Acta Biol. Exp. (Warsaw), vol. 28, no. 2, p. 61—69, 1968

QUALITATIVE VERSUS DIRECTIONAL CUES IN DIFFERENTIAL CONDITIONING

IV. LEFT LEG-RIGHT LEG DIFFERENTIATION TO NON-DIRECTIONAL CUES

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(Received November 15, 1967)

In a preceding paper of this series (Dobrzecka and Konorski 1967) it was shown that if the left leg-right leg differentiation is established in a dog on the basis of both qualitative and directional cues, the animal consistently utilizes the latter cue totally neglecting the former one. Therefore the problem arose as to whether the sam task can be mastered in the case in which the two differentiated stimuli operate from the same place, a circumstance which does not allow the animal to take profit of the orienting reactions towards the sources of the stimuli. In the present paper we are concerned with this problem.

MATERIAL AND METHODS

The method applied in the present study was in general the same as that in the preceding paper (Dobrzecka and Konorski 1967). The experiments were performed on dogs in a soundproof CR chamber. The animal was placed on the stand with the feeder situated to the front. Two indifferent stimuli denoted as S_R and S_L were presented in random order with the intervals of about one minute. Five seconds after the onset of the stimulus S_R the right foreleg of the animal was passively bent and placed on the feeder. This was done by a technician pulling a string attached to the wrist of that leg. Immediately afterwards the bowl with food was put into position. When stimulus S_L was presented the passive movement

of the left foreleg was produced by the same procedure. Eight or nine trials were given in each experimental session with random distribution of the two stimuli.

After a few sessions the animals started occasionally to perform actively the required movements during the operation of each CS. If the movement was correct it was immediately followed by food, if not, the CS was discontinued and food not presented. If no active movement was performed by the animal during the five seconds operation of the CS, the appropriate passive movement followed which was reinforced by food.

The following varieties of experiments were performed:

Variety 1 (2 dogs). As in the preceding series (Dobrzecka and Konorski 1967) S_R was the beating of a metronome (M) and S_L was the sound of bubbling water (B), however, in contradistinction to that series, the apparatuses producing these sounds were situated close to one another in front of the animal.

Variety 2 (5 dogs). Two tones were produced from a generator placed in front of the animal. S_R was the tone of 1500 c/sec (T_{1500}). S_L was the tone of 300 cps (T_{300}).

Variety 3 (3 dogs). In these experiments S_R was lightening of the lamp, S_L was bubbling of water. Both stimuli were presented from the front of the animal.

RESULTS

Part I

Variety 1 (M-B differentiation). The whole course of training with one of the two animals used in these experiments is presented in Fig. 1a. For the sake of comparison a typical course of differentiation of M and B sounding from different sources (Dobrzecka and Konorski 1967) is presented in Fig. 1b.

Comparing the two courses of training the clear difference between them is manifest. In the case when directional cues were presented the animals reached the 100% correct performance after two 80-trial blocks. On the other hand, when both CSs operated from the same place the differentiation training appeared to be exceedingly difficult and required no less than fifteen 80-trial blocks. Since the course of this training was similar for both dogs trained in this way, it can be described jointly.

Not taking into account the first 80-trial block in which the animals learned to perform actively the trained movements, the whole training may be divided into two periods. In the first period, including about six 80-trial blocks, both animals accepted the following strategy: in most instances they performed the correct movement (lifting the left foreleg) in response to bubbling and only occasionally did they make the incorrect movement of the right foreleg. On the other hand, in response to the metronome they performed the same movement as in response to bubbling, which was of course, not reinforced by food. Because of this the active movement to the metronome was soon extinguished and in most instances the dogs simply did not perform any movement in response to

