Go-no go avoidance discriminations in rats with simple "go" and compound "no go" signals: Stimulus modality and stimulus intensity

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Four groups of 16 rats were trained in a go-no go discrimination with symmetrical negative reinforcement (active-passive avoidance task). A 2 by 2 design was used with stimulus combinations as one factor [light-go, noise/light-no go, (L^+NL^-) vs noise-go, light/noise-no go (N^+LN^-)] and noise intensity as the other factor (90 dB, high, vs 70 dB, low). The two N^+LN^- groups learned both active and passive avoidance responses much more rapidly than the L^+NL^- groups. In later phases of training, high noise intensity facilitated passive avoidance in the L^+NL^- condition and exerted a slight effect in the opposite direction in the other condition. While the differences in active avoidance learning were the same as in previous work on light and noise CSs, the interactions between stimuli of different modalities appeared to be more important than stimulus modality or stimulus intensity per se in determining rate of passive avoidance learning.

Several studies have emphasized the role of conditioned stimulus (CS) factors in the acquisition of instrumental avoidance responses. It is well known that, for rats, noise is a more efficient active avoidance (AA) signal than light (Smith, McFarland, & Taylor, 1961; Biederman, 1967), but it must also be considered that it produces stronger unconditioned motor responses and more pseudoconditioning phenomena (see discussion in Morgan, 1968). Recent data on go-no go avoidance discriminations (active-passive avoidance tests) have provided new evidence about the effects of acoustic and visual CSs and of their interactions (Rosić, Frontali, & Bignami, 1969; Rosić & Bignami, 1970). Rats trained with noise as go (AA) signal and light plus noise as compound no go (passive avoidance, PA) signal (N^+LN^-) learned much more rapidly than animals trained with the opposite arrangement (L^+NL^-). The greater difficulty of the latter discrimination was due not only to a retardation of AA learning, as expected on the basis of the above data, but also to an impairment of PA learning. The latter difference could not be accounted for either by sensory factors or by differences in the response modulating properties of light and noise per se. In fact, both discriminations with simple go and no go signals (L^+N^- , N^+L^-) were learned with few PA errors. This indicates that the differences were due to an interaction between the two components of the no go signal, which cannot be explained on the basis of the available behavioral and neurophysiological evidence.

The literature data on the interactions between stimuli of different modalities (effects on the startle reflex: Ison & Hammond, 1971; effects on classical conditioning: e.g., Kamin, 1969; Rescorla, 1969;

Sutherland & Mackintosh, 1971) suggest that the differences mentioned above could be due to a variety of factors. An obvious problem to be solved prior to further investigation was whether the interactions between noise and light stimuli, leading to the differences between the N^+LN^- and L^+NL^- discriminations, were really due to stimulus modality rather than to stimulus intensity effects. In the present experiment, the acquisition of N^+LN^- and L^+NL^- discriminations was studied with two different noise intensities, using the same light intensity as in the work quoted above. In order to have a better control of intensity level, a speech noise from a standard generator was preferred to the buzzer used previously. This was based on a preliminary study, not to be reported in detail, showing that the L^+NL^- discrimination was much more difficult than the N^+LN^- discrimination, both with the buzzer noise and with the speech noise, at approximately similar intensities (90 dB; see Method). Furthermore, as in one of the previous experiments (Rosić & Bignami, 1969, Experiment 4), rats were not given AA pretraining, so as to avoid possible effects of primacy of AA training and interactions between this and other factors.

