Direct selection by color: Uncertainty reduction or signal enhancement?

Esther Vierck & Jeff Miller
Department of Psychology, University of Otago, Dunedin, New Zealand

Introduction

Recent research has provided evidence for a direct benefit of color cuing on perceptual selection, beyond the benefits attributable to selection of the locations of cued-color items (Vierck & Miller, 2005).

This direct color cuing benefit might result from either (or both) of two mechanisms: signal enhancement and uncertainty reduction. Signal enhancement refers to an *increased sensitivity to items in the cued color*, often assumed to stem from the allocation of more perceptual processing capacity to these items.
Uncertainty reduction views color benefits as resulting from *decreased sensitivity to distractor items in the non-cued colors*. On this view, color cues allow observers to give extra relative weight to the perceptual information from the cued item, thereby reducing statistical noise in the perceptual decision process by suppressing the contribution of confusable distractor items.

Research question

Multiple-item displays are not suitable for distinguishing between signal enhancement and noise reduction, because the two theoretical alternatives predict similar cuing benefits with such displays. To distinguish between these alternatives, then, we employed single-item displays.

If color cuing benefits result from signal enhancement, such benefits should be found even with single-item displays. Allocation of attention to the correct color should enhance processing of the presented target stimulus even if there are no distractors to be suppressed. If uncertainty reduction is responsible for color cuing benefits, on the other hand, then no cuing effects should be observed in single-item displays, because there are no distractor items to be suppressed.

Task and Stimuli

In each trial participants were asked to report which one of four possible geometrical forms was presented. Each target form was presented at the center of the display in either red or green, equated for luminance, followed by a mask. Target display duration was adjusted adaptively to keep overall performance in the range of 40%-60% (chance = 25%).

Experiment 1

In each trial a red or green X was presented as a color precue (Fig. 1). The color of the subsequent target form either matched that of the precue (valid condition, 80% of trials) or mismatched (invalid condition, 20%). To ensure that participants processed the cues, they were asked at the end of each trial to indicate in which color the cue had been displayed.

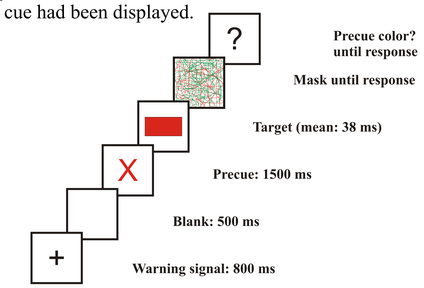

Figure 1. Example representation of a valid trial in Experiment 1.

Predictions

If color cuing produces signal enhancement, then form discrimination accuracy should be better in valid trials than in invalid trials. If color cuing produces uncertainty reduction, discrimination accuracy should not depend on cue validity.

Results

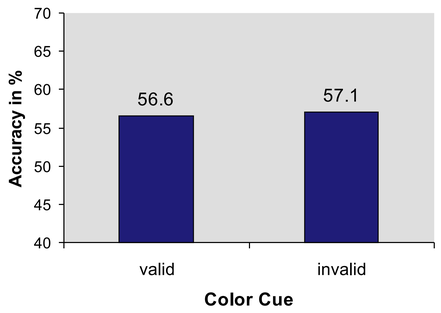

Figure 2. Average accuracy in % as a function of color cue and validity in Experiment 1.

Conclusions

There was no validity effect in this experiment with single-item displays. These results suggest that color cues do not produce signal enhancement.

Experiment 2

The absence of a cuing effect in the first experiment might be due to a color repetition disadvantage similar to that reported by Fox and de Fockert (2001). They found that repeating the stimulus color actually slowed target detection. Perhaps, then, repetition of the color from the cue to the subsequent target stimulus reduced discrimination accuracy in the valid condition of this study. To exclude this possibility we conducted an experiment using stimulus probability rather than cues to create color expectations. No cue was presented; instead, targets were displayed in one color in 80% of all trials and in the other color in 20%.

Predictions

If signal processing is enhanced for stimuli in the expected color, discriminations should be more accurate in trials where the expectation is met (the geometrical form is in the high probability color) than in trials where it is not met.

Results

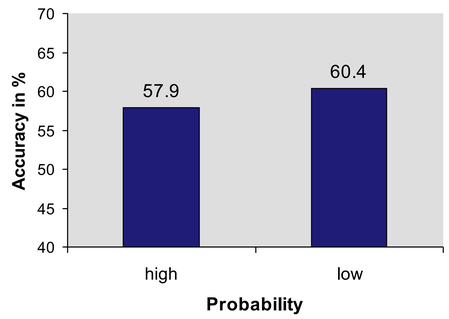

Figure 3. Average accuracy in % as a function of color probability in Experiment 2.

Conclusions

Performance did not differ for the two probability conditions. This again indicates that expectations for a stimulus in a particular color do not enhance the perceptual processing of stimuli in that color within a single-item display.

General Conclusions

- With single-item displays, there is no evidence for enhanced processing of stimuli in an expected color relative to an unexpected color.
- Previously observed performance benefits associated with color cuing are probably not due to signal enhancement.
- Uncertainty reduction therefore seems to be the most likely explanation of previously observed color cuing benefits beyond those attributable to selection of locations containing the cued color.
- Because signal enhancement has previously been shown to be a factor in location cuing effects (e.g., Bashinski & Bacharach, 1980), the underlying mechanisms of location and color cuing may differ.

References

Bashinski, H. S. & Bacharach, V. R. (1980). Enhancement of perceptual sensitivity as the result of selectively attending to spatial locations. *Perception & Psychophysics*, 28, 241-248.

Fox, E., & de Fockert, J.-W. (2001). Inhibitory effects of repeating color and shape: Inhibition of return or repetition blindness? *Journal of Experimental Psychology: Human Perception and Performance*, 27, 798-812.

Vierck, E. & Miller, J. (2005). Direct selection of color for visual encoding. *Perception & Psychophysics*, 67, 483-494.

Acknowledgments

This research was supported in part by a Marsden grant from the Royal Society of New Zealand to Jeff Miller.

Further details available at:
http://www.psychonomic.org/PP/forthcoming.htm