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AUDITORY DISCRIMINATION: THE KONORSKI QUALITY-LOCATION EFFECT

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Konorski showed that when a go/no-go procedure was used, sound quality discriminations were rapidly acquired and sound location discriminations were slowly acquired. These findings have been interpreted as a general constraint on the acquisition of auditory discriminations (quality-location effect). However, experiments carried out within an evolutionary framework (Harrison, 1984) have shown that the rate of acquisition of sound location discriminations varies widely as a function of the inclusion or exclusion of naturalistic features. These data suggest that Konorski's findings were a function of the special conditions of the experiments. The first purpose of the present experiments was to assess whether rats showed the effects noted by Konorski when studied under similar conditions. The second purpose was to study the effect of manipulating two natural features (novelty and stimulus-response adjacency) to assess whether the acquisition rates of quality and location discriminations could be greatly modified or made approximately equal, or both. When a go/no-go procedure was used and the other conditions were similar to those of Konorski, rats acquired a quality discrimination but did not acquire a location discrimination. However, when the S+ or S− were presented through a closely adjacent speaker, the sound location discrimination was acquired as rapidly as the quality discrimination. Finally, preexposing the animal to either S+ or S− retarded the rate of or prevented the acquisition of the quality discrimination. The experiments showed that the quality-location effect was determined primarily by the conditions used in Konorski's experiments, and that the effect is not a general constraint on learning.

Key words: auditory discrimination, go/no-go procedure, quality-location effect, constraints on conditioning, Konorski, location discrimination, rats

In a classical series of studies on auditory discrimination, Konorski and his colleagues showed that when a go/no-go procedure is used, auditory quality discriminations (e.g., metronome vs. buzzer, 300 Hz vs. 1,500 Hz tones) were more readily acquired than were discriminations of sound source location. When a go-left/go-right procedure was used, however, location discriminations were more readily acquired than were stimulus quality discriminations (Dobrzecka & Konorski, 1967, 1968; Dobrzecka, Szwejkowska, & Konorski, 1966; Konorski, 1967, p. 438; Lawicka, 1964, 1969). These findings, taken together, have been referred to in the literature as the quality-location effect (Burdick, 1979).

In discussions of the Konorski experiments, it is frequently assumed that the correlation between experimental paradigm and auditory stimulus dimension transcends the details of the particular experiments and that it is an example of an evolutionary constraint on learning (Seligman, 1970; Shettleworth, 1979). Miller and Bowe (1984) assumed the findings to be of fundamental importance in understanding learning, and they formulated the "quality-location" hypothesis in which the terms "quality difference" and "location difference" were extended to both stimulus and response properties. Burdick (1979), in an historical review, indicated that the quality-location effect has been observed from time to time throughout the history of the study of auditory discrimination.

It is quite possible that the results obtained were due wholly or in part to the particular conditions of the experiments, and that a change in these conditions may eliminate this correlation between experimental paradigm and ef-

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fectiveness of stimulus dimensions. The investigation of auditory discriminative behavior within an evolutionary context suggests that this is so. For example, some mammalian species have evolved a number of auditory behavioral properties whereby the acquisition of the discrimination of the location of a sound source is highly efficient only when the experimental conditions incorporate a number of naturalistic features (Harrison, 1983b, 1984). The wide range of performances obtained when the naturalistic features were varied showed that one cannot make general statements about the ease of acquisition of a sound location discrimination when a go-left/go-right paradigm is used.

The purpose of the present experiments was to investigate the extent to which the Konorski quality-location effect was produced by the specific conditions of the original experiments and the extent to which the effect can be modified by incorporating into the experiments features previously discovered to be influential (Harrison, 1984). In the present experiments we were concerned entirely with discriminations of stimulus quality and of stimulus source location, under a go/no-go operant paradigm. In the Konorski experiments, Pavlovian differentiation using salivary conditioning, and the motor-response analogue, constituted the go/no-go procedures. In all of those experiments, one stimulus (S+) was paired with reinforcement and the second stimulus (S−) was never paired with reinforcement. The present experiments used the same general approach applied to an operant procedure. Other experimenters have used the term "go/no-go" to designate other procedures. For example, Burdick (1980) and Weiskrantz and Mishkin (1958) used a procedure in which responding was reinforced in the presence of one stimulus (S+) and not responding was reinforced during the other (the no-go stimulus). Hence, in their procedure both stimuli were correlated with reinforcement. This and other forms of the go/no-go procedure were not investigated in the present experiments (see Elliott & Trahiotis, 1972, for a review).

The purpose of the first experiment was to determine whether rats showed the quality-location effect when Konorski's procedures were used. The purpose of the subsequent experiments was to determine whether the relative discriminability of location and quality differences could be modified by incorporating into the experiments naturalistic features known to be influential in other procedures.

EXPERIMENT 1

The purpose of this experiment was to train rats on quality and position discriminations under conditions similar to those used by Konorski in order to assess whether rats showed the effect described by the Konorski group.

METHOD

Subjects

The subjects were 8 male Sprague-Dawley rats, 90 to 150 days old at the start of the experiment. The animals were housed individually with free access to water. Body weight was reduced to 90% of the body weight of matched rats of the same cohort fed ad libitum. This procedure allowed the experimental animals to increase in weight in the course of the experiment to approximately 90% of what they would have weighed had they been fed ad libitum.

Apparatus

The apparatus consisted of a wire cloth cage, 30 cm deep by 34 cm wide by 30 cm high, with a response lever mounted on one wall, 5 cm from the corner and 10 cm above the cage floor (Figure 1). A speaker (Radio Shack Model 40-130) was mounted adjacent to the lever. An automatic liquid feeder was mounted at the center of the opposite wall, 3 cm above the floor. The feeder operated for 5 s per operation, and delivered 0.1 cc of diluted sweetened condensed milk (3 volumes water to 1 volume of milk) each time. In the majority of Konorski's experiments one speaker was mounted at the floor level and another about 2 m above the floor. A similar up-down arrangement was also used in the present experiments. One speaker was mounted 8.5 cm below the cage floor, 30 cm horizontally from the cage, and a second mounted 46 cm above the first, both outside and 34 cm from the cage. All speakers had aluminum funnels cemented over the speaker's opening in order to provide small (1 cm) sources of sound. A 5-W houselight was mounted on top of the apparatus. The apparatus was housed inside a five-sided acoustical chamber in a room separate from the control equipment.

