

The Psychophysics of Iconic Storage

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Some simple models of iconic storage, based on the persisting responses of photoreceptors, were tested in two experiments. Substantial changes in such physical parameters as adapting luminance, stimulus luminance, and stimulus contrast produced little or no change in the duration of partial-report performance. This is at odds with most receptor models. It seems unlikely that any model based on receptor persistence can accommodate the results, thus forcing one to locate the icon beyond the receptors and probably beyond the retina as a whole.

A briefly displayed visual stimulus leaves the viewer with a decaying trace of visual information. This short-term visual storage was first measured by Sperling (1960) and Averbach and Coriell (1961) using the partial-report technique. Later, Neisser (1967) coined the term *iconic storage* to name and describe it.

What is the nature of this iconic storage? One possibility that has recently been explored hinges on a resemblance between some characteristics of iconic storage and afterimages. Initially a strong representation, the icon fades quickly (in about 300 msec), much like an afterimage. The information retained in iconic storage also seems to have the raw, visual, relatively unencoded quality of an afterimage. Finally, the decay curve of an icon, as measured by the decline of partial-report performance with increases in cue delay, is often similar to an exponential—a simple decay function that suggests the fading of a sensory trace.

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This simple decay model, implicit in many discussions of iconic storage, has been formalized by Rumelhart (1970) in a mathematical model of letter recognition under tachistoscopic conditions. The first stage of this model is an exponentially decaying replica of the input, rather like a receptor afterimage. In later stages, visual information is extracted from this decaying trace. Coupled with certain assumptions about feature extraction and letter recognition, this model has achieved a good fit to the data from Sperling's (1960) original experiments, using time constants of 100 to 400 msec.

Recently, Sakitt (1975, 1976) has argued that persisting rod signals are the main source of iconic storage. She found that rod afterimages could provide sufficient information for a partial-report superiority effect somewhat similar to Sperling's, at least under conditions in which large letters (2° in height) were presented in a bright flash to a dark-adapted eye. Under the same conditions, she also found that the subjective persistence of the stimulus image was determined by rod and not cone persistence.

However, if one considers partial report performance rather than subjective persistence, there is no evidence that rods have any special importance when steady adapting fields are present or when smaller letters are used as stimuli. These are important conditions, since they reflect the more typical viewing situations encountered in

most visual information-processing experiments and, indeed, in most viewing circumstances outside the laboratory. Under these conditions, there is recent evidence that the rods play little or no role (Adelson, 1978; Banks & Barber, 1977). Furthermore, a rod afterimage cannot have been the source of the partial-report superiority in the classic experiments of Averbach and Coriell (1961), since the adapting fields in those experiments were sufficiently bright to keep the rods saturated throughout the experiment.

Thus, although rod persistence may be sufficient to contribute to performance characteristic of iconic storage under some conditions, it is not necessary for such performance under all conditions. But what about the cones? It remains possible that some form of receptor afterimage—due either to the rods or the cones—is the underlying source of all iconic storage.

The present article reports tests of this more general receptor afterimage hypothesis. The question we ask is: When simple physical parameters such as luminance and contrast are varied, does iconic storage change in the ways predicted by receptor persistence?

To test this question, partial-report performance was chosen as a measure of iconic storage duration for two major reasons. First, it has a great deal of precedent as a performance measure characteristic of iconic storage, having been introduced as such in the seminal work of Sperling (1960). Second, unlike a measure such as subjective persistence, it is an objective performance measure and can be verified by comparing verbal reports to actual stimulus configurations. Thus, although there have been some recent critiques of the partial-report technique (e.g., Holding, 1975, Sakitt & Appelman, 1978), it seems to form part of the core definition of what cognitive psychologists mean by iconic storage.

As mentioned above, our main concern is to establish whether partial-report performance changes with changes in physical-stimulus parameters, as predicted by the receptor hypothesis. The immediate difficulty is that we do not know the precise time course of the decay of receptor signals.

