Serial Probe Recognition Performance by a Rhesus Monkey and a Human With 10- and 20-Item Lists

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A rhesus monkey performed at high accuracy in a serial probe recognition task with color pictures as stimuli. The monkey’s serial position curve was similar in form to a human’s and demonstrated the theoretically important primacy and recency effects with lists containing as many as 10 or 20 items. The high accuracy of the monkey was shown to be largely due to the minimization of proactive interference through the use of more than 200 distinct items. These results encourage the view of similar mechanisms of memory in monkey and humans.

The ability of human subjects to retain a list of serially presented items has been one of the most studied phenomenon of human memory. Findings from list experiments, such as the bowed serial position curve (see Crowder, 1976, for review) or memory scanning rates derived from variable list experiments (Sternberg, 1966) are well documented and reproducible characteristics of human memory. A question of current interest is whether infrahuman subjects remember in ways similar to those of humans. To explore this question, it is necessary to study these animals in a multiple-item memory task commonly used with our own species.

One version of a multiple-item memory task that has been used extensively with humans is the serial probe recognition (SPR) task (Wickelgren & Norman, 1966).

In this task, a list of items, such as words or digits, is presented sequentially to the subject, and after a short delay, a probe item is presented that is either from the list (Same) or not from the list (Different). The subject’s task is to classify the probe item as either Same or Different.

Recently, there have been a few studies of SPR performance in animals. Thompson and Herman (1977) successfully trained a dolphin to perform well in an auditory SPR task at list lengths and accuracy comparable with those of humans. A list of items, each consisting of a particular sound, was presented underwater to a dolphin and was followed by a single test sound. The dolphin indicated whether the test sound was identical to one of the list items by moving one of two paddles. The dolphin was correct on slightly greater than 70% of the trials with the maximum list length of six items, and this performance increased rapidly with shorter list lengths. Furthermore, the dolphin’s serial position curve was similar to some curves obtained from human subjects (Wickelgren & Norman, 1966), which demonstrates a prominent recency effect (superior performance on terminal items relative to medial list items).

Similar attempts have been made with nonhuman primates. Gaffan (1977) trained rhesus monkeys in an SPR task, using either six different colors or six spatial positions as stimuli to explore the effects of fornix-
transsection on memory performance. Gaffan found only modest performance (75% correct) with three-item lists from unoperated control animals. Considering both the level of asymptotic discrimination performance and the list lengths employed, Gaffan's results, although interesting, are not overly encouraging in terms of any meaningful comparisons with human memory performance. Others (Davis & Fitts, 1976; Devine & Jones, 1975; Eddy, 1973) have also found low accuracy with short list lengths in similar multiple-item visual recognition tasks with nonhuman primates.

It seems surprising that highly sophisticated visual animals such as nonhuman primates capable of large numbers of visual discriminations (Bernstein, 1961; Moon & Harlow, 1955) should perform so poorly in visual memory tasks requiring retention of more than a few items. Methodological factors, however, may account for the poor performance of monkeys in these tasks. Previous studies all employed a limited stimulus ensemble of simple stimuli, such as colors, triangles, squares, and the like. Although testing with such items affords more control of the to-be-remembered items than do complex images, they may severely limit memory performance by creating a condition of proactive interference (PI) in which memory for earlier items adversely affects performance on later items. Proactive interference is known to have a substantial influence on performance in human short-term memory tasks when a small ensemble of stimuli is employed (Keppel & Underwood, 1962).

We have successfully trained a rhesus monkey to perform with high accuracy in a visual SPR task with long list lengths constructed from a large and varied item pool and have compared its performance with that of a human subject tested under nearly identical conditions. We further demonstrate that our success with the monkey was due to a procedure that minimized PI.

**Experiment 1**

In this experiment, the rhesus monkey was trained to perform the SPR task by transferring performance from a simultaneous same/different task to a delayed same/different task and then to the multiple-item SPR procedure. The human subject did not receive any special training procedures but was simply instructed on how to perform correctly in the SPR task.

**Method**

**Subjects**

A 4-yr-old experimentally naive male rhesus monkey (Macaca mulatta) and a 22-yr-old human female served as subjects. The monkey was tested daily and generally received all its food and water requirements during an experimental session. Occasional supplements of Purina Monkey Chow and water were given when these requirements were not met. The human subject worked in the identical apparatus without any explicit reward.

