Grasping in a Cluttered Environment: Avoiding Obstacles Under Memory Guidance

Hana H. Abbas & Jonathan J. Marotta

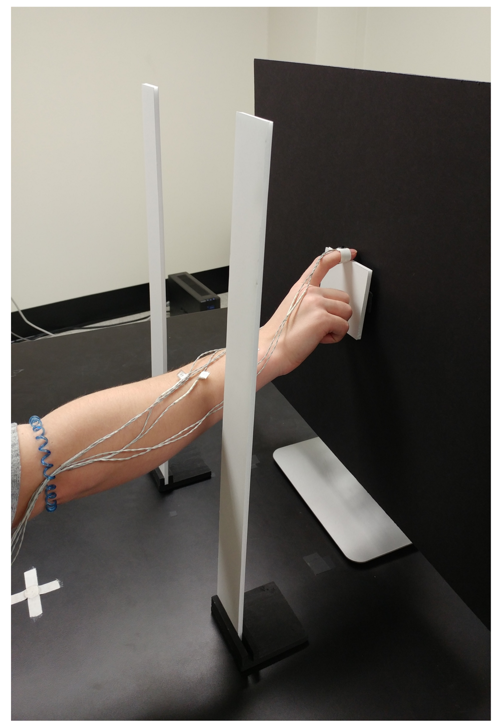
Perception and Action Lab, Department of Psychology, University of Manitoba, Winnipeg, MB, Canada

Introduction

When reaching to previously seen objects, we rely on our visuospatial memory of the scene to guide our actions[1,2]. It is possible that perceptual representations may exaggerate the risk associated with nearby obstacles in the scene. This study examined the obstacle avoidance strategies used during visually-guided and memory-guided grasping by manipulating the positions and widths of obstacles situated in the grasp space.

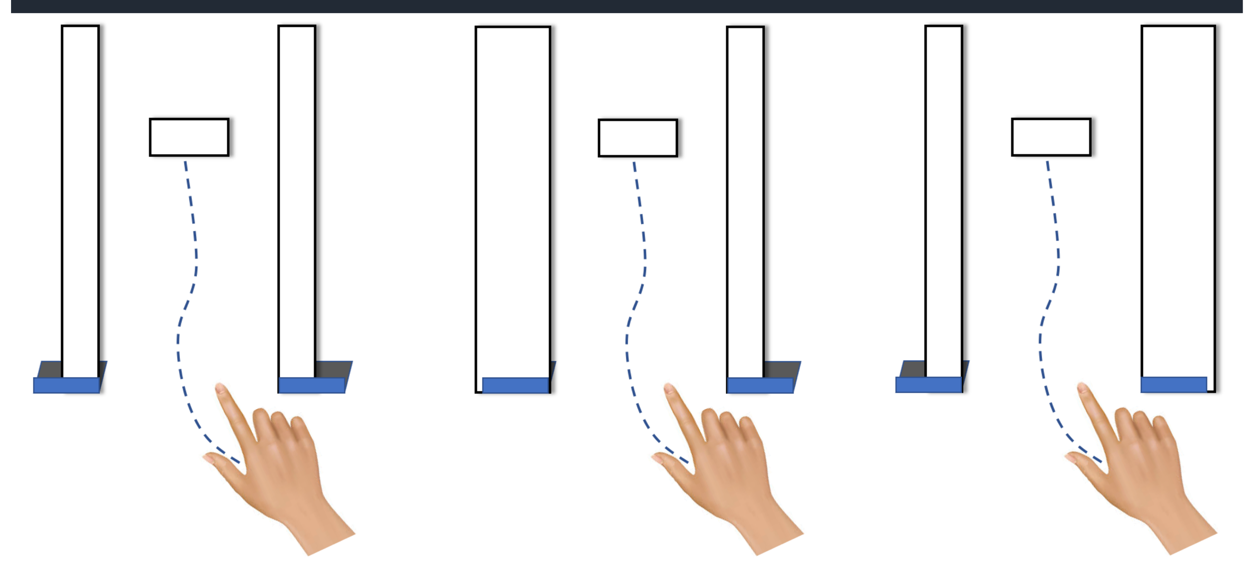
Methods

36 right-handed undergraduate students from the University of Manitoba (19 females; average age = 20.9 years) with normal or corrected-to-normal vision reached between a pair of obstacles in order to grasp a lightweight 3-D target object.