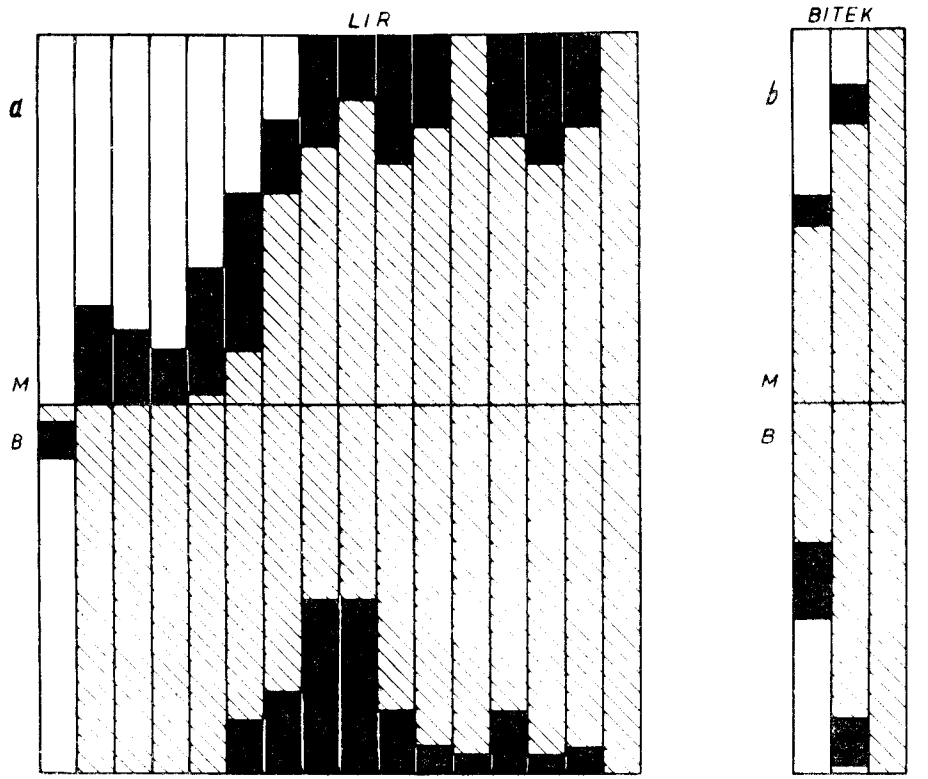

Fig. 1. Formation of **the left leg-right leg differentiation** to non-directional cues (a) and to directional cues (b) in two different dogs. Each column represents 40 trials. Columns below the middle line denote bubbling trials, those above the middle line denote metronome trials. White parts of the columns denote those trials in which passive movement was provoked; hatched parts denote those trials in which active correct movement was performed; black parts denote trials in which wrong movement was performed. Note the very prolonged training in a, and very quick training in b. Note also a long series of metronome trials in which no active movements were performed

this stimulus, but they waited till the right foreleg was passively lifted and then food presented.

Since such a situation remained unchanged for almost 500 trials, it seemed to be hopeless. However, after this lengthy period the situation changed in one dog gradually and in the other almost abruptly. The animals began to lift the right foreleg more frequently than before, performing this movement not only to the metronome but also to bubbling. Accordingly, the number of errors to the latter CS strongly increased. Nevertheless it may be observed that the general number of correct responses was above the chance level, showing that both animals had

found a cue by which the task should be mastered, not being able to utilize this cue in all the trials. Gradually the performance of both dogs became better and better, and eventually, after more than one thousand trials, it became errorless (Table I).

Table I

The performance of dogs in left leg-right leg differentiation

Name of the dog	Task	Total number of trials	Responses to S_R			Responses to S_L		
			no resp	wrong	correct	no resp	wrong	correct
Pucek	M→R	1240	251	85	284	22	61	537
Lir	B→L	1200	184	142	174	34	62	504
Śmiały		1760	15	423	442	27	291	562
Fifek	T_{1500}→R	1080	46	18	476	169	242	129
Borsuk	T_{300}→L	920	22	120	318	24	124	312
Żabot		920	9	169	282	23	186	251
Znajda	L→R	360	22	8	150	21	17	142
Czuj	B→L	360	17	12	151	20	17	143
Rudzik		180	30	4	56	26	11	53

During this lengthy training the animals occasionally exhibited all the symptoms of subneurotic states: they were restless, tried to get out of the CR chamber, and refused to take food from the feeder.

