A FAILURE TO TRAIN THE “SAME–DIFFERENT” DIFFERENTIATION OF PHOTIC STIMULI IN DOGS

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Abstract. Dogs were unable to learn “same–different” differentiation of pairs of photic stimuli when continuous light (CL) and pulsing light (PL) were presented in four combinations: CL-PL and PL-CL served as $S^D$ (positive instrumental conditioned stimulus), whereas CL-CL PL-PL were $S^A$ (inhibitory stimulus). Also the dogs which have learned this task with tones were unable to transfer to photic stimuli. Differentiation of the single stimuli (CL and PL) as $S^D$ and $S^A$ was quite easy and showed that the stimuli were readily discriminable.

INTRODUCTION

The “same–different” (S–D) differentiation in a 4-pair design was trained successfully in dogs using a variety of auditory stimuli, such as tones, clicks, bell, metronome and white noise (1, 7, 10). Since the S–D task is considered a useful method for studying the recent memory of stimuli (3) an attempt was made to use visual stimuli in the same experimental design as in the previous work of Brown and Sołtysik (1). Photic stimuli, namely, light flashes of different frequencies were used in the S–D differentiation learning in monkeys by Stępień and Cordeau (11) and therefore it was decided that in this experiment two similarly simple stimuli should be employed: a continuous light (CL) and rhythmic flashes (PL = pulsing light) delivered from a strobe lamp.

MATERIAL AND METHOD

Thirteen male mongrel dogs were used in this study; nine of them were experimentally naive animals and four were previously used in Brown and Sołtysik’s study (1) and were well overtrained in the S–D
task with tones. The experimental situation was described in another paper (6). In this experiment essentially the same procedure was used, except for the fact that only photic stimuli were employed. The illumination of the experimental chamber was of medium intensity and the stimuli were delivered from a 100 W strobe lamp (Type ALS-1, IBD Warsaw) placed on the feeder about 1 m in front of the subject. Two easily discriminable (to the human eye) stimuli were chosen: a constant light (CL) and rhythmic five per second flashes (PL = pulsing light). As in the previous experiment (1) a go–no go differentiation with asymmetric reward (i.e., a reward available only on “positive” trials) was employed. About 100 g of ground meat mixed with broth soaked bread cubes served as a reward.

RESULTS

Experiment 1. Training of the S–D differentiation using visual stimuli

Five adult, experimentally naive, mongrel male dogs were used as subjects. The training started with habituation to the Pavlovian stand, followed by exposure to the feeder and shaping of the bar press response. This initial part of training proceeded uneventfully and the dogs easily learned the instrumental response. The next step was to introduce a pair of two different stimuli as an S^D. The spontaneous responses were no longer rewarded at this period and only the bar presses occurring during the second stimulus of a pair were followed by food presentation. Continuous light (CL) and pulsing light (PL) were the stimuli used. The first stimulus was presented for 2 sec and after 1 sec pause (the delay or inter-stimulus interval ISI) the second stimulus was presented for 10 sec. Very soon the animals responded promptly to these stimuli and the duration of the second stimulus was shortened to 5 sec. The dogs were allowed to press the bar also during the first stimulus or the ISI but these responses were not rewarded; they did not affect the presentation of the second stimulus and, being essentially disregarded, tended to disappear in the course of further training. When the animals responded reliably to the CL-PL and PL-CL pairs, the “same” trials, with the pairs CL-CL and PL-PL, were introduced. Initially only a one “same” trial was presented among seven positive “different” trials. Gradually the number of “same” trials was increased to four while the total number of trials in the session remained eight, making thus the “same” to “different” trials ratio of 4 : 4.

After several hundred daily sessions, none of the dogs learned the task. Three dogs had to be discarded when they developed neurotic
symptoms after encountering difficulties in solving the task. The most frequent symptoms were, restlessness, refusal to eat in the experimental chamber and suppression of the instrumental response. Two remaining dogs could not meet the criterion after one year of training with shortest (1 sec) ISI (Fig. 1). Table I part A illustrates how many trials of each

