IS THERE INHIBITION OF RETURN FOR ISOLUMINANT COLORS?

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Abstract

In the present study we replicate experiments of Lupiañez et al. (1997) who addressed the issue of inhibition of return with respect to the color of stimuli. In contrast to that study, using non-isoluminant stimuli, we employed two pairs of isoluminant colors varying along either the red-green or blue-yellow cardinal axes of a color space – deutan or tritan confusion lines in the CIE 1976. Participants (normal trichromats; n=8) were exposed successively to the color pairs; their task was to respond to the second (target) stimulus by key pressing, whereby simple reaction times were measured. In different trial stimulus onset asynchrony (SOA) was varied: 100, 400, 700, 1000 and 1300 ms. At no SOA inhibition of return was found; instead, facilitation of return was demonstrated, this especially pronounced at the short SOA=100 ms. We found that participants were overall faster in the invalid condition when compared to the valid condition (F=25.986, p=0.001). We hypothesized that when isoluminants colors are employed as both cue and target, Inhibition of Return can't be establish.

Attention has a crucial role in the process of identifying and selecting relevant objects in a visual environmentof an organism. This process should be rapid in order to move attention from one location to another and, thus, improve discrimination and overall efficiency at the attended location. Immediately following an event at a peripheral location, there is facilitation in time in the processing of other stimuli near that location, this is said to reflect a reflexive shift of attention towards the source of stimulation. However, after attention has been removed from such peripheral location, a delayed responding to stimuli displayed there subsequently is registered. This inhibitory effect was coined by Posner and Cohen (1984) as inhibition of return (IOR). It is suggested that IOR encourages orienting towards novel locations and, hence, might facilitate foraging and other search behaviors (Klein, 2000; Riggio et al., 2004). Despite its relatively recent "discovery", IOR was and still is the focus of considerable amount of research in the last years.

The time course of this phenomenon is closely related to the attentional resources that the involved task requires. For instance, in a simple luminance-detection task, IOR starts around 225 ms after the onset of the target (Posner & Cohen, 1984); but when the task is more attentional demanding, IOR occur much later (Lupiáñez & Milliken, 1999) and could last for several seconds.

With respect to the color dimension, some authors expressed doubts on whether the IOR phenomenon could occur (Klein & Taylor, 1994; Terry et al., 1994). However, later a color-based IOR was indeed demonstrated (Law et al., 1995; Lupiáñez et al., 1997).

The Opponent Color Theory of the 19th century physiologist Ewald Hering (1964) derived by the analysis of subjective human color vision. Certain colors are not perceived together, i.e. they do not mix; for instance we never see bluish-yellows or reddish-greens.

Cone-opponency is constructed by the retina, starting at the outer layer level from cones sensitive to long (L), middle (M), and short (S) wavelengths by superimposing excitatory (ON) and inhibitory (OFF) signals from different parts of the visible spectrum (400-700 nm). Ganglion cells compare photon catches between L and M cones creating the L/M opponent axis in acone space. Small and large bistratified cells relay ON signals from S cones and OFF signals from L and M cones, giving rise to the S/(L+M) axis. These ganglion cells send their outputs to the Lateral Geniculate Nucleus, which in turn projects at least three parallel pathways (magno-, parvo-, and koniocellular) to V1. (Chatterjee et al., 2003).

The present study aimed at reexamining the inhibition of return to color by using the paradigm employed by Lupiáñez et al. (1997) in their detection experiments. However, we elaborated a modified approach with respect to stimulus chromaticity: instead of non-isoluminant colors used by those authors as cue and targets, isoluminant colors varying along deutan or tritan confusion lines of a color space were employed (Canto-Pereira et al., 2005, 2006).

Method

Participants. Undergraduate students (n=8) from the Ludwig Maximilian University, participated in the experiments. Inclusion criteria were (i) normal color vision as assessed with the City University Dynamic Colour Vision Test (Barbur et al., 1994) and (ii) 20/25 Snellen best-corrected visual acuity.

Apparatus. For stimulus presentation, we used a calibrated 17' Hitachi CM752ET monitor with a refresh rate of 100 Hz and a resolution of 1024 x 768. E-Prime software (Schneider et al., 2002) was used for stimulus presentation and response registration. A Minolta CS-100 colorimeter was used to measure the stimuli's u'v' color coordinates and luminance as well. Subjects sat in front of the monitor at a distance of 57 cm; head position was maintained by a chin rest. Experiments were performed in a darkened and sound proof room. Eye movements were monitored through Eye Link 2.01 (SMI GmbH).

