the dark control, whichever light is used. The small extent of germination following longer irradiation with red light (2 and 5 minutes), or the corresponding inhibition following longer irradiation with far red, can be explained as the effect of scattered light due to the long exposure. Seeds from which the fruit coats have been removed show essentially the same behavior as the normal seeds with fruit coats on.

A number of reports on light-sensitive seeds have indicated that the seed covering restricts germination in darkness mechanically and that its integrity determines the light sensitivity of the seed (*5–7*). In lettuce the presence of the intact endosperm layer or "seedcoat" has been shown to be necessary for the light sensitivity of the seeds (*5, 7*). This, however, does not necessarily mean that the endosperm is the light-sensitive site. Should the pigment system be in the endosperm layer, its presence must evidently be limited to the half which covers the hypocotyl, but since that is the part of the seed which elongates in germination, it seems more reasonable to conclude that the photoreceptor pigment is present in the hypocotyl itself. That the photoreceptor should be close to the extreme tip of the seed would, of course, give a simple explanation of the observation of Klein and Preiss (*3*), since this is the only part which can receive light from either direction.

It can, therefore, be concluded that the light-sensitive site is either in the seed covering at the hypocotyl end, or, more probably, in the tip of the hypocotyl itself. The hypocotyl would thus be not only the site of elongation but also the region of light sensitivity.

HIROSHI IKUMA
KENNETH V. THIMANN
Biological Laboratories, Harvard University, Cambridge, Massachusetts

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Magnitude of the Moon Illusion as a Function of the Age of the Observer

Abstract. The diminution in the apparent size of an object when viewed overhead as compared with its apparent size in the horizontal plane is greater for children than for adults. This relationship, of which the well-known moon illusion is a special case, is interpreted to be a consequence of the normal development of size constancy.

The relatively small perceived size of the moon when seen in elevation as compared with its large appearance at the horizon is one of the oldest recorded visual phenomena. Since the angle subtended by the moon's disk is actually somewhat smaller at the horizon, the striking difference in its perceived size has been referred to as the "moon illusion." A number of explanations have been offered for this phenomenon (*1*). It is the purpose of this report to attempt to relate the moon illusion to normal processes of perceptual development. To this end, the magnitude of the effect was determined for adults as well as for children of various ages.

Schur (*2*) has demonstrated that the essential feature of the illusion, that is, the change in apparent size as a function of elevation, holds not only for celestial but also for terrestrial objects. She projected a spot of light on the ceiling of a large room and asked adult subjects to adjust the size of a similar spot of light, at the same viewing distance but projected on a vertical screen at eye level, to match the overhead light. Under these conditions, the disk viewed overhead appears smaller than the one viewed in the horizontal plane.

We have repeated this experiment in a darkened theater at a viewing distance of 35 feet and also outdoors by extending a disk, parallel to the ground, from the roof of a building 85 feet high. In both experiments, the subjects sat directly below the overhead disk and compared its size with that of a similar disk in the horizontal plane at the same viewing distance. The subjects observed binocularly with unrestricted head, eye, and neck movements. In every case the disk in the horizontal plane judged equal in apparent size to the overhead disk was physically smaller than the overhead disk. Nineteen adults and nineteen children ranging in age from 4 to 11 years served in the outdoor experiment. The data plotted in Fig. 1 present the matched size of the horizontal disk

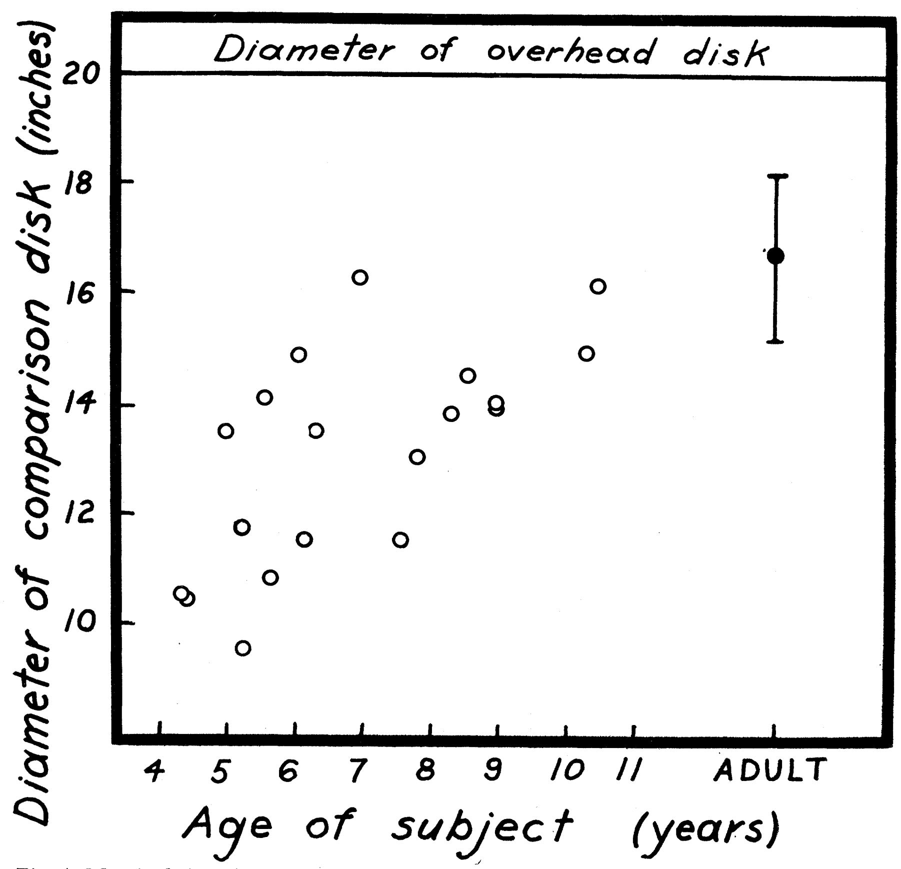

Fig. 1. Matched size of a comparison disk in the horizontal plane which was judged equal in apparent size to an overhead disk 20 inches in diameter. Open circles represent values for individual children. The mean for 19 adults, with the limits for one standard deviation, is given by the solid circle.

as a function of the age of the observer. On this plot, a correct size match would fall on the horizontal line representing 20 inches, the size of the overhead disk. It can be seen that all subjects underestimated the overhead disk and that the amount of underestimation is a function of the age of the subject. The youngest children demonstrate an underestimation of about 50 percent, this value decreasing with increasing age to about 16 percent for the adult subjects.

