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FURTHER FINDINGS ON THE SAME-DIFFERENT DIFFERENTIATION WITH ACOUSTIC STIMULI IN DOGS [1]

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In a widely used experimental design, short-term memory has been inferred from a consolidation failure or enhancement following some event intervening between learning and recall (e.g., McGaugh 1965). This procedure emphasizes the continuity between short- and long-term memory processes. In a recent discussion, Konorski (1967) proposed a concept of short-term, or transient, memory acting independently of a long-term storage or consolidation mechanism. According to this view, well-known stimulus events, which may participate in well-learned stimulus-response associations, continue to leave transient memory traces after each new exposure. It is possible to study such recent memory only with experimental designs which limit the participation of consolidated memories.

This requirement is met in a short-term memory test proposed by Konorski (1959). In general, the test involves differentiation between pairs of signals. From trial to trial signal values are varied both within and between positions in a pair. In an instrumental learning situation, responses are rewarded when they occur to the second member of a pair but only when both members have the same (or different) values; reward is omitted when both members have different (or the same) values. Thus, in order to respond appropriately to the second signal of a pair in this

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discrimination task, the subject must utilize stored information about the identity of the first signal. With this procedure, performance under different temporal intervals between signals is of great interest.

This paradigm has been used previously in the investigation of recent memory for acoustic stimuli in dogs (Chorążyna 1959, 1967; Chorążyna and Stępień 1961). The most recent of these studies illustrates two variations of the design, using as signals tones of different frequencies, low (L) and high (H). Dogs were trained to differentiate L-L and H-H compounds from an L-H compound. For one group the "odd" compound, L-H, was positive, and for a second group this compound was negative. The final phase of training was conducted with variations in the values of L and H frequencies. While both groups were able to master the discrimination, a clear superiority was shown by the L-H positive group in terminal performance. The differentiation deteriorated in this group, however, when the inter-stimulus interval was extended beyond 15 sec.

The purpose of the present study was to investigate further the properties of this three-pair paradigm with auditory stimuli in dogs, and to sample longer inter-stimulus intervals with this procedure.

METHODS

Six mongrel dogs were trained on the three-pair problem; a seventh dog, from a second study, was given training with four pairs, and served as a control animal in observations described later. Animals were fed once a day in their home cages following training sessions which were run six days a week in the early part of the day.

Tones were delivered by an acoustic generator which was later replaced by a Hewlett-Packard oscillator (Model 201 C). Within-dog comparisons revealed no difference between the two generators. A constant attenuation was used for all tone frequencies; acoustic intensities varied among tones from 85 to 90 db with an ambient noise level of about 45 db SPL. No attempt was made to control loudness of the tones.

Experiments were run in a sound-proofed chamber equipped with an automated feeder providing access to a reward of ground meat and broth-soaked bread. A paddle wheel was mounted to the right of the feeder; a wheel turn (CR) of 1.5 cm at its circumference activated a microswitch controlling the feeder circuit.

Dogs were first trained to perform the CR by a shaping procedure, then preliminary discrimination training was begun in which the CR was rewarded only during the presentation of a beating metronome (140 per minute). Nine trials per day were given, and training was continued until all latencies were below 5 sec with virtually no responding during a gradually approached 3 min intertrial interval.

Tones were introduced in the next phase of training. After the first several sessions consisting of positive trials only, three stimulus pairs, comprised of low (L) and high (H) tone frequencies, were always presented: L–H, L–L, and H–H. Following Chorążyna's (1967) results, L–H was positive and the remaining two pairs were negative. That is, a CR was rewarded only when it occurred to the second signal of the L-H compound. The duration of the first and second signals were always 3 and 5 sec, respectively, separated by a 1 sec interval.

The first trial of the session was always positive. During the first 15 to 20 sessions, the number of negative trials were increased to six (three of each negative compound), and the inter-trial interval was lengthened from 30 sec to 1 min. Occasionally, when performance was consistently poor on the positive compound, the number of positive trials was increased, with a concomitant decrease in negative trials. Except for the first trial, positive and negative compounds were presented in an unsystematic order varied daily, with the constraint that no more that two negative trials occurred in succession.

Two dogs, Alpha and Omicron, were treated with 200 and 300 Hz as L and H frequencies. These values were used throughout training for these dogs. A third dog, Delta, was also trained with constant tone values, but with a smaller difference between frequencies, 260 and 300 Hz.

Three dogs, Beta, Eta, and Zeta, began training with five different pairs of tones: 190 and 230, 210 and 250, 230 and 270, 245 and 280, 260 and 300 Hz. On each session one pair of values was used for three signal compounds, L-H, L-L, and H-H. Each of the pairs occurred once in a five day block in random order. The frequencies, differing by 40 Hz within pairs, were selected partly on the basis that they represented clearly discriminable tones for a human observer. Acquisition with these values proceeded slowly, however. For this reason, these dogs were switched to the 200 and 300 Hz frequencies on the 75th training session. These values were maintained in subsequent training.

