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PICTURE MEMORY (PSEUDOMATCHING) IN THE RHESUS MONKEY

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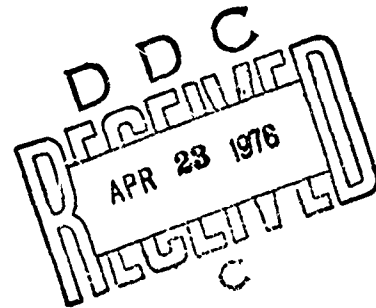
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Pseudomatching, the selection of the correct comparison stimulus without
dependence on presentation of a sample stimulus, was demonstrated in monkeys
being trained on a shock-avoidance, matching-to-sample task. Pseudomatching
occurred whenever the problem sets were not fully counterbalanced for key
position and correct symbol and seemed to represent memorization of specific
stimulus configurations. Some animals showed the capacity to memorize hundreds

20. ABSTRACT (Continued)

of different 4-choice problems as revealed by test trials on which the samples were omitted.

PREFACE

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INTRODUCTION

In a matching-to-sample task one cannot always assume that above-chance matching accuracy is necessarily due to the control exerted by the sample stimulus. Farrer (1967) found while training three chimpanzees that, despite outward appearances, his subjects were not really matching-to-sample, but had instead memorized his 24 uncounterbalanced 4-choice problem sets and could select the correct match choice even when the sample was not presented. This occurred even with randomization of the trial sequence, so long as the total stimulus configuration remained intact. Fading out portions of the stimulus complex, or reversing the symbols to their mirror images resulted in performance decrement. Farrer also found that the "picture memory discrimination" could be acquired without experience with the sample.

D'Amato and O'Neill (1970) suggested that such "pseudomatching" could be prevented by use of a large number of different stimulus configurations and varying trial orders when restrictions on randomization were unavoidable due to limited programming capability. In addition, they proposed the use of pseudomatching probe trials, on which no sample stimuli are shown, as a test to disclose memorization tendencies.

The present paper describes our experience in producing and preventing pseudomatching in rhesus monkeys. The delayed matching-to-sample task employed was based on shock avoidance rather than food reinforcement, the latter having been used in the previous studies, because we were testing for radiation effects and could not use food reinforcement due to the disruptive gastrointestinal side effects of irradiation.

METHODS

More than 60 male, juvenile (2-3 kg) rhesus monkeys (_Macaca_ _mulatta_) have been trained thus far under a variety of conditions on our delayed matching-to-sample task, the complete procedural details of which may be found in Bruner et al. (1975). Each monkey sat in a restraint chair facing a stimulus-response panel containing five, circular translucent keys, each 3.2 cm in diameter. The sample key was centered 6.5 cm above the row of four match keys, the latter being spaced 5.0 cm center-to-center. The stimuli were 55 multi-colored patterns (Figure 1) which were transilluminated onto the rear of the keys by a slide-coded projector. Two intensities of 60 Hz shock were administered via foot-restraint plates; a weak shock (6 - 13 mA, 0.50 sec) for
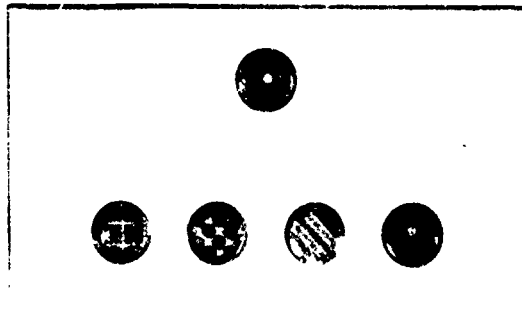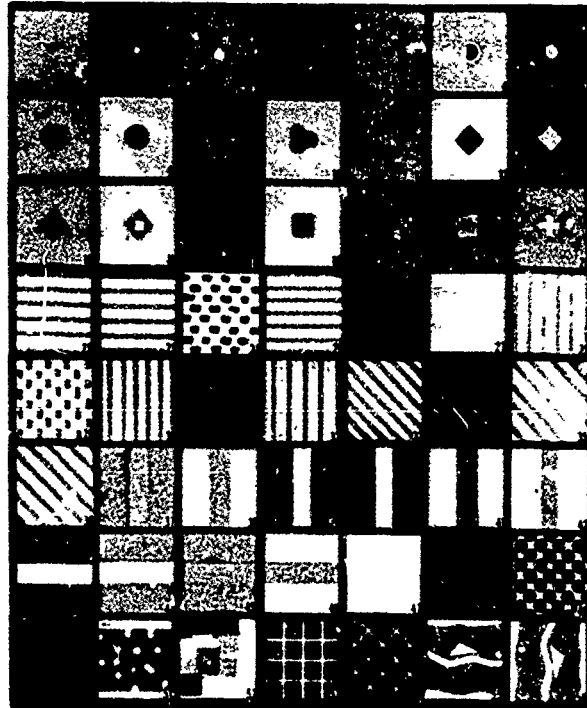
Figure 1. The 55 different stimuli employed. Each consisted of at least two colors, with a total of 10 different colors used. Pattern No. 55 is shown rotated 90 degrees as No. 56 as an example of how further stimulus variations were achieved to expand the array. At the bottom is shown the stimulus-response panel with a sample and four match choices illuminated. Color renditions of the stimuli are available from the first author on request.