Eye data was recorded using an Eyelink II. Hand data was recorded using an Optotrak Certus. MotionMonitor software integrated data into a common frame of reference.

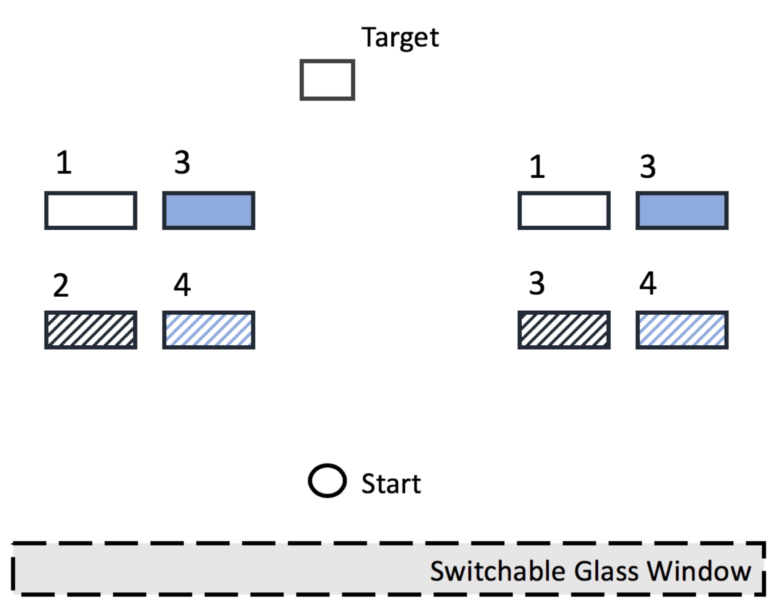
Experimental Design



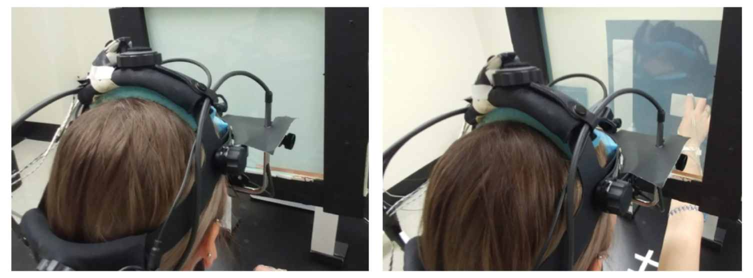
Widths of obstacles were manipulated, such that both obstacles were narrow (5 cm), or the left or right obstacle was wide (10 cm) while the other remained narrow. The inner edges of obstacles remained a constant distance apart.

The pair of obstacles were situated within the grasp space such that they were either centered or deviated to right.

Pairs of obstacles were situated either closer (12 cm) or farther (19 cm) from the start position.