As a working hypothesis, however, we may begin by modeling the receptors as single-stage low-pass filters, that is, systems that give exponentially decaying responses to impulse inputs. In this model we allow for the possibility that maximum-response size is limited by a saturating ceiling beyond the linear response (as in Penn & Hagins, 1972). This assumption has no effect on our predictions about iconic storage duration, however, since this duration is a function of the duration of the receptor response. The receptor response in turn is determined by the model's linear impulse response, which precedes the saturating nonlinearity.

Although too simple, this model is a convenient first approximation to the operation of the receptors. As such, it provides a useful starting place to account for iconic persistence. Similar models, only slightly more complex, have been used to account for electrophysiological data on receptor responses (e.g., Penn & Hagins, 1972) and psychophysical data on positive afterimages (e.g., Adelson, 1977, 1979; Geisler, 1979).

Experiment 1

Qualitatively, it is reasonable to suppose that as the inputs to the receptors become larger, the responses last longer. Thus, a bright or high-contrast stimulus will produce long-lasting persistence, whereas a stimulus that is barely visible will lead to a weak response that will quickly fall below threshold.

If we assume an exponential decay process, a straightforward quantitative prediction is possible as well. Any exponential decay can be characterized by its half-life—the time it takes for the response to fall to one half of its initial level. For a linear system, a doubling of input leads to a doubling of output. A doubling of output, in turn, will cause the response to take one more half-life to fall to some given level. That is, each time the input is doubled, another half-life will be required for the output level to fall to some threshold.

We tested this exponential assumption of the model as illustrated in Figure 1a. Suppose the response decays with a half-life of 200 msec, for instance. Suppose further

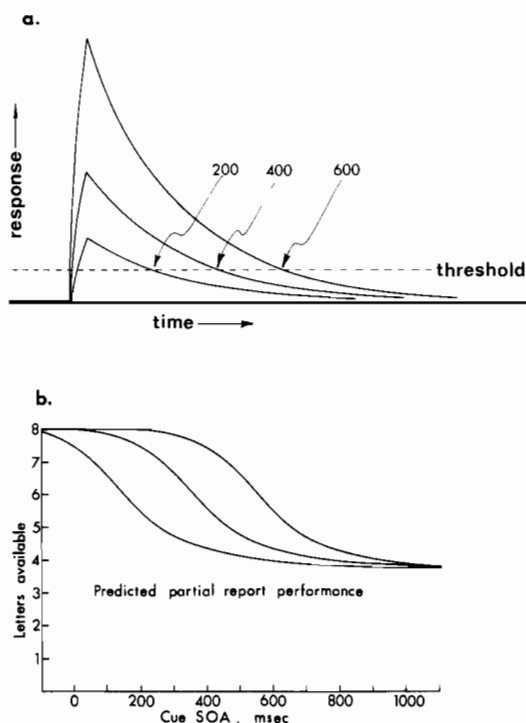


Figure 1. (a) Responses of a linear system displaying exponential decay with a half-life of 200 msec. (Each time the input is doubled, the response remains above threshold for one more half-life.) (b) Hypothetical partial-report curves resulting from a system like that in Figure 1a. (Each doubling of input intensity shifts the decay over by 200 msec.)

that there is some legibility threshold (represented by the dashed line in Figure 1a) below which subjects cannot use information in the afterimage any longer. If the input were doubled in strength, the afterimage would become legible for an extra 200 msec before falling below the legibility threshold. Thus, according to this model, there ought to be an orderly relationship between doublings of the input and the duration of iconic storage as measured by partial-report performance. This predicted effect, shown in Figure 1b, is tested by Experiment 1.

In this experiment, a steady adapting field was continuously present, with stimuli superimposed on this adapting field as increments. The stimuli, then, were perturbations from equilibrium: When the perturbation was small, the stimuli were of low

contrast and were difficult to read; when the perturbation was large, stimuli were of high contrast and were easily legible.

Method

Subjects. One undergraduate and one of the authors (J.J.) served as subjects. Both had prior experience with partial-report tasks.