incorrect choices and a strong shock (10-20 mA, 0.75 sec)
for response omissions.

Training consisted of various shaping and correction
procedures utilizing shock avoidance and successively approx-
imating matching behavior. About three months of 200 trials
per day (2-hr sessions) were required to bring the animal to
the final matching stage. The matching trials were as fol-
lows: The sample key was illuminated with a pattern and the
animal given 5 sec to press it in order to terminate the
stimulus and avoid the strong shock. Failure to respond was
shocked and after a 3-sec rest the sample was repeated. A
sample response was followed immediately, or after a delay
depending on the training stage, by illumination of the
match keys, with one of the match keys displaying the same
stimulus as had been shown on the sample key and with the
other match key stimuli being distinctly different. A
correct match choice avoided the weak shock, terminated the
stimuli, and initiated a 10-sec intertrial interval. An
incorrect match choice was punished with the weak shock and
the trial terminated. A failure to respond was punished by
the strong shock. In both latter cases a 5-sec intertrial
interval followed.

A usual daily session consisted of up to five 40-
trial blocks, each block separated by the few minutes

required for changing carousel slide trays. In the uncounter-
balanced condition found conducive to picture memory, the
same 40-trial block was repeated five times per day. Each
matching problem appeared only once and in a constant sti-
mulus configuration in each block, i.e., same correct key
position and correct symbol. For example, the 4-choice
problem illustrated at the bottom of Figure 1 would appear
as shown with the right-hand key always correct, once with-
in a given 40-trial block. This configuration would not
appear in any of the other 39 problems of this block, al-
though some of the symbols might be used again in different
combinations.

Pseudomatching probes followed most training ses-
sions. The pseudomatching test trials were identical to
the matching trials except that the samples were omitted.