Procedure. Prior to data collection, subjects will go through a training session to allow them to be acquainted with the procedure. Subjects were required to keep their gaze on a small white cross in the center of the computer screen which had a gray background (10.1 cd/m2). The target on each trial appeared in the center of one of two black square frames, displayed to the left and right of fixation. The frames remained on the screen throughout each trial and disappeared at the end of the trial. The frames subtended 3.5º x 3.5º of visual angle. The inner edge of each box was 7.5º from the fixation point. On every trial, at varying temporal intervals before presentation of the target, in one of the two boxes one of the four colors were flashed for 50 ms before returning to its original gray, this constituted the cue. The colors used as stimuli, cue and target, were isoluminant (10.1 cd/m2) and their u'v' coordinates were: blue (0.208, 0.367), yellow (0.180, 0.556), green (0.137, 0.458) and red (0.253, 0.439). A trial began after a 400 Hz warning tone (150 ms). After that a fixation cross located in the center of the screen were presented (1000 ms); followed by a cue (violet, yellow, purple or turquoise) (50 ms); the fixation point and the boxes remains on the screen for 50, 350, 650, 950, or 1,250 ms, depending on the stimulus-onset asynchrony (SOA) for that trial. Following this interval, the target was displayed for 50 ms, and then the fixation point and boxes are again displayed alone until the subject's response, or for a maximum of 2,000 ms, if no response was made within 2,000 ms, the next trial begins. The interval between trials was 1,000 ms in duration, and the screen remained gray throughout this interval.

Participants were requested to respond as quickly as possible to the onset of the target by pressing the key "5", with the index finger of the dominant hand, on a keypad connected to the PC's USB port. Reaction times (RTs) were registered with 1 ms accuracy

(Schneider et al., 2002). Catch trials, without a target, comprised 20% of total presentations, to which participants were instructed not to respond. A 250 Hz error tone (150 ms) sounded whenever there was an error, either a response made before the target onset, or no response within 1000 ms, or a response given on a catch trial. The sequence of events on each trial is showed in Figure 1.

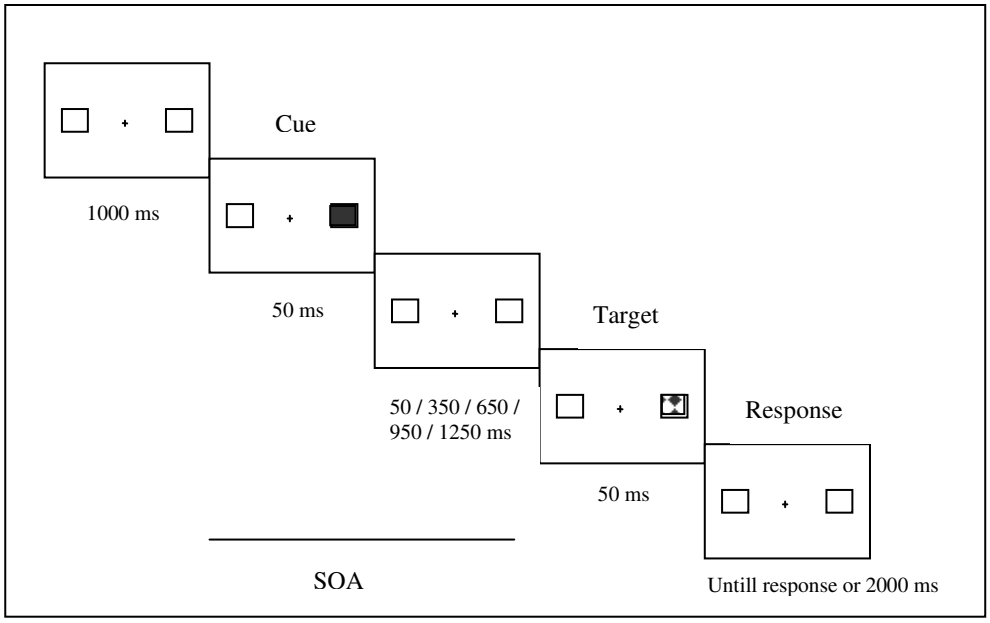

Figure 1. Time course of the experimental trials sequence, in this case was a valid condition, i.e. the target and cue were ipsilateral. Numbers indicate each event's duration.