Variety 2 (T_{1500}-T_{300} differentiation). These experiments were performed on 5 dogs, one of them was, however, discarded because he developed a severe neurosis and became unmanageable. The results of the experiments on the other dogs are presented in Table I, and the illustration of the course of training is shown in Fig. 2 and 3. It may be seen that the task the animals were confronted with, seemed to be for a long time insoluble. The difference between this group and the preceding one was that the animals had a stronger tendency to perform active movements (right or wrong) to both stimuli, that is, the long series of no responses to one of the CSs was absent. This was probably due to the stronger generalization between the two tones than between the metronome and bubbling. Whereas two dogs (Borsuk and Fifek) eventually solved the task (Fig. 2), the two other ones (Żabot and Śmiały) seemed to be hopeless (Fig. 3). In view of this fact it was decided to change the procedure in these dogs by presenting one of the tones (1500 cps) from the front and the other tone (300 cps) from behind. As is seen in Fig. 3b this measure brought a nearly immediate success and after about 120 trials the task was solved. It is interesting to note that when

afterwards in Żabot we returned to the original training, the two tones being produced from the front of the animal, the task has been eventually mastered and the dog succeeded in achieving the nearly errorless differentiation.

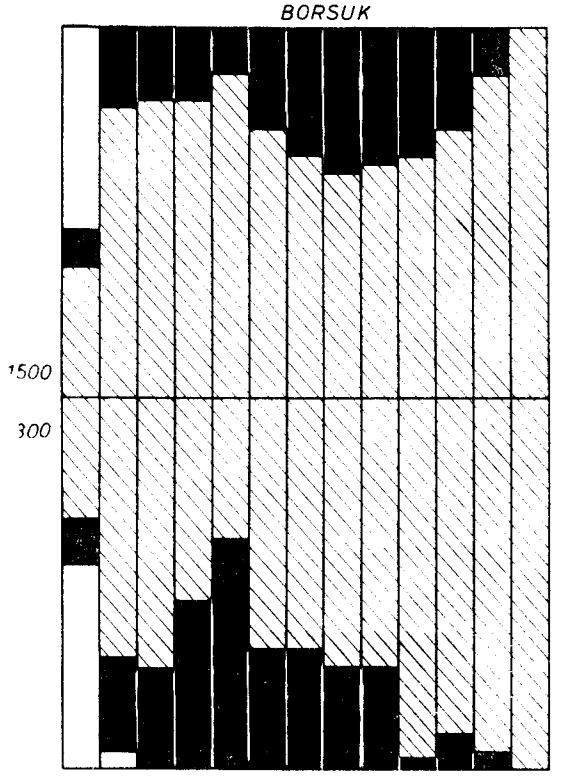

Fig. 2. Formation of the left leg-right leg differentiation to non-directional cues. Denotations as in Fig. 1. Columns below the middle line denote tone 300 cps trials, columns above the middle line denote tone 1500 cps trials. Note that the passive movement trials are here much less abundant than in Fig. 1

Variety 3 (L-B differentiation). In three dogs the right leg-left leg differentiation was established to the lightening of a lamp and the sound of a buzzer, both operating from the front of the animal. The task of differentiation turned out to be as easy as that with directional cues and the dogs mastered in less than 400 trials (see Table I).

Part II

Since in three of our dogs subjected to tone differentiation this task was ultimately solved, it was decided to bring the frequencies of tones nearer and nearer to one other to see how this procedure would affect

