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The hands shield attention from visual interference

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Abstract Recent investigations have revealed enhanced processing of information that is presented within hand space. A potential consequence of such enhancement could be that simultaneous processing of information outside of hand space is diminished, but this possibility has yet to be tested. Here, we considered the possibility that the hands can serve as a natural remedy for unwanted interference, by acting as a physical manifestation of the attentional window. Participants performed a flanker task in which they identified a central target letter in the presence of flanking letters that varied in their degrees of compatibility with the target. Participants either held their hands around the target, such that the flankers appeared outside of the hands (but in clear view), or held their hands away from the display, and thus not around any of the stimuli. Flanker interference was markedly reduced when the hands were around the target, and these effects were not attributable to visual differences across the conditions. Collectively, these results indicate that the hands effectively shield attention from visual interference.

Keywords Attention · Embodied perception · Visual attention · Selective attention · Hand posture · Embodied Cognition · Erikson flanker task

Although the details vary, every major theoretical conceptualization of attention has included some mechanism that prevents information received by the sense receptors from gaining access to conscious awareness. Even in the most goal-directed and task-constrained circumstances, however, selective abilities are limited, as irrelevant information often influences performance. We will consider here the possibility that the hands can serve as a natural remedy for unwanted intrusions of nearby information, acting as a physical manifestation of the attentional window.

The impetus for addressing this issue has come from recent demonstrations that *within* the space between the hands, objects enjoy enhanced perceptual and memorial processing and prolonged attentional processing, relative to objects that are far from the hands (Abrams, Davoli, Du, Knapp, & Paull, 2008; Cosman & Vecera, 2010; Reed, Grubb, & Steele, 2006; Schendel & Robertson, 2004; Tseng & Bridgeman, 2011). In contrast, no studies until now have considered whether holding the hands around an object might alter the processing of space *outside* of the hands. Because of this, it is unknown, for example, whether the processing enhancements conferred to objects between the hands come at the expense of information processing beyond the hands. As we shall see, the answer to this question has both theoretical and practical implications.

Experiment 1

Our participants performed an Eriksen-type flanker task (e.g., Eriksen & Eriksen, 1974) in which they identified a central target letter in the presence of flanking letters that varied in their degrees of compatibility with the target. Generally, these compatibility differences affect response times (RTs) to the target, indicating that the flankers often fail to escape selection. Here, participants either held their hands around the target, such that the flankers appeared outside of the hands (but in clear view), or held their hands away from the display, and thus not around any of the stimuli. If the hands can effectively shield attention from unwanted intrusions of information, then flanker interference should be reduced when the hands are

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held around the target. Additionally, this protection should not be afforded by physical barriers other than the hands.

Method

Participants A group of 36 undergraduate students at the University of Notre Dame participated in the study in exchange for course credit.

Stimuli, design, and procedure The stimuli consisted of a central letter (H or S; 1.3 cm wide × 2.2 cm high) flanked (7.7-cm center-to-center separation) by two adjacent letters (3 cm wide × 6 cm high; see the images at the bottom of Fig. 1). These stimuli were presented on a 43-cm LCD display laid horizontally at a viewing distance of approximately 40 cm. In a within-subjects manipulation, the participants performed one block (72 trials) in each of the following postures: In the *hands-near* posture, they placed their hands on the display between the target and flankers with their palms facing each other. In the *hands-far* posture, they oriented their hands similarly, but placed them to the side of the monitor, away from the letter displays. In the *barrier* posture, the hands remained to the side of the display (as in the hands-far condition), while two wooden blocks analogous in length, height, width, and shape to a typical pair of hands were placed on the display between the target and either flanker. The barrier mimicked the physical and visual segregation apparent in the hands-near condition. Participants registered their responses to the identity of the target (H or S) using two buttons positioned under the tips of their ring fingers in all conditions. The participants were instructed to respond as quickly and accurately as possible. For each trial, the stimuli remained onscreen until a response was registered, and this was followed by a 1,000-ms blank intertrial interval. Each block consisted of an equal number of compatible-flanker (same identity as target), incompatible-flanker (identity of the alternate but incorrect response), and neutral-flanker (X, not associated with any response) trials for both target identities. Our analyses, however, focused on interference effects as measured by the difference in RTs between the neutral and incompatible trials (see, e.g., Kopp, Rist, & Mattler, 1996), due to the interpretive ambiguity associated with compatible-flanker trials (e.g., Lavie, 1995). Breaks were provided between blocks. The trial order within each block was randomized for each participant, and the order in which each posture was completed was counterbalanced across participants. The participants were monitored throughout the experiment to ensure their compliance with the postural instructions.

