JOURNAL OF THE EXPERIMENTAL ANALYSIS OF BEHAVIOR 1975, 24, 377-381 NUMBER 3 (NOVEMBER)

# *RESPONSE PREFERENCES OF MONKEYS* (MACACA MULATTA) *WITHIN WAVELENGTH AND LINE-TILT DIMENSIONS*

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Four rhesus monkeys were tested for preferences within the wavelength and line-tilt dimensions. In the case of wavelength, the response panel was back-illuminated by light of one of the following wavelengths, presented in a random manner: 470, 525, 580, and 635 nm. Similarly, the line-tilt dimension was studied, by presenting a 5 cm by 0.3 cm black bar tilted at 0, 30, 60, or 90 degrees. No preferences were found within this latter dimension; in contrast, marked wavelength preferences existed, the order of preference being 470 (most preferred), 525, 580, and 635 nm (least preferred). These response preferences were resistant to behavioral manipulation; the number of responses to blue and to red in extinction was about equal when red was used as the training stimulus, but vastly different following training on blue. These results indicate that such response preferences must be taken into account in the design of a wide variety of experiments.

*Key words:* preferences, wavelength, line-tilt, panel press, monkeys (*Macaca mulatta*)

Research into the different aspects of visually controlled behavior, for example studies of conditioned reinforcers, discrimination learning, stimulus generalization studies, delayed matching to sample, and the determination of psychophysical thresholds, typically necessitate the use of more than one stimulus. Usually, these stimuli are chosen from within one dimension, such as wavelength; several authors (see Mackintosh, 1974, page 535) have argued that such intradimensional choices result in very good stimulus control over behavior.

Much of the work reported, however, fails to consider the possibility that an animal might respond more in the presence of one value of a stimulus rather than another, and that this feature may be due to factors other than intentional conditioning. For example, many studies use light of different colors to signal the presence of a particular schedule, with the rate of responding to the different colors being used as an index of the animal's preference for one schedule over another. But, unless suitable design controls for color preference are adopted, any differences in response rate could simply be ascribed to the animal's preference for that particular color, rather than for the schedule it signals. A fair amount of evidence has accumulated to indicate that such preferences may exist; Delius (1968) and Sahgal and Iversen (1975) have shown the existence of marked color preferences in the pigeon. Color preferences have also been found in ducklings (Tracy, 1970), and Humphrey (1971) found that monkeys tend to flood their test chambers with blue rather than red light.

The present work was undertaken to determine the extent to which rhesus monkeys (*Macaca mulatta*) would respond to stimuli differing in wavelength and in line-tilt, in the absence of any specific training along these dimensions. Any consistent differences would have to be regarded as (unconditioned) response preferences.

## METHOD

### *Subjects*

Four adolescent rhesus monkeys (*Macaca mulatta*), three males and one female, took part in the experiment; R1, R2, and R3 were experimentally naive, R4 had had training on auditory discrimination tasks, but had never served in a visual experiment. The animals'

[1]During this experiment A. Sahgal was in receipt of a Wellcome Trust Scholarship. The authors would like to thank Drs. D. R. J. Laming, S. E. G. Lea, and M. J. Morgan for their help in the statistical design of the experiments and in the analysis of the results, and Dr S. E. G. Lea for his detailed comments on the first draft of the manuscript. Reprints may be obtained from A. Sahgal, Psychological Laboratory, Downing Street, Cambridge CB2 3EB, England.

food intake was controlled to maintain deprivation in the testing situation: all animals were fed as much food as was consistent with their working reliably, 23 hr before testing.

*Apparatus*

The experimental chamber was constructed of Handy Angle and tempered hardboard and measured 54 by 40 by 59 cm high. This contained the animal in its transport cage. Illumination was provided by a 15-W Mains bulb mounted in the roof of the cubicle. The roof did not extend over the whole area of the top of the cubicle, and the floor was the wire mesh of the bottom of the transport cage: as a result, ventilation was provided by convection. All scheduling equipment was outside the testing room, and any inadvertent sounds were masked by white noise.

Nine 10 by 10 cm translucent Perspex response panels were hinged onto an aluminum panel in a $3 \times 3$ matrix. Microswitches were placed behind the panels (and out of sight of the animal); a press on any panel could thus be detected by the equipment. In this experiment, only the center panel was live; a press on any other panel had no scheduled consequences.