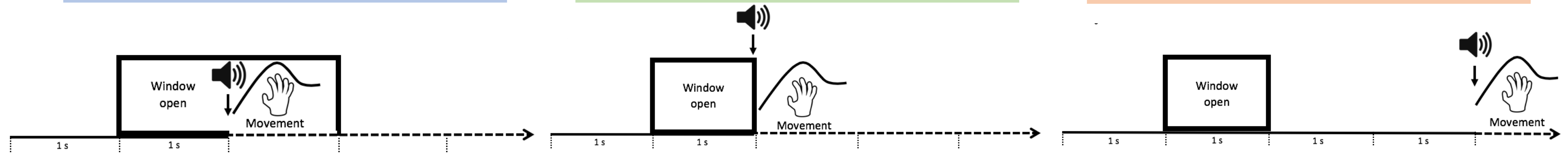


Different Obstacle Avoidance Strategies Within Viewing Conditions

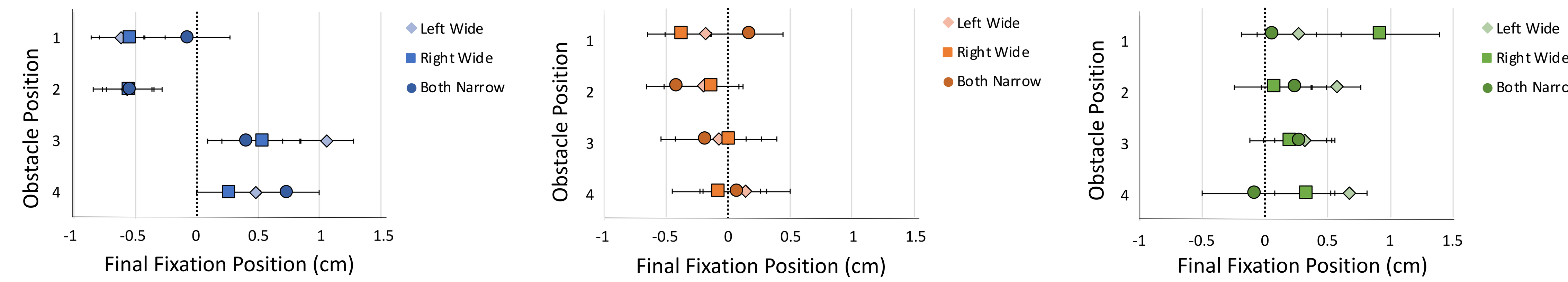


The availability of visual information was manipulated between-subjects using a **"switchable" glass window**, such that reaches occurred either with continuous visual information (visually-guided condition), immediately in the absence of visual feedback (memory-guided no-delay condition), or after a 2-s delay in the absence of visual feedback (memory-guided delay condition).

Visually-Guided Avoidance Strategies	Memory-Guided No-Delay Avoidance Strategies	Memory-Guided Delay Avoidance Strategies

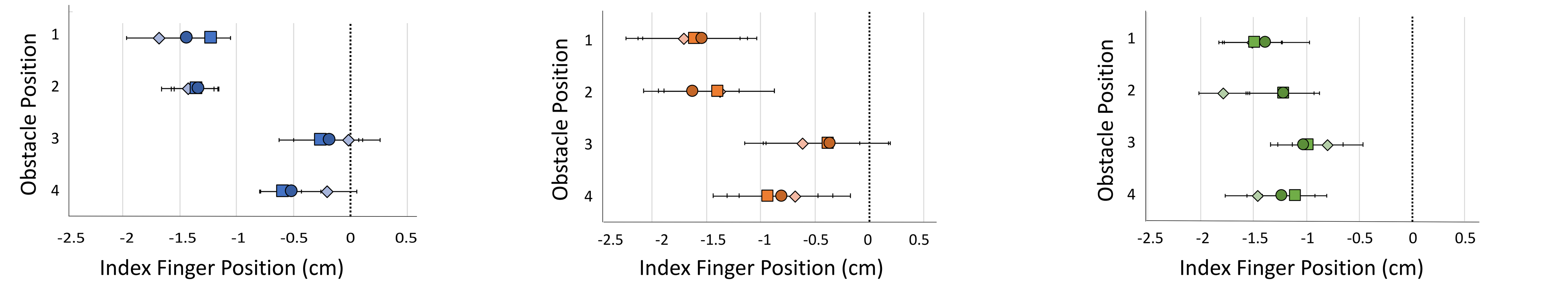


Final fixation position in relation to the target object's horizontal centre of mass (COM)