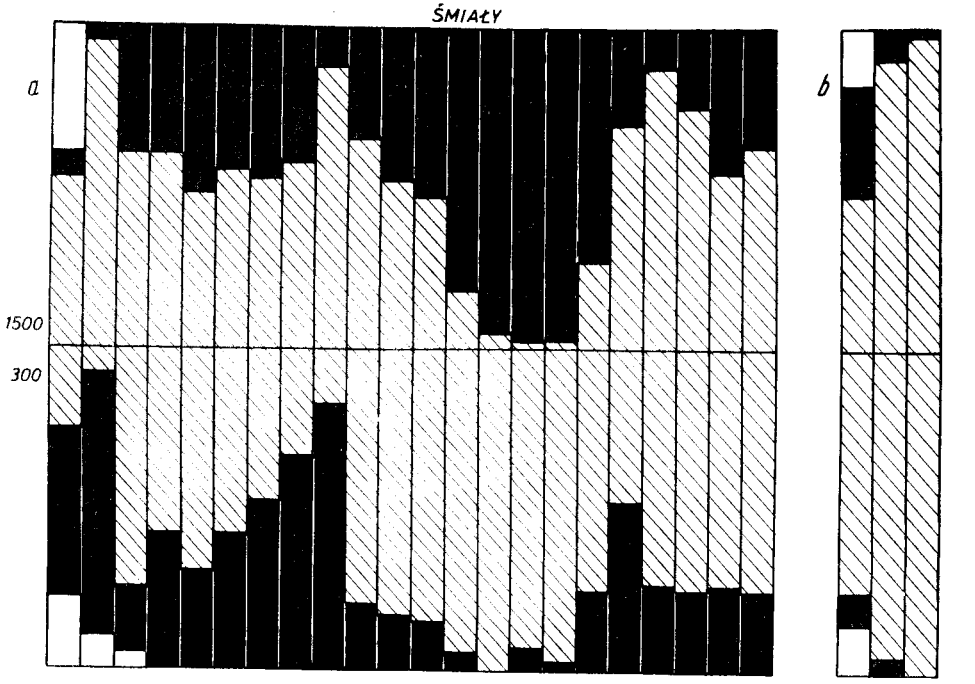

Fig. 3. Formation of the left leg-right leg differentiation to non-directional cues (a) and to directional cues (b) in the same dog. All denotations as in Fig. 2. Note that the training with non-directional cues was unsuccessful in spite of 1760 trials whereas the training with directional cues was completed after 160 trials

the performance of the animals. In three new dogs the go-no go differentiation was established to tones of 1500 c/sec and 300 c/sec respectively, and thereafter exactly the same gradual approximation of the tones was carried out. If the performance of the dogs was errorless, six experimental sessions were given (about 50 trials) and then the next step of approximation of tones was made. If the animals did perform errors the experiments with a given pair of tones lasted until the performance reached a criterion of 80% of correct responses in that series.

The results of the experiments in both groups are represented in Table II. Each figure of the table represents the percentage of correct responses in the last six sessions of a given task (including six last sessions of the original training).

It may be seen that in experiments with go-no go differentiation the gradual approximating of the tones produced only a negligible number of wrong responses, consisting in performing the trained movement in negative trials. In general, however, the performance of all three animals was errorless.

Table II

The effects of gradual approximation of differentiated tones upon the performance of animals

Dogs	The frequencies of tones					
	1500-300	1400-400	1300-500	1200-600	1100-700	1000-800
Left leg-right leg differentiation						
Fifek	97	83	88	80	79	79
Żabot	98	93	98	87	80	77
Borsuk	97	85	92	89	97	87
Average	97	87	93	85	85	81
Go-no go differentiation						
Bil	100	100	100	98	96	100
Kłapouch	97	100	100	100	100	100
Nicpoń	100	100	100	100	100	93
Average	99	100	100	99	99	98

The results in animals with go left-go right differentiation were quite different. In none of the dogs was the errorless performance attained, and the animals did not display any tendency to improve their responses during the training. In everage the performance in all the dogs did not surpass 90% and became slightly worse as the difference between the tones decreased. One of the dogs (Borsuk) displayed a severe neurosis in the 1000 c/sec versus 800 c/sec differentiation, and had to be „cured" by return to the original 1500 c/sec versus 300 c/sec differentiation.

DISCUSSION

The aim of this paper was to examine the course of right leg-left leg differentiation when two auditory CSs were operating from the same place. It has been found that whereas differentiation between the auditory and visual stimuli did not present any difficulties, the differentiation between two auditory stimuli was exceedingly difficult and in some dogs could not be mastered at all. This was true both with regard to quite distinct stimuli such as metronome and buzzer and with regard to two tones widely remote from one another (1500 cps versus 300 cps).