**Apparatus**

The experimental chamber was a sound- and light-attenuating box (90 × 55 × 120 cm), with a ventilation fan and a 100-W house light on the roof. At the front of the chamber were two rear-projection screens (18 × 12 cm), arranged vertically and positioned 16 cm apart (center to center). A speaker was located directly above the top screen.

Figure 1 illustrates the physical arrangement of the projectors, stimulus panel, and monkey seated in a primate chair (Foringer Model PC-802). During testing, the subject was seated in the primate chair and placed in front of the stimulus panel with a viewing distance of approximately 50 cm. The stimuli subtended a visual angle of 12° vertical and 20° horizontal. Kodak (Model 650H) carousel slide projectors were positioned 60 cm behind each screen, with solenoid-operated shutters constructed "in house" to control slide projection. A three-position response lever (left, right, and down) was placed within easy reach of the monkey's right hand. Correct responses were reinforced with either orange juice (Tang), banana pellets (Noyes, 1 g), or applesauce. The orange juice and applesauce were delivered through a pressurized air system. The banana pellets were delivered by a pellet dispenser (Gerbrands Model G5210). The use of multiple reinforcers allowed for many more trials to be conducted than possible with any one of the reinforcers alone. The monkey performed with equal accuracy with all three types of reinforcers. Experimental events and data acquisition were controlled by a specially designed transistor-transistor logic circuit constructed "in house."

The human subject performed under conditions comparable with those for the monkey. She sat in a chair at viewing distance of 100 cm from the stimulus panel and held the response lever in her right hand. The stimuli from this position subtended angles of 6°
vertical and 10° horizontal. Correct responses were followed only by a 4000-Hz tone.

**Stimuli**

The stimuli were a wide variety of items familiar and unfamiliar to the monkey, such as fruits, flowers, animals, people, and various objects. These types of stimuli were chosen over the more traditional stimuli, such as circles, triangles, and squares, to increase the likelihood that the monkey would attend to the stimuli and readily discriminate among them. There were a total of 211 different slides that constituted the pool from which items were drawn.

**Procedure**

*Preliminary training.* Initially, the monkey was adapted to being transferred between home cage and apparatus. The monkey was taught to enter a Plexiglas box where the experimenter placed a collar around its neck for restraint and ease of transfer. As soon as transfer proceeded smoothly, the monkey was trained to manipulate the response lever through standard shaping procedures.

*Simultaneous same/different training.* Same/different discrimination training began as soon as the monkey consistently manipulated the response lever. Pairs of slides were presented successively to the subject on the rear-projection screens. On Same trials, an identical pair of slides was displayed. On Different trials, two nonmatching slides were displayed. The monkey’s task was to classify the slides as either Same or Different by moving the response lever to the right or left, respectively. Correct responses were followed immediately by a short tone (4000 Hz, .25-sec duration), a reinforcer, and a 2-sec intertrial interval. Incorrect responses were followed by illumination of the house light, omission of the reinforcer, and a 10-sec intertrial interval. Sessions consisted of 140 trials and were typically conducted twice daily (once in the morning and once in the afternoon). Same and Different trials were presented in a pseudorandom sequence and occurred with equal frequency at the end of each session.

A correction procedure (repetition of incorrect trials) was used during the first 13,000 trials of the same/different training. This procedure helped to remove response biases that developed initially. The correction procedure was discontinued as soon as the monkey showed signs of acquisition, i.e., when accuracy approached 70% correct. Throughout this discrimination training, the pairs of Same and Different were not altered, although their order of occurrence within a session was changed every 2 days. As soon as the monkey learned to perform with high accuracy (90% correct or better) with a particular set of slides, a new set was reintroduced and training proceeded as before. Each new set of slides consisted of two 140-item carousel slide trays, one for the top projector and one for the bottom projector. A total of 210 slides were employed out of the 211-item (slide) pool during this phase of training. From these 210 slides, 70 (plus a matching slide) were selected at

![Figure 1](image.png)

*Figure 1.* Physical arrangement of the monkey, primate chair, response lever, stimulus panel, and projectors.
random for Same trials. The remaining 140 slides were 
used on Different trials. When accuracy was unaf-
fected by a change in set, the monkey was trans-
ferred to the next stage of training. The initial stage, 
just described, required approximately 28,000 same/ 
different trials spread over a 3-mo training period.