Results

Trials in which RTs exceeded three standard deviations from the mean on a participant-by-participant, condition-by-condition basis were excluded from the analysis (1.3% of trials). The mean RTs are shown in Table 1. A 3 (posture: hands near, hands far, or barrier) × 2 (flanker type: neutral or incompatible) repeated measures analysis of variance (ANOVA) on RTs revealed that overall, RTs were slower in the presence of incompatible as compared to neutral flankers, $F(1, 35) = 24.0$, $p < .001$, $\eta_p^2 = .41$. This pattern is in agreement with how flanker incompatibility typically interferes with target processing (e.g., Eriksen & Eriksen, 1974). Importantly, however, posture modulated the magnitude of that interference, $F(2, 70) = 4.21$, $p = .02$, $\eta_p^2 = .11$

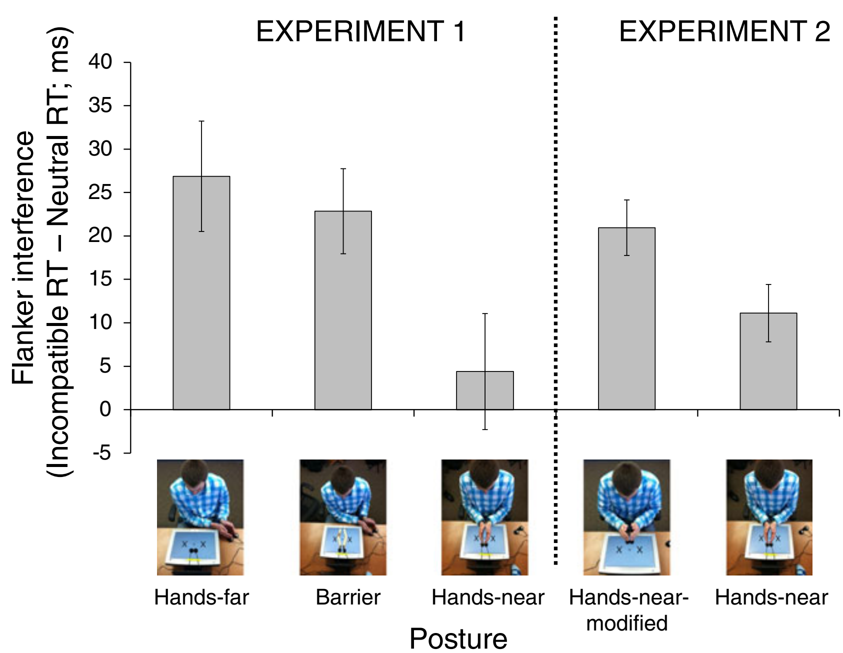

Fig. 1 Mean flanker interference effects in the hands-far, barrier, and hands-near postures of Experiment 1 (left to right, respectively) and the hands-near-modified and hands-near postures of Experiment 2 (left to right, respectively). Error bars represent one standard error of the mean

(see Fig. 1, left panel). Specifically, interference averaged 27 ms in the hands-far posture, and while the barrier did not attenuate interference (23 ms) [$t(35) = 0.58$, $p = .57$], interference was reduced by the hands-near posture (4 ms) as compared to both the hands-far and barrier postures [$ts(35) > 2.11$, $ps < .05$]. The main effect of posture was not significant, $F(2, 70) = 1.05$, $p = .36$, $\eta_p^2 = .03$, confirming that the diminished interference near the hands was not attributable to a general speeding induced by that posture.