A number of different stimuli were used in Konorski's experiments including 300, 900,

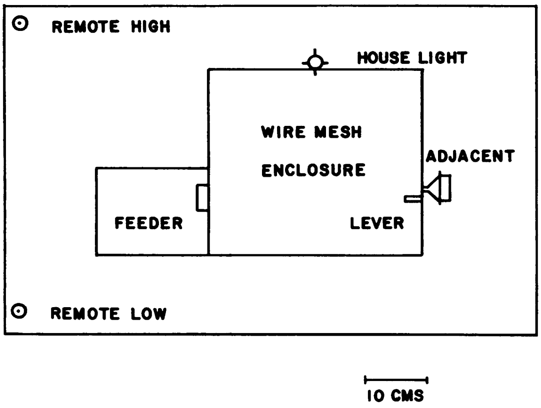

Fig. 1. Schematic diagram showing the front view of the animal enclosure and experimental apparatus. The remote high and remote low speakers faced away from the enclosure; the adjacent speaker faced the lever. Speakers were also positioned on a microphone stand at the same height as the remote speakers, but facing the enclosure and 2 feet away.

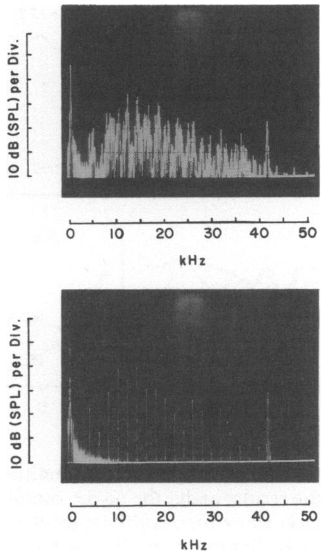

Fig. 2. Spectral analyses of the auditory stimuli. Top panel is noise; bottom panel is 2 kHz.

and 1,500 Hz tones, pulsed 10 ms square wave, a metronome, and a buzzer. In some of those experiments the stimuli in the training of quality discriminations were different from those used in the training of location discriminations. In the present experiments the same stimuli were used in all of the discriminations. The stimuli consisted either of noise bursts (125 ms on/125 ms off) or of bursts (50 ms on/50 ms off) of a rectangular pulse presented at 2 kHz. The noise had a continuous acoustic spectrum from 4 kHz to 50 kHz. The rectangular pulses produced a picket fence spectrum (spaced at 2 kHz) to 50 kHz (Figure 2). The acoustic spectra were measured using a 0.6-cm Bruel and Kjaer condenser microphone (4136) in conjunction with a Tektronix spectral analyzer (type 5L4N). The intensities of the stimuli were also set using the 0.6-cm microphone, calibrated with the Bruel and Kjaer pistonphone (model 4220). The intensity of a continuous nonbursting sample of the noise produced by the speaker adjacent to the response lever was set to 75 dB sound pressure level (SPL), 1 cm from the speaker. The intensity at the center of the cage produced by this continuous nonbursting sample of the signal was 46 dB SPL. The intensity of the noise at the upper and lower (remote) speakers was set to produce the same intensity at the cage center (46 dB SPL). Prior work has shown this noise to be an effective stimulus (Harrison, 1984). The acoustic signal produced by the 2-kHz signal was set to the same peak-to-peak amplitude as the noise, also using the 0.6-cm microphone. Prior experiments have shown that this stimulus was as effective as the noise in obtaining one-trial acquisition of a location discrimination at the 100% correct response level.

To reduce the background noise of the power amplifiers below the animal's auditory threshold (Kelly & Masterton, 1977), the speakers were connected to the amplifiers via −20 dB attenuators which prevented the background noise of the amplifiers from serving as discriminative stimuli. Random spikes coming in on the AC supply were reduced to the random noise level of the amplifiers by means of a constant-voltage transformer (Sola, type CVS-2), a line filter (Corcom, 10VR1), and multioxide varistors across common and differential modes of the AC supply. Cross talk between the two signals was reduced to the background noise level by using independent signal paths joined and grounded at only one place. To prevent uncontrolled and multiple grounding, the third prong of each AC power lead was removed. The noise was generated by a Grason-Stadler noise generator (901A) set to "white noise," and the 100-μs pulse was generated with Tektronix series 160 pulse and waveform generators. Both signals were switched by Grason-Stadler electronic switches

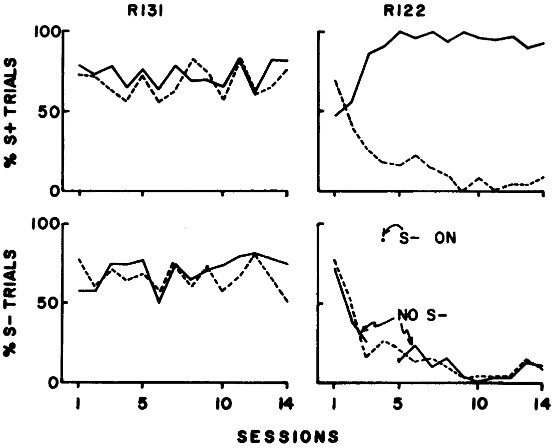

Fig. 3. Results under two control conditions. The left panels show the results under the no S+ condition (R131). The right panels show the results under the no S− condition (R122). In Session 4 the S− was presented. The graphs show the percentage of trials per session with at least one response. Stimulus trials are represented by solid lines, pseudotrials by dashed lines.

(models 829D and 829C). The experiments were programmed with relay equipment. Data were processed on line by a Timex-Sinclair 1000® microcomputer.

Procedure

Positive (S+) or negative (S−) stimuli were presented in a predetermined order at the end of variable intertrial intervals ($M = 22.55$ s) by a variable-interval timer that ran continuously throughout the session. When the timer timed out, either an S+ or S− trial was set up according to a preset order with alternation such that there never were more than three consecutive presentations of the same kind of stimulus. Negative stimuli were presented for 10-s trials, and they remained on for the duration of the trial independent of the behavior of the animal. Positive stimuli remained on until terminated by a response. Response data were also collected for the 10 s immediately prior to S+ (S+ pseudotrials) and S− (S− pseudotrials) trials. The animal received 40 S+ and 40 S− trials per session. All animals received at least 14 sessions of discrimination training.

