INCREASE VERSUS DECREASE IN NOISE INTENSITY AS A CUE IN AVOIDANCE CONDITIONING

Kazimierz ZIELIŃSKI

Department of Neurophysiology, Nencki Institute of Experimental Biology, Warsaw 22, Poland

Most of the experiments, in which a decrease in the level of external stimulation was used as a conditioned stimulus (CS), were devoted to the study of the effectiveness of such CSs, and only few of them were concerned with the problem of transfer between stimuli consisting of changes in the background intensity level in opposite direction. Although in an eye-lid conditioning experiment it was found nearly complete positive transfer between an increase and a decrease in light intensity (Logan and Wagner 1962), in other studies negative transfer was observed both for light intensity (Schwartz and Goodson 1958) and auditory intensity (Champion 1962, Zieliński 1965).

It was reported previously that positive transfer of the conditioned response (CR) to change in background white noise stimulation in the opposite direction was not observed, irrespective of whether the testing stimulus was at a different or at the same absolute intensity as the CS (Zieliński 1965). This is in favour with the hypothesis that the relation of the CS to the background intensity, not the absolute intensity of the CS, has a cueing function. However, these results were obtained with the CER (conditioned emotional response) procedure in which acquisition of the CR involved training to discriminate between antagonistic drives and response patterns: bar-pressing for food during the background noise intensity, and fear to the CS intensity. This dualistic character of the technique raises some theoretical problems. One may say that the direction of change in noise intensity (and not the absolute value of the conditioned stimuli) may posses cueing functions only when such changes are signals for two antagonistic drives and corresponding response patterns from the very beginning of training. The aim of the present study was to examine this possibility by carrying out similar experiments in a situation involving only one drive during the acquisition of the conditioned reflex.

MATERIALS AND METHOD

The *Ss* were twenty experimentally naive adult male cats. Experiments were carried out in a cage, 65×55×40 cm, with a grid floor to apply shock to the paws of the animal. The cage was placed in a soundproof CR-chamber. A bar, 10×2 cm, was located 10 cm above the floor in the middle of an oblong wall of the cage.

Twenty *Ss* were randomly assigned to one of two experimental groups of 10 *Ss* each. Training of an avoidance bar-pressing response was then carried out. As in previous experiments, a series of platforms of decreasing size was used to shape the bar-press response (Zieliński and Sołtysik 1964). For the first group (Increase Group) the CS consisted in an increase in the intensity of white noise from a background level of 60 db to the 70 db, and in the second group (Decrease Group) the CS was a decrease of the same background to the 50 db white noise intensity. A white noise from a Grason-Stadler Model 901A generator was delivered to the experimental box via a loudspeaker. The CS-US interval was of 5 sec duration. The US was an electric shock delivered through the grid floor. An a-c source at 50 hz was used. A resistance of 100 kohm was placed in series with the cat in order to approximate a constant current source. For all *Ss* the shock of 4 ma intensity was used, except of the first 3 days of training, when the shock intensity was manually adjusted to the *Ss* behavior. During the first 5 sec of the CS a bar press terminated the CS immediately and prevented shock. Response made after the onset of shock terminated the CS and the shock simultaneously. Only bar presses initiated during the CS were effective in terminating the trial. Each training session consisted of 10 trials, the intertial intervals were of 40, 60, and 80 sec duration, randomly distributed.

The training was carried out until a criterion of 90 avoidance responses in 10 consecutive sessions was reached. The last 10 training sessions are referred to as the criterion period. Three *Ss* which showed no progress in avoidance learning were discarded. Thus, data presented in this paper are based on 9 *Ss* in the Increase Group, and 8 *Ss* in the Decrease Group.