METHOD

Except for noise source and intensity, materials and methods were the same as in a previous experiment (Rosić & Bignami, 1969, Experiment 4). Ss were adult male albino rats of a Wistar-derived strain. The apparatus consisted of a series of 490 x 270 x 225 mm shuttleboxes without central partition or barrier, with sound insulation provided by cork-lined wooden boxes. Light was provided by a 10-W bulb mounted at the center

Fig. 1. Discrimination learning in a shuttlebox with noise as active avoidance signal and light/noise as passive avoidance signal ($N^+ LN^-$), and with the opposite combination ($L^+ NL^-$). The intensity of light was the same in all groups. The intensity of noise was either 90 dB (high) or 70 dB (low). Omission errors are active avoidance failures and commission errors are passive avoidance failures.

of the ceiling. Noise was provided by a Grason-Stadler generator (Model 901 B) connected to a 4-in. loudspeaker located behind the shuttlebox in a central position. High-intensity (high) noise and low-intensity (low) noise corresponded to generator settings yielding, respectively, 90- and 70-dB readings on a Brüel & Kjaer

sound level meter (Type 2203), with the microphone placed inside the box at floor level. Scrambled shock of 1.5 mA (105 V ac with a 70-K-ohm resistance in series) was given through the grid floor.

Four groups of 16 rats each ($N^+ LN^-$ high, $N^+ LN^-$ low, $L^+ NL^-$ high, $L^+ NL^-$ low) were given six daily sessions per week for 3 consecutive weeks. Each session consisted of 50 trials at 30-sec intervals, with 25 AA and 25 PA trials administered according to the sequence (AA-PA-AA-PA-PA-AA-PA-AA; AA...) repeated 6.25 times. AA trials consisted of the presentation of the go signal followed 5 sec later by shock (US). A crossing response in the CS-US interval terminated the CS and prevented US, while a response after US onset terminated both CS and US simultaneously. PA trials consisted of the presentation of the go signal preceded by 1 sec and accompanied for its whole duration (5 sec) by the stimulus of the other modality. Crossings during these 6 sec of no go signal presentation were punished by shock until the animal returned to the opposite side of the box. Intertrial responses were also punished.

RESULTS

The results are reported in Fig. 1. These were analyzed by ANOVAs for repeated measures (trend analyses; Edwards, 1962) week by week, so as to obtain information about the different learning phases in the four conditions (Table 1).

In the first six sessions, the $N^+ LN^-$ groups showed faster learning than the $L^+ NL^-$ groups, with little reduction of initial error frequencies in the latter situation. This was confirmed by the finding of a significant interaction between sessions and signal combinations (henceforth indicated as CS modality). Separate analyses of AA failures (omission errors) and PA failures (commission errors) indicated that the lower frequencies of total errors in the $N^+ LN^-$ groups were due to a rapid decrease in both types of errors, except for a transient initial increase in commission errors (compare Sessions 1 and 2). The $L^+ NL^-$ animals, on the contrary, seemed almost unable to discriminate in this period, since the increase in correct active responses went with an almost parallel increase in commission errors. In fact, ANOVAs showed a significant effect of CS modality and sessions on omission errors and a CS Modality by Sessions interaction in the case of commission errors. The inferior discrimination learning by $L^+ NL^-$ animals was evident also in the second six-session block with significant CS modality effects on

Table 1
Results of ANOVAs on Total (Tot), Omission (Om), and Commission (Com) Errors in Successive Phases of Training

	df	First Week			Second Week			Third Week		
		Tot	Om	Com	Tot	Om	Com	Tot	Om	Com
A*	1,60							4.75**		
B	1,60	44.16†	13.12†	6.39**	34.69†	5.73**	14.74†	24.40†		23.85†
A by B	1,60									4.12**
C	5,300	35.77†	51.55†		57.51†	9.22†		3.20†	2.77**	4.88†
A by C	5,300							2.75**		3.06**
B by C	5,300	6.54†		2.58**						
A by B by C	5,300									

*A = noise intensity, B = CS modality, and C = sessions

** $p < .05$

† $p < .01$

all scores and sessions effects on total and omission errors. In fact, PA levels remained stable in this period.