Fig. 1. Acquisition curves for learning the “same–different” differentiation with photic stimuli in two naive dogs. Each point represents a percentage of correct performance (ordinates) in a block of 40 consecutive trials (abscissae), i.e., five daily sessions. The combined percentage score is obtained by subtracting the percentage of errors of commision (responses to the “same” pairs) from the percentage of correct responses to the “different” pairs; the scale thus extends from $-100\%$ to $100\%$. Values near zero mean lack of differentiation. Values different from zero indicate the presence of differentiation. Positive sign denotes correctness of performance; plus scores are obtained when the responses to “different” pairs outnumber the responses to the “same” pairs. A balanced four pair design was used throughout the training.
Number of trials during acquisition of the “same-different” differentiation till criterion (B) or discontinuation of training (A, C)

A. Photic stimuli in naive dogs

<table>
<thead>
<tr>
<th>DOG</th>
<th>Pairs of stimuli</th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CL-PL</td>
<td>PL-CL</td>
<td>CL-CL</td>
</tr>
<tr>
<td>Mi</td>
<td>556</td>
<td>556</td>
<td>542</td>
</tr>
<tr>
<td>Ni</td>
<td>449</td>
<td>446</td>
<td>411</td>
</tr>
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</table>

Total average per dog = 1966

B. Tones in naive dogs. From (1).

<table>
<thead>
<tr>
<th>DOG</th>
<th>Pairs of stimuli</th>
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<tr>
<td></td>
<td>L-H</td>
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<td>L-L</td>
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<tr>
<td>Epsilon</td>
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<tr>
<td>Omega</td>
<td>291</td>
<td>291</td>
<td>291</td>
</tr>
<tr>
<td>Tau</td>
<td>294</td>
<td>294</td>
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</table>

Total average per dog = 979

C. Photic stimuli in dogs trained previously with tones

<table>
<thead>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>PL-CL</td>
<td>CL-CL</td>
</tr>
<tr>
<td>Epsilon</td>
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<td>330</td>
<td>199</td>
</tr>
<tr>
<td>Lambda</td>
<td>265</td>
<td>264</td>
<td>250</td>
</tr>
<tr>
<td>Omega</td>
<td>271</td>
<td>270</td>
<td>258</td>
</tr>
<tr>
<td>Tau</td>
<td>277</td>
<td>275</td>
<td>259</td>
</tr>
</tbody>
</table>

Total average per dog = 1053

kind were presented to each of this two dogs. To compare this with the acquisition of the same task with auditory stimuli (high tone, low tone) the data from other work (1) are presented in the part B of this Table. On the average less than 250 trials were needed to reach the criterion of 90% correct performance with the auditory stimuli, whereas even after twice as many trials with visual stimuli, no progress in learning was observed.
Experiment 2. Training of S–D differentiation using photic stimuli in dogs which had previously learned this task with tones

Four dogs from another study (1) were given, after 18 month rest, a “refresher” training using high (H) and low (L) tones of 1.200 Hz and 200 Hz respectively. Figure 2 shows performance of each dog during the retraining period. It is evident that all dogs easily reached high performance levels, even with delays extended from 2 to 5, 10 and eventually 20 sec. Following the retraining, a new experiment was carried out when the auditory stimuli (H and L) were replaced by photic

Fig. 2. Learning curves during the retraining with tones. Abscissae and ordinates as in Fig. 1. Horizontal line marks the 80%/ criterion level (in fact it is 90% for positive “different” pairs minus 10% acceptable errors to the “same” inhibitory pairs). Vertical arrows with numbers mark the moments of reaching the criterion and the accompanying numbers refer to increased delay (in seconds).
stimuli (CL and PL). The ISI was reduced to 1 sec and the training was designed in the same way as the original training with the H and L tones. Pairs of different stimuli, i.e., CL–PL and PL–CL served as an SD while the pairs of the same stimuli, CL–CL and PL–PL were presented as SA. Initially only “different” pairs (SD) were presented in eight trials constituting a daily session. When the dogs learned to respond well to the “different” pairs, the “same” pairs were introduced as inhibitory stimuli. Similarly as in Experiment 1, first, only one “same” pair was presented among seven positive trials (the number of trials was always eight per session). Gradually, the number of SA trials with the “same” stimuli was increased to four and the ratio of positive to inhibitory trials was 4:4 henceforth.