From the outset of acquisition of the tone differentiation, responses developed to the first member of the compounds. In an attempt to extinguish these anticipatory CRs, the L component was presented twice, occasionally, when such responding occurred (i.e., a negative trial was given). As a consequence, L–L trials exceeded H–H trials in initial trainnig. It appeared, however, from observations of a few dogs, that anticipatory CRs would "spontaneously" extinguish, and this procedure was eventually abandoned. Thus, prior to criterion performance with a 1 sec inter-stimulus interval, and subsequently, both negative trials were presented equally often.

As criterion was met, the inter-stimulus interval (ISI) was increased in the following steps: 2.5, 5, 10, 20, and 40 sec. The inter-trial interval (ITI) was increased with longer ISIs, and the number of trials per session was correspondingly reduced. The format is shown in Table I.

TABLE I

Interstimulus intervals (ISI) and corresponding inter-trial intervals (ITI), number of positive trials (no.+), and total number of negative trials (no.—) per session

ISI (in seconds)	ITI (in minutes)	no.+	no.—
1	1	6	6
2.5	1	6	6
5	1.5	6	6
10	2	5	4
20	2	5	4
40	3	3	2
80	4	3	2

Criterion performance was required prior to each increase in ISI. Correct performance with respect to the second signal was defined as a response with a latency less than 5 sec on positive trials, and no responding during the 5 sec signal on negative trials. Criterion was defined as at least 90% correct trials simultaneously for each compound, in the number of sessions required to meet this criterion on ten consecutive negative trials. That is, a minimum of 4 sessions were required when negative trials occurred three times each per session, 5 sessions when each negative trial occurred twice, and 10 sessions with one negative trial each. An increase in ISI did not always follow criterion immediately; post-criterion observations resulted in overtraining with some ISIs.

RESULTS

Data for all animals were computed beginning with the 20th training session. Table II presents the total number of trials to criterion for each of the three compounds L-H, L-L-, and H-H, under each ISI from 1 to 40 sec. Acquisition performance under the 1 sec ISI is divided into two phases for dogs Beta, Eta, and Zeta. The first phase corresponds to initial training when tone values for L and H were varied daily; in the second phase, tone frequencies were constant. No animal reached criterion during the presentation of varied tone frequencies.

TABLE II

Number of trials to criterion under increasing interstimulus intervals (ISI)[a]

ISI	1 sec VT			1 sec			2.5 sec			5 sec		
Stimuli	L-H	L-L	H-H	L-H	L-L	H-H	L-H	L-L	H-H	L-H	L-L	H-H
Beta	343	173	173	662	319	319	54	27	27	108	54	54
Zeta	329	181	162	283	138	130	30	16	15	84	42	42
Eta	329	166	165	760	118	118	178	85	85	24	12	12
Alpha[b]	—	—	—	717	284	395[b]	24	12	12	48	24	24
Omicron	—	—	—	432	64	65	42	21	21	24	12	12
Delta	—	—	—	689	323	319	96	48	48	72	36	36
$\bar{x}$				590	208	224	71	35	35	60	30	30
ISI	10 sec			20 sec			40 sec			80 sec		
Beta	40	16	16	35	14	14	72	24	24	96	32	32
Zeta	25	10	10	35	14	14	30	10	10	—	—	—
Eta	25	10	10	25	10	10	30	10	10	—	—	—
Alpha	206	84	84	25	10	10	30	10	10	—	—	—
Omicron	35	14	14	25	10	10	30	10	10	—	—	—
Delta	29	12	11	25	10	10	—	—	—	—	—	—
$\bar{x}$	60	24	24	28	11	11	38	13	13			

[a] Omitted from the table are trials given in the first 19 training sessions.

[b] In an attempt to extinguish consistent responding on H-H trials, an increased number of trials was presented during initial training.

Figure 1 displays, for dogs Beta, Zeta and Eta, the performance occurring during the training periods described in Table II. Figure 2 depicts performance for the other three dogs, Alpha, Omicron, and Delta, The bar graphs in the figures show per cent of responses with latencies less than 5 sec to each of the three compounds, under each ISI.

After 75 training sessions with varying tone frequencies, there was some evidence of differentiation. The graphs in Fig. 1 show that for Beta, Eta, and Zeta, fewer responses occurred to the negative compounds, L-L and H-H, than to the positive compound L-H. No strong evidence for transfer, however, was demonstrated after switching these animals to the constant tone condition. The total number of trials to criterion with a 1 sec ISI for Alpha, Omicron, and Delta, trained from the outset with constant tones, was 1596, 788, and 1658 (including the first 19 sessions), respectively. The other three dogs who received initially between 910 and 950 trials with variable tones, subsequently required 1300, 551, and 996 total trials to criterion with constant tones.