The next stage allowed the monkey to initiate the 
trials. A "ready" tone (2000 Hz) was presented at the 
start of each trial to indicate availability. A downward 
press of the lever terminated the "ready" tone and 
displayed the pair of slides on the projection screens.
The monkey then classified the pair as either Same or 
Different. This procedural change had no effect on 
performance.

Delayed same/different training. In this training 
stage, a response to the "ready" tone initiated a trial by 
displaying an item on the top screen (list item) for 1 sec. 
The list item was then removed from view and was 
followed immediately by a slide on the bottom screen 
(probe item). Reinforcement contingencies for same/ 
different responses were identical to those used before. 
Transition to this 0-delay same/different task resulted 
in only a slight and temporary drop in accuracy. Fol-
lowing 1,300 trials of 0-delay training, the delay inter-
val was gradually increased to 5 sec while maintaining 
high levels of accuracy (90%–100% correct).

Serial probe recognition training. Performance 
was finally transferred to a multiple-item SPR task by 
gradually introducing more than one item onto the top 
(list) screen. This was accomplished by starting with 
lists containing two items and gradually increasing the 
number of items at a rate of one item every 2 days 
until 10-item lists were obtained. Throughout 
acquisition and testing in this task, items were dis-
played for 1 sec with an .8-sec delay between suc-
cessive items. The probe item was displayed 1 sec 
after the presentation of the last list item and remained 
in view until a same/different response was made. 
Figure 2 illustrates a typical Same trial and the ap-
propriate response with the lever. In this example the 
first item (serial position 1) in a list of 10-items matches 
the probe, and hence the correct response is Same. 
A response cutoff interval of 2 sec was included to 
encourage fast reaction time to the probe item. If the 
subject did not respond during the cutoff interval, 
the trial was aborted, and the next trial was presented 
following a 10-sec delay with the house light on. 
Drops in accuracy of 5%–10% occurred with the 
lengthening of the list, but performance typically re-
covered quickly. Following acquisition of the SPR 
task, a systematic study of recognition performance 
with 10-item lists was conducted with both the monkey 
and the human.

The slide trays had a capacity for 140 slides, so it 
was possible to present 14 separate 10-item lists with-
out changing trays. Each experimental session con-
sisted of a set of trays with enough slides for 140 
trials, and a trial was defined as a 10-item list and 
probe. Each list thus appeared 10 times per session. 
Probe items matched target items at each serial position 
with equal frequency on Same trials. On Different 
trials, probes were items that were not contained in 
any list for that session. As before, Same and Different 
trials occurred equally often in a pseudorandom 
sequence.

For the monkey, four sessions were conducted with 
each new set of trays, and there were a total of 30 
separate sets of trays. To avoid the possibility that the 
monkey might gain familiarity with a particular set of 
lists, no two sets of trays were tested consecutively. 
This resulted in a total of 16,880 trials run over a 3-
mo period of daily testing. During this time, correct 
choices were reinforced 59% of the time with orange 
juice, banana pellets, or applesauce, depending upon 
the monkey’s temporary preference. Correct responses 
onto which no reinforcement was programmed were 
followed only by the short 4000-Hz tone.

For the human, one session was conducted with 10 
separate trays. This resulted in a total of 1,400 trials 
run over a 3-mo period of testing. Correct responses 
were followed only by the 4000-Hz tone.

Results

Figure 3 shows percentages correct as a 
function of serial position on probe trials for 
both the monkey and the human on the 10-item 
list. Each point on the serial position curve is 
an average of 840 observations for the monkey, 
70 for the human. The data clearly dem-
strate U-shaped functions which have 
maxima at the initial and terminal items of 
the serial sequence, identifying the primacy