Although the RTs for neutral (i.e., baseline) trials were not significantly different across postures, $ts(35) < 1.75$, $ps > .09$, numerical differences in the neutral baseline across postures led us to confirm the conclusions drawn above by contrasting the proportional difference in RTs between the neutral and the incompatible trials. This metric was computed by dividing the differences in RTs between incompatible and neutral trials by the RTs for neutral trials within each posture. Confirming our initial conclusions, a one-way (posture) repeated measures ANOVA, $F(2, 70) = 3.99$, $p = .02$, $\eta_p^2 = .10$, showed that the percentage increase in RTs was smaller in the hands-near condition (1.7%) than in either the hands-far (6.6%) or the barrier (5.6%) condition, $ts(35) > 2.07$, $ps < .05$, whereas the latter two conditions did not differ from one another, $t(35) = 0.63$, $p = .53$. Additional converging evidence in support of our conclusion that the hands block unwanted intrusions from peripheral stimuli was provided in Experiment 2.

Experiment 2

In Experiment 1, hand proximity was confounded with more gross postural differences (e.g., the angle formed between the stimuli and the limbs). We thus minimized such differences in Experiment 2 while adhering to the critical manipulation of holding the hands around (i.e., near to) or not around (i.e., far from) the target.

Method

Participants A group of 60 University of Notre Dame undergraduates participated in Experiment 2. None had participated in Experiment 1.

Stimuli, design, and procedure The stimuli and task were the same as in Experiment 1. In this experiment, however, posture constituted a between-subjects manipulation. One group ($n = 30$) adopted the same hands-near posture used in Experiment 1. The other group ($n = 30$) adopted a modified hands-near posture in which the hands were positioned at the near edge of the visual display, and thus not around any of the stimuli (see the right bottom images in Fig. 1). Thus, unlike Experiment 1, in which the hands-far condition required a slight turn of the participants' trunk and shoulders, in Experiment 2, the hands were positioned directly in front of the participants in both cases. Each group performed 216 trials.

Results

Again, trials in which RTs exceeded three standard deviations from the mean on a participant-by-participant, condition-by-condition basis were excluded from the analysis (4.3% of trials). As in Experiment 1, the analyses focused on incompatibility effects (see Table 1 and Fig. 1, right panel). A 2 (posture: hands near or hands-near modified) × 2 (flanker type: incompatible or neutral) mixed-factors ANOVA on RTs verified the previously observed RT pattern across flanker types, $F(1, 58) = 48.67$, $p < .001$, $\eta_p^2 = .46$, but this was again modulated by posture, $F(1, 58) = 4.58$, $p = .04$, $\eta_p^2 = .07$. Interference was substantially reduced when the hands were around (11 ms) rather than not around (21 ms) the target, $t(58) = 2.14$, $p = .04$. There was no main effect of posture, $F < 1$. We also compared the percentages by which incompatible RTs increased in relation to neutral RTs across both postures. We again found that the percentage increase was smaller in the

Table 1 Mean response times (with standard deviations) for each flanker type for all hand-posture conditions in Experiments 1 and 2. Mean response times (in ms) with standard deviations (in parentheses; in ms) for each flanker type for all hand-posture conditions in Experiments 1 and 2

Flanker Type	Hands Far	Barrier	Hands Near	Hands-Near Modified
Experiment 1				
Neutral	443.48 (71.92)	431.70 (66.68)	454.30 (78.54)	
Incompatible	470.35 (70.39)	454.55 (68.77)	458.68 (69.65)	
Compatible	427.42 (74.97)	406.20 (59.49)	438.33 (76.76)	
Experiment 2				
Neutral			410.15 (47.87)	410.03 (38.91)
Incompatible			421.27 (41.59)	430.98 (35.36)
Compatible			392.38 (43.14)	389.74 (35.37)

hands-near (3.0%) than in the hands-near-modified (5.3%) posture, $t(58) = 2.01$, $p < .05$, thus confirming our previous conclusions. It should be noted that overall, the RTs were somewhat faster in the present experiment than in Experiment 1. This was likely attributable to the emergence of practice effects, as participants completed more trials in each posture here than in Experiment 1 (216 vs. 72 trials per posture).