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In the first few trials with photic stimuli orienting responses and indiscriminate instrumental responding appeared. Bar pressing during the first stimulus, delay and intertrial intervals was observed, although the dogs had long been rid of these responses when the tone stimuli were used. Figure 3 shows percentage of the instrumental responses to the “same” and “different” pairs. When no or little progress was observed during the first 10 weeks of training, the experimenters decided to punish the incorrect responses by applying a mild shock to a hindleg. I did not help, however, in Tau while in Lambda and Omega a deterioration of responding to SD was observed as the only effect of this differential punishment. The fourth dog Epsilon, was known for his tendency to extinguish responses, so instead of punishment food deprivation was tried, however, without success. When the training reached or surpassed the number of trials which were required to meet criterion in the previous training with tones, and none of the dogs even approached the criterion performance with photic stimuli, the experiment was discontinued. Table I presents the number of trials to criterion in the original training with tones (part B) and the number of trials after which the training with photic stimuli was discontinued for the lack of progress in learning (part C). It is interesting that after this prolonged and unsuccessful training the dogs were very easily retrained with tones and used in other experiments (7, 10).

**Experiment 3. Training of the instrumental differentiation using simple photic stimuli**

To obviate the suspicion that the visual stimuli chosen for this study were not easily discriminable for our dogs, an additional experiment was carried out on four naive dogs. They were trained to press a bar in response to one photic stimulus (CL in Lolek and Bolek, PL in Tobik and Stefik) and not to press when the other stimulus (PL in Lolek and
Bolek, CL in Tobik and Stefik) was presented. Thus, the same experimental design in the same situation with the same response and reward was used, except that instead of pairs of stimuli the single stimuli were used as $S^D$ and $S^\Delta$. Similarly as in the two first experiments, the training started with shaping a response (a bar press) and then the animals were taught to respond to a sporadically presented $S^D$. A daily session consisted of eight trials. When the latencies of bar presses were consistently shorter than duration of the $S^D$ (5 sec), the differential stimulus $S^\Delta$ was introduced. Initially, it was presented only once in a session and only gradually the ratio of $S^D$ to $S^\Delta$ was equalized to 4 : 4. No punishment was used and the $S^\Delta$ simply meant that the reward was not available.
Figure 4 shows how easily the dogs learned to differentiate the stimuli. It is also evident, that while two dogs (Tobik and Lolek) learned the task very quickly, the other two (Stefik and Bolek) required twice as many trials to reach the criterion. Those who were fast learners started from the very beginning with a separation in responding of 20–30%. It is not evident in Fig. 3 which shows only the difference in responding to $S^D$ and $S^\Delta$, but Table II, which contains the scores separately, makes clear that the fast learners maintained 100% responding to $S^D$ while quickly extinguish the responses to $S^\Delta$. Their $S^D$ and $S^\Delta$ scores never overlapped. The slow learners did not maintain such errorless performance to $S^D$ and showed an overlap of scores in the first blocks.
Table II

Performance of instrumental response (%) to $S^D$ and $S^\Delta$ during the first 8 blocks of trials (1 block = 10 trials) in dogs trained to differentiate between the continuous (CL) and pulsing (PL) light stimuli.

<table>
<thead>
<tr>
<th>Dog</th>
<th>Stimuli</th>
<th>Blocks 1</th>
<th>Blocks 2</th>
<th>Blocks 3</th>
<th>Blocks 4</th>
<th>Blocks 5</th>
<th>Blocks 6</th>
<th>Blocks 7</th>
<th>Blocks 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tobik</td>
<td>PL = $S^D$</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>80</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CL = $S^\Delta$</td>
<td>70</td>
<td>30</td>
<td>30</td>
<td>50</td>
<td>20</td>
<td>10</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Lolek</td>
<td>CL = $S^D$</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PL = $S^\Delta$</td>
<td>80</td>
<td>70</td>
<td>40</td>
<td>40</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>StefiK</td>
<td>PL = $S^D$</td>
<td>100</td>
<td>90</td>
<td>60</td>
<td>100</td>
<td>90</td>
<td>100</td>
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<tr>
<td></td>
<td>CL = $S^\Delta$</td>
<td>90</td>
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<td>90</td>
<td>70</td>
<td>70</td>
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</tr>
<tr>
<td>Bolek</td>
<td>CL = $S^D$</td>
<td>100</td>
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<td>PL = $S^\Delta$</td>
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<td>60</td>
<td>70</td>
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</tbody>
</table>