These data were corroborated by the indoor experiment in which 10 children and 10 adults participated. The adults underestimated the overhead disk by 19.1 percent, and the children, who ranged in age from 5 to 8 years, by 32 percent. In both experiments the data for the adults are comparable to those obtained by Schur. In addition, the effect is seen here to be related to the age of the subject, the diminution in apparent size of the overhead disk increasing with decreasing age of the observer.

It is our interpretation that these results can be related to normal perceptual processes as indeed must be the case for all illusions. Since the moon illusion is a special case of the perception of size, any explanation of this effect must be in terms of the processes which generally subserve size perception.

It is a remarkable achievement of the human visual system that the apparent size of objects tends to be perceived correctly despite extensive changes in the dimensions of the corresponding retinal image resulting from variation in viewing distance. Although the mechanisms underlying this biologically important phenomenon, referred to in the psychological literature as size "constancy," have not been completely identified (*3*), the effects are clear. Size constancy results from a "correction" such that the greater the viewing distance for an object subtending the same visual angle—that is, producing the same sized retinal image, the larger the object will appear (*4*). The ability to make this correction for objects located near to the observer is good for both adults and children so that, for a given retinal image size, perceived size is proportional to distance. However, as the observation distance is increased, this correction is no longer complete, and especially so the younger the subject. Presumably the ability to make a size correction for distantly viewed objects depends on experience (*5*).

Such results for size perception in general suggest that the moon illusion may be a consequence of the fact that human beings have more experience with objects in the horizontal than in the vertical plane, and thus make a larger size correction for an object subtending the same visual angle—for example, the moon—when viewed horizontally. Since children have less experience with distantly viewed objects, especially when viewed directly overhead, the magnitude of the moon illusion is greater the younger the observer. Thus the moon illusion is interpreted as resulting from a normal developmental process, namely the dependence of the magnitude of the size constancy correction on experience (*6*).

H. Leibowitz
T. Hartman*
Department of Psychology, University of Wisconsin, Madison

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Self-Regulation of Brain-Stimulating Current Intensity in the Rat

Abstract. A modification of the self-stimulation technique of Olds enabled rats to regulate and maintain at a preferred level the amount of brain-stimulating current they received as reinforcement for lever pressing. The method used two levers to deliver brief brain shocks: each response at one lever increased the current intensity a small step and each response at the other lowered it one step.

It is well established that animals will work to stimulate certain portions of the brain electrically (*1*). This self-stimulation technique has considerable promise as a tool for investigating the central nervous system actions of many variables. Olds has reported, for example, that food deprivation, castration, or drugs will selectively change the baseline rates of self-stimulation of particular brain structures (*2*).

The present report describes an elaboration of the self-stimulation technique in which animals are furnished with the means to regulate the amount of brain-stimulating current they receive as reinforcement. The new method thus permits a continuous determination of the preferred intensity of stimulation, and at the same time gives the rate of self-stimulation as before (*3*).

The animals were trained in a small, sound-resistant box with two levers in one wall. Operations of either lever delivered brief brain shocks. A two-way stepping relay provided 24 equal current steps (from 0 to approximately 50 ma, depending on the electrode impedance) by introducing appropriate resistances into the stimulating circuit. Responses at one lever drove the stepper forward, producing brain shock reinforcements of increasing intensity, and responses at the other stepped it back, decreasing the intensity. Any current level, once established, could be maintained by alternating responses between the levers.

Continuous records of the amount of current selected were drawn by a recording potentiometer whose input voltage was controlled by the two-way relay through an auxiliary bank of resistances (*4*). A cumulative response recorder and impulse counters simultaneously provided records of the self-stimulation rate.

The stimulating current was supplied from a pulse-pair generator similar to that described by Lilly *et al.* (*5*). The relatively noninjurious wave form had positive and negative peaks each 50 μsec in duration and separated by 200 μsec. A brain-shock reward consisted of a train of pulse-pairs 50 to 100 cy/sec in frequency and fixed in duration at either 0.25 or 0.5 sec; the stepper could not be reoperated until a train was delivered. Optimal values of frequency and train duration varied for different animals and were selected experimentally.

The subjects were male albino rats with bipolar electrodes (0.01-in. platinum wires, twisted together and insulated except at the tips) permanently implanted in rhinencephalic, hypothalamic, and midbrain tegmentum sites (*6*). In preliminary training, the animals practiced conventional self-stimulation—either lever gave brain shocks of a fixed, moderately reinforcing intensity. After the self-stimulation rates had stabilized, the rats were required to alternate between the levers to obtain the fixed-intensity electrical stimulus (one 2-hour session).

Training in regulating the current followed on the next day. Most animals learned readily how to control the intensity of the stimulation, and variability decreased rapidly with practice. Assistance from the experimenter early in training—for example, raising the current when it was driven down and held at zero, or lowering it when punishing or convulsive levels were approached—greatly facilitated the process.

Sample records of several consecutive hours of current regulation by two well-trained animals are shown in Fig. 1.