Comment on Hawkins and Shulman's Type I and Type II visual persistence

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In an interesting theoretical note, Hawkins and Shulman (1979) recently attempted to ascribe certain discrepancies in the visual persistence literature to differences in the portion of the stimulus decay function attended to by observers. Specifically, they proposed that if observers focus upon the subjective offset of a target stimulus on some persistence task, they are, in effect, responding to the minimal detectable difference between the actual stimulus and its sensory residual. Given a gradually decaying, negatively accelerating trace, or icon, of the stimulus following its physical offset, such a persistence task would then exhibit an *inverse* relationship between stimulus luminance and the duration of the obtained persistence estimates. And, in fact, several investigators have reported such a relationship between target luminance and visual persistence (e.g., Bowen, Pola, & Matin, 1974; Efron, 1970a, 1970b, 1970c; Hansteen, 1971). Hawkins and Shulman refer to the persistence revealed by such tasks as Type I persistence. However, Hawkins and Shulman also suggest that observers may be able to respond to the minimum detectable residual or trace of the terminated stimulus. On a persistence task assessing this total duration of the gradually fading icon, a *positive* relationship between stimulus luminance and the duration of persistence is predicted. And, again, various investigators have reported this relationship on several iconic memory tasks (e.g., Eriksen & Collins, 1968; Keele & Chase, 1967; Sakitt, 1976). Hawkins and Shulman refer to the persistence revealed on these alternate persistence tasks as Type II persistence. This rational distinction between two types of visual persistence appears to provide a rather appealing solution to empirical contradictions that dominate the current persistence literature. The purpose of the present note is to extend the Hawkins and Shulman proposal by reference to recent empirical findings and to suggest possible physiological processes that may underlie the two types of persistence.

Concerning the supporting empirical evidence, Sakitt and Long (in press; Long, 1979) have demonstrated that observers are, in fact, able to distinguish target offset from the gradually fading image of the target. For a given target stimulus, observers provide quite different persistence estimates, depending upon which of the phenomenally available, poststimulus events they are instructed to attend to. Moreover,

consistent with the Hawkins and Shulman prediction, these different persistence estimates exhibit *opposite* relationships with target luminance. Persistence estimates related to perceived offset of the target show an inverse relationship with luminance; persistence estimates related to the end of the fading trace show a positive relationship with luminance. Needless to say, these results provide rather strong support for the Hawkins and Shulman proposal that differential aspects of a single decay function underlie performances on different persistence tasks. However, additional work has also indicated that such a single-process model of persistence as they (and others) propose may be somewhat oversimplified.

Sakitt (1975, 1976) and Sakitt and Long (1978, 1979) have reported evidence that traditional iconic memory, or short-term visual storage, has both cone and rod contributions, but with the rods providing the bulk of such persistence. Under typical viewing conditions, this finding in effect subdivides Hawkins and Shulman's Type II persistence into two parallel components: a long-lasting rod portion and a briefer cone portion. Both these "icons" show a positive relationship with target luminance.

With regard to Type I persistence, the suggestion has been made by previous investigators that so-called off-responses in the visual system may be involved on some persistence tasks (Bowen et al., 1974; Hansteen, 1971; Phillips & Singer, 1974). It is well known that there are cells in the vertebrate visual system, at least as early as the ganglion cells (Hartline, 1938), that respond to the offset of a stimulus; and this "transient" signaling is found up through cortical levels (cf. Breitmeyer & Ganz, 1976; Legge, 1978). And most importantly, the latency for firing in these cells to the offset of a stimulus is inversely related to the luminance of that stimulus. If an observer has access to this transient information, the latency for the off-response in the visual system could underlie what Hawkins and Shulman have referred to as Type I persistence. Most recently, Sakitt and Long (in press) have formally made this proposal to account for numerous persistence results—like Brown et al.'s, Efron's, Hansteen's, and others'—while attributing the more pronounced, generally longer lasting persistence effects (Type II persistence) to the probable photoreceptor sluggishness described above. In addition, the finding by Sakitt and Long (in press) that performance with colored stimuli on the former type of persistence task (i.e., latency for perceived target offset) exhibits photopic (cone) spectral sensitivity appears to localize that persistence in the cone system—at least under the conditions tested.

Figure 1 (a and b) represents an attempt to present schematically the proposals described in the

Figure 1. Hypothetical characterization of multiple poststimulus events to which an observer has access following a brief presentation of a high luminance target (a) and a low luminance target (b). It is assumed that the target is presented to an area of the retina that has both rods and cones, that the target is above threshold for both the rod and cone systems, and that the background level is insufficient to saturate the rod system.

preceding paragraphs. In contrast to Hawkins and Shulman's model, which proposes a single, monotonically decaying trace of the stimulus following its physical offset, three separate phenomenal events are depicted in the brief time after a stimulus is terminated. Replacing Hawkins and Shulman's Type II persistence are both cone- and rod-based persistences, or icons. As described by Sakitt and Long (1978, 1979; Sakitt, 1976), these are believed to be the primary bases for performance on most of the traditional iconic memory tasks, such as Sperling's (1960) partial report task and Eriksen and Collins' (1967, 1968) successive-field task. As seen in a comparison between parts a and b of Figure 1, both these rod and cone icons increase in duration with increasing target luminance.

Representing the possible locus of Hawkins and Shulman's Type I persistence is the latency for off-responses also indicated in the figure. These transient signals are shown, rather arbitrarily, as brief events whose subjective magnitude is directly related to stimulus luminance but whose latency for occurrence is inversely related to this variable. It is believed that the multiprocess view of visual persistence represented in Figure 1 provides a valuable working model of the factors underlying many of the persistence tasks that have been devised. It should be emphasized most emphatically that several aspects of the processes depicted in the figure are portrayed rather arbitrarily. For example, is the cone icon equal in subjective magnitude (brightness or clarity) to the rod icon at

$t=0$ msec as the figure indicates? Are the transient off-responses best represented as a normally distributed variable with a sliding mean value as target luminance is varied? Hopefully, further research will answer these questions. Nonetheless, it is proposed that the suggested functions depicted in the figure represent a significant improvement over current conceptualizations of visual persistence. Not only is this multiprocess model consistent with the results in the vast iconic memory literature, but it may also provide testable hypotheses concerning the effect of variables that can be expected to influence the various "types" of persistence in predictable ways. Some obvious examples of such variables include retinal location of the stimulus, background level, the state of adaptation of the eye, acuity requirements of the particular iconic task, stimulus wavelength, stimulus duration, eye movements, and probably many others.

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