Apparatus. Stimuli were presented in a three-channel Scientific Prototype tachistoscope (Model 320 GB); they were front illuminated at a viewing distance of 127 cm.

Stimuli. The stimuli were constructed of black dry transfer letters (Letraset 29-24-CLN) mounted on white card stock. The array on each stimulus card was constructed from eight letters (.25° in height) evenly spaced around the circumference of an imaginary circle 1.68° in diameter. The eight letters of each card were randomly chosen without replacement from all letters of the alphabet excluding Q and I. 100 such cards were constructed.

Procedure. Subjects viewed a steady adapting field (9 mL) containing a small black fixation dot. This field remained in view during all trial events. Following a verbal "ready" signal from the experimenter, the subject pressed a handswitch to initiate the trial. The stimulus array was presented for 50 msec, followed by a blank interval, followed by a bar marker that appeared for 50 msec. The marker was positioned like the hand of a clock within the circle of letters, and it pointed to one of the eight array positions. After the trial, subjects were required to report the marked letter.

Subjects were run for a total of six sessions. Each session was divided into two half-sessions, and each half-session used a single stimulus onset asynchrony (SOA), chosen at random from the set: -100, 50, 100, 200, 300, or 1,000 msec. The half-sessions were divided into four blocks of 32 trials, each block using a single luminance value (the order of luminances was randomized). Stimulus luminances were 8.7, 17.5, 35, and 70 mL. Each luminance-SOA condition occurred twice in the course of the experiment, for a total of 64 trials per data point per subject.

Results and Discussion

The results are presented in the four panels of Figure 2. In each panel, the points represent average data from the two subjects, each with 128 trials contributing to each point. The solid function in each panel is an identical template that has been fitted to the data with no normalization.

The 17.5-mL stimulus (Panel b) was the dimmest that gave full legibility in the precue condition (-100 msec SOA). Two doublings of stimulus intensity above this

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value (Panels c and d) produced only a trivial change in the duration of decay for partial-report performance.

Panel a displays the data for a stimulus intensity that was too dim to give full legibility even with a precue (8.7 mL). Yet even in this condition, partial-report performance decayed at the same rate as in the other three conditions. This is indicated by the dashed curve in Panel a, which is the same as the solid curves of the other three panels but normalized to fit the endpoints of the data. Although there was less information in the icon to begin with in this condition, the information decayed at the same rate as in the conditions with stronger stimulus intensity.

Apparently, significant changes in stimulus intensity produced only minor changes in the decay of partial-report performance. This clearly contradicts the linear-exponential model; hence, we must reject it. In fact, we must reject all models that are similar to the simple exponential one used here; minor modifications will not do. The observed results are dramatically different from the predicted ones; thus, only a model that is significantly different from one using a linear low-pass filter can be made to work.

To increase the generality of our findings and to further test the feasibility of receptor models, we extended the approach used in Experiment 1 to a wider range of conditions.

Experiment 2

In this experiment, we orthogonally varied the intensities of the stimulus and adapting fields. Stimuli could appear dim on a dim background, dim on a bright background, bright on a dim background, or bright on a bright background. A receptor model of iconic storage predicts two effects in these conditions: First, as in the previous experiment, stimuli that are much brighter than the adaptation level (i.e., bright on dim) should cause large and long-lasting receptor responses. By varying both the adaptation level and the stimulus intensity in this experiment, we were able to test a larger

range of contrasts than in the first experiment. Second, both electrophysiological and psychophysical data have consistently agreed that visual responses become somewhat faster as the adaptation level becomes brighter; furthermore, much of this change can be localized in the receptors themselves (Baron & Boynton, 1975; Baylor & Hodgkin, 1974; Baylor, Hodgkin, & Lamb, 1974; Kelly, 1973). Thus, if the icon is receptor, it should decay somewhat faster at a higher adaptation level.

Method

Subjects. Five graduate students served as volunteer subjects. Each participated in four sessions of 45 min each.

Apparatus and stimuli. These were identical to those of Experiment 1. The two values of stimulus field were 25 mL and 75 mL; the two adapting-field intensities were 10 mL and 50 mL.

