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Hand proximity—not arm posture—alters vision near the hands

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Abstract Recent research has revealed remarkable changes in vision and cognition when participants place their hands near the stimuli that they are evaluating. In this paradigm, participants perform a task both with their hands on the sides of the monitor (near) and with their hands on their laps (far). However, that experimental setup has typically confounded hand position with body posture: When participants had their hands near the stimuli, they also always had their hands up around shoulder height. Thus, it is possible that the reported changes "near the hands" are instead artifacts of this posture. In the present study, participants performed a visual search task with their hands near and far from the stimuli. However, in the hands-near condition, participants rested their hands on a table, and in the hands-far condition, they had their arms raised. After eliminating the postural confound, we still found evidence for slower search rates near the hands—replicating earlier results and indicating that the hands' proximity to the stimuli is truly what affects vision.

Keywords Visual search · Visual perception · Embodied cognition

Previous research has shown that stimuli near the hands are viewed and processed differently from those far away from the hands. For example, participants respond more quickly (Reed, Betz, Garza, & Roberts, 2010; Reed, Grubb, & Steele, 2006) and accurately (Dufour & Touzalin, 2008) to targets presented near an outstretched hand. In addition, the area near a hand receives biased "figure" representation in early perceptual figure–ground segregation (Cosman & Vecera, 2010). Participants also exhibit slower rates of visual search (Abrams, Davoli, Du, Knapp, & Paull, 2008), improved visual short-term memory (Tseng & Bridgeman, 2011), and enhanced cognitive control (Weidler & Abrams, 2013) when both of their hands are held near the stimuli being judged. Furthermore, participants take longer to switch between global and local decisions at brief delays (Davoli, Brockmole, Du, & Abrams, 2012), exhibit impaired semantic processing (Davoli, Du, Montana, Garverick, & Abrams, 2010), and reveal slower rates of learning about complex images (Davoli, Brockmole, & Goujon, 2012) when the stimuli are near their hands (for reviews, see Brockmole, Davoli, Abrams, & Witt, 2013; Tseng, Bridgeman, & Juan, 2012).

The various changes in vision and cognition for objects near the hands are thought to reveal the importance of thoroughly evaluating objects near the hands, because such objects may pose some danger, or may need to be manipulated (e.g., Abrams et al., 2008). Supporting those ideas, some researchers have reported that the changes appear to arise from selective activation of the magnocellular visual channel, which is involved in the control of action (Gozli, West, & Pratt, 2012; Weidler & Abrams, 2012). Finally, it is likely that bimodal visuotactile neurons that respond to both visual and tactile stimuli in the space surrounding the hands (e.g., Graziano & Gross, 1993) also play a role in making perception near the hands unique (e.g., Adam, Bovend'Eerdt, van Dooren, Fischer, & Pratt, 2012; Reed et al., 2010; Reed et al., 2006).

Researchers have succeeded in eliminating many potential alternative explanations of the previously described changes in vision for objects near the hands. For example, the effects of hand proximity remain when participants cannot see their hands (because the hands are shielded by blinders; Abrams et al., 2008; Reed et al., 2006), or when participants do not respond with their hands (and instead use

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foot pedal responses; Abrams et al., 2008). In addition, the effect does not seem to occur because additional effort is needed to hold the hands near the stimuli (Davoli et al., 2010).

Nevertheless, most previous research examining the effects of hand proximity has confounded the participant's arm position with hand proximity. In particular, in the experiments noted earlier (and in others), the visual display was positioned in front of the participant at approximately eye level. As a result, holding the hands near the stimuli required the participant to raise their arms, whereas holding the hands far from the stimuli allowed the participant to rest their arms on a flat surface. Thus, it is possible that the changes in vision and cognition that have been reported "near the hands" may have arisen simply because participants held their hands and arms in a raised position, and not because vision is truly different near the hands. We note two exceptions in which effects of hand nearness have been investigated on a flat surface (Adam et al., 2012; Davoli & Brockmole, 2012). Critically, both of these studies manipulated the geometric and spatial relationships of the hands to the stimuli entirely *on the flat plane*, and thus cannot address questions about a raised-arms posture. Furthermore, in the Davoli and Brockmole study, while a manipulation of distance was included, it had the same effect as a manipulation of hand posture that did not involve a distance change. Thus, the distance manipulation per se was ineffective. In particular, in that study, participants interposed their hands between a target stimulus and distracting peripheral flankers. The flanker compatibility effect did not depend on the overall distance between the hands and the display (compared across experiments), but instead depended on the particular location of the hands relative to the target and flankers. Thus, these experiments cannot rule out the possibility that the effects attributed to hand proximity in earlier studies were actually caused by the use of a posture with raised arms.

Why might body posture be responsible for changes in vision? Recent research has indicated that a person's posture (i.e., whether a person is standing or sitting) can profoundly alter visual processing (Davoli, Knapp, & Abrams, 2012). Specifically, Davoli, Knapp, and Abrams found that participants exhibited slower rates of search and enhanced cognitive control when standing, as compared to sitting. The authors suggested that changes in vision while standing may result from increased preparation to interact with the environment. Similarly, Gozli et al. (2012) have argued that many of the hand-proximity effects that have been reported reflect greater activation of brain mechanisms involved in the control of action. Thus, it is plausible that having the arms raised in front of the body, as in the typical hands-near posture in prior research, might affect vision through a similar mechanism—an enhanced readiness to act on the environment, but not an effect of hand proximity per se.

The preceding considerations raise the possibility that postural differences in arm height may be responsible for the effects that have instead been attributed to hand proximity. In the present article, we report an experiment in which we eliminated the confound of postural position and hand proximity. The results showed that the changes that have previously been attributed to hand proximity do indeed appear to reflect the effects of proximity, not of posture.