RESULTS AND DISCUSSION

Figure 2 presents percentage correct match choices
over 200-trial blocks per day for one monkey. At the far
left are shown two acquisition curves indicating memoriza-
tion of 40, 2-choice problem sets which were presented in
fixed sequence five times per day, with no counterbalancing
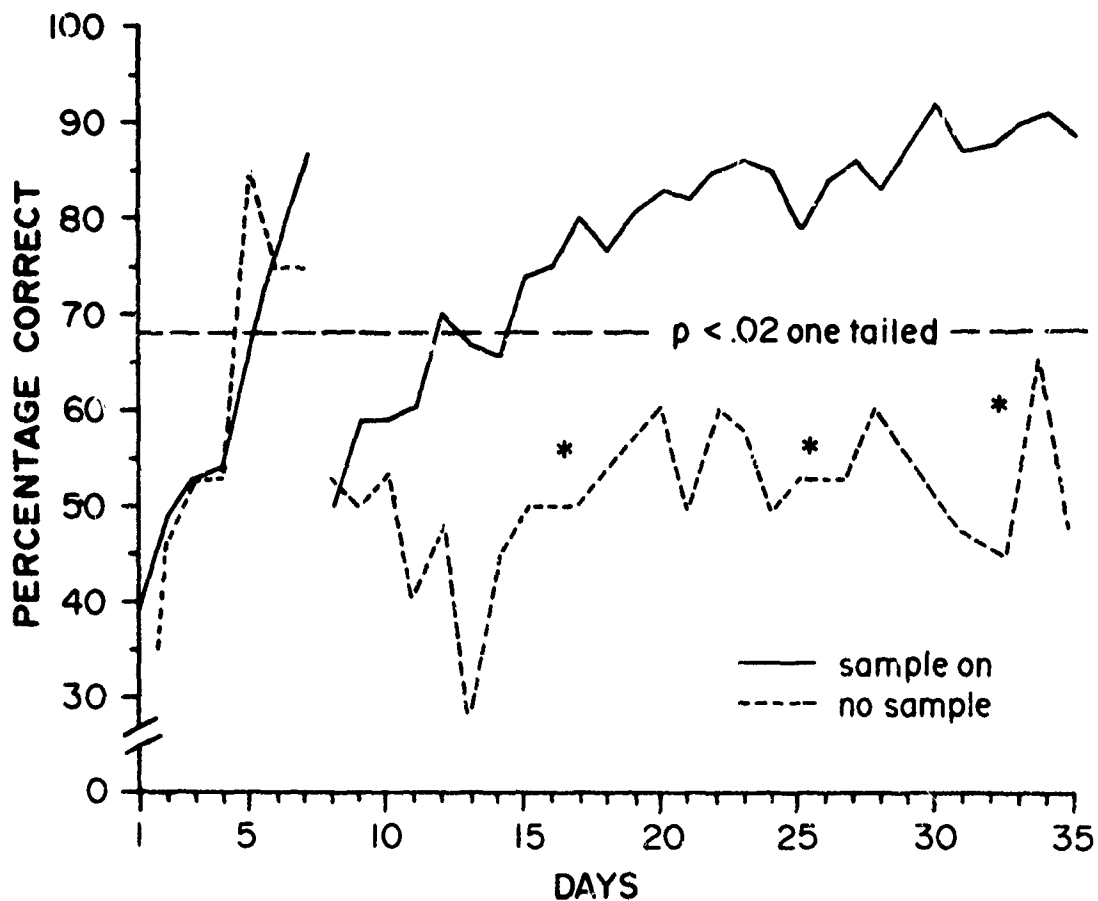of left-right position or correct symbol. (Only the central

Figure 2. Percentage correct on a 2-choice task with and without sample presentation for a picture memory monkey. Left-hand curves: 40 uncounterbalanced problems in fixed sequence. Right-hand curves: 60 counterbalanced problems, randomized sequence. The daily, sample-on trial blocks contained 200 trials each. The daily, no-sample probes consisted of 40 trials each, with the subset of 40 varying daily for right-hand curves.

two of the four match keys were used here.) It is evident that this monkey did as well when the sample was absent as when it accompanied the comparison stimuli in this simultaneous matching task.

The right-hand curves in Figure 2 depict 2-choice stimultaneous matching accuracy on 60 problems counterbalanced so that each problem appeared in each of the four possible ways as a result of alternation of key position and correct stimulus. Two hundred of the 240 problem sets possible were presented each day. Under this condition, the animal's matching and pseudomatching curves diverged over days as true matching accuracy approached 90% while pseudomatching remained in the 50's.

The three starred data points in Figure 2 indicate pseudomatching "accuracy" on the 40-problem series which was memorized initially and shown at the left of the figure. Subsequent to these 40 problems becoming a subset of the 240 counterbalanced recombinations, pseudomatching accuracy fell to about 60% correct from the earlier 80% indicating the animal's shift in strategy from memorization to matching. Still, many of the pseudomatching data points are greater than 50% more often than they are less. This probably stems from the fact that each 40-trial block was still being

administered in fixed sequence, so that memorization of some of the trials of each tray was still likely.

It should be pointed out that on the no-sample pseudomatching test trials a weak shock was administered for incorrect choices, as was done on the sample-on trials. The shock was found necessary to keep the animals working. At the same time this procedure would tend to facilitate memorization, since choosing the correct stimulus was rein- forced by shock avoidance. Consequently, our test condition for disclosing picture memory also tended to foster it. But the shock administration was not an essential condition for picture memory, as we observed many animals to give evidence of prior memorization of the problem sets by the time we be- latedly introduced pseudomatching probe trials.