A characteristic pattern for all six dogs during acquisition with the 1 sec ISI was greater responding on the H-H negative compound than on L-L, a significant difference ($p<0.02$) with a sign test. With longer ISIs (2.5–40 sec) this pattern was maintained for four of the six dogs, only Zeta and Delta showing a small reverse relationship during this period (*see* Fig. 1 and 2). This difference between negative compounds reflects the frequency of reward associated with the second tone component. That is, while the H tone in the second position was often associated with reward (positive trials), responses to the L tone were never rewarded.

Once the differentiation was mastered with the 1 sec ISI, learning proceeded with increasing rapidity as ISI was lengthened. Comparison

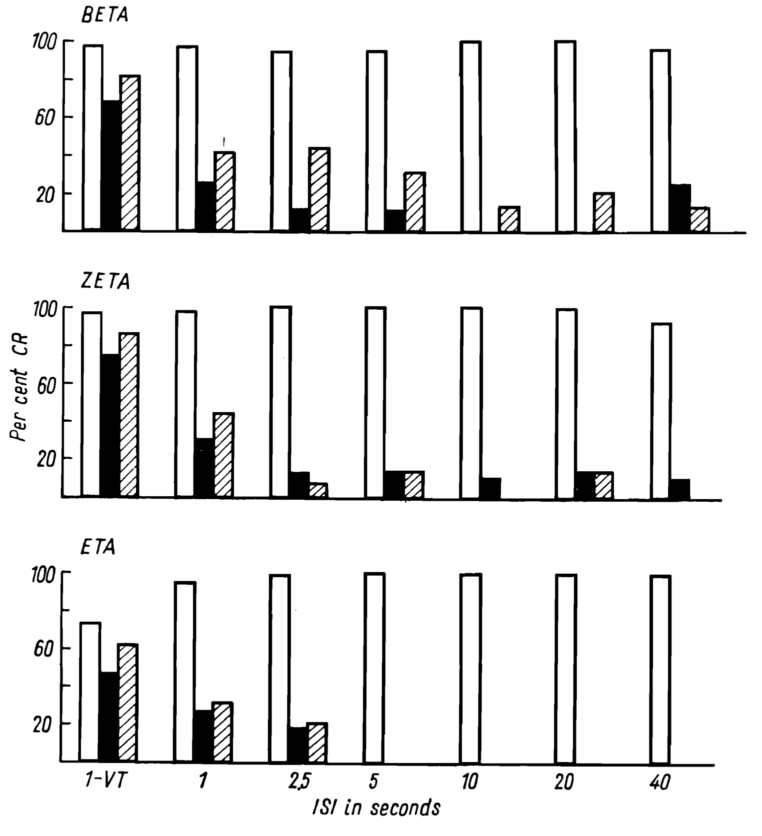

Fig. 1. Performance on the three stimulus compound under interstimulus intervals (ISIs) from 1 to 40 sec ISI. 1 sec VT denotes presentation of varying tone values. All bar graphs but those for ISI 1 sec VT depict performance to criterion. White bars, positive compound L-H; black bars, negative compound L-L; hatched bars, negative compound H-H. Constant tone values were 200 and 300 Hz. Further explanation in text.

of overall performance among ISI conditions is complicated by the fact that the number of positive and negative trials per session varied as ISI increased from 2.5–40 sec. However, as seen in Table II, during those periods in which number of trials per session remained constant, a decrease was seen in the mean number of negative trials to criterion. Thus, as ISI increased from 1 to 2.5 to 5 sec, the mean number of negative