After the avoidance criterion was met, two blocks of five test sessions each were run. Between the two blocks of test sessions, the *Ss* rested in their home cages for 10 days. During test sessions three intensities of the white noise were presented to each cat: 50 db (the CS intensity for the Decrease Group and the non-CS intensity for the Increase Group), 60 db (the previous background intensity), and 70 db (the CS intensity for the Increase Group and the non-CS intensity for the Decrease Group). In one test session the 50 db and the 70 db white noise were presented five times each, according to Gellerman (1933) series. Test session started with the 60 db white noise intensity and after each presentation of the 50 db or the 70 db a 60 db noise was given. Thus, in each test session the 60 db intensity was presented five times after the 70 db, and five times after the 50 db white noise. Each presentation of 50 db, 60 db, or 70 db noise lasted until the *S* responded but no more then 30 sec, and simultaneously with discontinuation of a given intensity another, programmed before, intensity of the white noise started. Thus, for each test intensity there were presentations terminated by *S*, and presentations in which bar-pressing did not occur. Proportions of presentations terminated by the bar-press in the overall number of presentations of a given test intensity are the main index of performance during test sessions. No shocks were delivered during the tests.

The third stage of the experiment consisted of 10 retraining sessions under the previously used procedure (shock intensity of 4 ma).

Latency of the bar-press was measured to the nearest 0.2 sec. The numbers of intertrial responses (ITR) were also collected. Automatic programming of experiments and recording of data was provided by relay, timer and counter systems.

RESULTS

Acquisition of the avoidance response. Cats reached the criterion of avoidance performance after 17 to 65 training sessions with a mean of 34.0 sessions in the Increase Group and 34.6 sessions in the Decrease Group. The ITR continued to occur even at the end of the acquisition stage. During the criterion sessions, the day-to-day variability of the ITR number for each individual was small.

Latency of the avoidance and escape response during the criterion period was carefully examined. For each *S* the median latency of the bar-pressing response during the last 100 training trials was calculated. For the Increase Group the median of individual medians was 2.40 sec and for the Decrease Group it was 2.83 sec. The difference between groups was not significant statistically (Mann-Whitney U test). An analysis of variance of median latencies by group and sessions within the criterion period also failed to yield significance (Lindquist 1953, mixed design type I).

An analysis of latency distributions (histogram analysis), similar to one previously described (Zieliński 1970), was used. The distributions for the two groups are similar form, and strongly skewed to the right (Fig. 1).

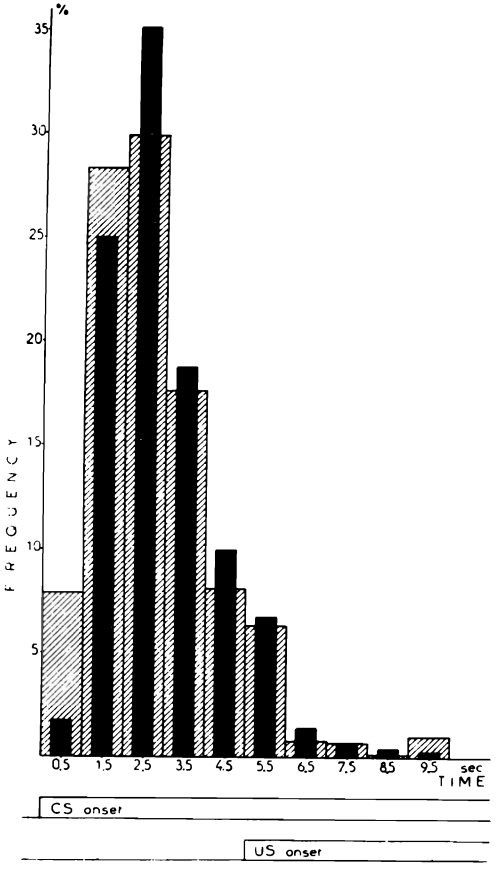

Fig. 1. Relative frequency histograms showing distributions of latencies of the bar-pressing avoidance or escape responses in the Increase (crossed area) and in the Decrease (blackened area) Groups. The CS-US period was of 5 sec duration, thus five bars on the left refer to avoidance response latencies and five bars on the right refer to escape response latencies.

