



Context preexposure influences the effectiveness of feedback stimuli in avoidance learning

Edward J. Callen*

Department of Psychology, University of South Carolina Aiken, Aiken, SC 29801, USA

Received 22 September 2003; received in revised form 5 December 2003; accepted 5 December 2003

Abstract

According to the effective reinforcement theory of avoidance learning, there is a positive relationship between the level of context fear and the effectiveness of feedback stimuli. The present research used different preexposure treatments to manipulate context fear and to evaluate the effects of feedback stimuli in two-way avoidance learning. Rat subjects received nonreinforced preexposure either to the nonvisual context cues (avoidance apparatus with the houselights extinguished), to the visual context cues (avoidance apparatus with the houselights on but with a Plexiglas floor covering the grids), or to a neutral box. During subsequent avoidance training conditioned stimulus termination was delayed for 5 s after an instrumental response and either a flashing light or darkness was presented as a feedback stimulus. Without preexposure, darkness produced better avoidance performance than did the flashing light. Preexposure to the visual context cues decreased the effectiveness of darkness as a feedback stimulus. However, preexposure to either the visual or to the nonvisual context cues facilitated avoidance performance when a flashing light was used as a feedback stimulus. The results suggest that the effects of a feedback stimulus may be dependent upon the amount and source of context fear.

© 2003 Elsevier B.V. All rights reserved.

Keywords: Avoidance behavior; Feedback stimuli; Context fear

1. Introduction

In studies of animal learning and motivation, considerable theoretical and empirical attention has been paid to the investigation of the processes underlying the development and maintenance of avoidance behavior. In a typical two-way avoidance learning task, the subject is placed in a shuttlebox consisting of two identical compartments, often separated by a partition or hurdle. An initially innocuous stimulus, called the conditioned stimulus (CS), is presented and is followed after some specified interval of time by a noxious, aversive event, the unconditioned stimulus

(US). The subject may terminate the CS and the US by locomoting from one compartment to the other (escape response), or the subject may terminate the CS and avoid the US by responding during the CS–US interval (avoidance response). Successful learning in this task is demonstrated by a shift in performance from predominantly escape responding to avoidance responding.

One of the earliest explanations of avoidance learning was Mowrer's (1947) two-factor theory. This theory postulates that the contiguous relationship between the CS and the US, which consistently occurs early in training, allows for the classical conditioning of fear to that CS. This fear presumably motivates the instrumental locomotor response, and termination of the CS after the instrumental response provides

* Tel.: +1-803-6413218; fax: +1-803-6413726.

E-mail address: edc@usca.edu (E.J. Callen).

reinforcement for that response through fear reduction. Thus, Mowrer's theory proposes that two factors are necessary for successful avoidance learning: a positive contingency between the CS and US providing for the conditioning of fear to the CS, and the strengthening of the instrumental response through fear reduction that occurs following the response.

Although Mowrer's two-factor theory has been relatively successful in explaining most of the data reported in the avoidance learning literature, the theory has not been without criticism. One such instance is based on demonstrations that successful avoidance learning can occur and be maintained even if CS termination is delayed, provided that an exteroceptive "feedback stimulus" is presented contingent upon the instrumental response (e.g. Bolles and Grossen, 1969; Bower et al., 1965; D'Amato et al., 1968; Keehn and Nakkash, 1959), suggesting that immediate CS termination (and the corresponding fear reduction) is not a necessary condition for the learning of an avoidance response.