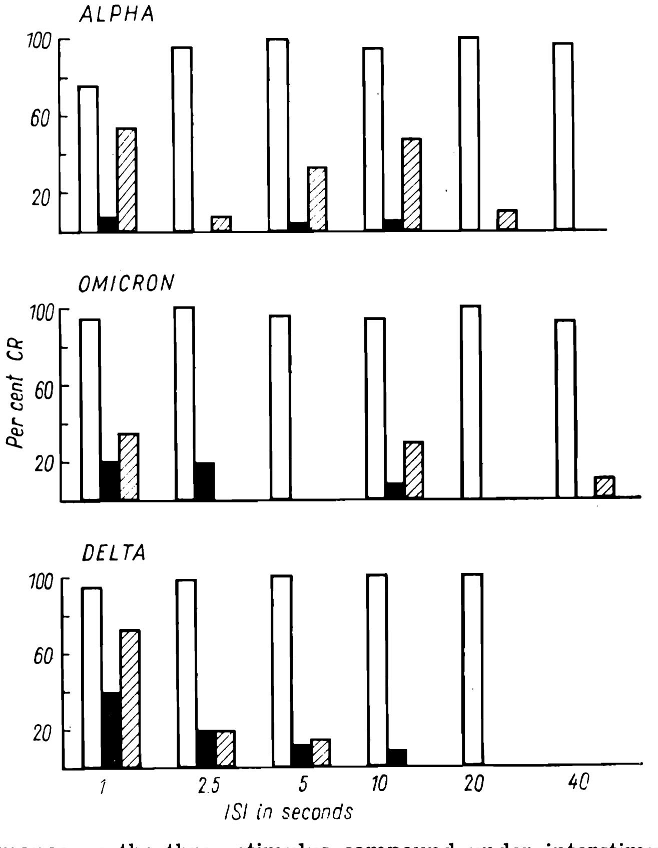

Fig. 2. Performance on the three stimulus campound under interstimulus intervals (ISIs) from 1 to 40 sec. Explanation as in Fig. 1. Tone values were 200 and 300 Hz except for Delta who received 200 and 260 Hz.

trials to criterion decreased from more than 432 to 70 to 60, over all dogs. Similarly, from 10–20 sec ISIs, the mean number of trials to criterion dropped from 48 to 22. During these periods, performance on positive trials was uniformly high. Improvement with increasing ISIs is also apparent in the overall performance during training on each ISI, as shown in Fig. 1 and 2. The number of animals reaching criterion in the minimum number of trials possible increased from 1 dog with the 2.5

sec ISI to 2, 3, 4, and 4 dogs with ISIs of 5, 10, 20 and 40 sec, respectively. Thus, both the trials to criterion measure and the performance during these trials demonstrate large amounts of positive transfer from shorter to longer ISIs. It is interesting to note that transfer occurred despite an increasingly adverse relationship between ISI and ITI. Although the ITI was generally increased as ISI was lengthened, the ratio of ITI to ISI concomitantly decreased. Under these conditions, positive transfer to longer ISIs seemed to have a limit at ISI-40 sec. It will be noted that one dog, Delta, failed to meet criterion at this interval, and showed in fact deterioration in performance. A return to ISI-20 sec for this dog brought rapid recovery. An attempt was made to extend the ISI to 80 sec in the remaining animals, with an increase in ITI to 4 min. Only one animal, Beta was able to reach criterion under these stringent conditions.

Reaction patterns to the first tone

The description of performance thus far has been restricted to the wheel-turn response to the second tone of a pair (i.e., L_2 and H_2). During training with the 1 sec ISI, however, it appeared that other behavior was correlated with the first tone of the pairs (i.e., L_1 and H_1). Following the onset of L_1, the dogs were observed to orient abruptly toward the speaker, situated in front of the feeder, and to maintain a motor state which may be characterized as arousal or alertness which lasted until the presentation of the second tone. This reaction occurred in all dogs, and varied only in intensity.

When the first tone was H, however, the reaction pattern was quite different. After a brief orientation to the speaker following the onset of H_1, most dogs turned away to one side, often hanging their heads for the duration of the tone. In other dogs such "subdued" behavior did not always occur; instead, H_1 was followed by displacement [3] activity (Eta) or barking (Omicron). Although reactions to H_1 were more variable than those to L_1, they were clearly distinguishable between the two tones. One animal, Beta, did not develop clear reaction differences between these tones during training with the ISI-1 sec, but the reaction patterns did emerge at longer ISIs.

In general, reactions to the second tone on both negative trials appeared identical to those occurring to H_1, while of course on positive trials, the reaction was terminated by the CR. Clearly, therefore, the difference in reaction patterns between L_1 and H_1 could not be attributed to the

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[3] Instead of withdrawing from the wheel on H_1 trials, this dog often attempted to climb the wheel chassis, occasionally in this way executing a CR.

difference in tone frequencies per se. A more reasonable interpretation is that the reactions varied with the relationship between the first signal and reward. That is, a positive trial was initiated on 2/3 of the trials with L_1, but was never associated with H_1. Accordingly, the reactions to L_1 and H_1 may be considered as "positive" and "negative" anticipatory reactions, respectively.

Testing responses to the novel compound H-L

In view of the relation between reaction patterns and reward contingencies, it seemed that tone H_1 had acquired inhibitory properties. It followed that a compound composed of tones H_1 and L_2 should be strongly inhibitory owing to their roles in the training compounds. Therefore, a test period was run in which the novel compound H-L was presented once each session for ten sessions during pre-criterion training with ISI-1 sec. CRs to the test compound were rewarded. Table III presents the

TABLE III

Performance during H-L test trials: % CRs to each compound

	Test 1				Test 2			
Stimuli	L-H	L-L	H-H	H-L	L-H	L-L	H-H	H-L
Beta	100	36	24	80	83	32	24	40
Zeta	98	17	15	0	98	20	12	10
Eta	100	50	20	10	100	33	20	0
Alpha	100	8	46	0	95	16	4	0
Omicron	96	33	10	10	98	20	0	0

results in terms of per cent CRs to each of the compounds for five dogs tested. For four of the five dogs, as expected, responding to the test compound H-L was absent or very low, and was weaker in fact than responding to the two negative compounds. For one animal, Beta, the opposite pattern of results appeared, with greater responding to H-L than to the negative compounds. In this regard, the failure of this animal to show clear differences in reaction patterns to the first tones during this period is noteworthy. Following additional training, a second test period was run, giving essentially the same results as the first test.