During preliminary training the speakers were disconnected, the animals were magazine trained, and their lever pressing was shaped by differential reinforcement. Responses were then reinforced by deliveries of milk on a 45-s variable-interval schedule (usually for 2 or 3 days) until the animals were emitting at least 200 responses per hour. On the following day, after five reinforced responses, discrimination training was started by connecting the speakers to the sound system. The order of S+ and S− trials in the first session was constant for all animals. One of the authors (JCN) observed every animal for the first 10 S+ and S− trials with sound in order to identify any immediate changes in behavior elicited by the novel sounds.

For the quality discrimination, both the S+ (2-kHz signal) and the S− (noise bursts) were delivered from the upper remote speaker. For the location discrimination, the 2-kHz signal was delivered through either the upper or lower remote speaker. For Animal R153 the S+ was the 2-kHz signal presented through the upper speaker and the S− was the 2-kHz signal presented through the lower remote speaker. For Animals R119 and R121 the S+ was the 2-kHz signal presented through the lower remote speaker and the S− was the 2-kHz signal presented through the upper remote speaker.

Measurement of Behavior

The response counts were designed to measure control of responding by S+, S−, and S+ versus S−. Control of responding by S− relative to intertrial stimuli was measured by comparing the percentage of S− trials per session in which one or more responses were made in the presence of S− with the percentage of S− pseudotrials per session in which one or more responses were made. If the percentage of S− trials responded to was larger or smaller than the percentage of pseudotrials responded to, then S− would be exerting some control. Control of responding by S+ relative to the intertrial stimulus was measured in a similar fashion. Comparison was made of the percentage of S+ trials in which one or more responses was made in the first 10 s of the trials with the percentage of S+ pseudotrials in which one or more responses were made. Differential control of responding by S+ versus S− was measured by the differences in control by S+ and S− as shown by the two foregoing measures.

RESULTS

Control Conditions

To provide a baseline against with experimental results could be judged, and to ensure

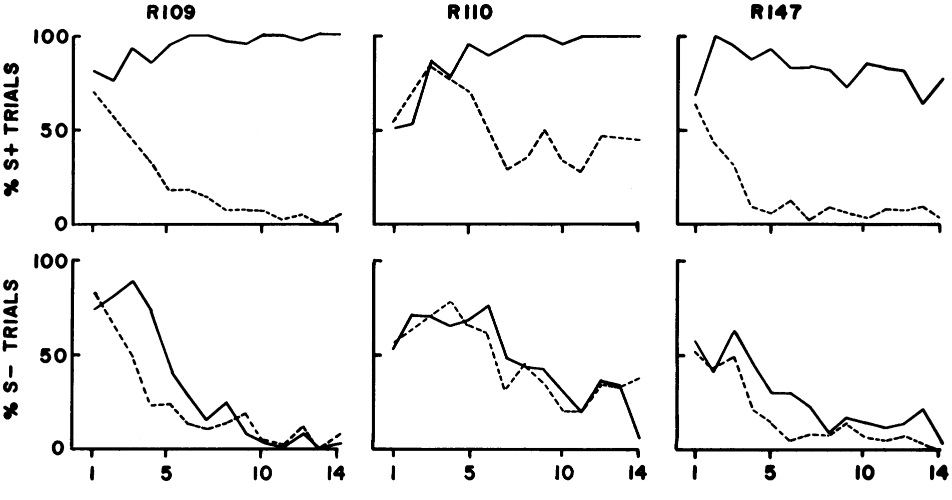

Fig. 4. Performances of 3 animals exposed to the remote quality discrimination procedure. The upper row of graphs shows the percentage of S+ trials (solid lines) in which at least one response occurred within the first 10 s, and the lower row shows the percentage of S− trials (solid lines) during which any responses occurred. Dashed lines show the percentage of pseudotrials that contained responses.

that there were no unknown artifacts differentially affecting responding, control animals were tested under conditions in which either the S+ or the S− speaker was unplugged during discrimination training. In these animals, "S+" or "S−" trials were simply additional pseudotrials, and there should be no systematic difference between responding in "S+" and "S−" trials and the corresponding pseudotrials. The behavior of 2 animals (R131 and R122), one with no S+ and the other with no S− during discrimination training, is shown in Figure 3. For R131, S− was pulsed noise presented through the upper remote speaker. The S+ circuit was not connected to any speaker. For R122, the S+ was the pulsed 2-kHz signal presented through the lower remote speaker. The S− speaker was disconnected and shorted, except during Session 4.

The left panels of Figure 3 show the performance of R131. Because the S+ circuit was not connected to any of the speakers, the "S+" trials were essentially pseudotrials. There was no systematic difference between responding during "S+" trials and pseudotrials. There was also no difference in performance in "S+" and S−, indicating, as expected, that there was no differential control of responding by S− trials versus "S+" trials nor any control of responding by S−.

The right panels of Figure 3 show the performance of R122 under the no S− condition. The S+ gradually acquired control of lever pressing. Except for Session 4 (when S− was presented) there was no systematic difference between responding in "S−" trails and pseudotrials. There was a large differential control of responding, as expected, between S+ trials versus "S−" trials.

Quality Discrimination

The performance of 3 animals during S+ (2 kHz) and during S− (noise) is shown in Figure 4. Both types of stimuli were presented from the remote upper speaker. By inspection of the figure it can be seen that all animals responded more during S+ than during the pseudotrials. In contrast, responding during S− was at the same level (R110) or at a slightly higher level (R109, R147) than responding during the pseudotrials. Responding during S+ clearly differed from that during S−; that is, there was differential control of responding by the two stimuli.