A modification of traditional two-factor theory, the effective reinforcement theory (e.g. Callen, 1986; McAllister et al., 1971, 1979), has been successful in explaining the operation of feedback stimuli in avoidance learning (e.g. McAllister and McAllister, 1991, 1992). In this theory, the important role played by fear of the CS in explaining two-way avoidance learning is acknowledged, but in addition, the contribution of the fear conditioned to the contextual cues is emphasized. Specifically, this theory states that the effective reinforcement for an avoidance response is *directly* related to the amount of fear reduction occurring with the response and *inversely* related to the amount of fear present following the response. Usually fear reduction would result primarily from CS termination, whereas the fear remaining after the response would typically be determined by fear of the contextual cues. Although effective reinforcement theory holds that a necessary condition for the learning of the instrumental avoidance response is fear reduction (reinforcement) following the response, it is *not* necessary that CS termination be the source of this fear reduction. When the termination of a CS is delayed beyond the point at which the instrumental response is performed, and a response-contingent stimulus is presented, some reinforcement or fear reduction may still occur due to a stimulus generalization decrement. That is, the

stimulus complex present after the response is different from that present before the response because of the inclusion of the additional feedback stimulus (McAllister et al., 1976, pp. 208–209; McAllister and McAllister, 1992). In other words, the post-response stimulus complex (CS + context cues + feedback stimulus) should elicit less fear than the pre-response stimulus complex (CS + context cues), and therefore, some reinforcement for the response should occur.

According to effective reinforcement theory, a feedback stimulus that not only reduces fear through a stimulus generalization decrement but also directly reduces the amount of contextual-cues fear after the response should provide more effective reinforcement, and hence, lead to better learning than a feedback stimulus that only produces a stimulus generalization decrement. One stimulus frequently utilized as a feedback stimulus which functions in such a dual fear-reducing capacity is the elimination of context illumination (i.e. darkness). In other words, response-contingent darkness should not only reduce fear through a stimulus generalization decrement, but it should also reduce fear by removing fear-eliciting visual cues, thereby increasing effective reinforcement (e.g. McAllister and McAllister, 1992; McAllister et al., 1979).

Based on these considerations, it follows from effective reinforcement theory that manipulations that change the level of context fear may differentially influence the effectiveness of different feedback stimuli. Specifically, with sufficient visual-cues fear, darkness should be a more effective feedback stimulus than another visual stimulus, such as a flashing light (e.g. McAllister and McAllister, 1992), assuming each stimulus is equally salient. Decreasing the amount of visual-cues fear present during avoidance training should degrade the effectiveness of darkness as a feedback stimulus, but should not influence the effectiveness of a flashing light in a two-way avoidance-learning situation. Alternatively, decreasing fear of a different, nonvisual context component (e.g. tactual cues) would not be expected to result in such feedback stimulus effects.

In the present experiment context fear was manipulated by administering nonreinforced preexposure to specific elements of the contextual cues prior to avoidance training (either the tactual cues or the visual cues). Preexposure to these stimuli should produce the

so-called latent inhibition effect (e.g. Lubow, 1973) so that the amount of fear conditioned to the preexposed cues during avoidance training should be attenuated. An empirical basis for this presumption that such preexposure before avoidance training reduces context fear has been provided by McAllister et al. (1979, Experiment 2). These investigators demonstrated that subjects preexposed to contextual cues before two-way avoidance learning exhibited less fear of those cues than nonpreexposed subjects, as indicated by an independent escape-from-fear measure. In addition to examining the effect of visual-cues preexposure, the present study also investigated the effect of preexposure to the nonvisual cues (e.g. tactual cues). These cues have been shown to be an integral component in contextual fear conditioning in other learning situations (e.g. Callen et al., 1984), so the present study attempted to determine the role such cues play in two-way avoidance learning as well as to ascertain whether preexposure to such cues would influence the effectiveness of the feedback stimuli.

2. Method

2.1. Subjects and design

The subjects, 96 experimentally naive female hooded rats (122–126 days of age) from the colony maintained by the Psychology Department of Northern Illinois University, were randomly assigned to one of six groups ($n = 16$). For ethical reasons, the experiment was halted for nine additional subjects that did not respond and therefore received 60 s of shock on each of five trials in a session. These subjects were discarded and replaced in the experiment. Food and water were available on an ad libitum basis in the home cage throughout the experiment. The experimental design featured three types of preexposure treatment factorially crossed with two types of feedback stimuli, yielding six groups: PV-D, PV-L, PT-D, PT-L, NP-D, and NP-L. The first portion of the group designation indicates the type of preexposure administered, to the visual cues (PV), to the tactual cues (PT), or not administered (no preexposure, NP). The last portion of the group designation indicates whether the instrumental response was followed by a darkness feedback stimulus (D) or a flashing light feedback stimulus (L).