These results clearly support the thesis that the qualitative aspects of the CSs are of no value for the dogs in the left leg-right leg differentiation of auditory stimuli, and these dogs base their responses chiefly, or exclusively, on orienting reactions elicited by the presented stimuli.

The easiness of differentiation between light and sound is easily explained by admitting that the visual and auditory stimuli obviously elicit quite different patterns of orienting responses.

It was further found that if the training of the left leg-right leg differentiation to the two auditory stimuli is persistent, it is possible, at least in some dogs, to attain the errorless performance. Therefore, the problem arose whether the animals are able eventually to utilize the qualitative cues in this type of differentiation, or whether they still make profit of the proprioception of orienting reactions, which is supposed to be slightly different to metronome and bubbling, or to tones of high and low pitch. In order to answer this very question the approximation of differentiated tones was undertaken.

The results of these experiments seem to suggest that rather the second hypothesis is true. It may be supposed that if the animals learned to utilize the qualitative cues for left leg-right leg differentiation, they would be able to cope with the gradual approximation of tones in the same way as in the go-no go differentiation. It has been shown in our experiments that the latter task does not present any difficulty for the dogs and their responses to the gradually approximating tones are practically errorless. On the other hand, the approximation of the tones in the left leg-right leg differentiation took another course, since the animals were not able to solve completely the problem and their errors slightly increased with the decrease of the difference between the tones.

In an earlier paper of one of the authors (Konorski 1962, see also Konorski 1967) the distinction was made between the process of discrimination, i.e. learning to discriminate two stimulus-patterns on the perceptual level and the process of differentiation in which the discrimination of the two stimuli is utilized for learning to perform a different response to each of them. It is clear that with regard to the qualitative aspects of a metronome and bubbling, or a tone 1500 cps and a tone 300 cps, the discrimination of the stimuli is perfect even before differentiation training. In consequence, in the go-no go training, in which these very aspects are utilized, the animal must merely learn which of the two different stimuli signals food and which one signals no-food. This is why the process of differentiation is very easy. On the other hand, since in the go left-go right differentiation this cue cannot be utilized because of the lack in the animal's brain of the appropriate potential connections (Ławicka 1964, Dobrzecka and Konorski 1967, Konorski 1967) the animal must resort to another cue, namely that of proprioception of orienting responses. It may be supposed that if both stimuli are presented from the same place, the corresponding proprioceptive stimuli are originally not discriminated by the animals, and that they learn to do so in the

course of differentiation training. This is why this training is so prolonged and why during a long period it seems to be hopeless.

It is interesting to analyse the strategy adopted by some dogs in the first stage of training. Since the task of left leg-right leg differentiation is in that stage insoluble (because of the lack of discrimination of the two proprioceptive cues), the animals tend to perform the same response to both stimuli. But it appears that the response is rewarded by food only to one stimulus and not to the other. Since the qualitative difference between the stimuli is clear for the animal, he learns to perform the trained movement to one of the stimuli and abstain to perform it to the other one, according to the go-no go procedure.

In other cases the animals learn, in the first period of training, to perform the same movement to both stimuli, accepting willy-nilly the irregular schedule of reinforcement. Only when the dogs begin to discriminate between the two proprioceptive cues connected with each of the two stimuli, do they learn to perform both movements, making at first some errors and then improving their performance.

SUMMARY

1. The left leg-right leg differentiation in dogs to two considerably different auditory stimuli, sounding from the same place, is a very difficult task which can be mastered only after more than a thousand trials. On the contrary, the same differentiation to an auditory and visual CS is very easy.

2. After the left leg-right leg differentiation to two widely separated tones has been established, the gradual approximation of these tones leads to the substantial increase of incorrect responses.

3. It is supposed that the left leg-right leg differentiation is based only on the difference between the orienting responses produced by each of the CSs, but not on their qualitative properties.

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