Information trial and successive reversal training effect in Japanese monkeys

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Two groups of male Japanese monkeys were given one of two modified forms of successive reversal training (SRT) in WGTA. Prior to usual SRT trials of each reversal, an information trial was introduced on which either baited positive stimulus [(p-1) group; n=3] or unbaited negative stimulus [(n-1) group; n=2] of new reversal was singly presented. Two-trial problems were given on three stages of the informed SRT’s so as to assess the development of choice strategies. (N-1) group tended to be superior to (p-1) group in 2-trial problems, and the latter group was inferior to (n-3) and SRT groups of the previous experiments. An assumption explaining these and other findings was presented.

Key words: interproblem transfer, discrimination learning, successive reversal training, choice strategies, Japanese monkeys.

Since the remarkable findings by Schusterman (1962, 1964) and Rumbaugh and Prim (1964), improvement of discrimination by prior administration of successive reversal training (SRT) has been confirmed in various species of monkeys. Schrier (1966), using cynomolgus monkeys and stump-tailed monkeys as subjects, brought out that SRT aids in learning-set performance. Warren (1966) gave two groups of rhesus monkeys 60 reversals of either spatial discrimination or object discrimination, and disclosed that both of the SRT’s improved object discrimination learning. Similar evidence has also been provided by Ricciardi and Treichler (1970) with squirrel monkeys, Riopelle and Kumaran (1971) with Patas monkeys, and Komaki (1974) with Japanese monkeys. Obviously SRT has the effect to aid in discrimination behavior.

Reversal performance during SRT, however, does not warrant for the effect to take place. In our previous experiment (Komaki, 1977), a group of Japanese monkeys [(p-3) group] were given, prior to every reversal phase of SRT, three p stimulus trials: The positive member of training stimuli was presented singly, and response to it was rewarded. Those information trials gave an impetus to reversal performance itself, but impaired the SRT effect. The (p-3) group was significantly inferior to the standard SRT group in 2-trial discrimination learning probes. Another group of monkeys [(n-3) group] which was given, prior to every reversal, three unbaited trials to new negative member of the pair, did not show such a deterioration. The (n-3) group displayed 2-trial task performance comparable to the SRT group.

These findings lead to the assumption that the SRT effect may depend on the level of attentiveness at which reversal choices are to be made. But, before elaborating this line of reasoning, it might be in order to collect more information on the function of p as well as n stimulus trial. In the present experiment, the trials were provided not in a trial block but singly: Single p or n stimulus trial was introduced prior to each reversal phase of SRT, and their possible influence on the SRT effect of facilitation was to be assessed.

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Method

Subjects
Six male adult Japanese monkeys (Macaca fuscata) served as the subjects. They were wild-born monkeys and were reared for more than two years at the Primate Institute of Kyoto University. All of them were experimentally naive. They were fed after their daily session in their individual home cages where water was always available. The reward given to them was a raisin. One subject that was assigned to the (n-1) group described below was very slow to learn and could not complete the whole session within the predetermined period. The data for this subject was not included in the following analyses.

Apparatus
All the training and the problems were given to the subjects in a modified version of WGTA (Komaki, 1974). Essentially, it was composed of two cages. A subject was introduced into one of the cages, and faced with a stimulus or a pair of stimuli presented on a movable stimulus tray in the other cage. The stimulus tray had three food wells on it, each one measuring 12 cm from edge to edge. The 63 pairs of stimuli used in our previous studies (Komaki, 1974, 1977) were the discriminanda. The stimuli were three-dimensional wooden objects, differentially colored, and varied in form and size. Three pairs were applied to the informed SRT and the remaining 60 pairs to the 2-trial problems.

Preliminary Training
According to the schedule described by Murofushi (1966–67), the subjects were given progressive stages of training. The criterion at the final stage of training was that each subject could displace an object covering one of the food wells as soon as the transparent screen was raised. Four subjects took eight days and the other subjects 12 days to pass the criterion. They were assigned in a counter-balanced order to one of the (p-1) and (n-1) groups described below.

Procedure

General training procedure and design. A trial started at the opening of the opaque screen. A few seconds later, when the subject looked forward, the experimenter raised the transparent screen about 10 cm above the floor. As soon as the subject was rewarded for a correct response or displaced the incorrect stimulus, the screen was lowered. Then the opaque screen was lowered and the trial was terminated. The intertrial interval was 25 to 30 s.