Analysis. Errors, trials with either RTs < 150 ms or RTs > 750 ms, and false alarms on catch trials were excluded from the following analysis; trials where eye movements occurred were also excluded. For RTs in valid trials, a 5x4x4x2 General Linear Model design was used to analyze data.

Results and Discussion

Participants were overall faster in the invalid condition when compared to the valid condition ($F=25.986$, $p=0.001$); also a target ($F=31.343$, $p=0.001$) and SOA effects ($F=15.298$, $p=0.001$) were found. The following interactions were found: SOA x cue ($F=2.144$, $p=0.022$); SOA x condition ($F=6.730$, $p=0.001$) and condition x target ($F=4.652$, $p=0.012$).

Figure 2 shows overall mean RTs in both condition (valid and invalid) as a function of SOAs. Figures 3 and 4 show mean RTs in both conditions (invalid and valid respectively) for the four targets (yellow, blue, green and red) as a function of the cues (yellow, blue, green and red).

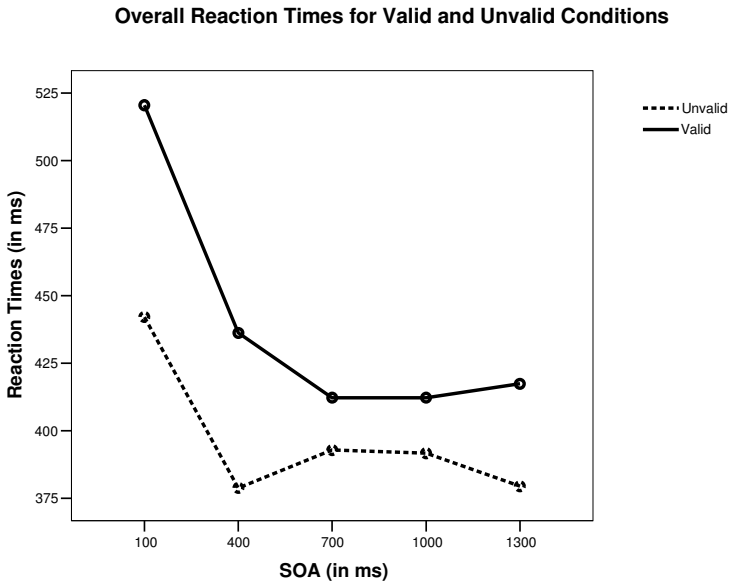

Figure 2: Overall RTs to targets as a function of SOAs and condition.

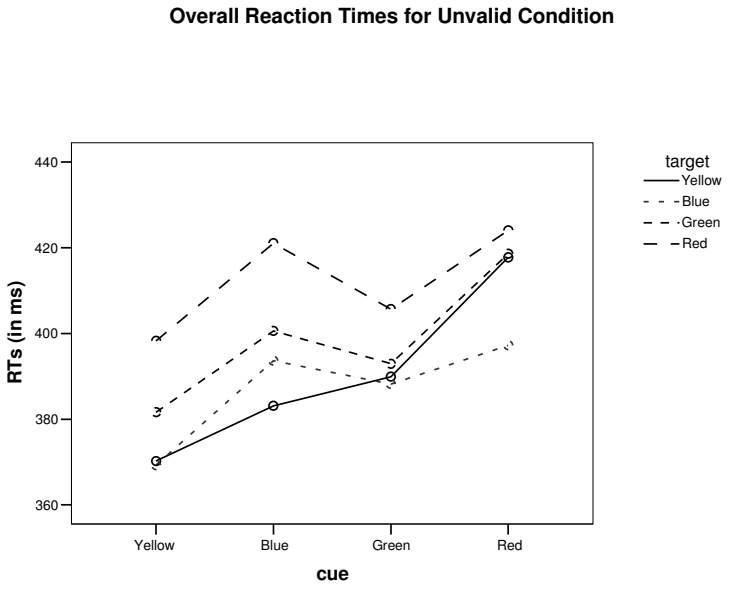

Figure 3: RTs in the invalid condition as a function of cue and target stimuli.

