Why we need iconic memory

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Haber's hypothesis is that iconic storage plays no role in visual information processing in ecologically relevant viewing situations. Within the framework of his definition, the storage hypothesis may well be correct, but his conclusion that we should expunge iconic storage from theories and textbooks does not follow.

The first problem in finding a role for iconic storage is that the term *iconic storage* – like *schizophrenia* – denotes different things to different people and none of these things is well understood. Such circumstances, obviously, are ideal for generating arguments and hopeless for settling them. Consider this: In our laboratory we believe we have isolated three levels of short-term visual information storage (Kaufman 1978; Sperling & Kaufman 1978). (I use the term *visual information storage* here in order to be neutral vis-à-vis theories). Which one (or more) of these three storages is (or are) iconic storage? Here I suspect, Haber, Neisser (who coined the term *iconic* in 1967), and others might disagree. Are all of these kinds of visual storage irrelevant to normal visual information processing? Not likely.

To bypass the semantic booby traps, let us define iconic storage as Haber does: persistence of vision which fails to survive the kind of new stimulation (masking) provided, for example, by successive visual fixations. Indeed, that kind of iconic storage probably is not important in natural viewing conditions.

But some aspects of iconic-level processing are important. How is it that stimulus effects can persist in receptors from one eye fixation to the next, and that new stimuli from the same location can jump all over the retina as the eyes move, and yet the visual world is usually seen as free of double images, stable, and devoid of the image smear generated by eye movements? These are fascinating problems, which are important and worthy of our investigation. The processes involved are intimately related to those of iconic storage. In these situations, where it is the *transformations* of information rather than the *quantity* of information that is at issue, we end up studying qualitative aspects of iconic storage (visual persistence) rather than the quantity of stored information.

But let us suppose our interest, like Haber's is not in the early stages of visual processing, but in higher levels of information processing in ecologically relevant situations. We wish to assume that details, such as cleaning up unwanted receptor persistence and retinal smear, have been taken care of, and that there is no need for iconic storage because the visual stimulus is physically available during the time that we need it. If we don't need iconic storage to store the stimulus, why then do we need iconic memory in our textbooks and in our theories? For three reasons: (1) We need iconic memory in our theories because, while our theories may intend ultimately to deal with normal perception, they are almost invariably tested with tachistoscopes (or their modern offspring, computer-driven cathode ray tube displays) and it would be pointless to have a theory that did not pertain to the experiments that purportedly established it. (2) We need iconic memory in our textbooks to keep our progeny from repeating the horrendous mistakes of our predecessors. (3) Finally, the decision to include iconic storage in an information-processing model may be influenced by an author's faith in analysis – that larger processing components will eventually be decomposed into smaller ad smaller components. Iconic storage is a very atomic process that represents an instance of successful analysis, and is therefore included in marginal cases. These reasons are now considered in more detail.

Suppose we could turn back the clock to the good old days before iconic storage. Psychologists then, as now, faced the practical problem that when the performance of a human or machine was perfect, it was difficult to discover the mechanism by which this performance came about. Tachistoscopes, then as now, were used to restrict the *time* for which information was available to the observer, with the expectation that the corresponding decrement in performance would reveal the underlying mental mechanism. We now know the flaw in this line of reasoning: As exposure duration is made smaller than 100 msec or so, the time for which visual information is available does not decrease proportionately; the apparent contrast of the visual stimulus is diminished, but not its time of availability. To measure the time for which brief stimuli are visually available, two new methods were developed: the method of partial report, based on Kulpe's (1904) introspective procedure (Sperling 1960), and the method of auditory synchronization (Sperling 1967). The auditory sunchronization method (adjusting the time of occurrence of a click to coincide with the beginning and end of a visual image) was used to great advantage by Haber and Standing (1969) and by Efron (1970b) to measure the apparent duration of brief visual exposures. All these methods show that with extremely brief exposure, visual information is available for at least 100 msec and frequently 200 msec or more. In the past, the misinterpretation of brief tachistoscopic exposures as controlling available processing time of visual stimuli led to misinterpretations of tachistoscopic experiments. Nobody would suggest today that if a 5 msec exposure sufficed for the identification of some letters or words, the reading time of the letters or words was 5 msec.

Once it has been established that information from a brief visual stimulus persists in a visual store long beyond the termination of the exposure, the problem becomes one of controlling the persistence. Again the solution is based on an old procedure: a postexposure blanking field, introduced by Exner (1868) and effectively used by Baxt (1871) in Helmholtz's laboratory. The modern innovation is replacing the blank postexposure field with a much more efficient masking stimulus, a visual noise field (Averbach & Sperling 1961, p. 202; Sperling 1963). In 1958 I first mailed copies of noise stimuli to colleagues urging them to use them. Today, most investigators seem to be sensitive to iconic storage problems in tachistoscopic experiments, and the use of visual noise and related masking stimuli seems to be universal. In order to understand the experiments with postexposure masking stimuli scattered throughout textbooks on visual information processing, the background provided by a chapter on iconic storage is essential.