2.2. Apparatus

The apparatus was a modified Lehigh Valley shuttlebox (Model 146-04), 450 mm long \times 200 mm wide \times 200 mm high, enclosed in a lightproof, sound-attenuating chamber. The shuttlebox, divided into two identical compartments by a 47 mm high roller hurdle, had end walls constructed of aluminum and top and side walls constructed of clear Plexiglas. The grid floor of each compartment consisted of 20 stainless steel rods, each 2.4 mm in diameter, spaced 11 mm apart (center to center). One 28-V lamp covered by a jeweled lens, 13 mm in diameter was laterally centered on each end wall, 140 mm above the grid floor. These lamps provided a constant illumination of 12 lx. Responses were recorded when the subject locomoted from one compartment to the other, thereby tilting the floor slightly and activating a microswitch. The responses and latencies were recorded by a microcomputer that was connected to the shuttlebox through an interface. Scrambled shock (80 V DC) was delivered through the grid floor by a BRS/LVE Model SGS-004 shock generator. The typical reaction of the subjects to this level of shock was vigorous movement and vocalization, and defecation occurred frequently. The white noise CS was provided by a Grason-Stadler white noise generator, Model 901B, which increased the ambient noise level in the apparatus from 72 to 78 dB, C scale. The illumination for the flashing light feedback stimulus was provided by two light boxes, one positioned behind and above each end wall of the shuttlebox, 335 mm above the grid floor. Each light box contained six 28-V bulbs which flashed at a rate of 0.25 s on, 0.25 s off and provided an increase in illumination from 12 lx (intertrial illumination) to 256 lx.

A wooden holding box, 200 mm long \times 200 mm wide \times 190 mm high, painted gray with Litter Green on the floor, was located in a separate experimental room and was used as a neutral context for nonpreexposed control subjects.

2.3. Procedure

The experiment was conducted on four consecutive days with approximately 24 h intervening between the experimental treatments.

2.3.1. Day 1: preexposure treatment

On this day each subject was transported to the experimental room and administered one of three preexposure treatments. Depending upon the group assignment, the subject received 2 h of exposure to the shuttlebox with the houselights on but with a Plexiglas floor covering the grids (visual cues preexposure—groups PV-D and PV-L), or with the houselights extinguished and without the Plexiglas floor covering the grids (tactual cues preexposure—groups PT-D and PT-L), or placement in a neutral box located in a separate room (no preexposure—groups NP-D and NP-L). No CS or US presentations were administered on this day.

2.3.2. Days 2–4: avoidance training

On each day the subject was transported to the experimental room, placed in the shuttlebox, and administered 100 signaled, two-way avoidance training trials. Each trial began with the presentation of a white noise CS. The US (shock) was presented if the subject did not activate the microswitch by locomoting to the other compartment within 5 s following CS onset. An escape response following shock onset terminated the US whereas an avoidance response, occurring during the 5-s CS–US interval, prevented shock presentation. For all groups the termination of the CS was delayed until 5 s after the escape or avoidance response. Both avoidance responses and escape responses resulted in the immediate presentation of either a 5-s flashing light (groups PV-L, PT-L, NP-L) or termination of the houselights for 5 s (groups PV-D, PT-D, NP-D). Thus, both the CS and the feedback stimulus terminated concurrently. After a 30-s intertrial interval beginning with the termination of the delayed CS, during which time the subject was free to respond, the next trial was begun. Avoidance and escape response latencies were measured, in 0.01 s, from the onset of the CS to the depression of the floor in the other compartment.