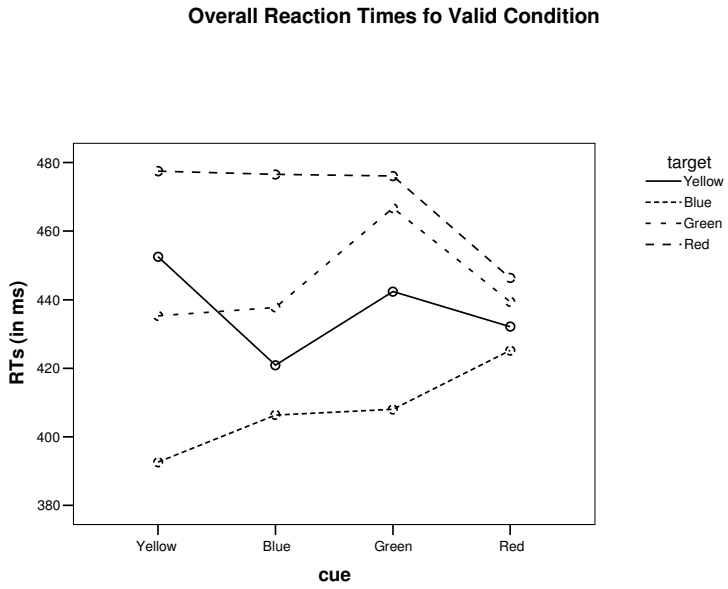

Figure 4: RTs in the valid condition as a function of cue and target stimuli.

In this study we argued that no IOR effects could be found at any SOA and it appears that luminance differences between both cue and target were the solely player in previous studies that demonstrate such phenomenon (Law et al. 1995; Lupiañez et al., 1997) as suggested by Canto-Pereira et al. (2006).

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References

Canto-Pereira, L.H.M., Lago, Lago, Costa, M. F., Rodrigues, A. R., Saito, C., Silveira, L. C. L. and Ventura, D. F. (2005). Visual impairment on dentists related to occupational mercury exposure. Environmental Toxicology and Pharmacology, 19, 517-522.

Canto-Pereira, L.H.M., Paramei, G.V., Morya, E. and Ranvaud, R.D. (2006) Inhibition or facilitation of return: Does chromatic component count? Visual Neuroscience (in press).

Chatterjee, S. and Callaway, E.M. (2003). Parallel colour-opponent pathways to primary visual cortex. Nature 426, 668–671.

Klein, R. M. and Taylor, T. L. (1994). Categories of cognitive inhibition with reference to attention. In D. Dagenbach and T. H. Carr (Eds.), Inhibitory mechanisms in attention, memory and language (pp. 113-150). New York: Academic Press.

Klein, R. M. (2000). Inhibition of return. Trends in Cognitive Sciences, 4, 138-147.

Hering, E. (1964) Outlines of a theory of the light sense. Translated by L.M. Hurvich and D. Jameson. Cambridge, MA: Harvard University Press.

Law, M.B., Pratt, J. and Abrams, R.A. (1995) Color-based inhibition of return. Perception & Psychophysics, 57, 402-408.

Lupiáñez, J., Milán, E. G., Tornay, F. J. and Tudela, P. (1997). Does IOR occur in discrimination tasks? Yes, it does, but later. Perception & Psychophysics, 59, 1241-1254.

Lupiáñez, J. and Milliken, B. (1999). Exogenous cuing effects and the attentional set for integrating vs. differentiating information. Journal of General Psychology. Special issue on attention, 126, 392-418.

Posner, M. I. and Cohen, Y. (1984). Components of visual orienting.In H. Bouma & D. Bouwhuis (Eds.), Attention and performance (pp. 531-556). London: Erlbaum.

Riggio, L., Patteri, I., and Umilta, C. (2004). Location and shape in inhibition of return. Psychological Research-Psychologische Forschung, 68, 41-54

Schneider, W., Eschman, A. and Zuccolotto, A (2002). E-Prime user's guide. Pittsburgh: Psychology Software Tools Inc.

Terry, K.M., Valdes L.A. and W. Trammell-Neill, W. (1994) Does "inhibition of return" occur in discrimination tasks? *Perception & Psychophysics*, 55, 279-286