Visual aging: A transient/sustained shift?

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One of the more consistently observed sensory/perceptual changes accompanying adult aging is a loss in the temporal resolving power of the visual system. Stimuli appear to show greater persistence in the older nervous system, and temporally contiguous events which can be seen as separate by younger observers are often indistinguishable to the older individual. Older persons show a well-documented decline in critical flicker frequency (CFF) threshold (e.g., McFarland, Warren, & Karis, 1958) and have greater difficulty escaping from visual masking (e.g., Kline & Szafran, 1975; Walsh, 1976). They also appear able to integrate form stimuli over longer intervals of time (Eriksen, Hamlin, & Breitmeyer, 1970), an ability which may account for their superior identification of words presented sequentially as corresponding halves (Kline & Orme-Rogers, 1978). It is proposed here that the interacting transient and sustained neural channels of the visual system age differentially and that this hypothesis provides a powerful means for understanding age-related change in the resolution and persistence of visual stimuli.

Converging evidence from both electrophysiological and psychophysical research indicates that sustained channels respond primarily to finely patterned targets (i.e., those of high spatial frequency) presented for prolonged intervals. Thus, sustained channels are responsible for mediating the perception of form. As implied by the name, these channels respond slowly and have a relatively long response persistence or integration time. Transient channels, however, are most sensitive to targets of low spatial frequency and respond optimally to rapid stimulus change, such as motion or flicker (see Breitmeyer & Ganz, 1976). In addition, transient channel cells have a short response latency and, when activated, appear to inhibit the prolonged activity of the sustained cells (Breitmeyer, 1975; Singer & Bedworth, 1973). Consistent with the demonstrated response characteristics of the transient and sustained channels, increases in the spatial frequency of the visual display from very low to high levels seems to be accompanied by increases in perceptual latency (Lupp, Hauske, & Wolf, 1976), the critical duration of form integration (Breitmeyer & Ganz, 1977; Legge, 1978) and in the duration of stimulus persistence (Bowling, Lovegrove, & Mapperson,

1979). It is intriguing to note that the temporal response profile of the young visual system to increases in spatial frequency seems to mirror the one which occurs with adult aging. That is, the aged visual system can be well represented as one which has experienced a relative loss in the efficacy of the transient mechanisms and, consequently, has become "sustained-channel dominant." Disjunctive aging of the two systems does not seem implausible, since the maturation of the sustained visual channels lags behind that of the transient channels (Boothe, Williams, Kiorpes, & Teller, 1980; Moskowitz & Sokol, 1980). Certainly, there is considerable evidence consistent with such a view of the aging visual system.

There are several studies which suggest a loss with age in the reactivity of the transient channels. As already noted, there is a decline in the ability to detect flicker (McFarland, Warren, & Karis, 1958). Dynamic visual acuity also appears to deteriorate with age (Burg, 1966). Relatedly, there appears to be an age-related deficit in detecting order of stimulus offset when measured as a function of offset asynchrony (Kline & Schieber, Note 1). Most directly to the point, Sekuler and Hutman (1980) found that, compared with their young group, older subjects with good visual acuity required considerably greater stimulus contrast to achieve threshold levels of sensitivity to low spatial-frequency gratings (to which transient channels are most responsive). However, at high spatial frequencies (to which sustained channels respond), the contrast sensitivity functions of the two age groups overlapped. The authors interpreted their results as indicating a loss of transient response with age.

If the effectiveness of the transient mechanisms is, in fact, diminished in the aged visual system, the sustained response mode would be expected to become dominant (although not necessarily unimpaired) for two related reasons. First, the relative strength of the two systems would be shifted in favor of the sustained channels; second, any erosion in the strength of the transient channels would lessen their inhibition of the sustained channels (e.g., Breitmeyer, 1975; Singer & Bedworth, 1973), thus enhancing the persistence of the form stimuli to which they respond. The apparent ability of older persons to integrate form over long intervals is clearly in accord with such a change. This model can also be invoked in the context of contemporary sustained/transient theories of visual masking (e.g., Breitmeyer & Ganz, 1976) to explain the protracted susceptibility of older persons to visual masking.

It is clear that there is an age decrement in the ability to track sequential visual events and mounting evidence that at least some of this loss can be attributed to greater persistence of visual stimuli in the senes-

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cent nervous system. A general persistence model, however, has only modest value for understanding these complex phenomena. Clearly, a model is needed which posits specific mechanisms to account for their occurrence. Pollack (1978) has suggested one such model based on research which places the stimulus persistence mechanism at the photoreceptor level (Sakitt, 1976; Whitten & Brown, 1973). The transient/sustained shift model offered here is another, not necessarily incompatible alternative, which places its emphasis on a neural rather than a photoreceptor mechanism. Its utility, however, will need to be evaluated by testing the many hypotheses it generates. Presumably this research would include systematic assessment of age differences in the discrimination of contiguous visual stimuli as a function of contrast level, duration, spatial frequency, and retinal location.

REFERENCE NOTE

1. Kline, D. W., & Schieber, F. *Visual persistence and temporal discrimination*. Paper presented at the Symposium on Aging and Human Visual Function, National Academy of Sciences, Washington, D.C., April 1980.

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