3. Results

Avoidance performance for each subject was determined by measuring, in blocks of 50 trials, the number of avoidance responses and the mean avoidance latency. These two measures were jointly used as dependent variates in multivariate analyses of variance

(MANOVA). Because there were no latency data if a block of trials contained zero avoidance responses, those cells with such missing data were excluded from the statistical analyses. As a result, the analyses reported were conducted with the following number of subjects per group: 12, 11, 12, 13, 14, and 15 for groups NP-D, PV-D, PT-D, NP-L, PV-L, and PT-L, respectively. There was no significant difference between the groups in the number of cases excluded, $\chi^2(5) = 2.40$, $P > 0.05$. A series of planned comparisons was carried out utilizing repeated measures MANOVA with groups as the between-subjects factor and trial blocks (1–6) as the within-subject factor. To assess the effectiveness of the darkness and flashing light feedback stimuli, the two nonpreexposed (NP) groups were compared. Another set of analyses was concerned with the avoidance performances of the groups preexposed to the tactual cues (PT). It should be noted that preexposing the tactual cues of necessity also resulted in preexposing one of the feedback stimuli. That is, because the preexposure phase was deliberately administered in darkness so as to avoid preexposure to the visual cues, the subjects in the PT-D group were preexposed to the feedback stimulus (darkness) to be used subsequently in avoidance training. Because any effect that this preexposure to the feedback stimulus might have had upon performance (facilitative or detrimental) would be present in the darkness group but not in the flashing light group, no direct comparisons between these feedback conditions were made. That is, avoidance performance was assessed separately within each feedback stimulus condition (PT-D versus NP-D and PT-L versus NP-L). A comparable set of analyses was performed to evaluate the effect of visual cues preexposure. To this end, the avoidance performances of groups PV-D and NP-D were compared as were those of groups PV-L and NP-L. A rejection region of $P < 0.05$ was adopted for all statistical tests.

The avoidance performance measures, presented in Table 1, show the mean number of avoidance responses in blocks of 50 trials and the mean avoidance latency in blocks of 50 trials over the 3 days of training for each group (the escape trial latencies are excluded). These data demonstrate that overall avoidance performance improved with trials, as reflected by the increase in the number of avoidance responses and the general decrease in avoidance latencies. Also,

Table 1
Mean number of avoidance responses and mean avoidance latency in blocks of 50 trials for each group on each day

	Day 1		Day 2		Day 3	
	Trial block		Trial block		Trial block	
	1	2	1	2	1	2
Group NP-D						
Response	11.75	22.92	33.92	42.58	39.92	41.42
Latency	2.85	2.91	2.72	2.51	2.44	2.56
Group PV-D						
Response	8.00	14.00	15.73	23.18	23.64	38.18
Latency	3.10	3.00	3.06	2.68	2.73	2.82
Group PT-D						
Response	10.75	17.00	29.83	38.92	35.17	41.50
Latency	2.76	3.17	2.82	2.62	2.80	2.59
Group NP-L						
Response	10.23	18.15	27.08	35.23	32.54	41.61
Latency	3.16	3.01	3.16	3.06	3.11	2.98
Group PV-L						
Response	11.28	16.36	23.00	34.78	31.14	37.64
Latency	2.70	2.87	2.92	2.68	2.89	2.78
Group PT-L						
Response	13.00	21.13	33.07	42.67	38.13	42.87
Latency	2.66	2.89	2.68	2.64	2.61	2.58

the two feedback stimuli were differentially effective, depending upon the preexposure manipulation. A clearer picture of this latter effect is presented in two figures which summarize the avoidance performance.