![Figure 2. Sequence of stimulus events and associated lever responses on a typical Same trial for a list of 10 items. (In this example the match to the probe occurs at serial position 1.)](image-url)
and recency effects, respectively, for item retention. Performance was less accurate with the medial items, with a minimum in the accuracy function at the third serial position for both subjects. These primacy and recency effects were substantiated by testing post hoc contrasts (Scheffé, 1953) across the means of the 10 serial positions. Computed F ratios were compared with Rodger's (1975) critical values, instead of the traditional values, in order to control the rate of erroneous rejections of the null hypothesis on a per-decision basis. Estimates of mean accuracy at each serial position were divided into successive blocks for statistical analysis, with each block corresponding to a particular tray. For the monkey, accuracy at serial position 1 (primacy effect) and at serial position 10 (recency effect) was significantly higher than at medial positions, 2, 3, 4: primacy, $F(9, 300) = 2.05, p < .05$; recency, $F(9, 300) = 5.37, p < .05$. For the human, similar effects were evident but were less pronounced because of a ceiling effect and fewer numbers of observations. A recency effect was indicated by higher accuracies at serial positions 9 and 10 than at positions 2-6, $F(9, 90) = 1.44, p < .05$. A primacy effect was also indicated since performance at serial position 1 (and at positions 7 and 8) was intermediate between these extremes, $F(9, 90) = .03, p > .05$. Overall, the monkey was 86% correct; the human, 93% correct. This difference in accuracy was also significant, $t(38) = 7.32, p < .05$. The monkey correctly identified Same probe items with 84% correct accuracy and Different probe items with 88% correct accuracy, which indicates a slight bias to respond Different. The human subject did not show a bias in either direction, as indicated by equal accuracy (93% correct) on Same and Different trials.

To assess the monkey’s performance with each of the 211 slides, we obtained individual bias-free measures of discriminability ($d'$ values), calculated from “hit” and “false alarm” rates (Elliott, 1964). Hits were defined as correct Same responses; false alarms, as incorrect Same responses (i.e., Same responses on a Different trial). This analysis for the monkey did not reveal any feature or category that seemed to be best discriminated. We ranked ordered each slide according to $d'$ (range: .64–4.37) and noted that various stimulus categories, such as faces, monkeys, and fruits, were evenly distributed throughout the hierarchy. This was also true for stimulus properties, such as intensity, color, and complexity. We do have anecdotal evidence, however, which suggests that the monkey does treat some of the slides as real objects. We have observed during the monkey’s performance in the task that some stimuli elicited stereotypic behavior, such as threat gestures, grimacing, or lip smacking. The stimuli that elicited these gestures were invariably pictures of familiar people, such as one of the experimenters or of other monkeys that were housed with our monkey. These behavioral responses, however, were confined to the initial exposure of the stimuli and diminished with repeated exposure.

**Discussion**

The serial position curves obtained from the monkey and the human with the present procedure were remarkably similar, the only major difference being the overall accuracy level. Both curves demonstrate...
a primacy effect. To our knowledge, this is the first demonstration of a primacy effect in a task directly analogous to human list recognition procedures. Both curves also demonstrate a recency effect, a result corroborating other findings in human and animal list recognition (Ellis & Hope, 1968; Jahnke & Erlick, 1968; Murdock, 1968; Phillips & Christie, 1977; Roberts & Smythe, 1979; Thompson & Herman, 1977; Wickelgren, 1970).

It is not clear why the primacy effect has not been demonstrated with infrahuman subjects. Some investigators have argued that the effect is specific to studies of human recall and that it is not found with recognition procedures (Roberts & Smythe, 1979). However, the effect is clearly demonstrated with our recognition procedure and in other recognition procedures with humans (Ellis & Hope, 1968; Jahnke & Erlick, 1968; Murdock, 1968; Shulman, 1970). Another possibility is that long list lengths are required for primacy effects to be evident. In other words, superior retention for initial items is dependent upon poorer retention of medial items, and the latter effect is tied to list length. The majority of previous animal studies used only short list lengths because accuracy was not sufficient when using longer ones. Longer lists, like the ones we used, allow performance to vary over a wider range and thus increase the chances of observing differential effects due to serial position.