Location Discrimination

The performances of 3 animals exposed to the location discrimination task are shown in Figure 5. By inspection of the figure it can be seen that both S+ and S− strongly and equally evoked lever pressing. Thus, there was no differential control of lever pressing by the dif-

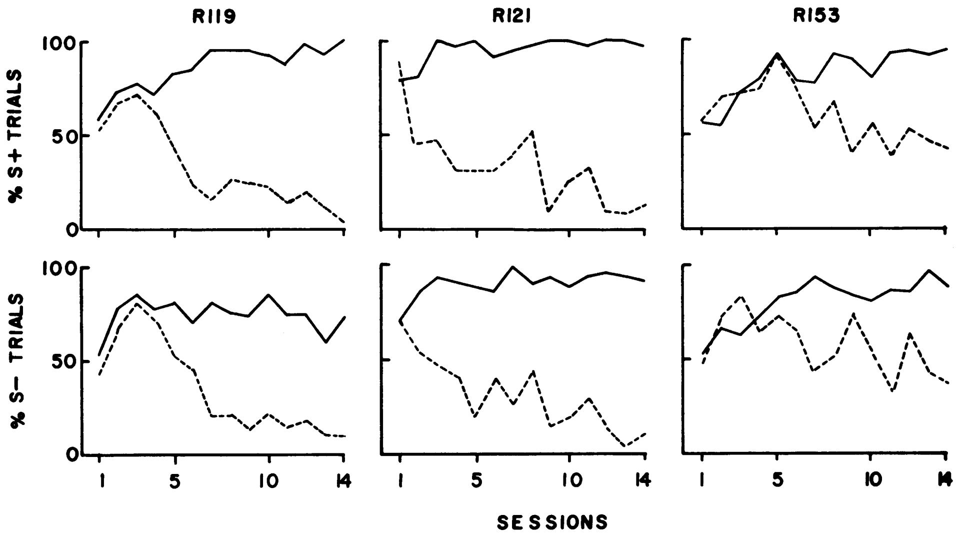

Fig. 5. Performances of 3 animals exposed to the remote (up-down) location discrimination procedure. Upper row of graphs shows the percentage of S+ trials (solid lines) in which a lever press occurred within the first 10 s, and the lower row shows percentage of S− trials (solid lines) during which any responses occurred. Dashed lines show the percentage of pseudotrials that contained responses.

ference in location of the 2-kHz signal source (responding in both pseudotrials dropped to a relatively low value, indicating acquisition of the sound/no-sound discrimination). The lack of differential control of responding by the position of the speakers would be a trivial finding if the animals could not localize the speakers. That the speakers could be localized was shown as follows (Harrison, 1979, 1983a). Behavior during the first discrimination session was observed in the location discrimination procedure. The first two or three presentations of sound from the upper speaker (when the stimulus was novel) resulted in the following performance in all animals: The animals immediately oriented to the speaker, ran over to the part of the cage closest to the speaker, and climbed the wall in a way that reduced their distance from the speaker. Presentations of the stimulus from the lower speaker resulted in a similar pattern of behavior directed at the lower speaker.

DISCUSSION

Results of this experiment support the findings of the Konorski group that quality discriminations are more readily acquired than are stimulus location discriminations when a go/no-go paradigm is used. The Konorski group showed that retarded acquisition of the location discrimination was not due to a lack of ability to localize the stimuli, because the location discrimination was readily acquired (in different animals) when a go-left/go-right procedure was used (Lawicka, 1969).

In the present experiment, differential control by position of the speakers was shown by the elicited exploratory behavior. When cats, rats, monkeys, and guinea pigs are exposed to novel sounds of low intensity, they orient to, approach, and explore the sound source (Buzsáki, 1982; Buzsáki, Grastyán, Molnár, Tveritskaya, & Haubenreiser, 1979; Clements & Kelly, 1978; Harrison, 1979, 1983a; Kelly, 1981; Pavlov, 1927, pp. 29, 43; Rogozea, Ungher, & Florea-Ciocoiu, 1970; West & Harrison, 1973). This phenomenon is robust and easily observed in rats. At the onset of the stimulus there is an immediate interruption of the stream of behavior. The animal immediately orients to and runs over to the sounding speaker. Here, the animal typically rears at the speaker and bobs around while sniffing at the aperture in front of the speaker. The directional aspects of the elicited orientation and approach are dependent upon binaural cues in rats, because the removal of the ossicles on one side or blocking of one ear abolishes orientation and approach but not the interruption of the stream of behavior (Burlile, Feldman, Craig, & Harrison, 1985; Clements & Kelly, 1978; Engelmann, 1928).

In the present experiment, rats acquired the quality discrimination but not the location discrimination, in line with Konorski's findings. Lawicka (1964, 1969) showed that when a go-left/go-right procedure was used, the location discrimination was readily acquired and the quality discrimination was not acquired. Lawicka concluded that a go/no-go procedure is required if quality discriminations are to be acquired and that a go-left/go-right procedure is required if location discriminations are to be acquired.

It is likely, however, that other variables can account for differences between acquisitions of quality and location discriminations in the go/no-go and go-left/go-right procedures. Thus, the investigation of auditory discriminations within an ethological context has shown that stimulus novelty and adjacency of speakers and response levers strongly affect the rate of acquisition (Harrison, 1981, 1983a, 1983b, 1984). Experiments 2 and 3 investigated the effects of stimulus novelty and speaker–lever adjacency on the rate of acquisition of the quality and location discriminations.

EXPERIMENT 2

In Experiment 1 and in the Konorski experiments, the speakers were not adjacent to the response sites and the stimuli were novel at the start of discrimination training. The conditions used in Experiment 2 enabled examination of the effects of adjacency of speaker and lever and the effects of stimulus novelty on the acquisition of the quality discrimination. Three conditions were used, in all of which the two stimuli were presented through the adjacent speaker (see Table 1). In the first condition, S+ and S− were novel at the start of discrimination training. Comparison of performance in this condition with performance in the quality discrimination in Experiment 1 (remote speakers) allowed the effects of adjacency to be assessed. In the second condition, the rats were preexposed to S− so that only S+ was novel at the start of discrimination training. In the third condition, the rats were preexposed to S+ so that only S− was novel at the start of discrimination training. Comparison of results obtained in the second and third conditions with the results of the first condition allowed the effects of the novelty of S+ and S− to be assessed.

Table 1

Adjacent quality discrimination.

	Stimulus state at start of training	
Condition	S+ (2 kHz)	S− (noise)
1	Novel	Novel
2	Novel	Preexposed
3	Preexposed	Novel

METHOD

Subjects

Nine male albino Sprague-Dawley rats were the subjects. The animals were experimentally naive and 90 days old at the start of the experiment. Each animal was individually housed and its body weight was reduced to 90% of that under ad libitum feeding as described in Experiment 1.

