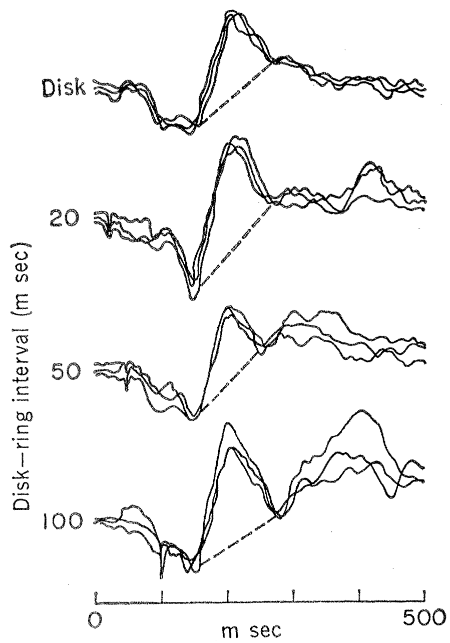

Fig. 2. Visual evoked responses from subject H.V. to 1.5° foveally projected disk (reference stimulus), and disk-ring combination at three different interstimulus intervals (ISI). Interrupted lines indicate the area of the response component measured to obtain the data illustrated in Fig. 3. At 20 msec, ISI apparent brightness of disk is greater than comparison disk; at 50 msec, suppression is maximum; recovery of brightness has occurred at 100 msec ISI.

nent with a maximum at about 200 msec after the first stimulus. The area of this component and the subjective disk brightness, estimated by a method of interocular brightness matching (*6*), are plotted in Fig. 3 as a function of the disk-ring interval. The concordance of these data is excellent except with the 80- and 90-msec delays for subject L.S.

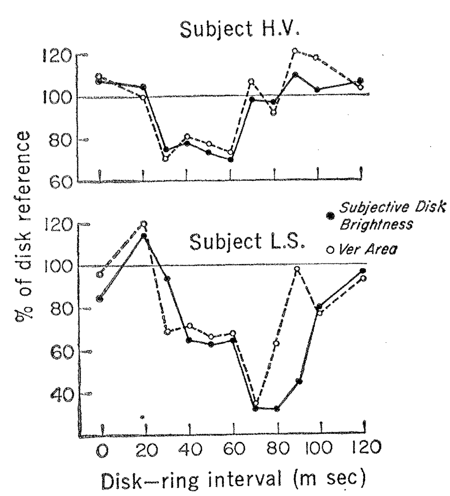

Fig. 3. Plots of VER area and subjective brightness for subjects H.V. and L.S. Values are expressed as a percentage of the disk VER area and of the comparison disk brightness.

A precise quantitative analysis of the relation between brightness judgments and the VER presents complexities which cannot adequately be discussed here. These concern a proper metric for relating changes in subjective brightness of the disk-ring configurations to the alterations in the VER waveform (*7*).

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4. The photic stimuli of 10-msec duration were presented in Maxwellian view to the right eye of each of two subjects (the authors). For the dark background condition a small red fixation cross was provided; for the light-adapted condition, the rectangular adapting field, about 11° by 11°, contained a diamond-shaped fixation pattern formed by four black dots within which the stimuli were projected. Intervals between stimuli, measured from the presentation of the disk to the presentation of the annulus, of 0, 20, 30, 40, 50, 60, 70, 80, 90, 100, and 120 msec were employed. Usually, the disk was presented alone between two successive presentations of the compound stimulus (disk and annulus). A period of 1.5 seconds intervened between the presentation of each stimulus configuration. Visual evoked responses were recorded from silver-silver chloride, bipolar, scalp electrodes with the lower electrode placed on or slightly above the inion and the other approximately 4 cm above and 3 cm to the left of it. The electroencephalogram was amplified by a system set for a bandpass of 0.2 to 50 hz and summated by a modified Mnemotron computer of average transients. Either 100 or 200 samples were summed for each VER recording. The data in Fig. 3 represent the mean area for three separate VER determinations at each disk-ring interval.
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6. We evaluated disk brightness by presenting a comparison disk to the left eye of the subject, alternating at 1.5-second intervals with the disk-ring sequence presented to the right eye. The duration of the comparison disk was varied in ascending and descending steps of 0.5 msec until a satisfactory brightness match of comparison disk to the disk in the compound stimulus was obtained for at least three successive presentations of the test and comparison stimuli. Since the durations employed were less than the critical duration for temporal summation, the stimulus duration was directly proportional to brightness. The brightness data for each disk-ring interval represent the median comparison disk duration for five trials at each separation. This duration is expressed in Fig. 3 as a percentage of the comparison disk duration required to match the brightness of the disk alone presented to the right eye.
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Dolphins and Multifrequency, Multiangular Images

Most discussions of dolphins inspecting the environment (*1*) stress their presumed ability to range on objects by echo, as by sonar; I submit that they "see" objects acoustically about as well as we do visually. My reasoning follows; I have no proof.

Dolphins emit a series of whistles, slide tones, and sharp sounds (clicks) having basic frequencies that cover a considerable range (200 to 150,000 hz). Each may have more than one transmitter and receiver. In any case, dolphins are generally moving, so that, no matter what object they are concerned with, they observe it from different angles. Thus they obtain multifrequency, multiangular information about the object.