Heart rate changes on L_1 and H_1 trials

As the ISI was lengthened, positive and negative reactions to the first tones were maintained, and they persisted throughout the ISI. It was feasible, therefore, to measure the anticipatory reaction patterns more objectively during the ISI itself, without the immediate influence of tone signals. This was accomplished by recording heart rate during training with the 10 sec ISI. Electrodes were attached in a triangular configuration for EKG recording, on the forelegs and a hindleg. Recording was achieved with an Alvar Reega-IVcc Portable polygraph, using a paper speed of 15 mm/sec. For purposes of analysis, the mean interbeat interval was computed during a 10 sec control period prior to the first tone, during the first tone, the 10 sec ISI, the second tone, and during the next 10 post-trial seconds. Data were included in the analysis only for those trials in which responding to the second tone was correct and no CRs occurred during recording, except as a correct response. Records were collected over approximately 50 sessions.

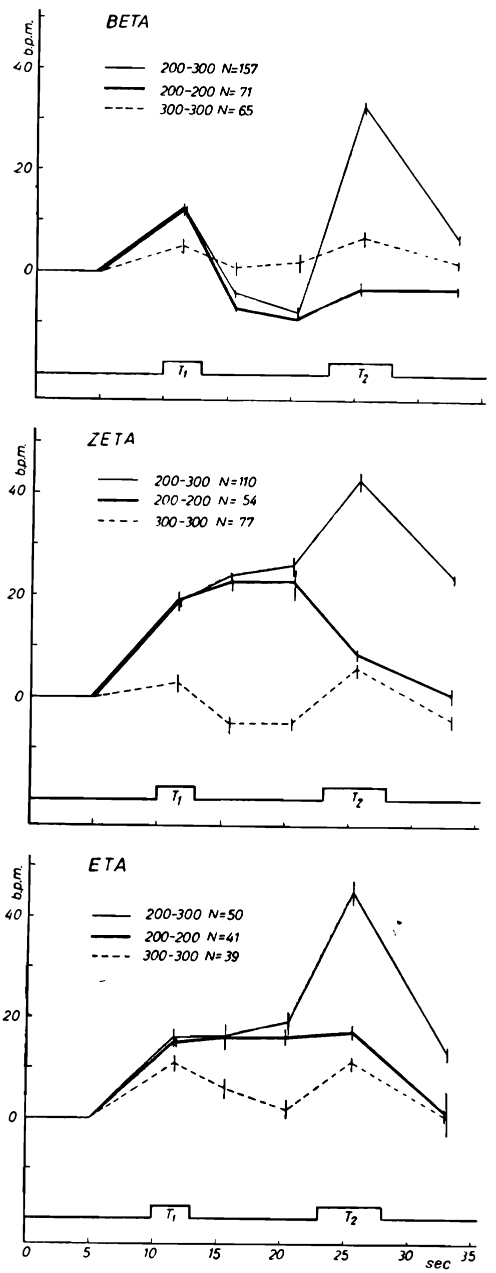
Figure 3 shows, for each dog, the mean change in heart rate from the pre-trial baseline to the 3 sec first tone, the 10 sec ISI in two 5 sec periods, the 5 sec second tone, and the 10 sec post-trial period.

Heart rate data is also presented for a four-pair control dog, Epsilon, in Fig. 4. This animal was trained with four compounds, L-H, H-L, L-L, and H-H. The H-L compound was positive with the reward contingencies for the other three compounds as described above. During the 10 sec ISI condition, L and H values for this dog were 200 and 1200 Hz.

The heart rate data support the conclusions drawn from visual observations. As seen in Fig. 3, for all dogs an increase in heart rate appeared with the presentation of the first tone. For the six three-pair dogs a difference in heart rate was evident between L_1 and H_1 tones. In five of the six dogs this difference increased with the tone offset, and was maintained throughout the 10 sec ISI, the dog Alpha being the only exception. Thus, in the absence of the auditory signals (i.e., during ISI) heart rate was correlated with L and H tones in the first position of a pair. As indicated by the standard errors in Fig. 3, this effect was highly reliable within dogs. Table IV lists for each subject the probabilities associated with t-tests performed on mean heart rate differences during the ISI.

In contrast to the three-pair dogs, Epsilon showed markedly different changes in heart rate. For this animal, L (200 Hz) and H (1200 Hz) tones in the first position were equally associated with reward (on 50% of the trials). Following a general increase in heart rate to the first tone, the four curves in Fig. 4 exhibit a decrease throughout the ISI for L_1 and H_1 trials alike.