Method

Participants

Thirty-four undergraduates participated for course credit. Two of the participants were replaced due to equipment failure.

Apparatus

The setup is shown in Fig. 1. Participants viewed an LCD display binocularly from a distance of 47 cm (fixed by a chinrest). The display rested horizontally (facing up) on a table top in front of the participant. In the *hands-near* posture, the participants placed their hands on two 6-cm-diameter buttons affixed to the sides of the display. In the

Fig. 1 Postures used in the experiment. Top panel: Hands-far posture. Bottom panel: Hands-near posture

hands-far posture, the participants placed their hands on the same buttons, mounted around shoulder height. The buttons were oriented identically and separated by the same distance (38 cm) in both postures.

Stimuli and procedure

Each trial began with the presentation of a fixation cross (1.2° × 1.2°) for 1,000 ms, followed by a search display containing one target (S or H, 1.2° × 2.4°) and either three or seven distractors (Es and Us). Participants were instructed to indicate the identity of the target letter as quickly as possible (while remaining accurate) by pressing one of the two response buttons. The display remained visible for 1,500 ms or until the participant responded, which was followed by a 2,000-ms blank intertrial interval. If participants pressed the wrong button or responded too slowly, an error message appeared for 1,000 ms.

Design

The participants performed ten practice trials, followed by four blocks of 48 test trials each, with breaks between the blocks. Within each block, each display size (four or eight letters) appeared equally often, and each of the target letters appeared equally often with each display size. The trials within each block were randomly ordered, and the identity of each distractor was chosen randomly on each trial. The location of each target was also chosen randomly on each trial, with the constraint that all letters must be separated by at least 0.6°. At the end of the second test block, the experimenter moved the response buttons to accommodate the alternative postural condition. All participants performed two test blocks with the hands near the stimuli and two with the hands far away (the initial hand position and response key assignments were counterbalanced across participants).

Results

Reaction times are shown in Fig. 2 as a function of display size, separately for the two hand positions. As expected, we found a main effect of display size, $F(1, 31) = 243.02$, $p < .001$, $\eta^2_p = .89$: Participants took longer to find the target in the larger display. No main effect of hand posture was apparent, $F(1, 31) = 1.31$, $p > .25$. But, critically, display size interacted with hand position: The increment in reaction times with increasing display size was greater for the hands-near posture, $F(1, 31) = 4.94$, $p = .034$, $\eta^2_p = .14$. As a result, search rates were slower when the hands were near the display (30.3 ms/item) rather than far from the display (25.2 ms/item). This is the same pattern that has been reported in earlier experiments that have examined the effects of hand proximity

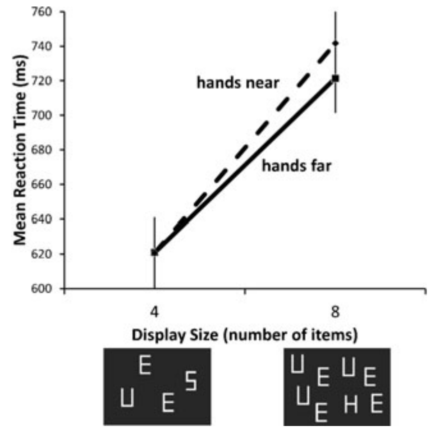

Fig. 2 Reaction times in the visual-search task as a function of display size for the two hand postures. Examples of search displays for each display size are shown below the *x*-axis (not drawn to scale). Participants exhibited slower rates of searching through the stimuli that were near their hands than with those farther away. Error bars depict standard errors of the means

(e.g., Abrams et al., 2008). The accuracy data revealed only poorer performance as display size increased, $F(1, 31) = 38.93$, $p < .001$, $\eta^2_p = .58$.

Discussion

In the present experiment, participants searched more slowly through displays that were near their hands than through ones that were far from their hands. This is precisely the same pattern that has been reported in earlier studies (e.g., Abrams et al., 2008). However, here, unlike in the earlier studies, participants lowered their hands to place them near the display and raised them to move them away from the display. Thus, the slower visual search rate can be attributed to the proximity of the hands to the display, and not merely to differences in the position of the participant’s arms. This finding implies that other reported changes in vision and cognition near the hands truly do arise from participants’ hands being near the stimuli.

It has been suggested that the effects of hand proximity occur because stimuli near the hands may be candidates for action; as a result, they deserve attentional prioritization (Reed et al., 2006), their accurate segregation from the background is important (Cosman & Vecera, 2010), they may need to be inspected more thoroughly (e.g., Abrams et al., 2008), and they would benefit from enhanced activation of the magnocellular visual pathway that is involved in controlling action (Gozli et al., 2012; Weidler & Abrams, 2012). A common interpretation of each of these changes is that they could be subserved by the activity of bimodal visual–tactile neurons that have receptive fields near the hands (see, e.g., Reed et al., 2006). If the effects could instead be attributed merely to changes in arm posture, this would weaken such an interpretation. The present results, however, confirm the assumption made by previous researchers that proximity of the hands per se affects visual processing.

Many of the changes in vision near the hands may have practical implications for the use of handheld devices in educational and workplace environments (e.g., impaired semantic processing, Davoli et al., 2010; improved cognitive control, Weidler & Abrams, 2013; attentional prioritization, Reed et al., 2006; enhanced temporal sensitivity, Gozli et al., 2012; and biased figure–ground segregation, Cosman & Vecera, 2010). As a result, the work on hand proximity may eventually help inform us as to how such devices can best be used as tools for learning and communicating.

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