Procedure

The general procedure was the same as that used in Experiment 1. The stimuli (S+, the 2 kHz signal; S−, noise) were presented through the adjacent speaker. For the animals that were preexposed to S−, S− trials of 10 s duration were presented on a 45-s variable intertrial interval during all phases of preliminary training. The conditions were so arranged that an S− trial never overlapped with or immediately followed reinforcement. A similar procedure was used for animals preexposed to S+, except that the 2-kHz signal was presented in place of the noise. Each animal's discrimination training was started when its response rate reached 200 responses per hour. Training continued for 14 daily sessions, each having a total of 80 trials.

RESULTS

Responding during S+ and during S− when both stimuli were novel (and adjacent) at the start of discrimination training for the 3 animals is shown in Figure 6. All animals responded above 90% in S+ trials except for R146 during the first session. In 2 animals (R98, R148) there was a slightly higher but persistent level of responding during S− than during pseudotrials. For R146, responding during S− declined to the same level as re-

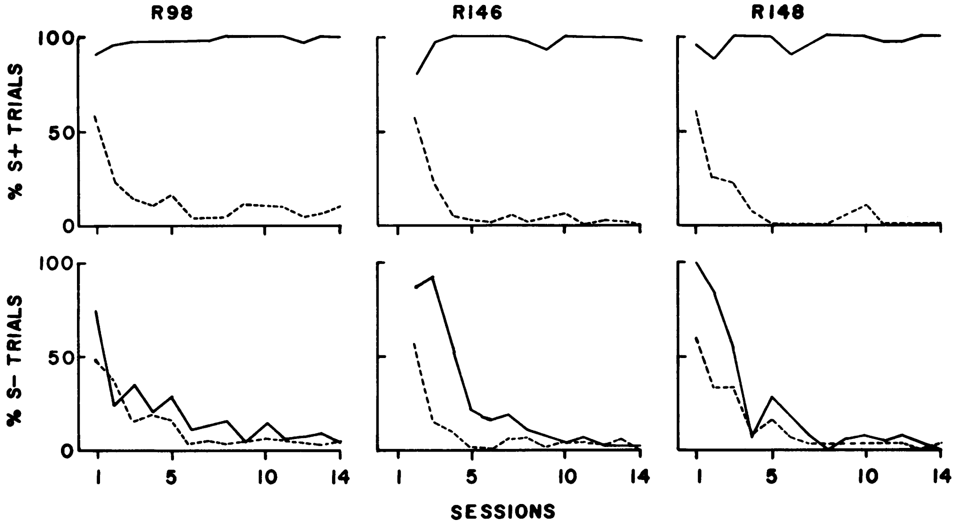

Fig. 6. Performances of 3 animals exposed to the adjacent quality discrimination procedure. The upper row of graphs shows the percentage of S+ trials (solid lines) in which a lever press occurred within the first 10 s, and the lower row shows the percentage of S− trials (solid lines) during which at least one response occurred. Dashed lines show the percentage of pseudotrials that contained responses.

sponding in the pseudotrials by Session 10. Thus, there was a large difference in the level of control of responding by S+ and S−; that is, there was strong differential control of responding by the quality difference between the stimuli. For R146, this control was perfect (100% for S+ and 0% for S− after the 10th session).

The effect of adjacency of speaker and lever on the quality discrimination can be seen by comparing performance of animals when the qualitatively different stimuli were presented through the adjacent speaker (Figure 6) with performance of the animals when the qualitatively different stimuli were presented through one of the remote speakers (Figure 4). Comparison of Figures 4 and 6 shows similar levels of responding evoked by the S− regardless of whether the stimuli were presented through the adjacent or the remote speaker.

Performance during S+ differed under the remote and adjacent conditions (Figures 4 and 6). When S+ was presented through the adjacent speaker, the percentage of S+ trials responded to within 10 s was higher than when the stimuli were presented through the remote speaker. Under the adjacent condition, Animals R98 and R148 responded within 10 s during more than 90% of the S+ trials in all sessions, and R146 responded in all but the first session (Figure 6). In contrast, under the remote condition (Figure 4), R109 and R110 required two to four sessions to reach the 90% level, and the S+ responding of R147 steadily declined from a high of 100% to below 90% over the 14 training sessions. The effect of adjacency was to improve differential control of responding by S+ versus S−, especially during early trials, through higher levels of S+ responding in the condition with adjacent stimuli.

Preexposure to S− resulted in higher levels of responding during S− in later sessions (Figure 7) than was found when S− was novel (Figure 6). Thus, for all the preexposed animals (Figure 7) responding during S− beyond Session 10 was clearly higher than the corresponding performances of the animals exposed to the procedure with novel S− (Figure 6). The data of Figure 7 suggest that responding during S+ also was affected by preexposure to S−. Thus, for 2 animals (R155, R159) control of responding by S+ for the first five sessions (Figure 7) was at a lower level than for all animals exposed to the precedure with novel S− (Figure 6). However, for one preexposed S− animal (R158) the S+ performance overlapped the S+ performances of the novel S− animals shown in Figure 6. In summary, preexposure to S− weakened the asymptotic level of differential control of responding by

