Patterns of Eye-Hand Coordination during Bimanual Reach-to-Grasp: A Pilot Study

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INTRODUCTION

Many daily activities involve two hands accomplishing separate motions at the same time. Visual information provides critical knowledge in performing motor tasks. However, little is known about how the eyes and hands are coordinated during bimanual tasks.

In this pilot study, reach movements and gaze patterns were analyzed when participants used both hands to reach for objects. We quantified the onset time of eye and hand movements as measures of eye-hand coordination.

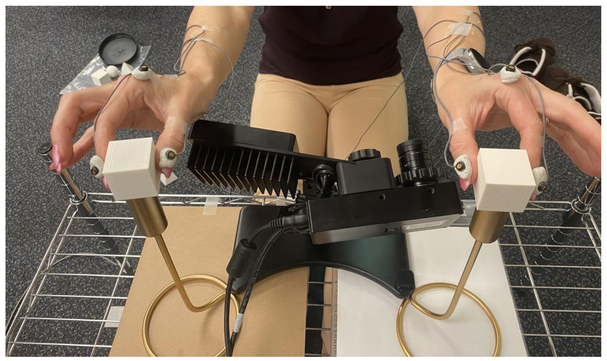
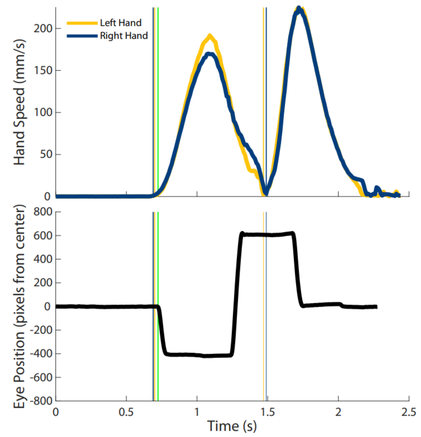


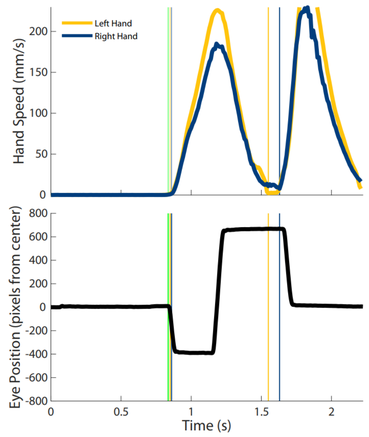
Figure 1: EyeLink 1000 Plus camera setup with object locations (cubes shown) and IRED position markers on participant's thumb, index fingers and MCP joint.

METHODS

- 5 healthy adults were asked to use both hands at the same time to reach, grasp and move small objects.
- 3 objects were used (cube, sphere, pyramid), all combinations of objects were included. There were 9 conditions and 10 repeats for 90 trials.
- Reach movement data were recorded in 3D with the Optotrak 3020 system (100 Hz), tracking IRED markers on right and left index and thumb fingertips, and the first metacarpal-phalangeal joints.
- Individual eye position data were collected with the EyeLink 1000 Plus eye tracking system (250 Hz). Data were calibrated as needed. Blinks were interpolated and eye position were collapsed into a gaze direction signal.
- Participants were asked to fixate on a target centrally located between the two reach objects until the "go" cue.
- After the "go" cue, participants were free to move the hands and eyes in any way in order to reach to the 2 objects, grasping 1 in each hand at the same time.
- Synchronized gaze position and movement data were plotted. Speed thresholds were used to determine the time of movement onset (each hand), time of object capture/grasp, and time of the first saccade.

Individual trials show coordinated eye-hand movement patterns





Figures 2 (left) and 3 (right): Hand speed (top) and gaze position (bottom) over the time of the trial for a single trial from one participant (left plot- P1, sphere (L), sphere (R); right plot- P3, sphere (L), pyramid (R). Thin vertical green line shows the time the first saccade begins, thin vertical yellow and blue lines show the onset of hand movement for the left and right hands and the onset of reach and the onset of return, respectively.

