Cognition 133 (2014) 232–237

Contents lists available at ScienceDirect

Cognition

journal homepage: www.elsevier.com/locate/COGNIT

Brief article

Differential effect of one versus two hands on visual processing

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ARTICLE INFO

Article history:
Received 18 October 2013
Revised 13 June 2014
Accepted 18 June 2014

Keywords:
Attention
Spatial attention
Hand position
Spatial sensitivity
Temporal sensitivity

ABSTRACT

Hand position in the visual field influences performance in several visual tasks. Recent theoretical accounts have proposed that hand position either (a) influences the allocation of spatial attention, or (b) biases processing toward the magnocellular visual pathway. Comparing these accounts is difficult as some studies manipulate the distance of one hand in the visual field while others vary the distance of both hands, and it is unclear whether single and dual hand manipulations have the same impact on perception. We ask if hand position affects the spatial distribution of attention, with a broader distribution of attention when both hands are near a visual display and a narrower distribution when one hand is near a display. We examined the effects of four hand positions near the screen (left hand, right hand, both hands, no hands) on both temporal and spatial discrimination tasks. Placing two hands near the display compared to two hands distant resulted in improved sensitivity for the temporal task and reduced sensitivity in the spatial task, replicating previous results. However, the single hand manipulations showed the opposite pattern of results. Together these results suggest that visual attention is focused on the graspable space for a single hand, and expanded when two hands frame an area of the visual field.

1. Introduction

Recently, interest has grown on the impact of body position on perception and particularly on how objects within the graspable space of our hands are processed visually. It is intuitively sensible that items near the hands would be preferentially processed to facilitate object identification and action planning. Consistent with this intuition, placing the hands near a display influences performance in a number of visual tasks, resulting in slower visual search rates, increased magnitude of the attentional blink, improved change detection, and slower switching between global and local features (Abrams, Davoli, Du, Knapp, & Paull, 2008; Davoli, Brockmole, Du, & Abrams, 2012; Tseng & Bridgeman, 2011). These findings suggest that there is an increase in attentional dwell time for stimuli near the hands. Hand position also impacts figure-background discrimination, such that a surface near the hand is preferentially treated as the foreground object (Cosman & Vecera, 2010), and responses to targets appearing near a hand are faster than those to targets far from the hand (Reed, Betz, Garza, & Roberts, 2010; Reed, Grubb, & Steele, 2006). These latter effects are similar to those seen at spatially attended locations in attentional cuing studies (Downing & Pinker, 1985; Posner, Nissen, & Ogden, 1978; Posner, Snyder, & Davidson, 1980). One interpretation of these results is that visual attention is preferentially allocated towards the graspable space of the hand (Reed et al., 2006).

A recent proposal for the mechanism underlying the impact of hand position on perception is that there is shift in the type of visual processing being performed (Gozli, West, & Pratt, 2012). Specifically, for locations near the hands processing is biased towards the magnocellular

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http://dx.doi.org/10.1016/j.cognition.2014.06.014
0010-0277/

visual pathway, which is sensitive to high temporal frequency (i.e., rapidly changing) and low spatial frequency information. Support for this magnocellular bias comes from evidence that when both hands are near the display, responses are more accurate in a temporal discrimination task than in a spatial discrimination task (Gozli et al., 2012). Placing both hands near the display also decreases the interference from object substitution masking, and decreases the response time for low spatial frequency compared to high spatial frequency stimuli, both of which are consistent with increased magnocellular processing (Abrams & Weidler, 2013; Chan, Peterson, Barense, & Pratt, 2013; Goodhew, Gozli, Ferber, & Pratt, 2013). Although the magnocellular bias theory provides an elegant explanation of these results, it is unclear whether the near hand visual processing differences found in single hand manipulation studies can be parsimoniously explained with this account (Cosman & Vecera, 2010; Reed et al., 2010, 2006).