A food cup was positioned in the bottom center of the aluminum panel. Peanuts were the reinforcers, dispensed by a Universal Feeder via a tube to the food cup.

Stimuli were provided by slides back-projected onto the center panel by a Kodak Carousel S-AV projector. Preliminary stimuli (light/dark) were two neutral density filters, giving brightnesses at the center panel of 100 and 4cd/m$^2$ respectively. Colored stimuli were prepared by mounting lighting cellophane in 35-mm slide holders, and were blue, green, yellow, and red. Their dominant wavelengths (determined by using a Unicam SP.800 spectrophotometer) were respectively 470, 525, 580, and 635 nm. These color stimuli were adjusted for brightness, at the center panel, at 20cd/m$^2$ each using a S.E.I. Exposure photometer. *Macaque* visual sensitivity is comparable to human (De Valois and Jacobs, 1968). The line-tilt stimuli were slides of a black bar tilted at 0, 30, 60, and 90 degrees (90 degrees being vertical). The bar was itself 5 cm long and 0.3 cm wide when projected. The background brightness of these stimuli was 100cd/m$^2$.

A two-pen cumulative recorder provided a continuous account of the animal's responses and reinforcements, and also indicated a stimulus change. A film-strip timer controlled the variable-interval schedule. Electromechanical counters provided the total number of responses made to the various stimuli. All programming was effected with electromechanical equipment.

*Preliminary training.* The animals were first trained to accept peanuts as reinforcers in the food cup. They were then trained by successive approximation to press the center panel, while orienting towards it. At this stage, the two training stimuli were introduced and presented in a random order for 10 two-minute periods (trials) each day, with the constraint that each stimulus was shown an equal number of times. Reinforcement was available on a variable-interval 1-min (VI 1-min) schedule. The animals were not allowed to proceed to the next stage of the experiment until they had made an equal number of responses to the two stimuli, and until, for four consecutive days, their total number of responses for any one day did not differ from the mean of the four days by more than 10%. It was a consequence of the schedule that they received an equal number of reinforcements in the presence of each stimulus.

Such training was given for two reasons: (a) it raised the animals' typically low response rate, without any specific discrimination being learned, and (b) it made responding very resistant to extinction (see Ferster and Skinner, 1957, pages 326-390). In addition, such training would render any unintentional brightness cues irrelevant, since responding to two different brightness levels was equally reinforced. It must be emphasized, however, that all the color stimuli were of the same brightness (20cd/m$^2$) and that the background brightness of all the line-tilt stimuli was 100cd/m$^2$.

*Procedure*

*Phase 1.* The subjects were divided into two groups, one group received color stimuli before tilts, and the other, *vice-versa*. Following preliminary training outlined above, responses to the test stimuli were measured in extinction. Subjects were given two warm-up trials of 1 min duration, during which the light and dark stimuli were presented, and reinforcement was available as before. Immediately after this, the test stimuli (color or tilt) were presented in a further eight 1-min trials, during which no response was reinforced. The next day was devoted to retraining, which consisted of 10 two-minute trials with the light and dark stimuli as in the preliminary training session. The following day was a further test period. This continued until the animals had completed four test days each; after this, they received the alternative set of stimuli under the same conditions. The total testing time for each animal was therefore 18 days. The stimuli were presented in such a way that for each set over the four days of preference testing, each subject produced two 4 × 4 Latin Squares, the first