The differences in heart rate changes between L_1 and H_1 trials in the three-pair dogs may be attributed to the differential association of first tones with reward. An alternative explanation that autonomic reactivity



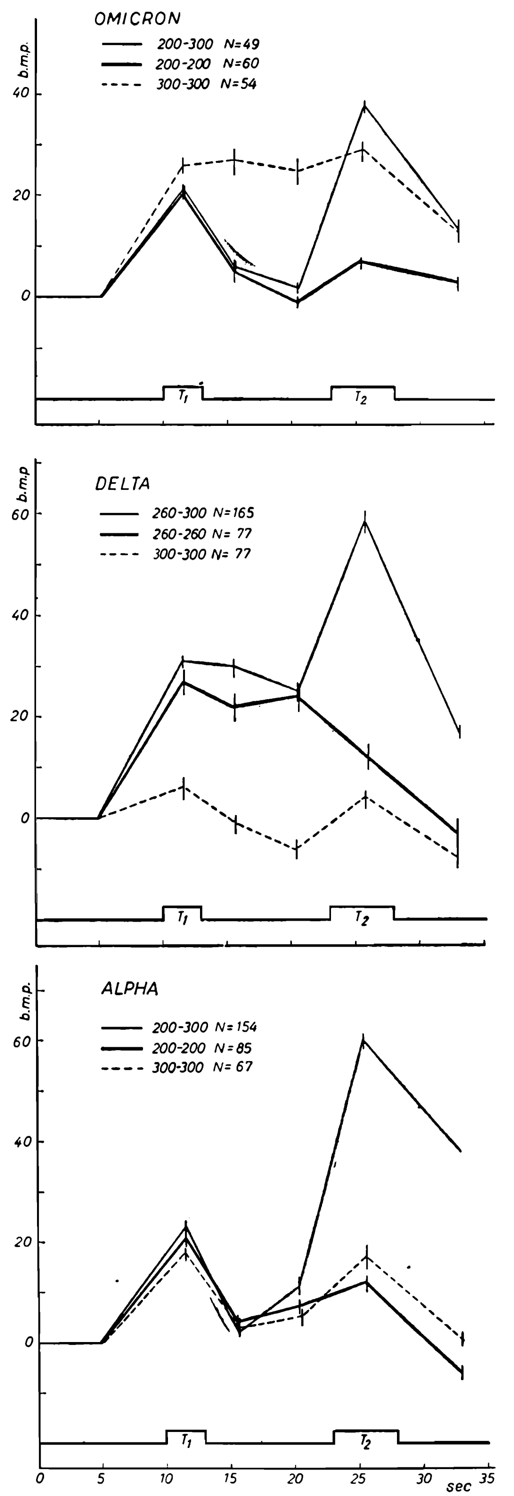


Fig. 3. Heart rate changes during the three stimulus compounds. Consecutive points on the curves denote: baseline level, the first tone (T_1), the two halves of the 10 sec ISI, the second tone (T_2), and the 10 sec posttrial period. Vertical bars correspond to standard errors.

varied with low and high tone values per se is not supported by the data. Three animals (Zeta, Eta, and Delta) showed higher rates on L_1 than on H_1 trials, while two dogs (Beta and Omicron) showed the reverse relationship. Although the reason for this difference is not clear, it may be

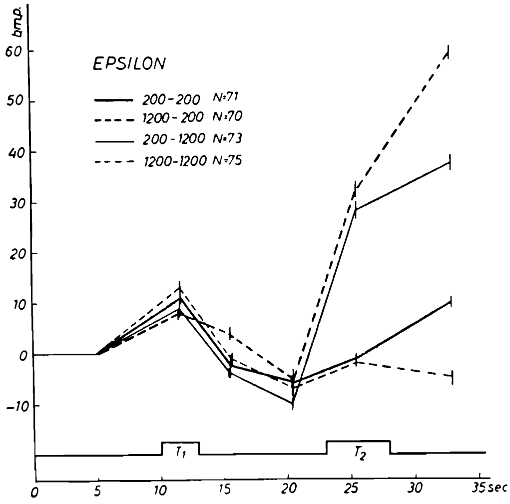


Fig. 4. Heart rate changes during the four stimulus compounds in dog Epsilon. Explanation as in Fig. 3.

partly explained by the difference in reaction patterns among dogs. Thus, Omicron, whose heart rate on H_1 trials was high, barked continuously in the ISI on these trials and remained less active on L_1 trials with a lower heart rate. Finally, the interpretation of the heart rate data in the three-pair dogs is supported by Epsilon s data in which only small differences between L_1 and H_1 trials were observed.

