What are the facts and implications of this simple experiment?

Foremost is the fact that the numbness is felt outside actual bodily limits. The subject "projects" a feeling of numbness to the locality of his partner's finger.

This use of *numbness,* meaning completely "dead" or "asleep," does not include partial sensation, such as tingling. It is like the numbness that is felt in an arm asleep over one's head when it must be lifted as a dead, heavy weight. It is like the feeling in one's lip experienced upon self-palpation after a dentist's injection of novocaine has completely numbed it. Whether this feeling is to be regarded as a negative tactile sensation, a positive tactile sensation, or a tactile sensation at all, poses an interesting semantic problem.

Three sources of stimulation may be recognized peripherally in the two-person Japanese illusion: cutaneous stimuli from the tip of the stroking finger, kinesthetic stimuli from the movement of stroking, and visual stimuli from observation of the act.

Conspicuously absent are cutaneous stimuli from the finger that is being stroked. But it has texture fairly like one's own finger, is in a position commonly occupied by it, and looks fairly like it. The brain's interpretation is then one previously learned for a similar pattern of sensory impulses: the part is asleep.

Certainly in the two-person illusion, and probably in other instances of this numbness, the feeling is entirely independent of cutaneous sensory impulses from the locality that feels numb. Visual stimuli (not to exclude visual imagery) are dispensable, since the illusion can be felt by the subject when his eyes are closed. But three subjects felt a numbness while watching the partner stroke his own finger! Apparently the numbness can also be felt upon the visual stimulation of watching the act and in the absence of the kinesthetic stimulation of the stroking movement. The implication is that criteria for this sort of numbness in a bodily part are: (1) palpation of the part (usually self-palpation), (2) absence of cutaneous sensory impulses from the part, and (3) self-identification of the part.

The third criterion, self-identification of the part touched, is interesting in the light of the concept of body-image. The central notion of body-image, developed and extended somewhat variously by Head (*2*), Schilder (*1*), and Lhermitte (*3*), is that every person holds in his nervous system a plastic model or idea of his own body, built up from past sensory experience (vision, touch, kinesthesis, etc.) and constantly modified by new experience. The body-image of a person gives the cues that permit him to locate accurately the parts of his own body, to judge properly the boundaries of his body in relation to other objects, and to have successful sensorimotor behavior in general. When a limb is amputated, the body-image is expressed in continued "projection" of sensation into a phantom limb; the body-image is said to be thus unmasked. Our experiment can also be said to unmask the body-image by demonstrating a potentiality of the nervous system for "projection" of numbness to a foreign bodily part under conditions sufficiently resembling those with which an own bodily part is identified.

An individual who immediately conceptualizes the experiment by properly identifying the fingers involved is not susceptible to the illusion. But when persistently asked if the stroked finger doesn't feel a little like his, he may presently report that he has captured the feeling. A suggestible person may almost turn the illusion on or off by persistently imagining that the stroked finger either is, or is not, his own. Similarly, concentrating attention on the stroked finger facilitates the illusion; on the stroking finger inhibits it. With repetition one may find that the illusion is increasingly difficult to produce. This suggests a learning of the new position or its incorporation into the body-image as other sensory data are brought to bear upon the problem.

A consideration of the phenomena of this and related experiments calls for greater structural definity of the still rather amorphous concept of body-image. Its review and elaboration bear on a physiological explanation of how somatic sensations are localized.

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2. HEAD, H. *Studies in Neurology,* Vol. 2, London: Oxford University Press (1920).
3. LHERMITTE, J. *L'image de notre corps.* Paris (1939).

The Mechanism of Visual Excitation

A significant advance toward the understanding of the mechanism of visual excitation has been made recently by Wald and Brown (*1*). They found that "the bleaching of rhodopsin by light exposes new sulfhydryl groups on opsin, two such —SH groups for each molecule of retinene liberated. The sulfhydryl group is highly reactive; it is weakly acidic, readily binds metal ions, and is a strong reducing agent." In particular, the sulfhydryl groups combine readily with silver ions.