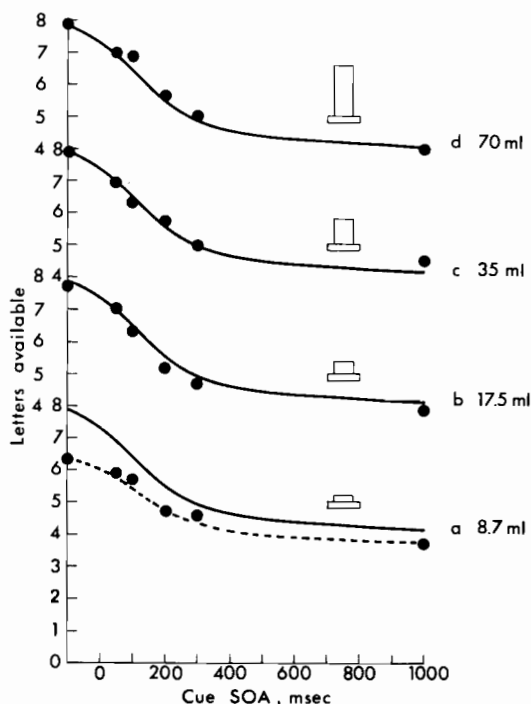


Figure 2. Partial-report decay curves for stimuli of increasing intensities. (Adapting luminance: 9 mL throughout. Stimulus luminance doubles in successive panels, from 8.7 mL in the bottom panel to 70 mL at the top. The solid curve is an identical template drawn with no normalization through the data of each condition.)

Procedure. The trial-by-trial procedure was the same as that of Experiment 1.

In each of the four sessions, subjects were run in the four major experimental conditions defined by stimulus and adapting field intensities (dim/dim, dim/bright, bright/dim, and bright/bright). These blocks of trials were further subdivided into five blocks of eight trials each, with each of these subblocks being run at one value of stimulus-cue SOA (50, 150, 250, 350, and 1050 msec). The order of these SOA subblocks, and of the major blocks, was randomly determined from subject to subject and from day to day.

Results

Figure 3 plots average partial-report performance in the four conditions (Panels a–d) as a function of SOA. Each data point represents 160 experimental trials. In each panel, a solid curve has been drawn through the data for that condition. The dashed line represents mean performance for all four conditions. It is obvious from Figure 3 that there was no substantial deviation of any of the individual data of each panel from the mean of all conditions despite the large differences among stimulus conditions that these data represent. Even the dim-on-bright condition, which had a high adapta-

tion level and low contrast, showed nearly the same results as did the bright on dim condition, in which a lower adaptation level was used and in which the test/background ratio was 15 times as great. Evidently, within the range of values sampled, both adaptation level and stimulus intensity had only the smallest effects on the magnitude and duration of partial-report performance.

For those who are specifically interested in the role of rods in iconic storage, it is worth mentioning that the 50-mL adapting field was bright enough to saturate the rods continuously. To establish this, we measured the subjects' pupil sizes while they viewed the steady adapting field; we then computed the resulting retinal illuminance. For every subject the retinal illuminance was found to be at least 1,000 scotopic trolands. Continuous rod saturation prevents any rod contribution to visual perception. (Sakitt, 1976, found that the monochromat whom she tested could see the rod afterimage only by closing her eyes and allowing the rod signal to fall below saturation.) In spite of the fact that the 50-mL adapting field continuously saturated the

