Does Subitizing Depend on the Magnocellular Visual Pathway?

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Introduction

Visual search of a multi-element display leads, under certain conditions, to "popout" or preattentive perception of a unique or highly salient item in the display (Treisman, 1988). What might be the neural locus of mechanisms underlying such preattentive visual perception? Visual processing occurs along two relatively distinct pathways, termed the magnocellular (M) and parvocellular (P) pathways (Livingstone & Hubel, 1987). Since responding and orienting rapidly to salient features in the environment carries a high survival value, we hypothesized that the phylogenetically older M pathway preferentially mediates the preattentive processing leading to eventual capture of attention by the stimulus of immediate interest.

Due to a number of physiological differences in the response properties of neurons in the two pathways, their relative contributions to visual perception can be psychophysically dissected (Livingstone & Hubel, 1987). For instance, perception of colored stimuli on an isoluminant background depends exclusively on chromatic cues and thus predominantly on the P system, the M system being relatively uninvolved (Livingstone & Hubel, 1987). We predicted that this should selectively impair preattentive, parallel visual processing while leaving later, serial processing relatively unaffected.

The task chosen for this examination was subitizing; the ability to rapidly and accurately enumerate small sets of items (e.g. Trick & Pylyshyn, 1994). Subitizing is a robust phenomenon that has recently been associated with preattentive mechanisms. For example, Trick & Pylyshyn (1994) showed that, when adults were asked to enumerate target letter Os in a field of distractor Xs (a condition where the targets typically "pop out"), the standard subitizing profile was observed. This is a small reaction time slope of around 50ms per item for collections of up to 4 items with a steeper slope in the range of 300ms for larger sets. However, when the Xs were replaced by distractor Qs (thus inducing attentive visual search for targets) reaction time was linearly related to the number of items being enumerated for all set sizes. Since subitizing is apparently possible only when preattentive mechanisms are in operation, we reasoned that it might be affected by manipulations affecting preattentive processing. We therefore adopted a subitizing task to test the hypothesis that preattentive, parallel visual processing depends preferentially on the M system.

Methods and Results

In a within-subjects design, subjects had their isoluminance point individually established and then were presented with 1 to 8 green rectangles which were either isoluminant with (ISO) or considerably greater in luminance (NI) than a red background. Their task was to report as quickly as possible how many rectangles they saw. Presentation time was terminated by subject response. We predicted that enumeration performance would be affected detrimentally by the isoluminant stimuli only and that the effect would occur only in the subitizing range. Our data showed a subitizing span of 3 objects for both ISO and NI stimuli. Within subitizing there was a significant increase in mean reaction time (of about 15 ms) for the ISO stimuli over the NI stimuli ($F(1,29) = 20.70$, $p < .001$). Outside the subitizing range, performance was not significantly different ($F(1,29) = .14$, $p = .713$). Thus, our initial results are as predicted. While further research is needed in order to examine this effect in greater detail, our findings appear to support the suggestion that the magnocellular visual pathway is the preferential processing route for a subitizing task; one that is closely associated with preattentive visual processing.

References

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