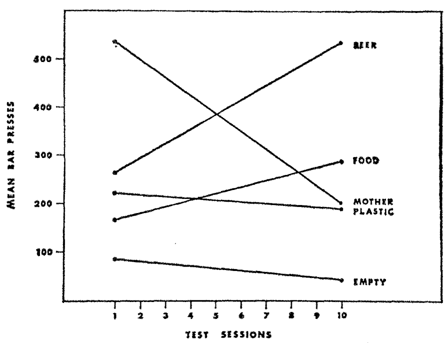

Fig. 2. Best fitting linear functions plotted for each stimulus condition over test sessions (group 1, mother reared, only).

stimulus-pair conditions, averaged over the 30-week test period, are presented in Fig. 1 (*3*). Differences in response rates between groups 1 and 2 were highly significant ($p = .005$, Mann-Whitney *U* test) on all stimulus pair comparisons. For the control condition (EE), both groups pressed the bars at relatively low but equal rates. For the remaining pairs of stimuli, however, the animals in group 1 maintained high response rates and demonstrated clear preferences, with food being preferred to the empty booth ($p = .02$), age peer to empty ($p = .01$), adult female to empty ($p = .01$), and adult female to age peer ($p = .05$). The preference for food, when paired with geometric forms, fell just short of significance and suggested that these stimuli were about equally attractive.

Response rates in group 2 were uniformly low for all stimulus combinations. The moderate rates seen in this group on the EP, EM, EPl, and MP pairings are misleading since the average number of responses for these pairings increased only toward the end of the experimental series when the animals were somewhat older; responses were virtually absent during the earlier period of testing. With the possible exception of condition EM, whose difference lacked significance, this group showed little evidence for stimulus preferences among the various conditions.

It was also of interest to trace performance changes to the individual stimulus conditions as a function of age. Although the data for the maternally separated group could not be evaluated statistically because of the low response rates, these trends are presented for the maternally separated group in Fig. 2. To minimize the effect on the data of a competing stimulus, only those conditions were chosen in which the paired stimulus for "mother," "peer," "geometric forms," and "food" was the empty condition.

The results indicated that standard deviations were proportional to the means. Accordingly, all data were subjected to a logarithmic transform and best fitting linear functions were determined for each pair of stimuli over the ten test sessions. The responses to adult female and peer stimuli showed opposite trends, namely, with increasing age maternally reared subjects showed an apparent decrease in interest for the adult female and a corresponding increase for the age peer. Geometric forms and food reflected generally lower response levels, with levels for the former showing little change, while those for the latter showed an increase corresponding to a normal transition from liquid to solid food at about 2 months of age. The empty booths, as expected, attracted the least attention. The means of the first five test sessions were compared with those of the last five test sessions by *T*-tests, which indicated significant differences on the "peer" and "mother" conditions ($p \leqq .04$). None of the other stimuli showed significant changes.

It is clear that early in development maternally reared infant monkeys establish a hierarchy of visual preferences for a variety of stimulus objects. Of those used in this study, the adult female was the most attractive to all infants in group 1, particularly during the early stages of development. Although none of the subjects possessed sufficient neuromuscular development to press the bars effectively before the 3rd week of life, this response was well established after the 5th week. The intensity of preferences changed considerably with increasing maturation and followed a trend toward progressively fewer responses to the adult female, more responses to the age peer, and relatively fewer responses to the inanimate objects.

Maternally deprived monkeys showed few responses to any stimulus compared with maternally reared animals, despite a comparable number of adaptation trials. These animals showed evidence of exaggerated fear and general inappropriateness of response throughout testing. In a typical trial, after several minutes in the experimental chamber, a deprived animal would visually sample each stimulus booth, retreat to a corner of the test chamber, and crouch almost continuously, exhibiting repetitive stereotyped movements such as rocking, hair-pulling, clasping, and "fear" vocalization. These nonadaptive responses emphasize the importance of mothering during the development of adaptive modes of behavior.

It is recognized that the variable of maternal deprivation is a complex one. The relative contributions of maturation, learning, and motivational variables to development of visual responses in the infant monkey must remain conjectural until more experimental evidence is available.

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References and Notes

1. R. A. Butler, *J. Comp. Physiol. Psychol.* **47**, 358 (1954).
2. H. F. Harlow, *Am. Psychol.* **13**, 673 (1958).
3. Amygdala lesions were created surgically in two animals in group 1 and three animals in group 2. These lesions appeared to have no influence on the response rates or object preferences of either group and the data for all the animals in each group were accordingly combined for analysis.
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Distance Perception in Darkness

Abstract. *Human subjects viewed round stimuli located equidistantly in the horizontal and vertical planes of vision under conditions where presumed cues to size were present and where they were systematically eliminated. Two experiments revealed a consistent tendency for the horizon object to be judged the closer. Cues introduced reduced the effect.*

The experiments described in this report began with attempts to induce the moon illusion indoors and to systematically vary some of the cues which were assumed to affect this illusion (*1*). The cues varied were the interposition of a city skyline silhouette between the subject and the moon stimulus and the placement of a blue phosphorescent background behind the moon. These cues were introduced for "moons" in both the horizon and zenith positions. The background simulated the "flat-sky" effect of Ptolemy while the skyline functioned as terrain intervening between observer and "moon" (*2*).