Grasping differently shaped objects did not change the initial hand-eye movement coordination

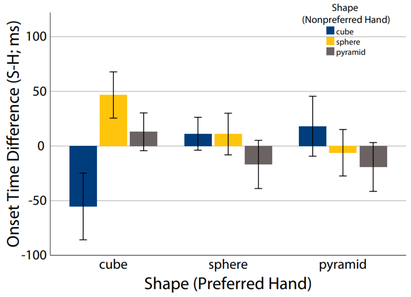


Figure 4: Difference between the time of the first saccade and time of the onset of the reach (Saccade time - Hand time) for all object conditions. Error bars are ±1 SEM.

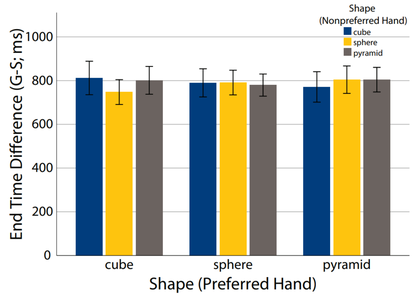


Figure 5: Difference between the time of grasp and time of the onset of the first saccade (Grasp time - Saccade time) for all object conditions. Error bars are ±1 SEM.

Participants had small individual differences, but remained consistent across the trials in initial eye-hand movements

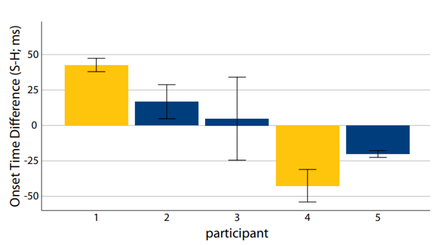


Figure 6: Difference between the time of the first saccade and time of the onset of the reach (Saccade time - Hand time) across all conditions for each participant. Left-handed participants (yellow) and right-handed participants (blue). Error bars are ±1 SEM.

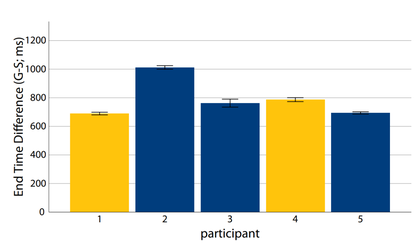


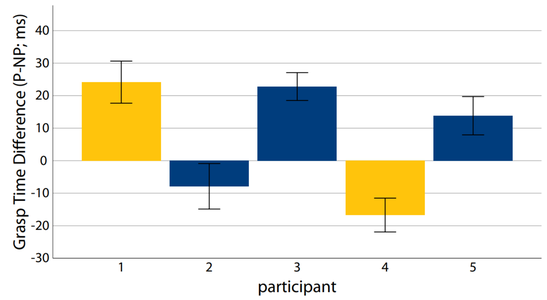
Figure 7: Difference between the time of grasp and time of the onset of the first saccade (Grasp time - Saccade time) across all object conditions for all participants. Left-handed participants (yellow) and right-handed participants (blue). Error bars are ±1 SEM.

Initial saccade was to non-preferred side, but initial grasp was variable

	% of saccades to nonpreferred
1	97.6%
2	65.6%
3	74.2%
4	96.8%
5	62.7%

Table 1. Percent of first saccades that are directed to the nonpreferred hand side for each of the 5 participants.

Figure 8: Difference between the time that each hand grasped the object (Preferred hand grasp time – Nonpreferred hand grasp time) across all conditions for each participant. Left-handed participants (yellow) and right-handed participants (blue). Error bars are ±1 SEM.



RESULTS

- Across all object conditions, the first saccade consistently occurred very near the onset of hand movement and about 800 ms before the hands grasped the objects (Figures 4 & 5).
- Each participant also tended to be consistent with these patterns (Figures 6 & 7) but there may have been slight differences in the strategy between participants.
- 3 participants primarily grasped with their nonpreferred hand first and 2 with their preferred hand (Figure 8).
- For most participants, the first saccade was to their nonpreferred side (Table 1).

CONCLUSIONS and FUTURE DIRECTIONS

- Few differences were detected in this initial analysis. Participants were consistent in the pattern of eye and hand movements across all conditions.
- Future planned analyses include examining the timing of other saccades during the task and well as the amount of time spent fixated on various locations in the workspace. Finally, we will examine for differences between successful trials and trials where the objects were dropped or fumbled.

ACKNOWLEDGMENTS

This work was supported by the McPherson Eye Research Institute Expanding Our Vision grant.

Thank you, Dr. K. M. Mosier at Indiana University for providing the Optotrak 3020.