From multiangular information (angular width of lobes in the pattern of scattered intensity) the lateral separation of centers on the object that scatter sound can be determined, and from multifrequency data the radial depth between centers can be determined. For simple geometry the lateral separation L in half-wavelengths $\lambda/2$ between a pair of scatterers is

$$L = (r/\Delta x)(\lambda/2) \qquad (1)$$

and the radial separation R is

$$R = (f/\Delta f)(\lambda/2) \qquad (2)$$

where r is the range to the object; Δx is the lateral distance, at right angles to the "line of sight," between interference fringes at one frequency, due to the pair (that is, the lateral distance required to produce phase shift of 2π in the intensity of the received signal; the variation from maximum to minimum depends on the product of the strengths or cross sections of the scatters); f is the frequency; and Δf is the change in frequency, at one location, needed for phase change of 2π in the intensity of the received signal.

Determination of L and R is equivalent to determination of the true separation $(L^2 + R^2)^{0.5}$ at an angle $\tan^{-1}(R/L)$. With more complicated three-dimensional geometry, additional trigonometric projection terms enter the equations. (Distances are measured in half-wavelengths rather than whole wavelengths because of the two-way path from the dolphin to the object and return. In Eq. 2 one may replace $f\lambda$ by the speed of sound in water, but such replacement masks the fundamental symmetry of the two equations.) If transmission and reception are phase-coherent and the dolphin has sensory capabilities to detect phase (as I believe humans do not), each center can be located uniquely in position relative to some arbitrary reference (instead of locations by pairs), and the strength of the center can be determined directly.

In a sense, none of this argument is new; in 1802 Young published (*2*) his famous principles of interference, which are taught in a different context of the "double-slit experiment" to all high school students of physics.

Consider a typical sonogram (a plot of frequency and intensity versus time) of two or three people talking at once, which looks fairly hopeless to decipher optically. Then compare the analysis with that done in real time by anyone's ear. While we as humans are busy trying to program big computers to do fast Fourier transforms (*3*) on vast amounts of data on underwater acoustics (to determine the Fourier components of variation of signal strength with space (Eq. 1) or with frequency (Eq. 2), and thus to analyze a complicated object), the dolphin probably does the same job in real time with little conscious effort. The ordinary laws of acoustics show that, with reasonable signal-to-noise ratio, precision of the order of one wavelength (for example, 1 cm at 150,000 hz) should be available to a dolphin acoustically inspecting an object and constructing a three-dimensional image of it.

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2. T. Young, *Phil. Trans. Roy. Soc. London* **92**, 23, 387 (1802). Both reports are reprinted (Nos. 7 and 8) in G. Peacock, Ed., *Miscellaneous Works, Thomas Young* (Murray, London, 1855). The key words are on p. 1 of the second paper: "Wherever two portions of the same light arrive at the eye by different routes, either exactly or very nearly in the same direction, the light becomes most intense when the difference of the routes is any multiple of a certain length, and least intense in the intermediate state of interfering portions; and this length is different for light of different colors." Note that Young indicates that the difference in length of routes may be associated with radial or lateral separation, and that the interference fringes or lobes have different geometry for different colors or frequencies.
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Computer-Based Journal Distribution for the Individual

The requirements of the user must always be a primary consideration in a system like the one proposed by Brown, Pierce, and Traub for computerized journal publication (*1*). Although stressing human as opposed to hardware implementation, they did not discuss several points.

What a system can provide to the user is mainly a problem of access, that is, how to specify to the computer what output is desired. The system must operate on terms that the subscriber uses and understands in his own work. Generation of indices on the basis of title, abstract, and content wording is technically feasible, and common-usage or nickname terms also might be used. The fact that the "customer is always right" may make the programmer's job more difficult, but an indexing system built on a series of acronyms and codes can rapidly become confusing and lose its utility to the subscriber.

Brown, Pierce, and Traub advocate storing outdated lists of index terms, requiring subscribers to understand the *Zeitgeist* surrounding topics from previous indices. A better solution might be a cumulative index, perhaps for use with older individual lists. A method is needed to amend indices—with new terms, apparatus, and techniques that continually crop up in the literature—and to delete obsolete topics. Since the balance between relevance and coverage is a function of index adequacy, terms used for indexing must be selected with extreme care.

The authors did not discuss the training, indoctrination, or knowledge necessary for a new subscriber to use a journal computer system. Presumably, this much-needed information would be supplied at the time of subscription. The training problem has apparently been overlooked in some other systems (*2*).

A major advantage of computerizing journal publication is that undue publication lags can be eliminated. Although preprints may have filled a need by making information available between completion of an investigation and subsequent publication, they are obviously too informal. A listing of research in progress could keep other workers aware of research not yet published and help avoid duplication of effort. High-speed computers make such listings entirely feasible.

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Cabe's concern with the *Zeitgeist* surrounding previous indices is relevant only when the system is used for retrieval. The issue does not arise for dissemination.

A new subscriber to the system requires neither training nor indoctrination, but only knowledge which may be acquired in a few minutes of reading.

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