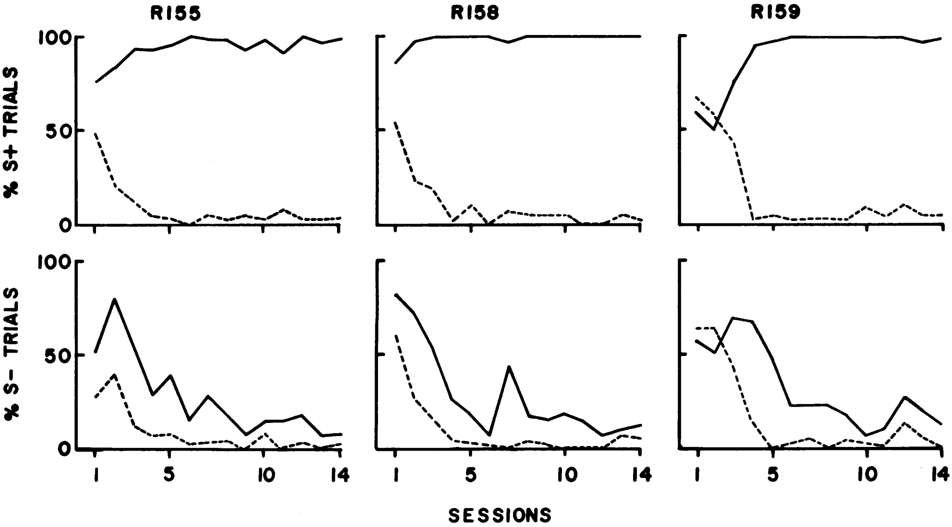

Fig. 7. Performances of 3 animals exposed to the adjacent quality discrimination procedure after preexposure to S−. The upper row of graphs shows the percentage of S+ trials (solid lines) in which a lever press occurred within the first 10 s, and the lower row shows the percentage of S− trials (solid lines) during which at least one response occurred. Dashed lines show the percentage of pseudotrials that contained responses.

S+ versus S−, mainly by raising the level of S− responding in later sessions.

The performances of 2 animals that had been preexposed to S+ is shown in Figure 8. The third animal died after only three discrimination training sessions, so the data were discarded. For Animal R162 there was no difference in responding in S+, S−, S+ pseudotrials, and S− pseudotrials, nor was there any decline in responding over sessions. The behavior of this animal resembled that of Control Animal R131 (Figure 3), for which the S+ speaker was unplugged during discrimination training, because no stimulus control was evident. The performance of Rat R163 resembled that of the animals that were preexposed to S− (Figure 7).

DISCUSSION

A comparison of the results of Experiments 1 and 2 suggests that adjacency of stimuli may be influential in the acquisition of the control of responding by the S+ in a quality go/no-go discrimination, and thus extends the earlier findings of an adjacency effect in go-left/go-right location discriminations (Harrison, 1984). Control of performance by S− was not affected by adjacency.

Preexposure appeared to have a larger effect on acquisition than did adjacency. Preexposure of the rats to either stimulus (especially S+, Figure 8) reduced the magnitude of the behavioral changes produced by subsequent exposure to the discrimination procedure. Previous work has shown that preexposure to S+ greatly reduced the rate of acquisition of discrimination between sound-source locations (Downey & Harrison, 1972; Harrison, 1983a,

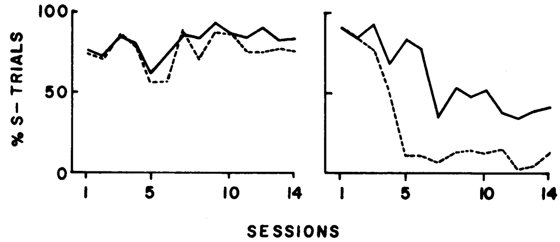

Fig. 8. Performances of 2 animals exposed to the adjacent quality discrimination procedure after preexposure to S+. The upper two graphs show the percentage of S+ trials (solid lines) in which a lever press occurred within the first 10 s, and the lower two show the percentage of S− trials in which at least one response occurred. The dashed lines show the percentage of pseudotrials that contained responses.

1983b). In rats, the discrimination was acquired in one trial when the stimuli were novel; following preexposure to S+, performance in the discrimination had not reached the asymptotic level after 10 sessions. Similar findings have been reported by Lubow (1973), who first discovered this effect of preexposure.

A likely function of orientation and approach to low-intensity sound sources is to bring an animal into contact with possibly biologically significant events (e.g., food). If the event is not a reinforcer, the elicited behavior rapidly declines to zero (Harrison, 1979, 1983a, 1983b). If, on the other hand, the event has reinforcing properties, the event will be approached and manipulated on subsequent occurrences (one-trial learning, Harrison, 1979). The present experiment, together with previous experiments on the effect of novelty in auditory discrimination (Downey & Harrison, 1972; Harrison, 1979, 1983a), showed that novel stimuli interact more strongly with the reinforcement of responding than do familiar stimuli.

EXPERIMENT 3

The purpose of our next experiment was to investigate the effect, on acquisition of the location discrimination, of making the position of one stimulus (either S+ or S−) adjacent to the response lever.

D'Amato and Salmon (1984) studied rats on an acoustic quality discrimination in which S+ and S− were presented through a speaker mounted under the response lever. The acquisition data were presented as the group discrimination ratio per session. The ratio steadily increased from about .5 to .9 over 12 sessions. This rate of acquisition is slow compared with the performance of the animals in the adjacent quality discrimination (Figure 6) in the experiments reported above. A previous finding in our laboratory, that adjacency was a highly significant variable in the rate of acquisition of go-left/go-right auditory discriminations (Harrison, 1984), suggested that adjacency may also be significant in the acquisition of the go/no-go location discrimination.

METHOD

Subjects

Six male albino Sprague-Dawley rats were the subjects. The animals were housed individually and were 90 days old at the start of the experiment. Body weights were reduced to 90% of those of cohort animals under ad libitum feeding, as described in Experiment 1.

Procedure

The general procedure was the same as that used in Experiment 1. For 2 rats (R138, R139), S+ consisted of trials of noise presented from the speaker adjacent to the response lever, and S− consisted of trials of noise presented from the high remote speaker. For the third animal of this condition (R141), the 2-kHz signal was used, with S+ still presented from the adjacent speaker. Three other rats (R134, R142, R143) were trained with the reverse conditions; that is, S− was noise presented from the adjacent speaker and S+ was noise presented from the high remote speaker. The speakers were unplugged during preliminary training so that the stimuli were novel at the start of discrimination training. The animals were studied for 14 consecutive daily discrimination sessions.

RESULTS

As already described, all animals oriented to both stimuli during the first few trials of the first discrimination training session.

Performances of the 3 rats in the location discrimination with S+ delivered through the adjacent speaker are shown in Figure 9. S+ evoked responding in more than 90% of the trials during all sessions for R138 and during all but the first session for the other 2 animals. Responding during S− occurred at a low level during all sessions. Thus, differential control of responding by the locations of the sound sources was strong.