All the subjects were given an original discrimination, three blocks of 20 informed reversals, and six series of 2-trial problems. Some of the 2-trial problem series were interpolated within the informed SRT and the other series were presented after the SRT. One of the first three 2-trial problem series was given after each of the three reversal blocks and the remaining series were provided in succession after the third series of 2-trial problems.

Informed SRT. All the subjects were initially trained on an original discrimination. One of the three stimulus pairs was assigned to one subject of each group, and the nonpreferred member of the pair was the correct stimulus. When each subject reached the criterion of 10 consecutive correct responses, the informed SRT which would be extended over three blocks of 20 reversals was initiated. Every reversal of the informed SRT was composed of two phases; one information trial and the usual reversal training. The information trial phase was differentiated between the two groups.

To the subjects of the (p-1) group the positive member of the new reversal was presented singly over the center food well on the stimulus tray, and the response to it was rewarded (p stimulus trial). To the subjects of the (n-1) group the new negative stimulus of the pair was presented
singly, and the response to it was not rewarded (n stimulus trial). When the subject did not displace the unbaited stimulus and 30 s elapsed, the trial was terminated and the response latency of 30 s was recorded.

The reversal training phase was common to the two groups. Paired stimuli were presented over the two extreme food wells, and alternated between left and right according to a predetermined order. Twenty-four sequences were selected from the table by Fellows (1967) and combined to form six series of 48 trials. These series were rotated every six days. The criterion of reversal learning was 10 consecutive correct responses. Daily trials were 47 to 49. When the subject reached the reversal criterion on the 47th trial of a day, the information trial for the new reversal was not given on that day. Instead, the trial was given before the administration of the 48 trials allotted to the next day.

Two-trial problems. All the monkeys received discrimination behavior probes made of six series of 2-trial problems. Each of the subjects took one of the three series on the day next to the day when it finished each informed SRT block, and the remaining three series in succession after the third series of 2-trial problems.

Ten baited and ten unbaited 2-trial problems constituted each series and made up a daily session of 40 trials. The baited problem was to test the so-called “winstay” strategy (Levine, 1959). On the first trials of the baited problems both the paired stimuli were baited, and the stimulus chosen on the trial by the subject was the correct stimulus for the next trial. The unbaited problem was to test what is called “lose-shift” strategy. On the first trials of the unbaited problems none of the paired stimuli were baited, and the stimulus not chosen was the correct stimulus for the next trial.

Positions of the paired stimuli were alternated on the second trial in half of the baited and the unbaited problems (differential problems), but not alternated in the remaining halves of the problems (duplicate problems). Thus, every 2-trial problem series consisted of four kinds of five problems involving four possible combinations: baited-differential, baited-duplicate, unbaited-differential and unbaited-duplicate problems. These problems were arranged in sequence according to a predetermined random order.

Sixty pairs of stimuli were also put in order to produce three sets of 20 pairs. These sets were given to the three subjects in each group as the first three problem series to form a 3 x 3 Latin square. These sets were used again in the same sequence as the second three problem series. The interval between the problems were 35 to 40 s and that between trials 30 s.

Results

Information Trial Performance

The three monkeys of the (p-1) group displaced the baited single stimulus object at nearly same response speed during the SRT. Response speed was defined as a reciprocal of time in seconds from the opening of the transparent screen to the displacement of the stimulus. Their relative response speed on p stimulus trials in the second and the third block of the SRT were from 93 to 114% of their response speed in the first SRT block. The two monkeys of the (n-1) group reduced their response speed on n stimulus trials. Their relative response speed to the unbaited single object were 14 and 71% of their first SRT block response speed.

Errors in SRT

Only the n stimulus trial achieved the effect to reduce errors on early trials of the reversals. Initial consecutive errors per reversal were counted for each subject and pooled for every 10 reversals. The same errors by the standard SRT group (Komaki, 1974) and by the (p-3) as well
Table 1
Mean initial consecutive errors in each of 10 reversal blocks