One critical methodological difference in this literature is the use of one hand or both hands near a visual display. Based on this difference, we hypothesize that a single hand in the visual field may encourage a tightly focused area of attention directly within the graspable space of the hand and that a dual hand manipulation may instead encourage a larger window of attention encompassing the region between both hands. This spatial window account is analogous to theories of spatial attention that propose the size of the window of attention is adjusted to match the size of an object or cue (Castiello & Umiltà, 1990; Eriksen & St James, 1986). Further, the scale of attention might operate to bias processing toward either high temporal resolution (broad attentional focus) or high spatial resolution (narrow attentional focus). For example, a single hand near the screen may induce a focused area of visual attention. Studies using small exogenous cues have demonstrated that tightly focused attention leads to a bias towards high spatial resolution parvocellular processing (Yeshurun & Carrasco, 1998; Yeshurun & Sabo, 2012). Small exogenous cues have also been shown to reduce performance on tasks requiring high temporal resolution magnocellular based processing, suggesting that the bias towards parvocellular processing comes at the expense of magnocellular processing (Yeshurun & Levy, 2003; Yeshurun, 2004). Critically, the spatial resolution benefits and temporal resolution costs of small cues were demonstrated in contrast to large neutral cues that spanned the presentation array. This suggests that the larger cue may have led to a broad focus of attention, and that this may induced a bias towards magnocellular processing relative to the smaller cues. Further evidence of a magnocellular bias under a broad attentional window comes from demonstrations that the global-precedence effect is reduced or extinguished by reducing low spatial frequency information (Badcock, Whitworth, Badcock, & Lovegrove, 1990; Michimata, Okubo, & Mugishima, 1999; Shulman, Sullivan, Gish, & Sakoda, 1986). Placing two hands up near the screen may activate a similar underlying mechanism as a large exogenous cue or monitoring the global aspects of a stimuli, leading to a broad window of attention and subsequent bias towards the magnocellular processing pathway. An insufficient number of studies have compared single and dual hand manipulations on relevant tasks to determine if these lead to the same perceptual processing modes.

The current study was designed to directly test between the spatial window hypothesis of hand position effects and the magnocellular bias account. The tasks were an extension of those employed by Gozli et al. (2012). These tasks contrast the ability to discriminate a short temporal gap (temporal sensitivity) with the ability to discriminate a small spatial gap (spatial sensitivity). A strict magnocellular bias account predicts greater accuracy on temporal tasks for any condition in which stimuli appeared close to one or both hands. Our spatial window hypothesis makes the same prediction in the two hand near compared to two hands far comparison, but predicts improved spatial and reduced temporal sensitivity near compared to far from a single hand. Results consistent with this second prediction would indicate adjustments to the scope of the attended window leading to a bias towards spatial resolution in the single hand near condition and a bias towards temporal resolution in the two hands near condition.

2. Method

2.1. Participants

Participants were 60 University of Iowa undergraduates (41 female, 55 right handed). Half completed the spatial discrimination task, and half completed the temporal discrimination task. Participants provided informed consent prior to data collection and were compensated with course credit.

2.2. Stimuli

Displays consisted of a grey background (RGB = 55,55,55) with a white fixation dot at the center of the screen (Fig. 1A). The critical stimuli were white circles ($0.8° \times 0.8°$ of visual angle) presented one at a time with equal frequency on the left and right side of the fixation cross, with 4° from the center of the circle to fixation. Two types of circles were presented in both tasks, a gap circle (50%) and a no-gap circle (50%), depicted in Fig. 1B. The no-gap circle for both tasks consisted of an unbroken circle presented for 80 ms. For the spatial task, the gap circle had a small (0.14 radians) section removed from the top. For the temporal task, the gap circle was presented for 32 ms, blinked off for 16 ms, and then reappeared for another 32 ms. For both tasks, the gap and no-gap stimuli occurred with equal frequency on the left and right sides of fixation.

2.3. Procedure

Participants were seated facing a computer monitor at a distance of 55 cm. An instruction screen at the beginning of each block indicated the hand(s) held near the screen for that block: left hand, right hand, both hands, or no hands. For each hand condition, the hand(s) were placed near the screen such that the middle finger touched a green dot on