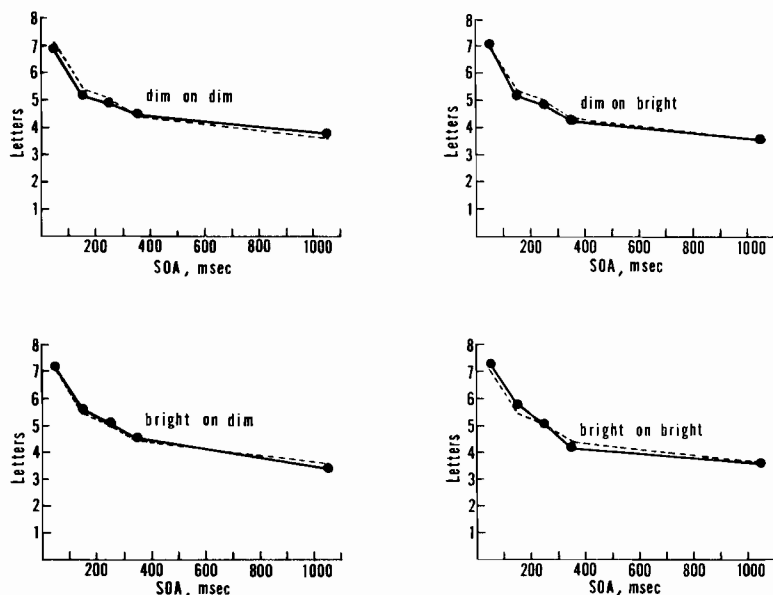


Figure 3. Partial-report decay curves, for four combinations of bright and dim stimulus fields and adapting field. (Stimulus luminance: 25 mL or 75 mL. Adapting luminance: 10 mL or 50 mL. The dashed line in each panel is the mean of all four conditions. SOA = stimulus onset asynchrony.)

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rods, the partial-report advantage in our experiment showed the usual persistence and decay.

Discussion

In the foregoing experiments, we adopted a simple model of receptor response to be able to make predictions about expected partial-report results. There were two important assumptions in the model: The first was that the response is linear with incremental light intensity, and the second was that the response decays with an exponential time course. Since the assumptions were unrealistically simple, we might be accused of attacking a straw man. But the real questions are: How far off are these assumptions, and can one find a model that is consistent with the physiology of receptor responses, yet also consistent with our data on partial-report decay?

The assumption of linearity is a surprisingly reasonable one, based on the available data from intracellular recordings (see later). It is true that the response to a steady light does not increase linearly with light intensity, but the response to a briefly presented increment does tend to be nearly linear, as long as the input is not too large. At a given adaptation level, increments that are sufficiently large will begin to encounter a saturating nonlinearity, which limits the peak height of the response. If one compares the conditions of our Figure 1 with the conditions studied by Kleinschmidt and Dowling (1975) in *sekko* photoreceptors, one predicts that the peak of the response to the 70-mL flash should be on the order of 3-3.5 times that of the 8.7-mL flash, rather than the 8 times predicted by linearity. On the other hand, Fain's (1976) experiments on light-adapted toad rods indicate that responses remain fully linear over this range of conditions.

Moreover, the linearity of the peak height is not really at issue here. What is at issue is the time it takes for the response to decay to baseline. Even if the response peak is reduced by saturation, the response duration can continue to increase as predicted by linearity. Exactly this effect was ob-

served in Penn and Hagins's (1972) work on rat rods.

The assumption of exponential decay is much less realistic than is the assumption of linearity. Indeed, there is some evidence, both electrophysiological and psychophysical, pointing to a biphasic response in the cones at moderate levels of light adaptation (e.g., Baylor & Hodgkin, 1974; Kelly, 1971a; Sperling & Sondhi, 1968). It becomes rather difficult to make predictions about how increases in stimulus intensity will affect iconic storage if one assumes a biphasic-impulse response, but one would probably not expect the duration to increase by fixed increments for each doubling of input, as was the case with the exponential model.

On the other hand, the evidence is that cone responses are brief at the adaptation levels we have studied (this is especially true in the conditions that show biphasic responses). Based on the electrophysiology of Baron, Boynton, and Hammon (1979), as well as the psychophysical analyses of Kelly (1971b) and Sperling and Sondhi (1968), one might expect the cones to support a persistence of between 50 and 80 msec. This is a far cry from the 300 msec of persistence commonly encountered in partial-report experiments. Thus, a genuinely realistic model, biphasic or not, has difficulty even explaining the basic phenomenon under study.