Performances of the 3 rats in the location discrimination with S− delivered through the adjacent speaker are shown in Figure 10. Three to five sessions were required for S+ to control responding above the 90% level. Further, responding occurred at fairly high levels during both S− and the intertrial stimulus during the first several training sessions. Thus, differential control developed more slowly than for animals in which S+ was delivered through the adjacent speaker. But, most importantly, there was good differential control by location when either stimulus was adjacent to the lever. This result is in marked contrast to the virtual absence of differential control by location when both stimuli were remote from the lever (Experiment 1, Figure 5).

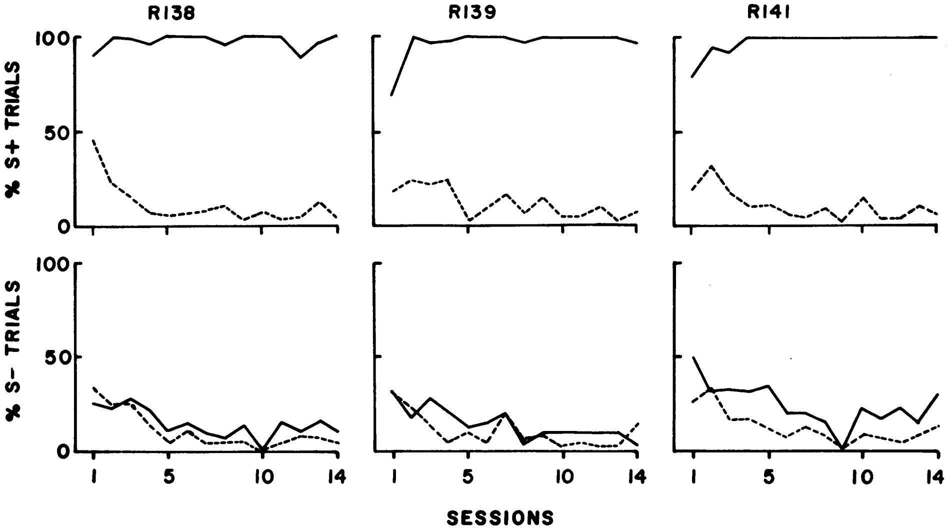

Fig. 9. Performances of 3 animals exposed to the location-discrimination procedure with S+ presented through the adjacent speaker. The upper row of graphs shows the percentage of S+ trials in which a lever press occurred within the first 10 s (solid line), and the lower row shows the percentage of S− trials in which at least one response occurred. The dashed lines show the percentage of pseudotrials in which at least one response occurred.

GENERAL DISCUSSION

The present experiments, together with earlier work (Harrison, 1983b), showed that there is no support for the quality-location effect as a general phenomenon. There appears to be no general relationship between experimental procedure and the two kinds of auditory discrimination.

The Quality-Location Effect

The quality-location effect refers to the assumption that animals readily acquire auditory quality discriminations but not location discriminations when a go/no-go procedure is used, and that they readily acquire location discriminations but not quality discriminations when a go-left/go-right procedure is used. This view can be examined by varying the experimental conditions to assess whether location discriminations can be readily acquired using a go/no-go procedure and not readily acquired using a go-left/go-right procedure, and to assess whether quality discrimination cannot be readily acquired using a go/no-go procedure and can be readily acquired using a go-left/go-right procedure.

Rapid acquisition of location discrimination with a go/no-go procedure. Differential control of responding by the locations of auditory sources was present from the first session (large difference between S+ and S− responding) when S+ was presented from the adjacent speaker (Figure 9). In fact, this discrimination was more rapidly acquired than any other in the present experiments. Less, but still substantial, differential control was obtained when the S− was presented from the adjacent speaker (Figure 10).

Retarded acquisition of location discrimination with a go-left/go-right procedure. In previous work (Harrison, 1983b, 1984) the rate of acquisition of an auditory source location discrimination with a go-left/go-right procedure was found to be slow (10 to 20 sessions) when either of the stimuli was presented through speakers which were not adjacent to the levers, or when the animals were preexposed to the stimuli.

Retarded acquisition of quality discrimination with a go/no-go procedure. Differential control of responding by stimulus quality was relatively poor when the animals were preexposed to S− (Figure 7) and especially when they were preexposed to S+ (Figure 8).

Rapid acquisition of quality discrimination using a go-left/go-right procedure. There are no analytical experiments addressing this condition.

The foregoing findings fail to support the quality-location effect as a general phenomenon.

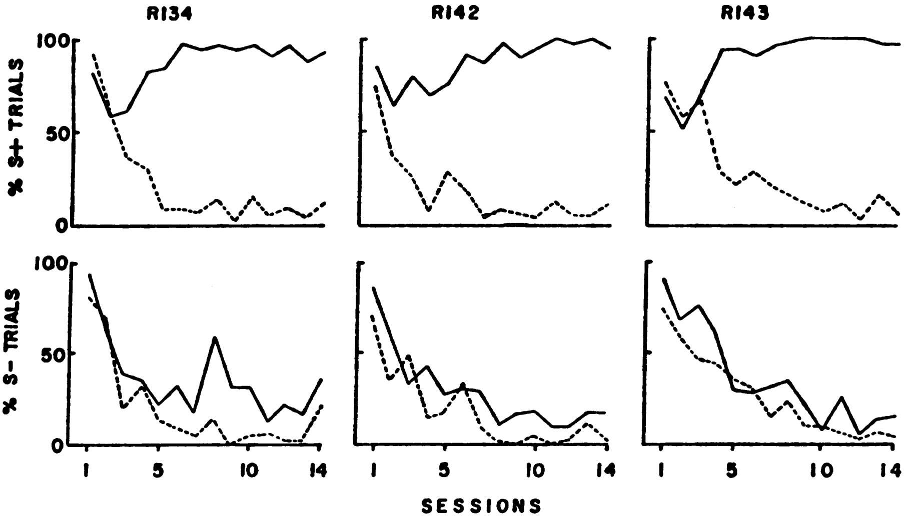

Fig. 10. Performances of 3 animals exposed to the location-discrimination procedure with S− presented through the adjacent speaker. The upper row of graphs shows the percentage of S+ trials in which a response occurred within the first 10 s (solid lines), and the lower row shows the percentage of S− trials (solid lines) in which at least one response occurred. Responding during pseudotrials is shown in dashed lines.