Theoretical accounts of serial position effects can be divided conceptually into either single or dual trace models. Unitary trace explanations include intralist interference and differential accessibility. Intra-list interference theory suggests that the primacy and recency effects can be derived from gradients of PI and retroactive interference (RI) within a list (Foucault, 1928; Waugh, 1960). The primacy effect occurs because the initial items are subjected to less PI from previous items in the list. The recency effect occurs because terminal items are subjected to less RI from later items in the list. Medial items of the list show the poorest retention because they are subjected to both PI and RI. Differential ac-


cessibility theory (Tulving, 1968), on the other hand, suggests that serial position effects reflect the effectiveness of ordinal information as retrieval cues. It is assumed that information concerning the serial position of items is stored at the time of list acquisition and that ordinal information for initial and terminal items is somehow more distinctive than medial items of the list. It is postulated that this additional information facilitates the retrieval of items at the beginning and the end of the list and results in the primacy and the recency effect, respectively.

Dual trace models of memory suggest that serial position effects are the result of two distinct memory systems: a long-term memory represented by the primacy and medial portions of the serial position curve and a short-term memory represented by the recency portion of the serial position curve. One dual process theory of memory has postulated that incoming items are held in a rehearsal buffer of limited capacity and remain until displaced or degraded by incoming information (Atkinson & Shiffrin, 1968). The longer a particular item remains in the buffer, the more information about that item is transferred to long-term memory. The primacy effect occurs because at the beginning of a list, fewer items are maintained in the buffer, hence the initial items of the list remain longer in the buffer and more information about these items is transferred to long-term memory. The recency effect occurs because items at the end of the list are still resident in the short-term rehearsal buffer at the time of the retention test. Whatever the appropriate model for memory (Atkinson & Shiffrin, 1968; Ratcliff, 1978; Waugh & Norman, 1965), our results show that they must also be extended to cover rhesus monkey memory and probably primate memory in general.

Experiment 2

The previous experiment demonstrated that a rhesus monkey can perform accurately with 10-item lists in an SPR task. In the present experiment, we increased the
list length from 10 to 20 items to explore the limits of the monkey's performance.

Method

List construction and parameters of stimulus presentation were identical to those in the previous experiment, with the exception that 20-item lists were used and only 70 trials were conducted daily. All correct responses were reinforced. For the monkey, a total of 12 separate sets of trays were tested four times. The human was tested on the identical 12 trays one time. This resulted in a total of 3,360 trials conducted with the monkey and 840 with the human.

Results and Discussion

Serial position functions for the 20-item list are illustrated in Figure 4. Like the experiment with 10 items, the serial position curve for the monkey clearly demonstrates a primacy and a recency effect. Estimates of mean accuracy at each serial position were divided into successive blocks for statistical analysis, with each block corresponding to a particular tray. A recency effect was indicated by higher accuracies at serial positions 17–20 than at positions 2–8, \( F(19, 209) = 2.5, p < .05 \). A primacy effect was also indicated since performance at serial position 1 was not significant, \( F(19, 209) = .10, p > .05 \), from serial positions 2–8 and 17–20 and therefore must be intermediate between these extremes. The human curve is more variable due to the fewer number of trials conducted at this list length (21 observations at each serial position for the human compared with 84 observations for the monkey), but nevertheless it shows a significant recency effect. A recency effect is indicated by higher accuracies at serial positions 18–20 than at positions 2–5, \( F(19, 209) = .74, p < .05 \). As with the 10-item list, overall accuracy for the human was significantly higher than for the monkey (90% vs. 81% correct, respectively), \( t(22) = 6.9, p < .05 \). Both the human and the monkey identified Same and Different probe items with equal accuracy.

This experiment indicates that good overall levels of accuracy can be achieved by a rhesus monkey with lists containing as many as 20 items, which suggests that possibly even longer list lengths could be used and still maintain modest levels of accuracy. The high level of accuracy achieved by the human subject is consistent with previous studies of picture recognition in humans (Shepard, 1967; Standing, Conezio, & Haber, 1970). However, the level of accuracy achieved by the monkey contrasts sharply to the much lower levels of performance obtained in previous studies with short list lengths (Davis & Fitts, 1976; Devine & Jones, 1975; Eddy, 1973; Gaffan, 1977) and demonstrates that the rhesus monkey has much greater visual recognition capabilities than ever before realized.