Twenty-one monkeys were run in essentially the same manner as the monkey presented in Figure 2. Eleven showed picture memory similar to the animal illustrated, whereas the other 10 showed only true matching (i.e., no significant pseudomatching runs) yielding a near-equal division between subjects prone to memorize versus those that match-to-sample on the same 40-problem, uncounterbalanced set. Therefore the task, as presented, effectively divided the animals into two populations differing in their approach to solving the

task. The reasons underlying this split in preferred strategy remain obscure. We may speculate that we are witnessing individual differences in conceptual learning readiness, viewing matching-to-sample as a form of conceptual learning and picture memory as not. We cannot say that the memorization strategy was any less efficient in the present instance, however, since the numbers of trials to achieve significant performance accuracy were not different between the memorizers and matchers.

Other animals trained using fewer than 40 uncounterbalanced problem sets did not show the same strategy split, however. Five animals received 10, 2-choice uncounterbalanced problems repeated 10 times per daily session. The stimulus symbols were different for each problem. All five picture-memorized the array. Of five other monkeys receiving 20 different uncounterbalanced problems repeated six times per day, four showed picture memory. Although almost all showed picture memory under these two conditions involving fewer than 40 problems, their acquisition rates were no faster than the animals memorizing the 40-set array.

All of the monkeys, both memorizers and matchers, initially trained on a memorizable array, readily converted to, or continued to show, true matching behavior after

introduction of the large (60 problem) counterbalanced array,
as did the subject in Figure 2. The former picture memory
animals matched as accurately as those matching originally
and there was no difference in overall training time to bring
the animals to the final delayed matching-to-sample phase.
Hence the initial memorization strategy, when allowed, seemed
neither to hinder nor help the eventual acquisition of delayed
matching behavior.

Partially counterbalanced problem arrays were also
used for the training of some of the animals. Under this
condition we found that the memorization-prone animals would
eventually memorize the correct choice on some or all of
those problem sets which were not presented in all possible
counterbalanced ways Whereas they would be forced to employ
matching behavior on the fully counterbalanced problems,
they would still tend to rely on picture memory on those
trials where it was possible due to incomplete counterbal-
ancing of key position and correct symbol. Thus, their
pseudomatching probes would reveal chance performance on
the counterbalanced problem sets and consistently correct
choices on the uncounterbalanced configurations. It was not
uncommon to see animals utilizing both matching and pseudo-
matching strategies under this condition. This was noticed

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when the animal's sample-on performance accuracy was consist-
ently higher than its no-sample accuracy, with the extent of
the difference reflecting the degree to which matching be-
havior was employed to supplement picture memory. The experi-
menter must, therefore, examine individual trial outcomes on
the daily no-sample probes to disclose any particular prob-
lem sets being correctly pseudomatched consistently. For
example, it is possible for an animal to memorize only 14
2 choice-problems out of 40 to yield significantly beyond-
chance accuracy (p <.02, one-tailed), assuming that the out-
comes on the remaining 26 problems are determined by chance.*

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* Likewise the "true matching" animal need "learn" only
the equivalent of 14 of the 40 problems, the probability of
which is enhanced by the subject's tendency to partition the
controlling samples into nominal versus effective stimuli, as
explained by D'Amato and O'Neill (1970). Percentage correct
trials appear as a deceptively oversimplified measure of per-
formance here when it is realized what a small proportion of
the problems and the stimuli presented may actually be in-
volved in determining the subject's choice accuracy.

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The only way we have found to preclude the develop-
ment of picture memory is through complete counterbalancing
of key position and symbol correct plus sequence randomiza-
tion. None of the 13 subjects receiving only fully counter-
balanced and randomized problem sets from the outset of
training has shown significant pseudomatching probes beyond
the occasional, isolated runs expected by chance.