**DISCUSSION**

The failure to learn a same–different differentiation with photic stimuli by our dogs was an unexpected finding. Dogs are believed to be guided in their behavior to a greater extent by olfaction and hearing than vision. A number of studies in Pavlov's laboratories have shown that visual signals used as conditioned stimuli elicit much weaker conditioned responses than auditory or even cutaneous stimuli (e.g., 4, 8). However, the dogs are also known to be capable of fine visual discriminations. In the classical conditioning situation, dogs were found to discriminate: intensities of light, patterns, movements of objects and directions of such movements (6). Subsequent experiments in Pavlov's laboratories proved that dogs could discriminate circle from ellipse, with the limit of discrimination at the ratio of major to minor axis equal to 9:8 (9). In discriminating intensity of illumination, dogs equal or surpass the human eye (2).

The stimuli used in the present study were not difficult to discriminate and, in fact, the control subjects of the third experiment learned quite easily the differentiation in an instrumental $S^D$ vs. $S^\Delta$ paradigm. Why then were they unable to cope with the S–D task? The delay (i.e., the interstimulus interval) was only one second long so the task did not rely much on memory. Rather, it seems that the dogs were not attentive enough or were unable to grasp the gist of the task. Even more surprising was the failure of four animals which had earlier learned this task with
auditory stimuli. These four dogs were found (7) to transfer readily the S–D differentiation to new auditory stimuli, and yet were unable to learn the very same task with photic stimuli. Several tentative explanations may be proposed.

*Lack of trans-modality recognition of “sameness” and “differentness”*

In contrast to monkeys, which easily learn an S–D task with visual and auditory stimuli (11; S. Sołtysik, N. A. Buchwald, C. D. Hull and T. Lidsky, in preparation) the dogs may be unable to recognize the abstract property of being the same or different, when a new sensory modality is used. This hypothesis would explain the lack of positive transfer from auditory to visual stimuli but does not explain the complete failure to learn this task with photic stimuli. More experiments with other modalities are needed to substantiate the notion of the dogs being restricted in their concept formation to the modality of stimuli for which the concept was formed.

*Artificiality of stimuli*

The choice of constant and blinking light was dictated by planned consecutive electrophysiological experiment in which the physical simplicity of stimuli is a desirable feature. However, the dogs may have found our stimuli too difficult to remember and compare because of their artificial and “meaningless” nature. More natural stimuli, such as known objects, might be easier to perceive and match.

*Lack of perceptual ability to cope with compound visual stimuli*

There is some morphological evidence that the subcortical, and particularly thalamic, visual nuclei in dogs are relatively less complex than the auditory structures (12). The differences are most striking in the lateral geniculate and pulvinar, when compared to the same structures in monkeys. The dogs may thus be lacking a necessary neural apparatus to cope with temporally compound visual stimuli.

Perhaps, both factors, artificiality of our stimuli and a lesser importance of visual modality in the canine “Umwelt” contributed to the failure of the dogs in the present experiment.

**SUMMARY**

Discrimination of visual stimuli was trained in three groups of dogs. In the first, experimentally naive group, two photic stimuli, a continuous light (CL) and rhythmic flashes (pulsing light = PL) of five per sec, both
delivered from a 100 w strobe lamp, were used as positive (SD) and inhibitory (S\textsuperscript{A}) conditioned stimuli in a simple go–no go instrumental (bar press) learning situation. The dogs easily learned the task with either CL or PL as a go-signal (i.e., SD). The second group of experimentally naive animals was trained in a “same–different” differentiation with the same stimuli. The stimuli were presented in pairs (one stimulus following the other after a 1 sec interstimulus interval), and the “different” pairs, CL-PL and PL-CL, were go-signals whereas the “same” pairs, CL-CL and PL-PL, were no go-signals. None of 5 dogs in this group could learn the task. In the third group all subjects were well acquainted with the “same–different” differentiation of tones and performed above 90\% correct responses even with the inter-stimulus interval of 20 sec. However, when the tones were replaced by CL and PL the animals failed to learn the task even after a period exceeding the original training with tones. The results of these experiments are discussed in the context of lesser importance of vision than hearing in the dogs’ life and the anatomical data are quoted concerning the differences in the neural apparatus processing the auditory and visual stimuli.

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