Experiments of the Konorski Group

The present results were not entirely unexpected since the magnitude of the effect reported by the Konorski group using the go/no-go procedure varied considerably from publication to publication. Lawicka (1964, 1969), for example, found that the location task (300 Hz, up-down) was not acquired in 360 trials, while the quality task (300 Hz vs. 1,500 Hz) was acquired in from 38 to 54 trials. These two experiments represent the most dramatic form of the effect. In contrast, Szwejkowska and Sychowa (1971) reported 300 to 900 trials were required for acquisition of the location discrimination and 400 to 900 trials were required for acquisition of the quality discrimination. In addition, Lawicka, Mishkin, and Rosvold (1975) reported an average of 400 trials for the acquisition of the quality discrimination (2,400 Hz vs. 300 Hz) and an average of 420 trials to acquire the location discrimination (10 per second 50 ms pulse) (estimated from their Figure 3). In both of these experiments, the quality-location effect was weak or absent.

Szwejkowska (1967a), in a go/no-go motor differentiation with dogs as subjects, used a buzzer behind and metronome in front as stimuli. When the differentiation was complete, test trials were given in which the positions of the stimuli were interchanged. Mixed results were obtained in the test trials, with some animals responding to the position and others to the quality of the stimulus. Szwejkowska also reported that dogs rapidly acquired (in 35 to 90 trials) a location discrimination with the same quality sound from before and behind, a finding also at variance with the quality location effect and the results of Lawicka (1964, 1969). Similar results were obtained in a study using salivary conditioning (Swzejkowska, 1967b). In summary, the procedural and other variations in the published experiments resulted in dramatic changes in the magnitude or presence of the quality-location effect.

Significance of Adjacency of Sound Source and Manipulandum

Adjacency of sound source and manipulandum has been found to be critically important in the acquisition of go-left/go-right location discriminations (Beecher & Harrison, 1971; Downey & Harrison, 1972; Harrison, 1979, 1981, 1983b; Harrison, Downey, Segal, & Howe, 1971; Harrison, Iversen, & Pratt, 1977; Lawicka & Szczechura, 1979), and also appeared to be influential in the development of S+ responding in the present experiments. Adjacency may be effective for at least two reasons. First, the effect of reinforcing a response in the presence of a source of novel low intensity acoustic stimulation is to strengthen the behavior of orienting to, approaching, and manipulating that source (Beecher & Harrison, 1971; Buzsáki, 1982; Buzsáki, Grastyán, Molnár, 1979; Buzsáki, Grastyán, Winiczai, & Mod, 1979; Grastyán, 1961; Grastyán & Vereczkei, 1974; Harrison, 1979; Kupalov, 1969, 1978; Lawicka, 1979; Sokolov, 1963). Under everyday conditions, the location of the origin of a sound is the same as the location of the event producing the sound, and the strengthening of the subject's approach is functionally appropriate to this ubiquitous coincidence. However, in auditory discrimination experiments in which the sound source (typically a speaker) and the manipulandum are not adjacent, the strengthened orienting and approach will take the animal to the speaker rather than to the manipulandum and, thus, interfere with the acquisition of the discrimination.

Second, adjacency might be effective because of a necessarily large difference between the sound intensity gradients available to the animal produced by the accessible (adjacent) speaker compared with that available to the animal from the inaccessible (remote) speaker. There was a 29-dB difference between the intensity of the sound at the adjacent speaker and the intensity at the center of the cage. In contrast, for the upper remote speaker there was only a difference of 4 dB between the intensity at the cage center and the intensity at the closest point the animal could get to the speaker. The large intensity gradient available to the animal when the adjacent speaker was used in the location discriminations may be responsible for the improved performance. It is unlikely, however, that the large gradient functioned as a localizing mechanism, for Burlile et al. (1985) found that when the incus was removed from the middle ear on one side in rats, the animals were no longer able to localize the sounding speaker or acquire a go-left/go-right location discrimination. The unilateral removal of the incus degrades the auditory intensity threshold by 60 dB and thus destroys the normal interaural intensity cues available for localization. The intensity gradient, however, is still present and unaffected at the normal ear, and the animals did not localize the sound source in spite of the availability of that gradient. Some species are able to localize a sound source after being deafened in one ear, and in these cases the large gradient may be partially responsible for their correct performance (Casseday & Neff, 1975; Masterton, Jane, & Diamond, 1967).

Stimulus Novelty

Stimulus novelty has proved to be a significant variable in auditory discrimination experiments in two contexts. First, as already described, the first few presentations of a low-intensity novel sound to a rat that has been habituated to the apparatus elicits an exploratory response of the source. This behavior declines both within and between sessions (Harrison, 1979, 1983a, 1983b). In discrimination experiments in which a novel S+ is present adjacent to the manipulandum, the elicited behavior brings the animal into close contact with the manipulandum during the first few trials. For example, the behavior elicited by a novel sound brought animals (monkeys and rats) to the vicinity of the correct lever in a go-left/go-right location discrimination and resulted in a correct response (Beecher & Harrison, 1971; Downey & Harrison, 1972; Harrison et al., 1977).

Second, the effect of reinforcement on a response in the presence of a novel auditory stimulus (S+) is different from the effect in the presence of a preexposed sound. With a novel stimulus, a single reinforcement resulted in the animal approaching the source on subsequent soundings (Harrison, 1979). If, however, the animal is preexposed to the stimulus prior to reinforcement of a response in the presence of the stimulus, 500 or 600 reinforcements may be needed to result in the animal consistently approaching the source (Downey & Harrison, 1972; Harrison, 1979, 1983a, 1984; Harrison, et al., 1977). A similar effect was obtained in the present experiments. Preexposure to S+ retarded the development of stimulus control by S+ (Figure 8). A parallel lessening of control due to S− preexposure may also have been demonstrated (Figure 7 vs. Figure 6).

The retarding effect of stimulus preexposure on the acquisition of discriminations has been studied under the name of latent inhibition (Lubow, 1973). In experiments in which rats were exposed to an auditory stimulus paired with shock, preexposure reduced its effectiveness as a conditioned stimulus (Carlton

& Vogel, 1967; Crowell & Anderson, 1972; Hall & Pearce, 1979; Lubow, Schnur, & Rifkin, 1976; Rescorla, 1971). Equivalent effects using food-based behavior have been reported by Harrison (1979), Halgren (1974), and Mellgren and Ost (1971).

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