Fig. 1 presents avoidance performances for the two nonpreexposed groups, NP-D and NP-L, and for the

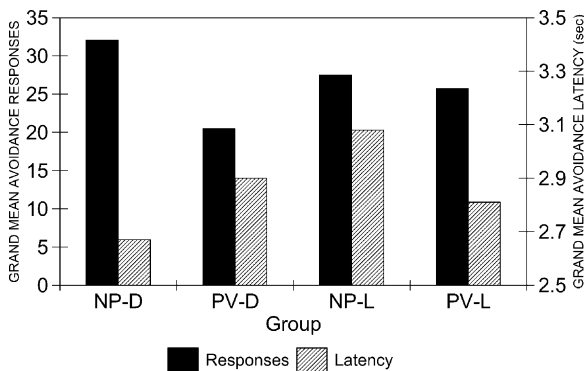


Fig. 1. Grand mean number of avoidance responses and grand mean avoidance latency during two-way avoidance training with darkness (D) or flashing light (L) feedback stimuli for the nonpreexposed (NP) groups and for the visual-cues preexposure (PV) groups.

groups preexposed to the visual context cues, PV-D and PV-L. In this figure the grand mean number of avoidance responses during training is plotted with respect to the left axis, and the grand mean avoidance latency is plotted with reference to the right axis. Better avoidance learning is reflected by greater numbers of avoidance responses and lower (faster) avoidance latencies. From this figure two important findings can be observed. First, for the two nonpreexposed groups, better avoidance performance was obtained with the darkness feedback stimulus than with the flashing light. That is, Group NP-D showed better avoidance learning than did Group NP-L. The results of a repeated measures MANOVA substantiated this impression with a significant effect of groups, Hotelling's $T^2 = 11.22$, $F(2, 22) = 5.37$. There was also a significant effect of trial blocks, $T^2 = 737.16$, $F(10, 14) = 44.87$. The groups \times trial blocks interaction was not significant.

Fig. 1 also presents the effect of visual-cues preexposure for each feedback condition. It is clear from this figure that the two feedback stimuli did not operate similarly under this preexposure manipulation. When preexposure to the visual context cues was given, the effectiveness of darkness as a feedback signal was degraded as compared to the nonpreexposed control group. That is, Group PV-D showed poorer avoidance performance than did Group NP-D. This effect of preexposure did not occur with the flashing light feedback stimulus, in that Group PV-L performed better than Group NP-L considering the measures conjointly.

These impressions were confirmed statistically. Repeated measures MANOVA for groups PV-D and NP-D revealed a significant difference between the groups, $T^2 = 7.31$, $F(2, 20) = 3.48$, and a significant effect of trial blocks, $T^2 = 253.64$, $F(10, 12) = 14.49$, the latter reflecting the improvement in performance by both groups with trials. The interaction between these two factors was not significant. MANOVA comparing the avoidance performances of groups PV-L and NP-L yielded a significant effect of groups, $T^2 = 16.20$, $F(2, 24) = 7.78$, and of trial blocks, $T^2 = 420.07$, $F(10, 16) = 26.88$, indicating that both groups performance improved with trials. The interaction was not significant.

Fig. 2 presents the effect of tactual-cues preexposure upon avoidance performance with each of the two feedback stimuli. With the flashing light,

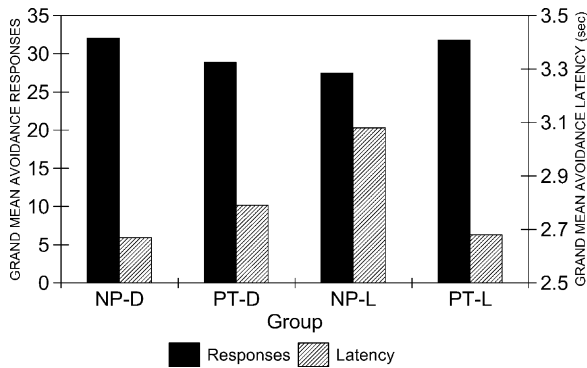


Fig. 2. Grand mean number of avoidance responses and grand mean avoidance latency during two-way avoidance training with darkness (D) or flashing light (L) feedback stimuli for the nonpreexposed (NP) groups and for the tactual-cues preexposure (PT) groups.

preexposure to the tactual context cues facilitated avoidance learning. Group PT-L produced overall better avoidance performance as compared to the nonpreexposed control group, Group NP-L. However, when darkness was employed as a feedback stimulus, no such effect was obtained. Group PT-D did not differ from Group NP-D in overall avoidance performance.