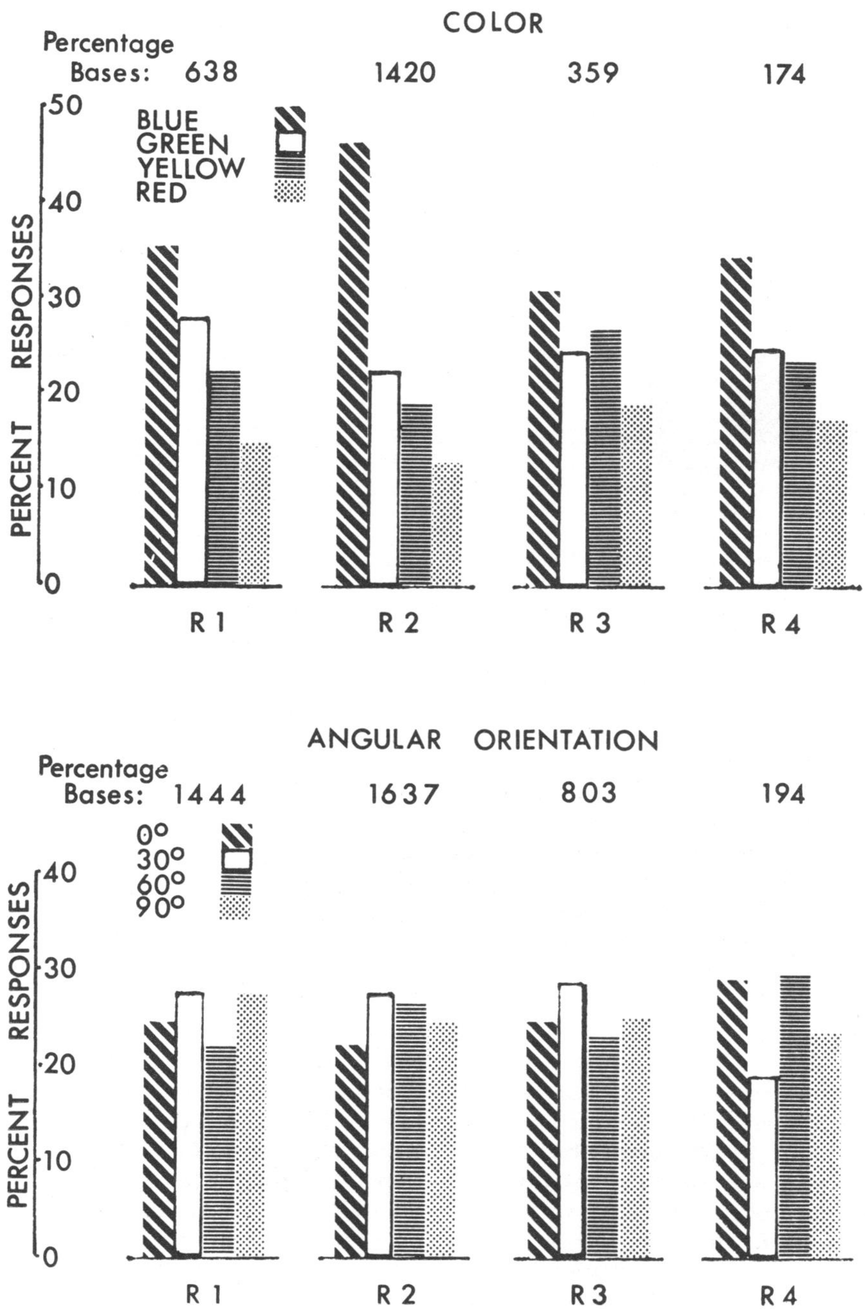


**Fig. 1. Percentages of responses to four colors (upper half) and to four tilts (lower half) for each of four monkeys. Data cumulated over all testing days in Phase 1.**

