

DISCRIMINATION OF TIME INTERVALS IN CATS

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Abstract. Fourteen cats were trained to discriminate between 5 and 20 s periods of confinement as evidenced by differential responding to two feeders. In a subsequent titration procedure the cats discriminated 5 from 10 or even 8 s. Positional mediation of correct responses was observed only in some animals. The present task may complement the classical and operant conditioning situations in which the temporal distribution of responses reflects the animals' abilities for both time discrimination and response inhibition.

INTRODUCTION

Ethologists have demonstrated that temporal properties of the environment are important determinants of animal behavior (see 9, for a review). Temporal conditioning was established in classical (17) and operant (1, 7, 21, 22, 23) paradigms. These paradigms have, however, limitations in the study of time perception. When the dependent variable is omission vs. commission of the conditioned response, time perception can be inferred only from the temporal distribution of responses. As pointed out by Catania (2), "measurement of both stimuli and responses in the same units, i.e. units of duration, runs the risk of confusing stimulus properties and response properties (p. 36f)". An alteration in the temporal patterning of responses may be interpreted to indicate a change either in time perception or in response modulation. As an example, the impairment on DRL schedules in rats with septal lesions was attributed to response disinhibition or to disturbed temporal discrimination (6, 16, 20).

Complementary techniques need to be used for research on the temp-

oral determinants of behavior. Non-temporal measures of responding to predetermined time intervals have been described and the ability of animals to discriminate durations was demonstrated (3, 12, 13, 18, 19, 24).

These findings suggest that temporal discrimination may sustain correct performance in situations where external stimuli are not available at the moment of responding, as in delayed response typed tasks and complex mazes. The frequent use of such procedures in neuropsychological research warrants further investigation of time discrimination in animals. The present study assessed the ability of cats to perform temporal discrimination in a discrete-trial situation (3) involving differential locomotor responses to predetermined periods of detainment.

METHOD

Subjects

Fourteen experimentally naive, mongrel cats of both sexes were brought from private homes to the laboratory 1–3 mo prior to this study. The cats weighed between 2.2 and 5.2 kg at the beginning of the experiment. They were fed $1\frac{1}{2}$ –3 h after training and maintained at 90–95% of their ad lib. body weights.

Apparatus

The animals were trained in a modified Nencki Testing Situation (illustration in 5) which consisted of a restraining wire cage situated between two feeders. The cage could be raised or lowered manually by the experimenter sitting in front of the open side of the apparatus. Correct responses were reinforced with 5 g of a liquid mixture of canned cat food, fish cream, and water. A stop watch was used for time readings. A ventilator served to mask extraneous sounds.

Procedure

All animals were trained 6 days a week at approximately the same hour each day. The cats were initially shaped (i) to eat from both feeders, (ii) to accept detainment in the wire cage for 1–2 s, (iii) to approach one of the feeders immediately following release, and (iv) to return promptly under the cage after eating a portion of food. Pretraining was usually completed in 5–10 sessions.

Acquisition. The animals were trained to make differential locomotor responses following different periods of confinement in the cage. Responses to the right feeder were reinforced after detainment of 5 s, while responses to the left feeder were reinforced following confinement periods of 20 s. Approach to the opposite feeder after a given detainment period

was recorded as an error, and correction trials were subsequently given until the animal was rewarded. A new trial began immediately when the animal returned to the cage. Presentation of the two time intervals was randomized according to Gellermann series (10). The cats had 20 reinforced responses in daily sessions to a criterion of no more than a total of 10 errors within 5 successive days and no more than 4 errors in any single day. When a cat made less than 4 errors on each of 3 consecutive days, a new experimenter tested the animal until 3 errors or less were committed in one session. This procedure was included to examine whether inadvertent cues from the tester might have influenced the animals' performance.

A *titration* procedure was instituted next. The shorter time interval was kept unchanged at 5 s, while the duration of the longer interval was contingent on the animal's performance in the preceding session. On the first day the animals were trained on a 5 vs. 18 s discrimination. The longer interval was decreased by 2 s when a cat had made less than 3 errors in the previous session, remained unchanged when the cat had committed 3 or 4 errors, and was increased by 2 s following more than 4 errors. The longer stimulus was not reduced below 8 s, even if the animal was successful at the level. Titration training ceased when the animal did not further reduce the duration of the longer interval during 10 successive sessions. The animal's discriminative accuracy was subsequently determined as the minimal value of the longer time interval with which the cat three times or more within the final 10 sessions was capable to perform with less than 5 errors per day.