<table>
<thead>
<tr>
<th>Groups</th>
<th>1st SRT block</th>
<th>2nd SRT block</th>
<th>3rd SRT block</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st half</td>
<td>2nd half</td>
<td>1st half</td>
</tr>
<tr>
<td>(n-1)</td>
<td>3.15 .80</td>
<td>1.15 .45</td>
<td>3.15 .60</td>
</tr>
<tr>
<td>(p-1)</td>
<td>4.67 1.67</td>
<td>1.57 1.70</td>
<td>4.67 1.33</td>
</tr>
<tr>
<td>SRT†</td>
<td>3.13 1.90</td>
<td>1.87 1.80</td>
<td>3.13 1.67</td>
</tr>
<tr>
<td>(n-3)††</td>
<td>1.63 .57</td>
<td>.20 .33</td>
<td>1.63 .23</td>
</tr>
<tr>
<td>(p-3)††</td>
<td>2.90 1.40</td>
<td>1.30 .80</td>
<td>2.90 1.37</td>
</tr>
</tbody>
</table>

Table 2
Trials to achieve each SRT block of 20 reversals
(Information trials are not included.)

<table>
<thead>
<tr>
<th>Groups</th>
<th>Subjects</th>
<th>SRT blocks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>(n-1)</td>
<td>1</td>
<td>629 364</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>729 410</td>
</tr>
<tr>
<td>(p-1)</td>
<td>3</td>
<td>469 269</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>733 350</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>618 309</td>
</tr>
<tr>
<td>SRT†</td>
<td>a</td>
<td>538 420</td>
</tr>
<tr>
<td></td>
<td>b</td>
<td>706 476</td>
</tr>
<tr>
<td></td>
<td>c</td>
<td>715 415</td>
</tr>
</tbody>
</table>
† Komaki (1974).

as the (n-3) group (Komaki, 1977) of the previous experiments were also counted for comparison. Mean consecutive errors per 10 reversals are shown in Table 1 for the five groups. Groups × Reversal Blocks analysis of variance with unweighted-means solution (Winer, 1971, p. 599) was applied. The main effect of Groups was significant ($F=12.21$, $df=4/9$, $p<.01$). Individual comparisons (Winer, 1971, p. 603) revealed, among other things, that the (n-1) group made fewer initial errors than the SRT group ($p<.05$), and that the (p-1) group was not different from the SRT group. The stimulus trial, when provided singly to the monkeys, could not cause the effect to guide reversal performance and to reduce errors. The main effect of Reversal Blocks was significant ($F=28.54$, $df=5/45$, $p<.01$) but Groups × Reversal Blocks interaction was not. All the groups made significantly greater initial consecutive errors in the first 10 reversal block than the other blocks ($p<.05$). The reduction of early reversal errors by $n$ stimulus trial and lack of the effect by $p$ stimulus trial are also seen in performance during the initial 10 reversal trials. On the first reversal trials of the SRT, the (n-1) group made significantly fewer errors than the SRT group ($p<.05$), but the (p-1) group did not.

Reversal Trials
Reversal trials needed to achieve reversal phases of the SRT were not affected by the introduction of the information trials. Trials to achieve each SRT block of 20 reversals are shown in Table 2 for the five subjects. Trials by SRT group subjects are also presented in the table for reference. An analysis of variance with SRT Blocks being repeated measures was applied. Neither the main effect of Groups nor the interaction of Groups × SRT Blocks was significant. Only the main effect of SRT Blocks was highly significant ($F=170.95$, $df=2/18$, $p<.01$). Pairwise comparisons revealed that the first SRT block trials were significantly greater than the second and the third SRT block trials ($p<.01$).

Two-Trial Problem Performance
Mean correct responses made by the groups in each of 2-trial problem series are shown in Fig. 1 separately for baited problems (left panel) and unbaited problems (right panel). Percentages of correct responses to biased as well as unbiased pairs of stimuli (Komaki, 1983) in each of the baited and unbaited problems were calculated for each subject, and they were transformed into inverse sine roots. An analysis of variance of Groups × Problem Types (baited and unbaited) × Stimulus Pairs (biased and unbiased) was applied to the scores (Winer, 1971, p. 601), the
latter two being repeated measures. The same sort of scores by the (n-3) group, the (p-3) group and OT groups (overtrained groups—Komaki, 1973, 1974) of the previous experiments were added for comparison. According to their face values the (n-3) group was best and the (p-3) group was worst, the (n-1), SRT, (p-1) and OT groups being intermediate between them in that order. The main effect of Groups was significant \((F=6.70, df=5/14, p<.01)\). Pairwise comparisons revealed that the (n-1) group, which proved to be not different from the (n-3) and SRT groups, was significantly superior to the OT and (p-3) groups \((p<.01)\) and tended to be superior to the (p-1) group \((p<.10)\). The analysis also revealed that the (p-1) group was not different from the (p-3) and OT groups, significantly inferior to the (n-3) group \((p<.05)\), and tended to be inferior to the (n-1) and SRT groups \((p<.10)\).