Repeated measures MANOVA for groups PT-L and NP-L revealed a significant effect of groups, $T^2 = 8.96$, $F(2, 25) = 4.31$, as well as a significant effect of trial blocks, $T^2 = 842.60$, $F(10, 17) = 55.09$, the latter reflecting the improvement in avoidance performance with trials. The interaction was not reliable. MANOVA of the performances of groups PT-D and NP-D indicated no effect of groups, $T^2 = 0.81$, $F(2, 21) = 0.39$. However, both groups did improve avoidance performance with training as indicated by a significant effect of trial blocks, $T^2 = 347.91$, $F(10, 13) = 20.56$. The groups \times trial blocks interaction was not significant.

4. Discussion

The findings of the present research are, in general, consistent with the tenets of effective reinforcement theory (e.g. Callen, 1986; McAllister and McAllister, 1991; McAllister et al., 1979). Manipulations involving preexposure to different components of the

context cues were found to differentially affect the influence of the feedback stimuli. When a flashing light feedback stimulus was used, avoidance performance following preexposure, either to visual context cues (PV-L) or to tactual context cues (PT-L), was superior to that of the nonpreexposed control group (NP-L). The explanation of these findings proposed here rests on the assumption that in the present study preexposure reduced the amount of fear that became conditioned to those context cues during avoidance training (e.g. McAllister et al., 1979, Experiment 2). Consequently, it was expected that there would be less fear present following the response and greater effective reinforcement in the preexposed groups as compared to the nonpreexposed group. The resulting facilitation of performance with preexposure to different elements of the context is consonant with other research which has shown that preexposure to the total context improves two-way avoidance learning in other situations (e.g. Dieter, 1977; McAllister et al., 1979). It should be noted that a decrease in the amount of fear present after the response is also proposed to take place because of a stimulus generalization decrement of fear that occurs with the presentation of the flashing light feedback stimulus. However, this latter source of reinforcement would be expected to be the same in each of the three groups (PV-L, PT-L, NP-L).

When darkness is used as the feedback stimulus, other considerations are required. With preexposure to the visual cues (PV-D), the consequent reduction in the amount of fear conditioned to these cues during avoidance training would degrade the effectiveness of darkness as a feedback stimulus. That is, with little fear of the visual cues, the fear reduction occurring with presentation of the darkness feedback stimulus would be minimal in the preexposed group. On the other hand, for the nonpreexposed group (NP-D), with greater fear of the visual cues, a larger amount of fear reduction would be expected to occur with presentation of the darkness feedback stimulus. As a result, superior avoidance performance should occur in the nonpreexposed darkness group, as compared to the visual cues preexposed group, as was found in the present study.

A complication arises in predicting the effect of preexposure to tactual context cues when a darkness feedback stimulus is employed. For both the

preexposed (PT-D) and the nonpreexposed (NP-D) groups, the darkness feedback stimulus is predicted by effective reinforcement theory to facilitate performance by removing the fear of the visual context cues, and this effect should be equal in these two groups because there was presumably equal visual cues fear present. It might be expected that an advantage in performance should accrue to the preexposed group PT-D compared to NP-D because of the lesser amount of fear of these cues present after the response. However, an offsetting effect may have been present attributable to the preexposure treatment itself. Because preexposure to the tactual cues was administered in darkness, subjects in Group PT-D were effectively preexposed to the feedback stimulus, and this procedure may have compromised the ability of this stimulus to produce a stimulus generalization decrement of fear after the response occurred. Some support for this notion is provided by Feldman (1977) who reported that preexposure to a feedback stimulus reduced the effectiveness of that stimulus in an avoidance-learning situation. Perhaps the similar performances of the PT-D and the NP-D groups may be attributed to these opposing effects.