There are other important phenomena related to iconic storage. Subjects in tachistoscopic experiments frequently make the curious observation that they saw more than they remembered. Explanations for provocative phenomena of this kind are best introduced within the framework of information-processing models; iconic memory was the original example and is a good place to begin. A score of interesting experimental techniques, together with correspondingly interesting interpretations, have evolved in the study of iconic memory. We have already mentioned partial report, auditory synchronization, and postexposure visual noise fields. A far from exhaustive list of other methods (cf. Coltheart 1980; Long 1980) that comes to mind is: picture completion (two time-separated partial stimuli are combined iconically to produce a coherent whole), introduced by Eriksen and Collins (1967) and significantly improved by Hogben and Di Lollo (1974); action spectrum of complex mental phenomena (determining the equivalent energy required for a constant level of performance as the wavelength of stimulus illumination is varied), Sakitt (1976); interruption and flicker methods which relate iconic persistence measurements to visual psychophysics (Wundt; Coltheart 1980); and the study of errors. In the first report on iconic storage, errors – acoustic confusions between B and D, D and T – were observed to occur in a task in which stimuli were presented visually and reported in writing, a task in which items were never overtly represented in an acoustic form (Sperling 1960, p. 21; Sperling & Speelman 1970, p. 152). The study of such errors by Conrad (1964) and many others has had an important influence on cognitive psychology; the impetus came from the study of iconic storage. Knowledge of the parallels (and differences) between the methods used to study visual and auditory memory, particularly iconic and echoic memory, is critical for students who wish to gain a mastery of the modern technology of human information processing. When it comes to iconic memory, they need the full chapter.

With respect to the inclusion of iconic storage in theories, I surveyed the half-dozen recent textbooks that were being considered by our department for a course in Human Information Processing. Iconic storage and iconic memory occur as (visual) sensory memory, (visual) sensory store, and preperceptual visual store, in contrast to short-term visual memory which is assumed not to be sensory. Iconic storage occurs in models which are used to explain the original tachistoscopic experiments that led to the concept, the word/letter phenomenon, visual search and automatic detection, paired-comparison probe experiments, and so on. According to this sample, iconic storage occurs in models that deal with tachistoscopic presentations and not in models that deal directly with everyday experiences, although some authors are not at all hesitant to suggest possible everyday parallels. The conclusion of this survey is that, where iconic storage occurs in information-processing models, it is required by the kind of laboratory data on which these models are based. While some might lament that there is not more of ecological relevance being offered in these chapters, personally I think a good start is being made. A review of my introductory physics books shows much of theoretical importance, but little of direct practical use.

I specifically mentioned physics because classical physics – for better or for worse – has long represented the kinds of hierarchical models that captivate psychologists. Solids are composed of molecules, which are composed, in turn, of atoms, subatomic particles, and so on. The laws at higher levels can, in principle, be derived from the properties of lower levels. Recently, psychologists have begun to focus on an analogous hierarchy of levels in computer science: There are programs which call subroutines, which in turn call lower level subroutines, which are composed of statements in a high-level language, which compile into machine language statements, which are executed by microcode, and so on.

Wouldn't it be nice if behavior, like reading, could be decomposed into a succession of acts of apprehension, and if each such act could be further decomposed into processes such as registering, decoding, and interpreting information? We know now that reading is quite complex, involving many overlapping processes. But it wasn't so long ago that the span of apprehension was taken as an irreducible individual constant. As a consequence of the research on iconic storage, we now know that what is reported from a brief visual exposure – the measure of the span of apprehension – depends on component processes such as iconic storage, scanning, rehearsal, and the like. The span – the atom of the first half of this century – has been split. Undoubtedly, the resulting components themselves will again be split. One of the attractions of doing research on visual information processing is the opportunity of developing and testing quantitative theories about mental microprocesses by using carefully chosen but readily available visual stimuli. I believe that the fascination with microprocesses is what led to the deluge of reaction-time experiments following Sternberg's (1969) introduction of an additive factors methodology. The iconic/tachistoscopic and RT experiments that allow us to infer mental microprocesses have not, as of now, made great inroads to the higher-level practical questions which concern Haber any more than did the experiments on atomic physics in the early part of this century. This new style of experimentation and theory – modern human information processing – has been under way for 20 to 25 years. There is no guarantee that it will ever lead to anything more fundable than "understanding." Whether out of deep curiosity or the hope of future explosive practical impact, the style of research exemplified by the iconic memory experiments has interested many psychologists and found its way into their theories and texts. From the looks of things, it will remain there for a while.

Sperling, George. Why We Need Iconic Memory. <u>The Behavioral and Brain Sciences</u>, 1983, <u>6</u>, 37-39.

(A commentary and reply to: Haber, R. N. The Impending demise of the icon: A critique of the concept of iconic storage in visual information processing.)