The animals' bodily orientation immediately before release from the cage was recorded throughout the experiment. If the animal was positioned within an angle of approximately 90° toward one of the feeders the orientation was classified as directional. Orientation toward either the back of the apparatus or the experimenter was marked as neutral.

RESULTS

All cats learned to discriminate intervals of 5 and 20 s (Table I). The animals did not seem to rely on inadvertent exteroceptive cues; with the new experimenter nine cats were tested only once, four animals made 4–12 errors on the first day but regained proficient performance on the second day, and one subject responded efficiently only on the third day of the control testing.

The cats reacted differently to reduction of the longer interval in the titration phase; whereas the performance deteriorated immediately in some animals, other cats remained proficient until required to discrimi-

TABLE I

Number of trials and errors. Trials and errors during the criterion period in acquisition and during the last 10 sessions in titration are not included. a, includes correction trials.

Phase	Trials ^a		Initial errors		Repetitive errors	
	Median	Range	Median	Range	Median	Range
Acquisition	569.5	408-1611	115	84-369	59	14-104
Titration	253.5	105-504	20	4-55	2	0-16

nate 5 from 10 s. After variable amounts of training (Table I) seven cats were able to discriminate 5 from 8 s: for six cats the minimal duration of the longer interval was 10 s, and one animal failed to decrease the longer interval below 12 s. The discriminative accuracy was not related to the amount of training in the titration phase, but the faster learners of the 5 vs. 20 s discrimination eventually reached lower values of the longer interval than the slow learners (Fisher exact probability test for frequencies above and below the respective medians, $p < 0.05$).

Individual differences were observed in the animals' behaviors during the confinement periods. Two cats usually remained in a neutral position, while one cat tended to face the right side independently of the duration of restraint. Four cats changed position after a period of time; typically, these animals initially faced the right side, turned after 7-12 s, and remained oriented toward the left feeder or adapted a neutral position. Less consistent behavior was noted in all other animals.

The number of directional orientations to the correct side decreased slightly but significantly during the experiment (Table II), and was in-

TABLE II

Number of responses preceded by bodily orientation to the correct side in 100 trials. Data for correction trials are not included. a, data for only 12 animals.

Phase	Median	Range	Comparison with	
			A	B
A. Beginning of acquisition ^a	33.5	5-86	—	—
B. End of acquisition	29.0	3-77	n. s.	—
C. Beginning of titration	24.5	1-76	n. s.	$P < 0.002^*$

* Sign test, two-tailed.

versely related to the number of trials in the titration phase (Fisher exact probability test, $P < 0.05$), but unrelated to the rate of acquisition of the 5 vs. 20 s discrimination.

DISCUSSION

Cats were able to make differential locomotor responses to confinement periods of 5 and 20 s. In the titration procedure most animals discriminated 5 s from 10 or even 8 s. The subtle discriminative performance manifested in several subjects was not a result of prolonged experience with the task, since the discriminative accuracy was positively related to the rate of original acquisition.

Rats trained on DRL schedules were reported to develop stereotyped behavioral chains in the intervals between bar presses (14, 15). Since this activity was functionally related to the efficiency of DRL performance, it was believed to provide discriminative stimuli for lever pressing. In the present task mediating responses may similarly have sustained correct performance. Supporting this notion are observations that several cats changed their bodily orientation during the longer intervals as a function of time, and that the amount of training in titration was inversely related to the occurrence of this behavior. Positional habits, however, were not crucial for solving the task, since (i) directional orientations were absent in some cats, (ii) the rate of initial acquisition was not related to the frequency of such behaviors, and (iii) the occurrence of directional orientations declined in the last phase of the experiment when finer differentiations were required.

The determining cues for the animals in the present time discrimination task are unknown. Each time interval is initiated and terminated by a complex of visual, auditory, and, possibly, tactual and kinesthetic cues. For both shorter and longer intervals the exteroceptive cues were identical. The determining stimulus is therefore the result of an organismic process which takes place during the time interval. This process was suggested to be based on dissipation of internal inhibition (17), an increasing tension (12), response chains (14, 15), or neuromuscular sensory feedback (8). However, both the nature of this process and its functional relation to time are at present unknown.

The time discrimination task may be applied to problems which have been studied with the delayed response task. Both tasks are characterized by the absence of exteroceptive cues signalling position of reward at the moment of choice. Intact temporal orientation is necessary in delayed response type tasks to determine the differential recency of retained stimuli. A difference between the tasks is that the organismic cues for correct responses are self-generated in the time discrimination task, while originating from the environment in the case of the delayed response task. These similarities and differences between the time dis-

crimination and delayed response tasks may be useful in analysis of short-term memory (see 4) and of the deficit following prefrontal cortical lesions (e. g. 11).

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