Experiment 3

The overall performance of the monkey with 10- and 20-item lists is considerably higher than expected on the basis of previous data with nonhuman primates (Davis & Fitts, 1976; Devine & Jones, 1975; Eddy, 1973; Gaffan, 1977). We have suggested that the use of a larger than small pool size for list construction may be responsible for these results. When lists contain a limited number of stimuli, each individual item must reappear many times per session if the session is to contain enough trials to obtain a reliable index of performance. Consequently, a previously seen item used as a probe on a Different
trial may lead one to incorrectly respond Same because it is remembered and confused with the list in question. Indeed, the one study to find good performance with lists longer than three items employed a large pool of stimuli. Thompson and Herman (1977) obtained good performance from a dolphin tested in an auditory SPR task employing a 600-item pool.

To test this hypothesis, we constructed 3-item lists from either a 211- or a 6-item pool similar to that employed by Gaffan (1977) in order to determine whether performance is significantly affected by this variable.

**Method**

In this experiment, we tested our subjects under conditions of high and low PI. Low PI was generated by constructing 3-item lists from the entire 211-item pool. Items appearing as Different probes were not seen in any of the previous lists. High PI was generated by constructing 3-item lists from a 6-item pool. Items appearing as Different probes were viewed many times during a session. The 6-item pool consisted of the best discriminated items from Experiment 1. We chose these particular items because their high discriminability should, if anything, work against PI and hence give a conservative estimate of its effects.

In all other respects the procedure was the same as in the previous experiments. A total of 1,120 trials were conducted with the monkey, 280 with the human. High and low PI sessions were tested in a random sequence.

**Results**

Figure 5 illustrates the results from the interference manipulation. Both the human and the monkey were less accurate with lists constructed from a 6-item pool than from the 211-item pool. The drop in performance for the monkey was substantial: 93% correct under low PI to 70% correct under high PI, \( F(3, 12) = 9.9, p < .05 \). The corresponding change in accuracy for the human was similar although less dramatic: 96% correct under low PI to 89% correct under high PI, \( F(3, 12) = 4.2, p < .05 \). Recency effects are clearly evident in all serial position functions. Primacy effects, on the other hand, are noticeably absent in all conditions.

The only response bias observed in this experiment was for the monkey under the high-interference condition. The monkey was biased to respond Different, as indicated by lower accuracy on Same trials than on Different trials (61% vs. 79% correct).

**Discussion**

The monkey's performance with 3-item lists constructed from a 6-item pool replicates the findings of previous investigators (Devine & Jones, 1975; Eddy, 1973; Gaffan, 1977) using similar procedures and item pools of similar size. Considering the substantial loss in performance relative to that with large pool sizes, the present results lend further support to the hypothesis that PI from previous list items is a critical variable in SPR tasks. High-interference conditions lead to poorer performance than do low-interference conditions. This finding is in agreement with the effects of PI in human short-term memory tasks (Keppel & Underwood, 1962).

The results from this study suggest why previous studies of delayed response (Fletcher, Garske, Barron, & Grogg, 1968; Medin, 1969; Riopelle, 1959) and delayed matching to sample (Etkin & D'Amato, 1969) may have failed to find effects attributable to PI. Since all of these studies employed a very limited number of stimuli, PI was already very high, and a PI ceiling effect likely masked any effect of the PI.
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independent variable manipulation. Relevant to this argument are the findings of Keppel & Underwood (1962), who showed that PI builds up quickly and reaches asymptotic levels within a few trials when a small set of stimuli is used for short-term memory tasks.

The lack of a primacy effect with 3-item lists suggests that good performance with substantially longer list lengths is necessary to explore a phenomenon such as primacy in both animals and humans.

General Discussion

The literature on human memory is broad and extensive in comparison with the animal memory literature. Perhaps one of the reasons for this discrepancy is the absence of a paradigm similar to the one used in human studies. We believe the present experiments to be particularly important because they supply just the sort of paradigm needed to explore, in other animals, some of the memory phenomena exhibited by humans. With the SPR procedure, we have demonstrated at least two human memory phenomena in a rhesus monkey: primacy and recency. Furthermore, these experiments demonstrated that a critical factor for obtaining high levels of accuracy in the SPR task is the minimization of PI. In our experiments, we minimized the effects of this variable by employing a large and varied item pool.