For nonpreexposed subjects, darkness as a feedback stimulus (Group NP-D) produced better avoidance performance than did the flashing light (Group NP-L). This result supports the proposition that effective reinforcement is inversely related to the amount of fear present after a response. As applied to this experiment, the assumption is that both feedback stimuli reduce fear following the response by producing a stimulus generalization decrement. However, effective reinforcement theory also proposes that the darkness feedback stimulus additionally increases effective reinforcement by removing the fear of the visual cues, with a consequent facilitation of avoidance performance. The better performance observed in Group NP-D as compared to NP-L is consonant with this proposition. It should be noted, however, that an alternate explanation for this finding cannot be ruled out. It is possible that differences in salience between the two feedback stimuli, if present, could have produced such a result. That is, if darkness was a more salient feedback stimulus than the flashing light, then the superior performance of NP-D to NP-L may be attributable in part to that

variable rather than to the other factors proposed above.

Acknowledgements

The present research was conducted at Northern Illinois University and was supported in part by Grant MH-36610 from the National Institute of Mental Health awarded to Wallace R. McAllister and Dorothy E. McAllister, to whom the author is grateful for their valuable comments on an earlier version of this manuscript, and by a grant awarded to the author from Northern Illinois University.

References

- Bolles, R.C., Grossen, N.E., 1969. Effects of an informational stimulus on the acquisition of avoidance behavior in rats. *J. Comp. Physiol. Psychol.* 68, 90–99.
- Bower, G., Starr, R., Lazarovitz, L., 1965. Amount of response-produced change in the CS and avoidance learning. *J. Comp. Physiol. Psychol.* 59, 13–17.
- Callen, E.J., 1986. Fear of the CS and of the context in two-way avoidance learning: between and within-subjects manipulations. *Anim. Learn. Behav.* 14, 80–89.
- Callen, E.J., McAllister, W.R., McAllister, D.E., 1984. Investigations of the reinstatement of extinguished fear. *Learn. Motiv.* 15, 302–320.
- D'Amato, M.R., Fazzaro, J., Etkin, M., 1968. Anticipatory responding and avoidance discrimination as factors in avoidance conditioning. *J. Exp. Psychol.* 77, 41–47.
- Dieter, S.E., 1977. Preexposure to situational cues and shock intensity in two-way avoidance learning. *Anim. Learn. Behav.* 5, 403–406.
- Feldman, M.A., 1977. The effects of preexposure to a warning or a safety signal on the acquisition of a two-way avoidance response. *Animal Learning. Anim. Learn. Behav.* 5, 21–24.
- Keehn, J.D., Nakkash, S., 1959. Effect of a signal contingent upon an avoidance response. *Nature* 184, 566–568.
- Lubow, R.E., 1973. Latent inhibition. *Psychol. Bull.* 79, 398–407.
- McAllister, D.E., McAllister, W.R., 1991. Fear theory and aversively motivated behavior: some controversial issues. In: Denny, M.R. (Ed.), *Fear, Avoidance, and Phobias: A Fundamental Analysis*. Lawrence Erlbaum Associates, Hillsdale, NJ, pp. 135–163.
- McAllister, W.R., McAllister, D.E., 1992. Fear determines the effectiveness of a feedback stimulus in aversively motivated instrumental learning. *Learning and Motivation* 23, 99–115.
- McAllister, D.E., McAllister, W.R., Dieter, S.E., 1976. Reward magnitude and shock variables (continuity and intensity) in shuttlebox-avoidance learning. *Anim. Learn. Behav.* 4, 204–209.

- McAllister, W.R., McAllister, D.E., Dieter, S.E., James, J.H., 1979. Preexposure to situational cues produces a direct relationship between two-way avoidance learning and shock intensity. *Anim. Learn. Behav.* 7, 165–173.
- McAllister, W.R., McAllister, D.E., Douglass, W.K., 1971. The inverse relationship between shock intensity and shuttle-box avoidance learning in rats: a reinforcement explanation. *J. Comp. Physiol. Psychol.* 74, 426–433.
- Mowrer, O.H., 1947. On the dual nature of learning—a re-interpretation of “conditioning” and “problem-solving”. *Harvard Educ. Rev.* 17, 102–148.