The mechanism seems to become even clearer if we note that the *affinity of the sulfhydryl groups for such positive ions makes the totality of such groups an effective cathode.* But we already know that a nerve becomes excited under the cathode when the stimulus becomes sufficiently strong. One would therefore expect that the rod cells would become excited when a certain critical amount of rhodopsin has been bleached, thus producing a sufficient number of sulfhydryl groups.

The problem of how such effective cathodes cause

ions to move is one of considerable interest, but the excitation of nerve itself may perhaps be more profitably studied using real cathodes, since more is known about the way in which they function. However, it is conceivable that once one has the mechanism of excitation of nerve worked out, it may be possible to work backward and to piece together the intermediate processes occurring in the visual organ.

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Book Reviews

The American Illustrated Medical Dictionary, 22nd ed. W. A. Newman Dorland, Ed. Philadelphia-London: Saunders, 1951. 1736 pp. $10.00.

As science makes advances new terms are constantly being added. The job of keeping a medical dictionary up to date is difficult and complicated, and such a book requires numerous revisions and editions. Saunders medical dictionary, now in its twenty-second edition, has long served as an authority in its field, and this latest edition, published on its fiftieth anniversary, maintains its previously high standards of excellence. New terms are covered adequately, and old terms have been retained and elaborated upon in a satisfactory manner.

The volume is in a new typography and format, characterized by many illustrations to keep abreast of modern findings and changes in nomenclature.

Among new features in the book the editor has included a valuable preliminary article on the fundamentals of medical etymology and a table of modern drugs and dosages. He and the publishers are to be congratulated on this new edition; its excellence should assure continued publication for the next fifty years.

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The Computation of Elements of Eclipsing Binary Systems. Zdeněk Kopal. Cambridge, Mass.: Harvard College Observatory, 1950. 181 pp. $5.00, $4.00 paper.

Eclipsing variables make it possible to study many properties of the stars which would otherwise be almost, or completely, closed to our investigation. Almost all our reliable information about their diameters and densities comes from this source, and under favorable circumstances it becomes possible to enter analytically the otherwise inaccessible interior, and find the internal concentration of density.

Modern photoelectric methods make observation of the light of an eclipsing system a simple matter—for the expert—with an accuracy approaching one part in a thousand. From such observations, covering the whole period, and showing fully the effects of the eclipse of each star by the other, a remarkable amount of knowledge may be derived.

Analytically, the theory that deduces the size and brightness of the stars, the orbital inclination, etc., is surprisingly complicated. Even the simplest case (two spherical stars and a circular orbit) can be solved only with the aid of extensive numerical tables of special functions. With their aid a precise solution is usually possible, but there remain cases in which a solution is indeterminate without additional information. In the more complex cases, when the stars are close together, distorted by tidal forces, and heated on the facing sides by each other's radiation, a fair approximation may be reached by a theory, first suggested nearly forty years ago, that assumes the components to be similar ellipsoids. Methods for improving this solution to any desired degree with the aid of very extensive expansions in series were later developed by Dr. Kopal. Still more complications, such as the presence of streams of gas escaping from the stars, or of bright patches on their surfaces, sometimes occur, but are not yet amenable to theory. Eclipsing systems, therefore, are as interesting to the mathematician as to the astrophysicist.

The present work supplements the author's earlier volume, *An Introduction to the Study of Eclipsing Variables,* published in 1946, and deals with methods for the numerical solution of the various forms presented by the problem. Though no numerical examples are given, the presentation of theory and practical procedure is complete and lucid. The specific treatment is highly technical (as it should be) and comment on its details may well be left to reviewers in professional journals.

It appears more to the point to note certain differences in the manner of discussing even such recondite matters when seen from different angles. These are primarily differences of taste and preference and all the more interesting because of the traditional impossibility of resolving the dispute.

Dr. Kopal's approach is that of a fairly pure mathematician who feels strongly the element of uncertainty and of personal idiosyncrasy involved in the use of a freehand curve drawn to represent the observations. He prefers to make even the first of the successive approximations required in the solution by a discussion of all the relevant observations by least-squares—even though it is clearly recognized that the first approximation must ordinarily start with such