences between uncontrollable and naive animals are reported, such differences may not indicate operant learning. Hence, the importance of an adequate test, which must provide reliable evidence of learning in naive animals. Our test met this criterion fairly successfully.
Our results also attest for the generality of the phenomenon. The fact that, under FR 1, learned helplessness could be observed with dogs, but not with rats, has puzzled researchers. This led to the creation of different tests, each with some advantages over the others, but none with the consistency necessary to validate learned helplessness as an animal model of depression.

Other experiments conducted in our laboratory have shown that the jump test is also sensitive to the effects of antidepressants—such as an acute administration of imipramine (Gouveia, 2001), or ipsapirone and Bay R 1531, with both shown that the jump test is also sensitive to the effects of learned helplessness as an animal model of depression.

The fact that, under FR 1, learned helplessness could be observed with drug metabolism (Wilson and Roy, 1986). Conversely, it has often been reported that chronic treatment with imipramine was necessary to reverse helplessness (Geoffroy et al., 1990; Petty and Sherman, 1979; Sherman and Petty, 1982; Sherman et al., 1979), the only exceptions being a study by Kametani et al. (1983) and ours. It is possible that these divergent results are due to the different behavioral processes underlying each case: operant selection, in our case, versus an operant/respondent interaction in which the predominant effects are on motor activity.

The time course of learned helplessness has also generated doubts regarding the behavioral process under investigation (Levis, 1976), since the mere passage of time, by all accounts, should not affect learning. Therefore, the existence of time-course effects suggested that it was not a learning process. One possible contributor to these time-course effects could be lower levels of motor activity produced by noradrenaline (NA) depletion in the central nervous system, as a result of uncontrollable shocks (Weiss et al., 1970). The fact that NA levels are restored over time supported this physiological hypothesis. However, although learning undoubtedly occurs at a physiological level (Donahoe and Palmer, 1994), it is a more permanent process, being altered mainly by new interactions between the organisms and their environments and not by the mere passage of time. Our results showing that learned helplessness is obtained even after long periods of time had elapsed support an operant-learning interpretation of learned helplessness.

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