Since heart rate changes to L_1 and H_1 tones persisted throughout the ISI, the possibility arises that heart rate was reflecting a process

TABLE IV

t-tests of mean heart rate differences in the interstimulus intervals

Trials		Subject						
		Beta	Zeta	Eta	Alpha	Omicron	Delta	Epsilon
L_1(L-H)	t	1.87	1.28	0.62	0.28	1.59	2.18	
vs.	df	454	326	180	476	216	482	—
L_1(L-L)	p	0.1	0.3	0.6	0.7	0.2	0.02	
	t	6.33	15.61	8.19	1.57	10.80	11.38	3.33
L_1 vs. H_1	df	584	480	258	610	324	636	576
	p	0.001	0.001	0.001	0.2	0.001	0.001	0.001

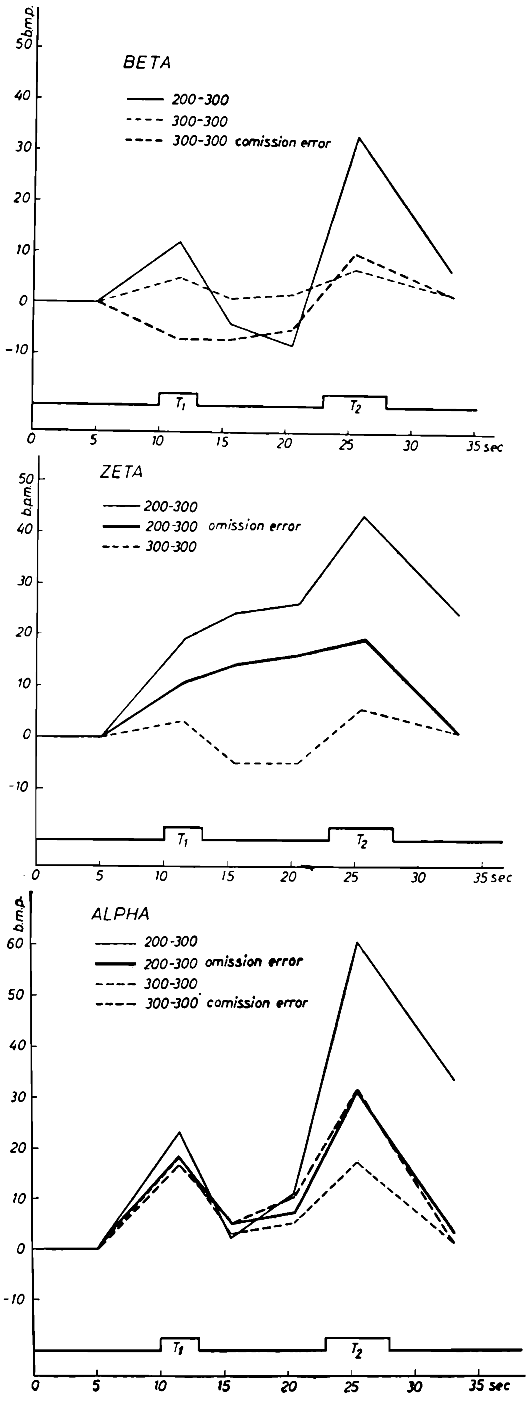


Fig. 5. Heart rate changes accompanying incorrect performance during the three stimulus compounds. Explanation as in Fig. 3.

controlling CRs to the second tones. To pursue this possibility, heart rate changes were examined on trials in which CR errors occurred. Although only three animals made five or more errors on any compound, the results are worth brief comment. As seen from the error curves in Fig. 5, when CRs occurred on H-H trials, heart rate in the ISI was identical to that on L_1 trials (Beta, $N=7$). On the other hand CR omission on L-H trials was accompanied by a shift in heart rate toward the level seen on H_1 trials (Zeta, $N=6$). The third dog, Alpha, showed no heart rate differences in general between L_1 and H_1 trials. It is interesting to note that this animal made the largest number of errors (L-H, $N=46$; H-H, $N=9$).

DISCUSSION

Two clear findings of the present study are that the three-pair same-different differentiation is solvable with a half-octave difference between tones, and that differentiation performance transfers readily to prolonged interstimulus intervals of more than 0.5 min.

In the present design, the L-L compound was used to preclude responding to L-H solely on the basis of the L component. Similarly, the H-H compound ensured that the H component alone did not govern responding to the positive compound. However, several other analyses of the three-pair problem with constant tones are possible, in which comparison between the first and the second stimuli need not serve as an exclusive basis for solution. For example, the problem may be considered as two separate tasks in which the dog learns on the one hand that responses are never rewarded following H_1, and on the other that following L_1, responses are rewarded to H_2, but not to L_2. In this case, responding may be governed in part by information present in the *first* tone regarding probability of reward. The most prominent finding in the present study was the development of different reaction patterns to the L and H signals in the first position of a pair.

