ON THE ACCURACY OF ACCOMMODATION*

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To attain keen visual perception of near objects, the refractive power of the lens is changed with amazing accuracy and rapidity by what is called the faculty of accommodation. The question arises whether this most refined focusing activity is an innate property, comparable to pupillary constriction by light—a true reflex, or an acquired mechanism, the perfection of which is gradually achieved by practice.

Two approaches may be taken in answering the question. The direct, and more difficult one, is in investigating unprejudiced newborns. The alternative is to create experimental conditions wherein normal past experience cannot furnish guidance. Should it be possible to show that accurate accommodation is firmly dependent upon such truly acquired faculties as the judgment of distance and magnitude, then it may be concluded with reasonable certainty that precise accommodation itself is acquired; and, if indeed accommodation is conditioned by acquired knowledge, then no specific physical stimulus can automatically regulate its amplitude through reflex arcs.

FIG. 1.—Scheiner's experiment demonstrating the state of accommodation.

Method and Instrument

To visualize accommodation, Scheiner's experiment (1619) was employed as suggested by Porterfield (1759) and first carried out in similar fashion by Young (1801). The method has the following foundation:

Point *a* (Fig. 1), viewed monocularly through a double pinhole (*e, f*) appears single when accommodation is correct (*n*). When accommodation is excessive (as though the retina were at locus *l*) or insufficient (retina at *m*), a double image is seen. The distance between the two images will be the further, the greater the accommodative error.

* Received for publication October 30, 1961.

The instrument ("optometer" was proposed by Porterfield) consists of a black tube, about 10 mm. in length and 5 mm. in diameter, at one end of which is mounted a dark plate containing two pinholes, about $\frac{3}{4}$ mm. in diameter and 3 mm. apart (Fig. 2). It is placed in the back compartment of a trial frame and centred within the limits of the pupil until both holes are seen equally well. The fellow eye is occluded and the subject attempts to read print of various sizes at various distances. Adequate amplitude of accommodation is, of course, prerequisite.

The optometer seems adequate for the qualitative nature of this study and its simplicity can further facilitate study of the experiments by others.

FIG. 2.—The pinhole optometer.

Results

A word, or other groups of ordered objects, viewed through the optometer, is seen single and uninterrupted when accommodation is correct. The left half of the word is seen through the right pinhole, the right half through the left hole (Fig. 3*b*). When the subject is reading at the usual distance (about 25 to 30 cm.), some letters in the centre of the word are duplicated (Fig. 3*a*) and the word "mood", for instance, reads "moood". When the subject is reading distant print (400 cm.), some letters at the centre are missing and the word seem to be compressed (Fig. 3*c*).

It follows that, even though the print is well within easy reading distance, accommodation is insufficient. When the print is at a great distance, accommodation is excessive under identical conditions.

When the fellow eye is uncovered, and the subject then concentrates on reading the print, it appears continuous also to the eye behind the optometer. The original state of accommodative excess or insufficiency is restored as soon as the fellow eye is occluded, and precise focusing cannot be achieved even by conscious knowledge of the proximity of the print.

FIG. 3.—Reading through the optometer when accommodation is (a) insufficient, (b) correct, or (c) excessive.

Discussion

Many criteria by which the eye may gauge distance were absent in the pinhole instrument: spherical and chromatic aberrations, the Stiles-Crawford effect, limited depth of focus, other objects in the field, convergence, and stereopsis.

In viewing near objects the stimulus was thus inadequate and accommodation insufficient. The accuracy of accommodation improved as soon as the fellow eye was uncovered and more normal conditions restored. Whence, then, the stimulus which was active when, under identical conditions, distant print was read? The most likely explanation seems to lie in the normal association of reading with accommodative effort; this past effect (engram?) had apparently superseded when external stimuli were missing.

Accommodation is by definition a function of distance, yet accurate judgment of distance must first be acquired, consciously or unconsciously, by experience. The psychologically conditioned relation of distance to magnitude is clearly demonstrated by the apparent variation in the size of the moon when seen at the horizon and overhead. Children will believe that distant persons are "cute little dolls" until they learn that distant objects only *appear* to be smaller (von Helmholtz, 1896). Similarly, it would follow that, only when clues to the proximity of objects are correctly interpreted, is one also able to learn to accommodate correctly.

This concept is corroborated by the experiments of Campbell (1959), which demonstrated that a wide variety of clues may be used by subjects to obtain guidance on the required direction of accommodation, and that some of these clues could be learned very quickly. Fincham (1951) held the opposite view that accommodation was a true reflex, with chromatic aberrations as its specific physical stimulus.

Summary

By means of a simple double pinhole instrument the accuracy of accommodation may be gauged qualitatively. When proximal print is read through this pinhole accommodation is insufficient in relation to the distance, but when the print is farther than customary accommodation is excessive. It is therefore deduced that the accuracy of accommodation is conditioned by the acquired clues to the correct distance of an object in view, which were excluded by the pinhole.

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