In the first series of experiments it was hypothesized that the cues provided would both individually and in combination make the moon appear larger and closer to the observer regardless of whether it was viewed in the horizon or zenith position. Ninety subjects were used, divided into six groups of 15. In three of these experiments, the conditions were such that the horizon moon had no cues while the zenith moon had either a background or the interposed object, or both. In the other three experiments, the zenith moon had no cues, and the horizon moon had the background object, interposed object, or both. The experiments were conducted in a room [45 feet (13 m) in length and 17 feet high] which remained darkened during the testing procedure. Stimulus objects were 7½-watt light bulbs exposed through a 1⅛-inch (2.8 cm) aperture dimmed with a filter of exposed film. The lights were placed at a distance of 8¾ feet from the eyes of the subject in both the horizon and zenith positions. They were switched on individually. The interposed object was a blue phosphorescent-painted silhouette of a city skyline, and the background object a 3½-foot square of blue phosphorescent-painted cardboard. The background was placed 2 feet 2 inches beyond the moon; the interposed stimulus 2 feet 2 inches in front of it. The subjects made size estimates by matching with a series of phosphorescent circles provided by the experimenter. After a subject made two size estimates for each position they were exposed again and he was asked to estimate the distance to the light.

Judgments across all six conditions yielded consistently larger size estimates for the horizon than for the zenith moon. Also, the zenith moon was judged farther away than the horizon moon. Since preliminary analysis indicated that there was no significance due to the presence of either or both of the stimulus objects, the combined groups for which cues were present were contrasted with the situation in which no cues were present, as indicated in Table 1. The interaction between cues fell short of significance.

Table 1. Mean size and distance judgments for the horizon and zenith positions. (Size estimates are in ⅛-inch intervals, distance estimates in feet.)

Condition		Judgment			
		Size		Distance	
Horizon	Zenith	Horizon	Zenith	Horizon	Zenith
Dark	Cues	9.58	8.89	6.94	8.86
Cues	Dark	8.69	8.39	9.48	11.79

However, the main effect of position of the moon was substantiated for both the size and distance judgments ($p < .001$).

Position interacted significantly with the presence of cues versus no cues ($p < .001$. A test for the simple effects of moon position within the cues condition and of moon position within the no-cues condition yielded no significant difference between the moon positions with the cues present, but the difference for the moon positions within the no-cues condition was significant at the .001 level. It was concluded that in this series of experiments the effect of the cues was to interfere with the illusion and bring about judgments more consistent with the real relationships between the stimuli rather than in the illusionary direction. Most revealing however, was the finding that the illusion occurred in a situation in which we had, as systematically as possible, omitted all cues to size and distance.

The purpose of the second series of experiments, therefore, was to replicate in part the findings of the first series with certain changes in procedure. Twenty-seven subjects were used and each subject was given three trials at estimating various distances before being brought into the experimental situation proper. We used a much smaller experimental room (15 feet in length and 12 feet in height) in which the stimulus objects were located only 6 feet from the subject. We employed an adjustable chair so that we might maintain eye position relatively constant for all subjects. The stimulus objects used were phosphorescent-painted plastic golf balls. In the first series of experiments, the instructions had been for the subject to state how far the object seemed to be from him; in the second series our question was more specific; we wanted the subject to tell how far each object was from his eyes. Except for the stimulus objects, the room remained dark throughout the procedure.

The results with distance judgments in the first series of experiments were substantiated. When our "moon" objects were viewed in a horizontal position, they were judged to be a mean of 7¾ feet away from the subjects, while the same subjects viewing the zenith stimulus judged them to be 9 feet 1 inch distant. These differences are significant at the .05 level, as measured by both parametric and nonparametric tests, and support the previous finding that even in the absence of any prominent cues there is a tendency for the subject to judge an object above him to be more distant than an object directly in front of him.

Our findings pertain to previous conclusions with respect to what factors may be producing the moon illusion, although it should be noted that primary concern here became that of distance judgment which may or may not be a relevant factor with respect to the occurrence of the moon illusion. One of the most immediate possibilities for explaining the findings may be found in the earlier work of Holway and Boring (*3*) concerning the angle of regard and size estimation. Their hypothesis was that the moon illusion itself might be accounted for in terms of the angle at which the subject regarded the moon. This was the most prevalent explanation for the moon illusion until the publications of Kaufmann and Rock who concluded that the presence of intervening terrain was crucial. Systematic study of the relations among stimulus location, angle of regard and distance estimation now is indicated.

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References

1. R. H. Day, *Ann. Rev. Psychol.* **15**, 1 (1964); W. Epstein, J. Park, A. Casey, *Psychol. Bull.* **58**, 491 (1961).
2. L. Kaufman and I. Rock, *Science* **136**, 953 (1962); I. Rock and L. Kaufman, *ibid.*, p. 1023.
3. A. H. Holway and E. G. Boring, *Am. J. Psychol.* **53**, 109 and 537 (1940).

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