In the third block, the most relevant feature was the appearance of noise intensity effects, previously absent. Both high groups showed lower frequencies of total errors than did the corresponding low groups, as indicated by the significant Noise Intensity by Sessions interaction. In fact, the analysis on omission errors showed only a significant effect of sessions, while the analysis on commission errors showed both a significant CS Modality by Noise Intensity interaction and a significant Noise Intensity by Sessions interaction. The former was evidently due to the better PA learning with a high than with a low noise intensity in the L^+NL^- test, while the difference, although less marked, was in the opposite direction in the case of the N^+LN^- discrimination. On the other hand, PA levels were stable during the last six sessions in the low groups, while the improvement continued in the high groups. This obviously accounts for the Noise Intensity by Sessions interaction.

DISCUSSION

The above results confirm the major role of stimulus factors in go-no go discriminations with symmetrical negative reinforcement, using a simple stimulus as AA signal and the same stimulus compounded with another from a different modality as PA signal. The higher frequency of omission errors in the L^+NL^- than in the N^+LN^- condition is in agreement with the data showing faster AA acquisition with a noise than with a light CS (Smith, McFarland, & Taylor, 1961; Biederman, 1967). The difference in PA learning, however, cannot readily be explained. Noise intensity level exerted some effect; nevertheless, the above general statement applies to situations using markedly different intensities. Therefore, the interactions between stimuli of the two modalities remain the main source of variance in the above type of test. Although the present data gave a clear answer on the latter point, only tentative hypotheses can be made concerning the nature of these stimulus factors.

In a previous discussion (Rosić, Frontali, & Bignami, 1969), it was hypothesized that species-specific responses to stimuli of different modalities were responsible for the differences observed. In fact, a motorogenic stimulus (noise) may be particularly unsuitable to act as "suppressor" of a locomotor response conditioned to a light signal in the AA trials (L^+NL^- discrimination). Vice versa, a stimulus with less marked motorogenic effects (light) may be used more efficiently to "suppress" the motor response to an acoustic signal (N^+LN^- discrimination). This tentative conclusion appears to be reinforced by the data showing that the enhancement of locomotor activity by noise is less marked in the presence than in the absence of light

(Seegal & Isaac, 1971). The data from the last block of sessions in the experiment reported here apparently contradict the above explanation, since the L^+NL^- high group performed better than the L^+NL^- low group. This, however, may simply indicate that stimulus discriminability influences asymptotic performance, while rate of acquisition depends mainly on the suitability of particular stimuli for controlling particular responses.

After excluding that stimulus intensity per se constitutes a major source of variance, it appears difficult to understand the nature of these interactions between stimuli of different modalities. Several phenomena of increasing complexity must be considered here. The first is exemplified by the work on the startle reflex, indicating that, prior to any formal training, the changes in the auditory and visual environment can lead to opposite types of response changes, depending on stimulus intensities and on interstimulus intervals (Ison & Hammond, 1971). The second is exemplified by the experiments on overshadowing and blocking in classical conditioning situations, indicating that modulation of fear by external stimuli can be a highly selective process (Kamin, 1969; Rescorla, 1969; Sutherland & Mackintosh, 1971). Finally, additional interactions can be expected between stimulus factors and response factors at the instrumental level, since it is well known that response requirements must be evaluated in connection with species-specific defensive behaviors (Bolles, 1971; Wahlsten, 1972).

Within a given type of avoidance discrimination, the attention must also be focused on response consequences outside the AA period. The test so far used includes two types of PA contingencies, namely, relatively short periods in which locomotor responses are punished in the presence of a signal and relatively long periods in which responses are punished in the absence of go and no go signals (ITR punishment). Therefore, the above results may be due at least in part to the fact that punishment of an escape or avoidance response can lead to much more complex response changes than simple extinction (Brown, 1969).

In conclusion, it appears that avoidance discriminations with different stimulus combinations and with different response consequences outside the AA period can be used for further research on avoidance response acquisition and maintenance, using Ss exposed to different contingencies at the same time (AA and PA; AA and extinction). As concerns stimulus factors, it appears necessary to ascertain whether or not the hypothesis of Konorski (1967), based on experiments with positive reinforcement, can be extended to situations with negative reinforcement. This hypothesis postulates that the signaling systems responsible for drive modulation are at least in part separate from those responsible for response choice under a given drive operation.

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