Trial order did not seem important for the develop-
ment of picture memory by Farrer's chimpanzees (1967), nor
did it in the present study. Five of the present monkeys,
which received five different sequences of the same 40 un-
counterbalanced problems daily, reached above-chance perform-
ance as quickly as did monkeys receiving a single sequence.
Two of the five showed memorization whereas three were match-
ing animals. The two picture memory animals demonstrated
that they could perform at about the same high accuracy on
the pseudomatching probes regardless of the trial sequence
tested--backwards, forwards, completely reshuffled, etc.
The same indifference to trial order has been demonstrated
by numerous other pseudomatchers initially trained on only
one fixed sequence. Consequently it appears that stimulus
problem configuration can be the primary feature enabling
picture memory. This was essentially Farrer's (1967) con-
clusion too.

Figure 3 shows the prodigious capacity of one monkey
to memorize following extensive practice. Pseudomatching
probes were not begun until after this animal had already
received 61 days training on 200 different, uncounterbalanced
4-choice problems. After an additional 26 days, as shown
in Figure 3, the animal achieved 98% correct without benefit
of the sample's presence. On a reversed sequence probe of
all 200 problems administered on the final day, he achieved
92% correct. Needless to say, whether or not a delay was
interposed between the sample and match stimuli was ir-
revelant with respect to this animal's choice accuracy.

We would readily agree with D'Amato and O'Neill (1970)
that, if complete counterbalancing and randomization cannot
be arranged conveniently in a matching-to-sample paradigm,
then pseudomatching probes should certainly be employed to
determine whether the subject is memorizing or matching,
as the monkey's capacity for memorization, when allowed
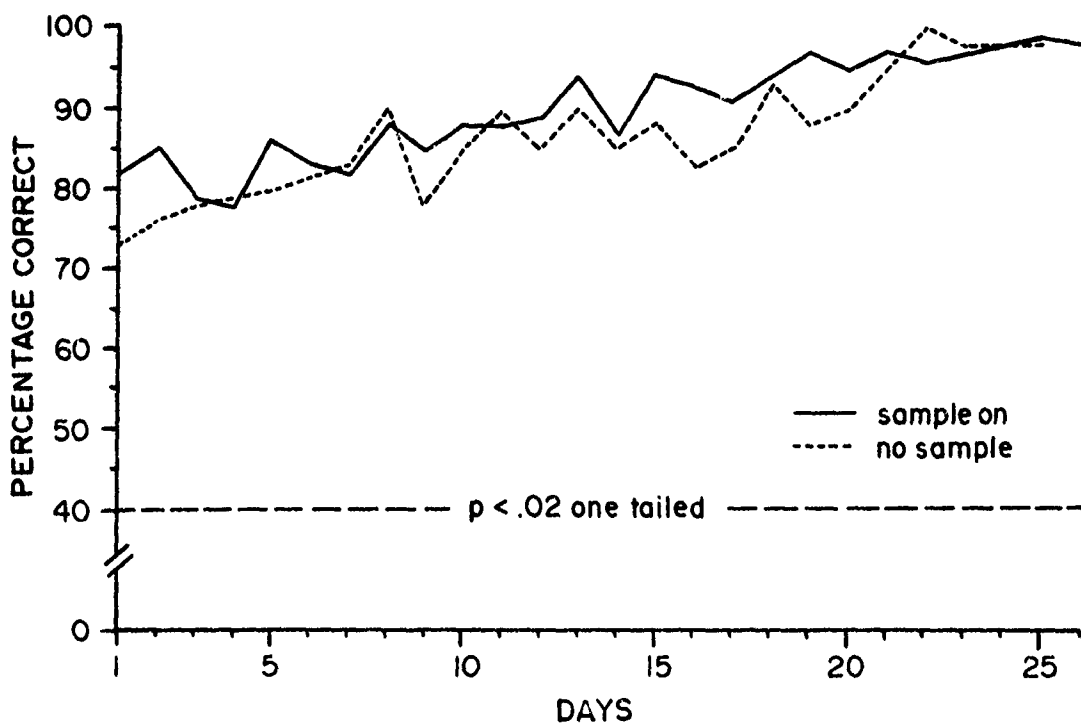the opportunity, is indeed remarkable.

Figure 3. Percentage correct on a 4-choice task with and
without the sample on the same 200 uncounter-
balanced problems l̨te in training for a picture
memory monkey. The daily, sample-on trial blocks
were 400 in length, divided into two sessions per
day. The daily, no-sample probes consisted of 40
trials each, with the subset of 40 varying daily.

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