To explain the persistence of partial-report performance in terms of a receptor response, one must suppose that the response lingers for hundreds of milliseconds and at the same time is insensitive to the intensity parameters of the stimulus. Neither of these qualities would be expected of the receptors in the present circumstances; thus, when these qualities are found together, they make the receptor hypothesis difficult to maintain.

General Discussion

We have tested simple receptor models of iconic storage in two experiments, and they have failed to account for the obtained results. In the first experiment we found that

as soon as the display letters became fully legible, they produced a full-fledged partial-report performance, and increases in stimulus intensity had virtually no effect on the duration of this performance. In the second experiment, we found the icon to be insensitive to adaptation level and contrast, two variables that have large effects on receptor responses. These results are consistent with those of Eriksen and Rohrbaugh (1970), who varied stimulus contrast in a light-adapted experiment. They found little change in the rate of decay of partial-report performance.

Other investigators have reported certain cases in which physical stimulus parameters do affect the iconic duration, though. In general, these experiments have involved dark-adapted conditions rather than the light-adapted conditions we have used here. For example, Sakitt (1976) had her subjects dark adapt for 1 hr and then ran a partial-report experiment with 2.8 troland stimuli flashed for 50 msec. When she repeated the experiments using 4,800 troland flashes—1,700 times as bright as in the first condition—she found a larger partial-report advantage. This effect was apparently due to a rod afterimage, as Sakitt has claimed. Such afterimages become prominent when bright flashes are delivered to dark-adapted eyes.

Keele and Chase (1967) also performed a series of dark-adapted partial-report experiments, varying the stimulus intensity. They found increasing overall performance as luminance increased, with a hint of increased persistence. The effect is smaller than Sakitt's, but this may be due to Keele and Chase's use of relatively small letters (.3° high), rather than the large letter (2° in height) used by Sakitt. Because rods have low resolution, it may be necessary to use large letters to produce a useful rod afterimage.

The results of Sakitt (1976) and Keele and Chase (1967) show that under the right conditions one can produce receptor afterimages that can provide the basis for a fairly long lasting partial-report effect (a photographer's flashgun will do the trick nicely). If the eye is dark adapted, if the

stimuli are sufficiently bright, and if the letters are sufficiently large, these conditions may be satisfied. But variations from these conditions may destroy the usefulness of rod afterimages. We have already noted, for example, that the small letters of Keele and Chase apparently prevented the long persistence shown by Sakitt (1976). More importantly, Sakitt and Long (1979) found that even a small amount of light adaptation could destroy rod persistence in a successive integration paradigm. They found that a background that exceeded only .05 scotopic mL would prevent a rod persistence of 150 msec, even with the brightest stimulus available in the experiment (9 scotopic mL). Despite the dim scotopic adaptation level, a stimulus more than 100 times brighter was needed to generate a brief rod afterimage.

The fragility of persistence effects studied by Sakitt and Long can be contrasted with the robustness of the partial-report effects we have measured here. In the present experiments, adaptation level was up to 1,000 times higher than the level used by Sakitt and Long, and the ratio of test to background intensity was as much as 400 times less than their maximum. In fact, the contrast was sometimes so low as to be on the edge of legibility. Yet even under these conditions—conditions that are decidedly adverse to the survival of receptor afterimages—we always found a substantial partial-report effect. We must, therefore, conclude that under these conditions, the icon does not behave like the decaying trace of the receptor models we have tested. Indeed, it is hard to see how any receptor model could account for the present results.

Once we have set our sights beyond the receptors (and probably beyond the retina as a whole), any number of alternatives appear. Nonlinear cells sensitive to edges or contours, for example, could produce the effects of the present experiments as long as these cells have a threshold for response and a fairly long response persistence that is insensitive to gradations of suprathreshold stimuli. The present experiments place no limit on how central the icon may be but do

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limit how peripheral it may be; the receptors, by themselves, will not do.