Discussion

The SRT effect of facilitation was also impaired by introducing \(p\) stimulus trials in SRT in the present experiment. The (p-1) group to which one \(p\) stimulus trial was provided on each reversal was worse than the (n-1) group in 2-trial task discriminations. Furthermore, the (p-1) group proved to be inferior to the SRT and (n-3) groups. Obviously \(p\) stimulus trial is detrimental to the SRT effect. \(p\) stimulus trial achieves two sorts of effects. It aids in reversal performance and reduces reversal errors during SRT. This can be seen in the initial consecutive errors by the (p-3) group of the previous experiment (Komaki, 1977). Nevertheless, it hampers the growth of some process or mechanism which yields the SRT effect of facilitation.

\(N\) stimulus trial does not produce such a negative influence. This trial aids in reversal performance and reduces errors as \(p\) stimulus trial does. But \(n\) stimulus trial is by no means detrimental to the SRT effect. Conversely, there is a sign of enhancement of the SRT effect by \(n\) stimulus trial. Though statistically unreliable, the (n-3) as well as the (n-1) group was at a higher level of performance than the standard SRT group in the 2-trial discrimination behavior probes (Komaki, 1983).

It should be noted at this point that the SRT to which \(n\) stimulus trials were introduced did not favor any of the choice strategies. As seen in Fig. 1, the (n-1) group was better than the (p-1) group in

![Fig. 1. Mean correct responses made by the groups in each of the 2-trial problem series.](image-url)
both of the baited and unbaited problems. And, the (n-3) group of the previous experiment (Komaki, 1977) was also superior to the (p-3) group in both sorts of the problems. The informed SRT with n stimulus trials actually aids in "win-stay" as well as "lose-shift" strategy performance. The same is true for the standard SRT. These findings permit us to infer that the effect of facilitation by these SRT's may be due to more general basis of learning than the selective strengthening of specific choice strategies.

$P$ stimulus trial proved to be detrimental to the SRT effect of facilitation. On the contrary, $n$ stimulus trial was by no means detrimental, but beneficial to it. The source of the difference must be that the stimulus on $n$ stimulus trial brings no reward and signifies the absence of reward to the subjects. One way of explaining the significance of this difference and the SRT effect by a single principle is this. Occurrence of nonrewarding or anticipation of it during training might suppress hasty responses in the first place, and might provoke in well-motivated monkeys various attentional responses such as multiple looking or quick comparison of stimuli. Each of the attentional responses, when evoked often and reinforced to be a dominant response in the situation, might come to be a component of response pattern constituting discriminative behavior, and serve as a basis for improving subsequent discrimination learning. On the contrary, $p$ stimulus trial could not produce any profitable influence. Indiscriminate provision of reward on the trial might induce hasty responses, and also extinguishes the attentional responses that have been strengthened on nonrewarding trials in the reversal phases of SRT.

Evidence of overtraining in monkeys seems to lend support for the above line of consideration. There is a substantial body of literature which reveals that overtraining in monkeys neither improves nor retards reversal (Beck, Warren, & Sterner, 1966; Cross & Boyer, 1966; Cross, Flekling, Carpenter, & Brown, 1964; D'Amato, 1965; Tighe, 1965). Furthermore, the overtrained groups of our previous experiments (Komaki, 1973, 1974) displayed, after 1200 to some 1600 trials of overtraining, near-chance level performance in the 2-trial probes. Overtraining appears to provide nothing to establish a basis for inter-problem transfer. Monkeys do not profit from overtraining presumably because they rarely make errors during overtraining and thus have few chances to learn the attentional responses as well as the suppression of hasty responses.

For the SRT effect of facilitation to take place, something other than reversal performance is necessary. Incorrect responses which inevitably take place on the early trials of each reversal seem to have crucial importance: They give rise to nonrewarding and nonrewarding in turn alters well-motivated monkeys to cautious and tentative behavior. This aspect of SRT seems to be one of the principal determinants for the effect of facilitation of SRT.

References


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