Moving Targets: Effects of Occlusion on Eye and Grasp Movements

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Introduction

Performing an accurate grasp requires the unconscious analysis of visual information provided by the target object[1,2] as well as the object's location with respect to surrounding aspects of the environment[3].

Previous work from our lab has focused on how we visually pursue and grasp moving targets[4]. However, when reaching for an object in motion, visual feedback may not always be constant or reliable.

The aim of this study was to examine how we track and grasp a moving target that becomes occluded during travel, and to determine whether the presentation of background cues influences these strategies.

Method

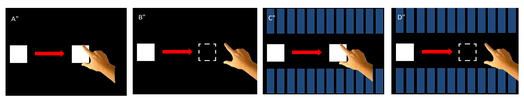
Participants: Eighteen (15 female) right-handed undergraduate psychology students with normal or corrected-to-normal vision between the ages of 18 and 33 years (*M* = 20).

Eye position was recorded using an Eyelink II and grasp movements were recorded using an Optotrak Certus. This data was integrated into a common reference frame via Motion Monitor software (Innovative Sports Training).

Experimental Task

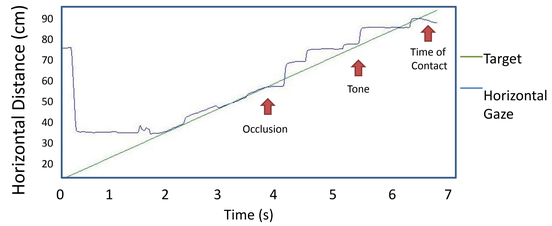
Participants were asked to reach for a translating 4x4 cm computer generated target that randomly A) remained visible for the duration of travel, or B) appeared to move behind an invisible occluding object during travel.

Upon hearing a tone, participants reached for the visible target (Visible Feedback conditions), or where they believed the occluded target to be (Occlusion conditions) as if the target was an actual 3-D object.



The presence of additional blue blocks along the top and bottom of the screen was manipulated to test for an influence of increased cue presence on gaze and grasp accuracy.

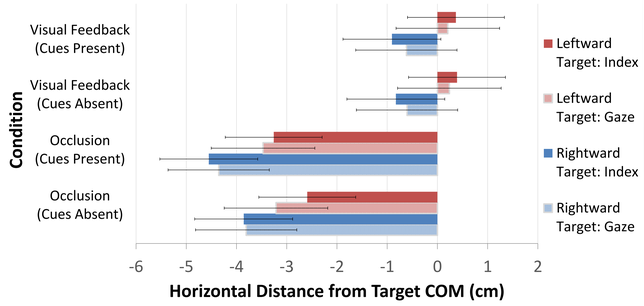
Visual Pursuit of Target Occlusion



- Smooth pursuit eye movements were used to track target motion prior to occlusion. Following occlusion, saccadic eye movements were used to extrapolate target motion.

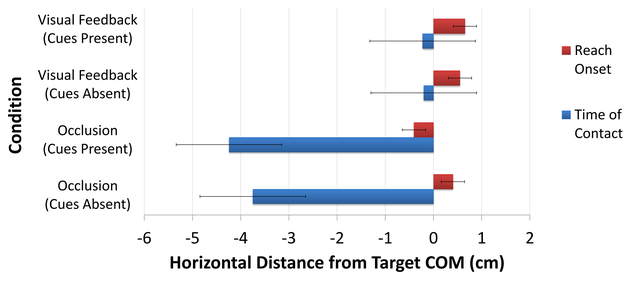
Overall Gaze and Grasp Accuracy

Distance from Final Index and Gaze Positions to Target COM



- Final index placement (p<.001) and gaze position (p<.001) were more accurate when reaching for visible targets than for occluded targets.

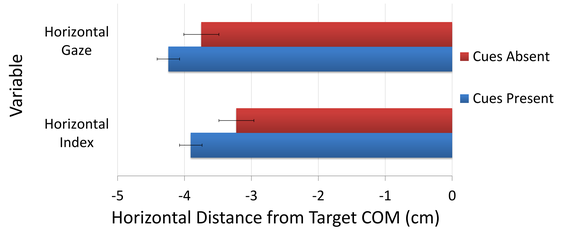
Comparison of Gaze at Reach Onset and Time of Contact



- Gaze at reach onset was significantly closer to the target's center of mass than at time of contact when reaching for occluded targets (p<.001).