However, the percentage of responses with latencies of less than 1 sec, was five times greater in the Increase Group than in the Decrease Group. A statistical comparison of these distributions by the Kolmogorov–Smirnov two-tailed test shows that they differ statistically ($p<0.005$). The greatest difference between the two cumulative frequency distributions was observed at a value of 1.7 sec. During the criterion period 25% of responses in the Increase Group had latencies less than 1.7 sec, whereas in the Decrease Group only 10% of responses had latencies shorter than this value.

Performance during test sessions. The test sessions were designed to answer two questions: Is there any transfer between 70 db and 50 db white noise intensities, and how much responding will occur to the 60 db intensity presented after higher or lower intensities? As seen from Table I *Ss* responded more often to the CS intensity than to the non-CS intensity. Such behavior was observed in each cat during the first, as well as during the second block of test sessions.

TABLE I

Proportion of test intensity presentations terminated by the bar-press in over-all number of presentations of a particular noise intensity

Group	Intensity			
	50 db	70 db	60 db after	
			70 db	50 db
The first block of test sessions				
Increase	0.21	0.88	0.39	0.72
Decrease	0.94	0.29	0.68	0.34
The second block of test sessions				
Increase	0.14	0.86	0.35	0.59
Decrease	0.91	0.26	0.40	0.34

Differences in latencies of responses to the 50 db and the 70 db white noise during the test were also observed. As shown in Fig. 2, the relative cumulative frequency distribution of latencies to CS intensities and to non-CS intensities have different forms. All curves are similar in slope up to a value of 3 sec. They then diverge: the numbers of responses emitted to non-CS intensities rapidly decrease and the slope of these curves are nearly constant between the values of 3 and 30 sec.

Six comparisons between the frequency distributions were made using the Kolmogorov–Smirnov two-sample test. The distributions of latencies to non-CS intensities (50 db in the Increase Group and 70 db in the Decrease Group) did not differ significantly. All other comparisons revealed differences significant at the $p < 0.001$ level. Over-all median latencies of responses to the CS intensities were longer during test sessions than during the criterion period, as would be expected as the result of omitting shock during the test sessions.

A return to a 60 db noise level after 50 db test stimulus entails an increase in intensity, whereas a return to 60 db after a 70 db test stimulus entails a decrease in noise intensity. Data presented in Table I indicate that *Ss* trained with an increasing CS-intensity responded more to a 60 db intensity when it was preceded by a 50 db stimulus (increase to 60 db)

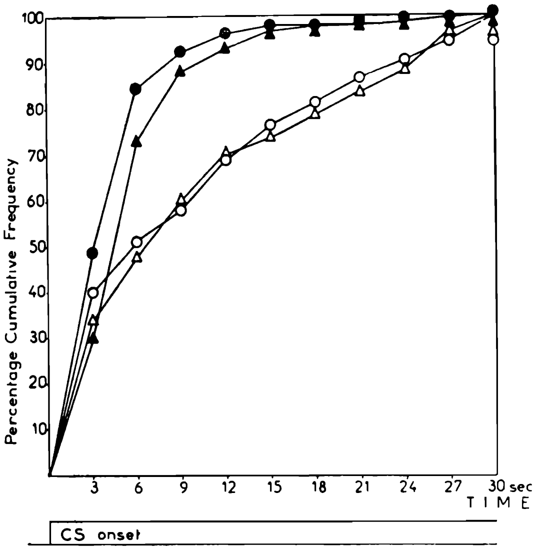

Fig. 2. Cumulative frequency distributions of the latencies of bar-pressing responses to 70 db (circles) and 50 db (triangles) white noise presentations during test sessions. Full signs correspond to the CS intensity and open signs correspond to the non-CS intensity.

than when preceded by a 70 db stimulus. Similarly, after training to a CS of 50 db, *Ss* responded more to 60 db intensity when it was preceded by a 70 db stimulus (decrease to 60 db) than when preceded by a 50 db stimulus. Comparison of the numbers of responses emitted during the first block of test sessions to the 60 db presented after 70 db or after 50 db white noise shows positive transfer from the direction of change during training in all but one *S* ($p < 0.002$, binominal test, two tailed). During the second block of test sessions positive transfer was observed in 11 *S*s, two *S*s showed opposite relation, and in four *S*s there was no difference in number of responses emitted to 60 db white noise presented after 70 db or after 50 db noise.