In summary, this control experiment confirmed that the placement of the hands around the target, and not gross differences between the postures in Experiment 1, was the mitigating factor for reduced interference. This finding is consistent with other demonstrations of altered processing near the hands in which gross postural differences have been ruled out as a source of the effects (e.g., Abrams et al., 2008; Davoli & Abrams, 2009; Davoli, Du, Montana, Garverick, & Abrams, 2010; Reed et al., 2006; Tseng & Bridgeman, 2011).

Discussion

In two experiments, we have shown that placing the hands around an object can shield attention from unwanted intrusions of information. In this case, the interference normally conferred by peripheral distractors was effectively eliminated in an Eriksen-type flanker task. Rather notably, such shielding was not achieved by physical barriers of a size and shape similar to the hands, emphasizing the importance of the hands in matters of visual processing. These results have several important theoretical and practical consequences.

First, the experiments presented here are the first to show that attending to objects within hand space has an impact on attentional control across aspects of the visual field that fall outside of hand space. Not only does placing the hands around an object enhance several aspects of perception, attention, and memory, so too does it diminish processing of potentially interfering objects falling farther afield. Diminished processing outside of hand space may not be absolute, however. In both of our experiments, compatible trials received faster responses than did neutral trials in all hand posture conditions (see Table 1). It is therefore possible that the "protection" provided by the hands is specific to situations in which conflict resolution is required, a circumstance that would suggest that the hands attenuate postperceptual interference, as opposed to diminishing the perception of external information. We approach this conclusion with caution, however, as the causes of facilitation may differ from those related to interference, with the latter representing a more stringent test of selection processes (Lavie, 1995). Regardless, our results are informative as to the underlying mechanism, as of yet not understood, that fosters prioritized attention (Reed et al., 2006), enhanced perceptual sensitivity (Schendel & Robertson, 2004), altered figure–ground assignment (Cosman & Vecera, 2010), prolonged and detail-oriented processing (Abrams et al., 2008; Davoli, Brockmole, Du, & Abrams, 2012; Davoli, Brockmole, & Goujon, 2012), and improved working memory (Tseng & Bridgeman, 2011) for held objects: By restricting the allocation of attention to distal objects, greater resources may be available for processing information within the space of the hands, thereby leading to a host of benefits. Whether this "bending" of the attentional window around the hands has analogous consequences for perception and memory is an important avenue for future research.

An interesting parallel between the results of the present study, previous observations of hand-altered vision, and neural evidence detailing how the space on and around the hands is represented can also be drawn. In particular, hand space appears to be represented by a system of bimodal, visual–tactile neurons that respond both to tactile stimulation on the skin and visual stimulation near to (i.e., within several centimeters of) the same region of the skin (e.g., Graziano, Hu, & Gross, 1997; Murata, Gallese, Luppino, Kaseda, & Sakata, 2000). Furthermore, the distribution of bimodal receptors is thought to correspond to the distribution of tactile receptors, and, accordingly, the palms (regions of high tactile receptor density) seem to enjoy stronger visual representation from hand-centered bimodal neurons than do the backs of the hands (regions of relatively lower tactile receptor density; Brown, Morrissey, & Goodale, 2009). Thus, processing enhancements within hand space perhaps arise from greater bimodal neuronal representation of that space, whereas the diminished processing of objects outside of hand space might be a consequence of that space receiving lesser representation from bimodal neurons. Future work directly mapping the behavioral and neurological consequences of hand-proximity manipulations will clearly be required.

Finally, the present findings may have implications for how people consume visually presented information. As technology is driving more and more information into our hands, by means of smart phones, tablet computers, and e-readers, the present results serve as a reminder to consider both the advantages and the disadvantages of how attention to the visual environment is shaped by the hands. While placing to-be-consumed information between the hands may, at least in some cases, reduce one's susceptibility to intrusions, it is sometimes in one's best interest to be susceptible to intrusions. Hence, it may be advisable to let conditions dictate when hand-held consumption of information is most appropriate. The present results also suggest a natural and straightforward means for isolating a specific item amidst a cluttered visual field, particularly when contrasted against the demands of maintaining an (invisible) attentional window using the mind alone. This application may be particularly useful as a potential cost-free intervention for attentional deficiencies.

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