The specific reaction patterns occurring in the three-pair dogs persisted throughout the ISI. This behavior is comparable to the "mediating behavior" observed by Blough (1959) in delayed matching with pigeons. The persistence of the reactions in the ISI precludes a strict analysis on the basis of recent memory since the task may be reduced to a conditional discrimination (Pavlovian conditioned switching) based on the simultaneous compound of the second tone and response-produced cues correlated with the first tone.

The positive transfer exhibited as ISI was lengthened may be attributed directly to the maintenance of reaction patterns during ISI, already learned at shorter intervals, and favored by the gradual increase of ISI in steps. The beginning of the breakdown of differentiation performance, noticeable at ISI-80 sec and in some cases at 40 sec, may reflect the increasing difficulty of discriminating ISI from ITI intervals. Thus, although the absolute difference between ISI and ITI increased with longer ISIs, the ratio of ITI to ISI decreased from 24 at ISI-2.5 sec to 3 at ISI-80 sec. On the other hand, the performance breakdown could be due to the failure of differential reactions during ISI to persist longer than about 30 sec.

Several observations suggest that a cue function per se was not the only property of the differential reactions to the first tone: (i) For four out of five dogs tested, fewer CRs were evoked by L_2 when preceded by H_1 (novel compound) than when preceded by L_1. This difference appeared in spite of large amounts of prior differentiation training with L-L as a negative compound, and the presentation of reward for CRs to H-L. (ii) Heart rate changes on L_1 and H_1 trials are consistent with previous findings that, prior to an instrumental response in an appetitive situation, heart rate increases in response to a positive CS, and decreases with the addition of a "conditioned inhibitor" (Sołtysik 1960). (iii) Also the overt behavior to L_1 revealed a clear motor arousal, whereas a rather opposite pattern of "subdued" attitude was elicited by H_1. On the basis of these observations, it is plausible to consider the total response patterns to L_1 and H_1 as manifestations of "excitatory" and "inhibitory" states, respectively, which function either to potentiate or suppress prevailing response tendencies. Whether or not this construction is merely a redundant version of the cue function interpretation could be tested by ascertaining the effect of prior L_1 and H_1 presentation on responding to separately trained instrumental CSs.

The present study differs from Chorążyna's (1959, 1967) experiments chiefly in the use of constant rather than variable tone values between trials. For the study of recent memory, the pitfalls of the three-pair design are manifold. To be sure, these may be eliminated to a great extent or completely with the use of variable tone cues. However, even in this case, rigorous control is required to obviate any differential connections between the first pair members and reward. For example, during the phase of variable tone training in the present experiment, the first trial of a session provided at once the constant values of L_1 and H_1 to be used on a given day. Clearly, the three-pair design with constant tones as used in the present study, cannot be considered a "same-different" discrimination. Since the novel compound H-L is an equally "different" compound as the L-H pair used in training, a high degree generalization between them should be expected. This was not found in the present test series. On the contrary, the opposite effect occurred. The results of this test as well as other observations suggest that quite a different solution rule was used by the subjects, based upon the assymetrical association between first tones and reward.

A prerequisite for the same-different problem in studies of short-term memory is that differences between first pair members are independent of reward contingencies. This condition may be achieved by a balanced design in which each first member of a pair is associated equally often with each second member. No differences in overt reactions to the first tones were observed in one animal in this study trained with a balanced four-pair design.

It is rather surprising that dogs confronted with a task easily solvable on the basis of recent memory resorted to another mode of solution, which intuitively seems more complex. It may be asked if this is true for all modalities in dogs? Do dogs in fact use short term memory for acoustic stimuli? This question may be answered with the use of a task solvable only on the basis of recent memory.

SUMMARY

Three-pair design of short-term memory test was investigated in dogs. Animals were trained to discriminate between three pairs of acoustic stimuli; compounds consisting of two same tones (e.g., two low tones or two high tones) were differential CSs and instrumental responses occurring during their presentation were not rewarded, whereas a compound of a low tone followed by a high tone was a positive CS and responses to the second tone were rewarded. The dogs were able to learn this task, first with short interstimulus intervals (1 sec) and transferred readily to longer intervals up to 40 and even 80 sec.

Analysis of overt behavior which differed to high and low tones presented as first signals of a pair, and during interstimulus intervals, as well as comparison of heart rate responses to the tones suggested that dogs mastered the task not on the basis of short-term memory by discriminating the "same" pair from the "different" pairs of tones, but resorting to a seemingly more complex solution based on the assymmetrical associations of the first tones with reward. This conclusion was supported by applying a novel pair of stimuli in which a high tone was presented first and a low tone second. Not only was no generalization found from the well trained low-high pair but the new high-low compound elicited less responses than any of the well trained negative pairs, high-high and low-low. It was concluded that the three-pair design

cannot be considered a test of short-term memory and that a fully balanced four-pair design with equal contingencies between all tones and reward may provide a satisfactory solution by preventing the subjects from using any long-term assymetrical associations.

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