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Altered attention for stimuli on the hands

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ABSTRACT

Attention operates in the space near the hands with unique, action-related priorities. Here, we examined how attention treats objects on the hands themselves. We tested two hypotheses. First, attention may treat stimuli on the hands like stimuli near the hands, as though the surface of the hands were the proximal case of near-hand space. Alternatively, we proposed that the surface of the hands may be attentionally distinct from the surrounding space. Specifically, we predicted that attention should be slow to orient toward the hands in order to remain entrained to near-hand space, where the targets of actions are usually located. In four experiments, we observed delayed orienting of attention on the hands compared to orienting attention near or far from the hands. Similar delayed orienting was also found for tools connected to the body compared to tools disconnected from the body. These results support our second hypothesis: attention operates differently on the functional surfaces of the hand. We suggest this effect serves a functional role in the execution of manual actions.

1. Introduction

If you look at your hands while reaching for an object, the action can feel unnatural and clumsy. Yet we rarely do this spontaneously, despite the near ubiquity of the hands in the field of view. It is as though attention is predisposed to ignore the hands in order to focus on potential targets. In this article, we examined how we attend to – or perhaps, how we ignore – our hands; we examined whether our hands are perceptually distinct from the space surrounding them. Are our hands attentionally "special"?

From a complex environment, visual attention must select the information that guides action. In agreement with this notion, attention operates in the space near the hands (peri-hand space, henceforth) in a manner that reflects action-related priorities. For example, the rate of visual search is slower in peri-hand space, suggesting that graspable stimuli receive a more thorough analysis (Abrams, Davoli, Du, Knapp, & Paull, 2008). Targets are detected faster near the hands, an effect that attenuates with distance (Reed, Grubb, & Steele, 2006). In a similar study, enhanced detection depended on orienting the palm – rather than the back of the hand – toward the target, reinforcing the idea that this enhancement serves action (Reed, Betz, Garza, & Roberts, 2010). And change detection is improved in peri-hand space, suggesting that graspable stimuli enjoy robust representation in visual short-term memory (Tseng & Bridgeman, 2011). Together, these studies support the idea that attention prioritizes stimuli in peri-hand space, and that this prioritization could assist manual action.

This attentional prioritization makes sense when interpreted as a way to gather information for future actions. Consider that during manual action, eye movements remain slightly ahead of the hands (Johansson, Westling,

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Backstrom, & Flanagan, 2001; Land & Hayhoe, 2001). This tendency to look forward is an anticipatory bias. In contrast, information about objects in contact with the hand would be of lesser interest to an anticipatory bias, because they have already been touched. Consequently, the attentional prioritization for stimuli in peri-hand space may not be important for stimuli in contact with the hand. With this in mind, we consider how attention treats stimuli in contact with the hand.

None of the studies describing attentional enhancement in peri-hand space used stimuli in contact with the hands. Even though contact is a necessary condition of every manual action, it is unknown whether visual attention treats peri-hand and on-hand stimuli with the same biases.

In four experiments, we examined how attention for stimuli on the hands compares to attention in peri-hand space. We employed a traditional spatial cueing paradigm (Posner, Walker, Friedrich, & Rafal, 1987) to measure attention on versus near the hands. Participants detected a target that could appear at an uncertain location, preceded by a cue. They responded to the onset of the target as quickly as possible, regardless of cue location. When the cue is valid (same location as the target), response times are fast. When it is invalid, response times are slow, because attention has been drawn to the invalidly cued location and must move over to the target. The difference between response times for invalid and valid cues (the validity effect) reflects the added cost of orienting attention from the cue to the target. The novel manipulation in the present studies involved having stimuli appear on the hands. We tested two hypotheses.

1.1. The surface of the hands as the ultimate case of peri-hand space

At the proximal edge of peri-hand space lies the surface of the hands. Attentionally, the surface of the hands may simply be the ultimate case of proximity. Given that detection of peri-hand stimuli improves with proximity to the hand (Reed et al., 2006), detection of stimuli on the hands may be enhanced further. In this case, we would predict that targets should be detected faster when appearing on the hands compared to near the hands, regardless of the validity of the cue.

1.2. The hand as an attentionally distinct surface

Existing research on attention in peri-hand space was guided by the theory that stimuli around the hands are attentionally special because they are the things we could potentially grasp – or the things that could grasp us (e.g. Abrams et al., 2008; Reed et al., 2006). However, objects in contact with the hands have passed the threshold of potentially relevant. They *are* relevant. Therefore, they can be thought of as belonging to a different functional status than stimuli that are not yet in contact with the hands. Given that stimuli on the hands are functionally distinct from stimuli near the hands, the surface of the hands may be attentionally distinct.

Making contact between the hand and an object in the environment is unlike other tasks, as far as visual attention is concerned. When guiding the hand, the target location is often already known – so spatial allocation of attention may be prioritized differently compared to a situation where it is scanning a scene. Attention selects information for action by looking to peri-hand space – an anticipatory bias (Johansson et al., 2001; Land & Hayhoe, 2001). The hands and held objects are hardly ever fixated upon, indicating that perception for contact is about predicting where and when contact will occur; it is preparatory.

These studies suggest that successful manual action depends on attending to graspable space rather than the hands themselves. Anecdotally, it feels unnatural and awkward to attempt a grasping action while attending to your hands. If attending to the hands deters the initiation of contact (i.e. grasping), then there may be safeguards or costs built into the visual system to prevent attention from orienting to the hands when they make contact with stimuli in the environment (thereby maintaining attention in graspable space).

With these insights in mind, we predict that attention should be predisposed to avoid the hands in order to remain in peri-hand space. In this case, we would predict delayed orienting to the hands, but no differences for orienting attention in peri-hand space. This hypothesis predicts an interaction between Cue Validity and hand position. The validity effect should be larger for stimuli on the hands relative to peri-hand space.

2. Experiment 1A: shifting attention to or from the hands

To test these hypotheses, we modified designs from prior research on attention in peri-hand space (e.g. Reed et al., 2006), such that stimuli were projected onto a table instead of displayed on a monitor. The novel manipulation involved a condition where stimuli were projected onto the participants' hands, in addition to near or far from their hands, thereby allowing us to assess how people attend to stimuli on the hands.

2.1. Method

2.1.1. Participants

Sixteen undergraduate students (8 female; 6 left-handed) from Purdue University participated for course credit.

2.1.2. Materials and stimuli

A small projector was mounted 35 cm above a table. All participants wore white latex gloves to control for differences in skin tone. In some conditions, stimuli were projected onto a white wooden block ($18 \times 13 \times 2$ cm). This block was approximately the width and thickness of two hands held adjacently flat on the table. It was a control surface for the condition where stimuli appeared away from the hands or near the hands. Projecting stimuli directly onto the table would have made them appear larger and out of focus compared to stimuli on the hands. Stimuli were a central fixation cross (1.1 cm^2), two empty