It is important to show how test stimuli influence the rate of response. For each *S* the mean rate of responding to the 60 db background noise during the criterion sessions was calculated. To estimate the mean rate

TABLE II

The number of bar-presses emitted in 1 min to the 60 db background noise during criterion sessions (ITR rate) and to test intensities of the white noise

Group	Criterion sessions ITR rate	Test sessions Rate of responding to 50 db	70 db	60 db after 70 db	60 db after 50 db
Increase	1.98	0.37	11.76	0.96	2.91
Decrease	1.84	8.26	0.31	1.59	0.25

of responding to a particular test intensity, the number of bar-presses emitted to this intensity and the time of action of this noise intensity in all 10 test sessions were used. The group medians from those individual means shown in Table II indicate that non-CS intensities and the 60 db noise after a change of intensity in opposite direction than from background to the CS markedly reduce rate of responding. However, there was a positive correlation between intertrial rate of response during criterion sessions and numbers of bar-presses to the non-CS intensity as well as to the 60 db noise during test sessions (in each case $p < 0.05$, Spearman rank order correlation).

Performance during retraining sessions. In spite of omission of shock during 10 test sessions, only a few applications of shock were necessary to reestablish avoidance response. During the first retraining session four *S*s performed avoidance to each presentation of the CS, and another six cats failed only once. In consequency, most *S*s performed at least 90 avoidance responses during the 10 retraining sessions. Three *S*s from the Increase Group and two *S*s from the Decrease Group which did not reached 90% level of performance have had small numbers of ITR during the criterion sessions and emitted comparatively small numbers of responses during the test sessions.

No group differences were observed during retraining sessions except of frequency distributions of latencies, similarly as during criterion sessions.

DISCUSSION

The question of whether the onset of a stimulus is equally, or more effective, than the offset of the same stimulus is important for theories concerning the relation between the energy of the conditioned stimulus and response strength. According to the Pavlovian "law of strength" (Pavlov 1949), and Hullian "stimulus intensity dynamism" (Hull 1949, 1952) the response strength is positively correlated with the absolute intensity of the CS. Thus the onset of the stimulus has to be more effective than the offset of the same stimulus. Similarly, the increase of the background stimulation level has to be more effective than comparable decrease of the same background stimulation. On the other hand, according to the "discrimination" interpretation of the stimulus intensity effect (Champion 1962, Logan 1954, Perkins 1953) onset and offset of a stimulus could be equally effective as conditioned stimuli. These authors assume that the amount of learning is independent of the intensity of the CS. The response strength to the given CS is determined by two opposite factors: an excitatory potential acquired in the course of conditioning and an inhibitory potential which is generalized from the intertrial stimulus on the given CS. Thus "... stimulus intensities appropriately chosen as equal j.n.d. distances away from the intermediate stimulus should give the same probability of CR even through one is more intense than the other" (Logan 1954, p. 78).

One of the reason why some experimental data concerning the effectiveness of a decrease in the external stimulation level as a CS are in favor of the first and others of the second group of theories, may be that not all indices of the response strength are sensitive to CS intensity. In the present experiment the only index which showed differences between the two experimental groups was positive skewness in the relative frequency distributions of latencies. Cats trained to respond to an increase in intensity performed the avoidance response faster than cats trained to respond to a decrease. These data indicate that an increase in the intensity of white noise is more reflexogenic than a decrease. The shorter latency could become an important consideration under the circumstances of a short CS-US interval.

During the acquisition of the avoidance response a between-*S*s design was used to examine the effect of the intensity of the CS. During the test sessions a within-*S*s design was used, in which each *S* was exposed to four conditions of noise intensity change, one of them being identical to the change used as the CS during the avoidance training. This made possible comparisons based on the direction of change and on the absolute level of intensity. As in the original transposition studies, one can preserve a relation between two stimuli although their absolute intensities are changed.