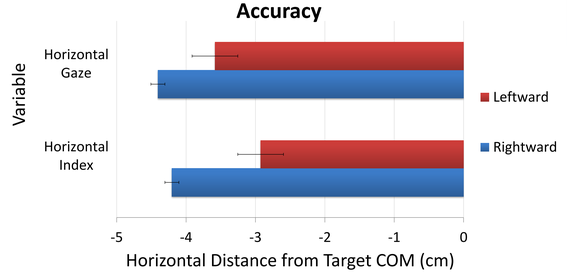
Gaze and Grasp Accuracy for Occluded Targets

Influence of Cue Presence on Gaze and Grasp Accuracy



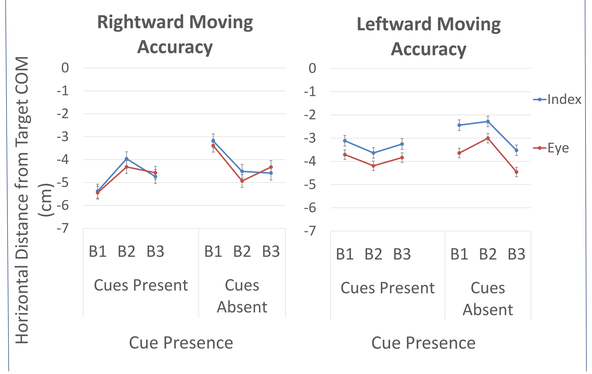
- Cue Presence impaired final grasp accuracy (p=.005), however no influence was found for final gaze positon (p >.05).

Influence of Direction on Gaze and Grasp Accuracy



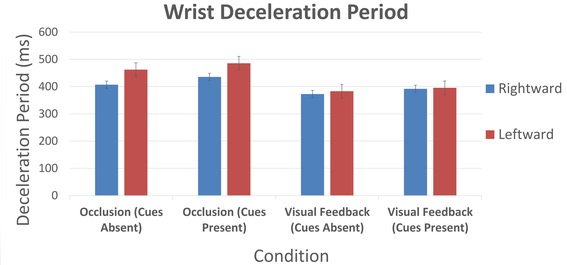
- Both final gaze position and index placement were more accurate when reaching for leftward moving targets (p=.017 and .001 respectively).

Gaze and Grasp Accuracy by Block: Occluded Targets



Reach Kinematics

Wrist Deceleration Period



- Overall, cue presence was associated with longer WDPs (p=.02).
- When reaching for occluded targets, WDPs were longer during reaches for leftward moving targets (p=.009).

Conclusion

- Grasps were more accurate (index finger placed closer to the target's horizontal midline) when visual feedback of the target was available.
- Final gaze and grasp positions were more accurate when reaching for leftward moving targets
- While accurate at reach onset, gaze was significantly displaced from occluded targets during the reaching motion, resulting in an inaccurately placed grasp — potentially the result of attentional resources being allocated to reach mechanics
- Rather than provide a benefit, the presence of cues may be acting as a distraction or obstacle, impairing grasp accuracy and resulting in longer wrist deceleration periods.

References

1. Jeannerod, M., Arbib, M. A., Rizzolatti, G., & Sakata, H. (1995). Grasping objects: The cortical mechanisms of visuomotor transformation. *Trends Neurosci. 18*(7), 314-320.
2. Desanghere, L. & Marotta, J. J. (2011). "Graspability" of objects affects gaze patterns during perception and action tasks. *Exp Brain Res. 212*(2), 177-87.
3. Camors, D., Jouffrais, C., Cottereau, B. R., & Durand, J. B. (2014). Allocentric Coding: Spatial range and combination rules. *Vision Research, 109*, 87-98.
4. Bulloch, M. C., Prime, S. L., & Marotta, J. J. (2015). Anticipatory gaze strategies when grasping moving objects. *Exp Brain Res. 233*(12), 3413-23.

Acknowledgements

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