The preliminary program to train the monkey in the SPR task with long list lengths was extensive. Over 38,000 trials of training were required to achieve good performance with 10-item lists. However, the majority of training trials was devoted to the initial acquisition of the simultaneous same/different task. Relatively little difficulty was encountered thereafter in the transfer to related tasks. In fact, compared with the earlier stages of training, the rapidity with which the SPR task was acquired suggests that the limiting acquisition step may have been the development of a same/different concept by the monkey. The necessity for the monkey to respond on the basis of same versus different rather than on the basis of specific stimuli comprising each pair should be obvious. Hundreds of stimuli and thousands of combinations make it impossible to solve the task by learning to respond to specific pairs of stimuli. The task becomes possible only when the subject responds to the relation between the target and the probe stimulus (i.e., respond Same when the item was contained in the list, Different when the item was not contained in the list). Adult humans, of course, can easily acquire general concepts of same/different, but whether or not animals are capable of similar types of abstraction has been previously questioned (Premack, 1978).

The procedure adopted in the present study was designed to facilitate relational responding. From the outset of training, a large pool of stimuli (211 items) was used. Most investigators start with a few stimuli and then increase the number of stimuli to facilitate initial acquisition; however, this strategy of training could bias the subject to respond in an absolute manner (respond on the basis of the individual stimuli) instead of in a relational manner that would facilitate the acquisition of a same/different concept. This conclusion is supported by the finding that acquisition of matching- and nonmatching-to-sample problems is facilitated when a large rather than small stimulus pool is employed (Levine & Harlow, 1959; Mishkin & Delacour, 1975).

The serial position curves reported here are consistent with those in a large number of list memory studies with humans (see Crowder, 1976). Typically, serial position curves obtained from human immediate-free-recall experiments demonstrate pronounced primacy and recency effects. Serial position functions for long lists (i.e., 10 and 20 items) are characterized by a large middle segment of stable recall performance (asymptotic portion) followed by a sharp increase in recall at the more terminal items of the list. The serial position data obtained in the present study do not demonstrate any asymptotic portion; rather, the curves for the 10-item list show a dip in performance at approximately the third serial position followed by a gradual improvement in accuracy for both monkey and human. This result is consistent with other

Comparison with human recognition studies exploring serial position effects with pictures or visual shapes as stimuli is more difficult because of the large differences in stimuli and testing procedures employed. In addition, human studies of pictorial recognition are often characterized by very high levels of accuracy (Standing et al., 1970) which might obscure serial position effects. Nevertheless, serial position curves have been described which show a recency effect with no primacy effect (Hines, 1975; Phillips & Christie, 1977; Potter & Levy, 1969) or a very gradual recency effect with long list lengths (Nickerson, 1965; Weaver, 1974). There have been a few studies, however, that have failed to find serial position effects (Shaffer & Shiffrin, 1972; Weaver & Stanny, 1978), but procedures and stimuli were quite different from those in the present study.

Serial position curves have also been described for infrahuman subjects other than primates with procedures and stimuli somewhat different from those typically employed in studies of human recognition. Recently, Roberts and Smythe (1979) showed that serial position curves for retention of spatial cues in rats were characterized by a pronounced recency effect but no primacy effect. Wagner and Pfautz (1978) obtained a bow-shaped serial position function from rabbits in a habituation paradigm employing lists of items from several modalities. Thus it appears that serial position phenomena may be generalized to other infrahuman subjects as well.

Our findings suggest that the rhesus monkey can be an excellent model of the human memory system. There are several situations in which such a model would prove invaluable. First, it is possible with animal subjects to examine performance over longer periods of time and more intensively than might be acceptable for the use of human subjects. This can be particularly valuable if precise quantitative relations are desired, because large numbers of trials are frequently needed to detect such relations (i.e., serial position effects with long lists).

Second, it is possible to conduct biological experiments in animals which cannot be performed, for obvious reasons, with human subjects. Currently, there is a broad interest in the biological basis of learning and memory (cf. Rosenzweig & Bennett, 1976); without an adequate animal model of human memory, the results of pharmacological, anatomical, and electrophysiological studies are difficult to relate to humans. Finally, through a comparative approach to memory, it is possible to determine what aspects of memory can be generalized across species and what aspects differentiate one species from another.

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Received April 28, 1980
Revision received May 27, 1980