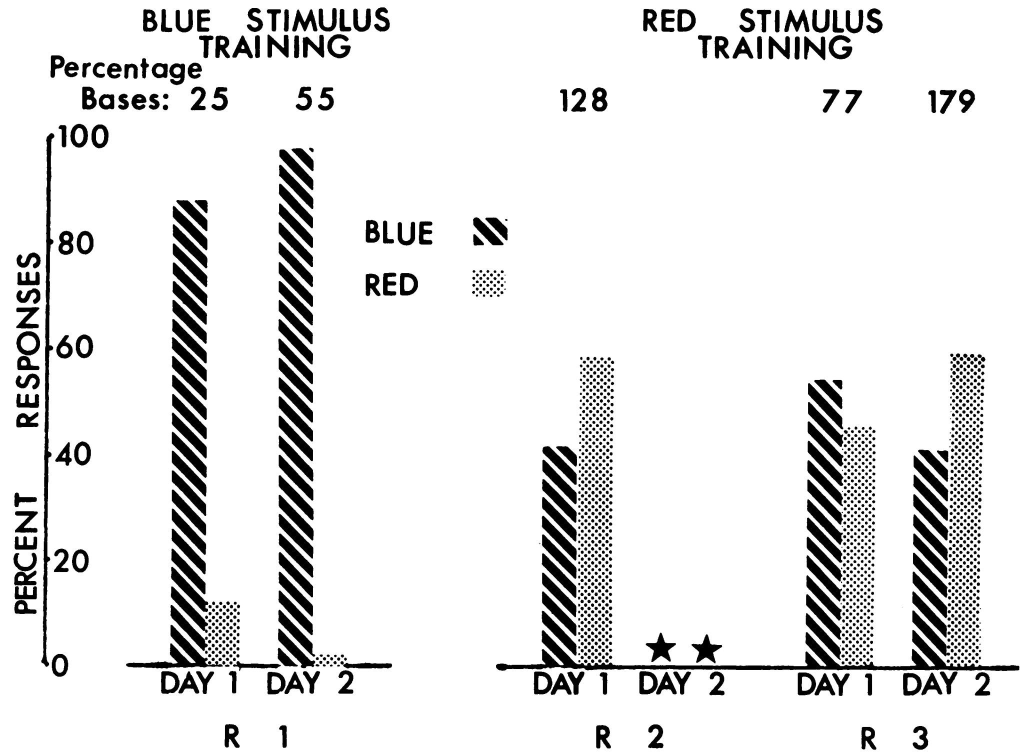


Fig. 2. Data from Phase 2. Percentages of responses in extinction to the blue stimulus (470 nm) and to the red stimulus (635 nm) following reinforcement of responses to blue at left ("Blue stimulus training") and to red ("Red stimulus training"). The star indicates data lost due to apparatus failure.

being derived from test trials 1 to 4 and the second from trials 5 to 8. On each day, the order of stimuli for trials 5 to 8 was the reverse of that for trials 1 to 4. Each animal received a different Latin Square.

Phase 2 was a test of generalization following pretraining on blue or red. Subject R4 was excluded from this stage on the grounds that the auditory discrimination training it had received might bias the results. The animals were divided into two groups, R1 and R2 + R3. Both groups were given four days of VI 1-min reinforcement training, R1 receiving a blue stimulus, and R2 and R3 receiving red. The animals were then tested for responses to both colors presented alternately in extinction, with an initial warm-up period as described above. Each animal received four presentations of each color on each of two test days, with three days of retraining in between, during which the appropriate stimulus was reinforced.

*Statistical analyses.* The Friedman two-way analysis of variance (Siegel, 1956) was applied to the data from Phase 1, each subject being treated separately and the $\chi^2_r$ values summed. Where this result was significant, the Jonckheere Statistic (Jonckheere, 1954) was applied to assess the significance of the trend between response preference and the stimulus dimension under study. In addition, a coefficient of concordance, *W*, was calculated (Friedman, 1940). The data from Phase 2 were analyzed by the 2-tailed binomial test (Siegel, 1956).

## RESULTS

Figure 1 summarizes the results obtained for color and tilt in Phase 1. Detailed analysis shows that the distribution of responses to the four colors was not due to chance ($p < 0.001$). This was not true for tilt, where the distribution was not distinguishable from a chance one ($0.3 < p < 0.5$). The Jonckheere Statistic on the color data showed the existence of a monotonic trend between response preference and wavelength ($p < 0.0001$, 2-tailed).

Figure 2 shows responses, on a percentage basis, per animal per test day in Phase 2. Data for R2 on the second day were lost due to apparatus failure. Analysis shows that the difference between the number of responses made by R1 to blue and to red was highly significant ($p < 0.0001$). In contrast, R2 and R3 responded equally to both ($p > 0.05$).

## DISCUSSION

On the basis of the results of Phase 1, it was concluded that the rhesus monkeys showed marked color preferences, where blue was the most preferred color, followed in order by green, yellow, and red. On the other hand, stimuli within the tilt dimension were treated as being equivalent to each other, in their ability to elicit responses. It may be argued that such color preferences are inherently weak, easily overcome by normal test procedures, such as those employed in operant research. Such weak preferences would not bring into serious question the assumption that any differences in responses to different stimuli are the result of experimental manipulation. However, the results from Phase 2 enable one to conclude with reasonable confidence that the animals' initial response preferences for blue were stable. Thus, in this case, reinforcement of responding to blue increased its ability to elicit responses, whereas reinforcement of responding to red did not overcome the animals' natural inclination to respond to blue.

The existence of such unconditioned response preferences has many obvious implications for operant research: at the simplest level, it implies that counter-balanced designs must be employed when color stimuli are used. Failure to do this may result in the inability to rule out alternative interpretations of data.

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*Received 16 April 1975.*
*(Final Acceptance 24 July 1975.)*