References

- Adelson, E. H. Decay of rod signals following bright flashes. *Journal of the Optical Society of America*, 1977, 67, 1427.
- Adelson, E. H. Iconic storage: The role of rods. *Science*, 1978, 201, 544-546.
- Adelson, E. H. *The response of the rod system to bright flashes of light* (Doctoral dissertation, University of Michigan, 1979). *Dissertation Abstracts International*, 1979, 40, 10B, (University Microfilms No. 80-07, 699)
- Averbach, E., & Coriell, A. S. Short-term memory in vision. *Bell System Technical Journal*, 1961, 40, 309-328.
- Banks, W. P., & Barber, G. Color information in iconic memory. *Psychological Review*, 1977, 84, 536-546.
- Baron, W. S., & Boynton, R. M. Responses of primate cones to sinusoidally flickering homochromatic stimuli. *Journal of Physiology*, 1975, 246, 311-331.
- Baron, W. S., Boynton, R. M., & Hammon, R. W. Component analysis of the foveal local electroretinogram elicited with sinusoidal flicker. *Vision Research*, 1979, 19, 479-490.
- Baylor, D. A., & Hodgkin, A. L. Changes in time scale and sensitivity in turtle photoreceptors. *Journal of Physiology*, 1974, 242, 729-758.
- Baylor, D. A., Hodgkin, A. L., & Lamb, T. D. The electrical response of turtle cones to flashes and steps of light. *Journal of Physiology*, 1974, 242, 685-727.
- Eriksen, C. W., & Rohrbaugh, J. Visual masking in multielement displays. *Journal of Experimental Psychology*, 1970, 83, 147-154.
- Fain, G. L. Sensitivity of toad rods: Dependence on wavelength and background illumination. *Journal of Physiology*, 1976, 261, 71-101.
- Geisler, W. S. Initial-image and afterimage discrimination in the human rod and cone systems. *Journal of Physiology*, 1979, 293, 165-179.
- Holding, D. H. Sensory reconsidered. *Memory & Cognition*, 1975, 3, 31-41.
- Keele, S. W., & Chase, W. G. Short-term visual storage. *Perception & Psychophysics*, 1967, 2, 383-386.
- Kelly, D. H. Theory of flicker and transient responses, I. Uniform fields. *Journal of the Optical Society of America*, 1971, 61, 537-546. (a)
- Kelly, D. H. Theory of flicker and transient responses, II. Counterphase gratings. *Journal of Optical Society of America*, 1971, 61, 632-640. (b)
- Kelly, D. H. Flicker. In L. M. Hurvich & D. Jameson (Eds.), *Handbook of sensory physiology* (Vol. 7/4): *visual psychophysics*. Heidelberg, West Germany: Springer, 1973.
- Kleinschmidt, J., & Dowling, J. E. Intracellular recordings from gekko photoreceptors during light and dark adaptation. *Journal of General Physiology*, 1975, 66, 617-648.
- Neisser, U. *Cognitive psychology*. New York: Appleton-Century-Crofts, 1967.
- Penn, R. D., & Hagins, W. A. Kinetics of the photocurrent of retinal rods. *Biophysics Journal*, 1972, 12, 1073-1094.
- Rumelhart, D. E. A multicomponent theory of the perception of briefly exposed visual displays. *Journal of Mathematical Psychology*, 1970, 7, 191-218.
- Sakitt, B. Locus of short-term visual storage. *Science*, 1975, 190, 1318-1319.
- Sakitt, B. Iconic memory. *Psychological Review*, 1976, 83, 257-276.
- Sakitt, B., & Appelman, I. B. The effects of memory load and the contrast of the rod signal on partial report superiority in a Sperling task. *Memory & Cognition*, 1978, 6, 562-567.
- Sakitt, B., & Long, G. M. Spare the rod and spoil the icon. *Journal of Experimental Psychology: Human Perception and Performance*, 1979, 5, 19-30.
- Sperling, G. The information available in brief visual presentations. *Psychological Monographs*, 1960, 74, (11, Whole No. 498).
- Sperling, G., & Sondhi, M. M. Model for visual luminance discrimination and flicker detection. *Journal of the Optical Society of America*, 1968, 58, 1133-1145.

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