In the present experiment the CS and the intertrial stimulus were not completely discriminated as indicated by ITRs observed in all *S*s. Thus, in test sessions, when shock was omitted, it was possible to use the rate of responding to show how different test stimuli change the same mode of behavior. When the direction and amount of change were the same as during the acquisition of the avoidance reflex, and only the initial and final white noise intensities were different, a positive transfer of responses was observed. When the relations between the initial and final intensities of the white noise were reversed, the rate of responding was markedly reduced.

Results of the present experiment are in full agreement with those of previous study in which rats were used as experimental animals and acquisition of the conditioned reflex involved discrimination of two drives and response patterns (Zieliński 1965). Results of both experiments support the conclusion that as far as noise intensity is concerned, direction of change is more important than absolute level in determination whether or not a conditioned response will occur.

ERRATUM

The third Reference *should be:*

HULL, C. L. **1949.** Stimulus intensity dynamism (V) and stimulus generalization. Psychol. Rev. 56: 67–76.

SUMMARY

Avoidance bar-pressing response was trained in two groups of cats. The change of the white noise intensity from 60 to 70 db was the CS in one group and the change from 60 db to 50 db was the CS for the second group. The groups did not differ in the rapidity of learning, however, an increase of the noise intensity evoked a greater number of short-latency responses than its decrease. During testing 50, 60 and 70 db intensities of the white noise were presented to each cat. No transfer between 70 db and 50 db noise intensities was observed. The amount of responses performed to a noise of the 60 db intensity has been determined by the preceding intensity of the noise. When the direction of the intensity change was the same as that from the background to the CS during training, a positive transfer of the conditioned response was observed. The 60 db noise after a change of intensity in the opposite direction markedly reduced rate of responding.

This investigation has been aided by a grant from the Foundations' Fund for Research in Psychiatry. The author is indebted to Dr H. M. Jenkins for valuable suggestions during preparation of this paper and for correction of English text.

REFERENCES

CHAMPION, R. A. 1962. Stimulus-intensity effects in response evocation. Psychol. Rev. 69: 428–449.

GELLERMAN, L. N. 1933. Change orders of alternating stimuli in visual discrimination experiments. J. Genet. Psychol. 42: 206–208.

HULL, C. L. 1952. A behavior system. An introduction to behavior theory concerning the individual organism. Yale Univ. Press, New Haven. 372 p.

HULL, C. L. 1952. A behavior system. An introduction to behavior theory concerning the individual organism. Yale Univ. Press, New Haven. 372 p.

LINDQUIST, E. F. 1953. Design and analysis of experiments in psychology and education. Riverside Press, Cambridge. 393 p.

LOGAN, F. A. 1954. A note on stimulus intensity dynamism (V) Psychol. Rev. 61: 77–80.

LOGAN, F. A. and WAGNER, A. R. 1962. Supplementary report: direction of change in CS in eyelid conditioning. J. Exp. Psychol. 64: 325–326.

PAVLOV, I. P. 1949. Dvadtsatiletniï opyt ob"ektivnogo izucheniya vyssheï nervnoï deyatel'nosti (povedeniya) zhivotnykh — uslovnye refleksy. Izdat. AN USSR, Moscow. 605 p.

PERKINS, C. C., Jr. 1953. The relation between conditioned stimulus intensity and response strength. J. Exp. Psychol. 46: 225–231.

SCHWARTZ, M. and GOODSON, J. E. 1958. Direction and rate of conditioned stimulus change in avoidance performance. Psychol. Rep. 4: 499–502.

ZIELIŃSKI, K. 1965. The direction of change versus the absolute level of noise intensity as a cue in the CER situation. Acta Biol. Exp. 25: 337–357.
ZIELIŃSKI, K. 1970. Retention of the escape reflex after prefrontal lobectomy in cats. Acta Neurobiol. Exp. 30: 43–57.
ZIELIŃSKI, K. and SOŁTYSIK, S. 1964. The effect of pretraining on the acquisition and extinction of avoidance reflex. Acta Biol. Exp. 24: 73–87.

Received 25 January 1971