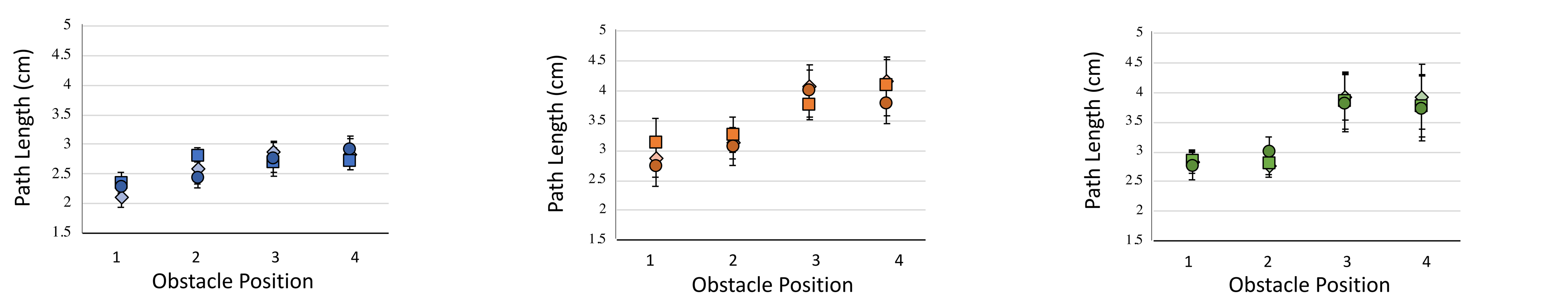
- **Without visual information throughout the reach, fixations on the target object were not adjusted to account for positioned obstacles in either memory-guided condition.**

Final index finger position in relation to the target object's horizontal COM



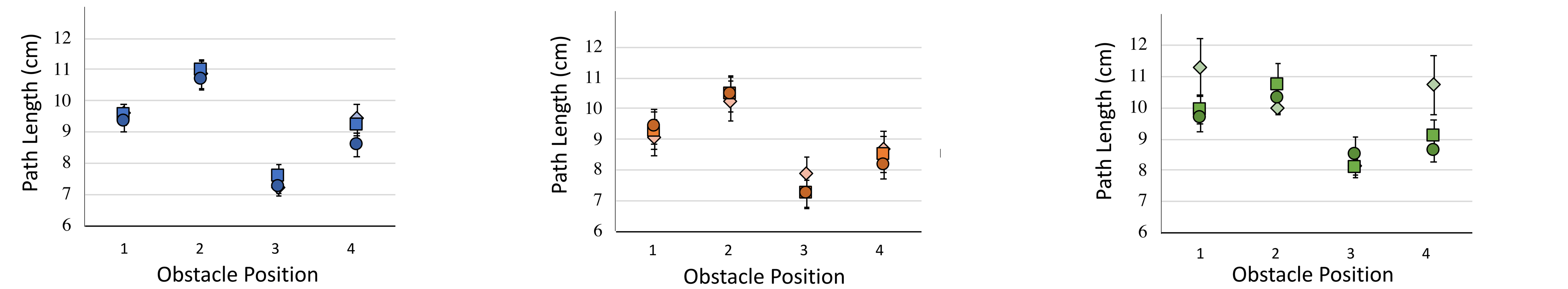
- **The memory-guided delay group was least able to use visual information about the scene to adjust final index finger position on the target object to account for positioned obstacles.**

Horizontal path length of the index finger (maximal horizontal distance travelled by the index finger)



- **The smallest index finger path lengths occurred in the visually-guided group (efficient obstacle avoidance) while the longest path lengths occurred in the memory-guided no-delay group (inefficient obstacle avoidance).**

Horizontal path length of the wrist (maximal horizontal distance travelled by the wrist)



- **Relying wholly on perceptual representations of the scene, the memory-guided delay group made the fewest attempts to adjust the path of the wrist to account for positioned obstacles.**

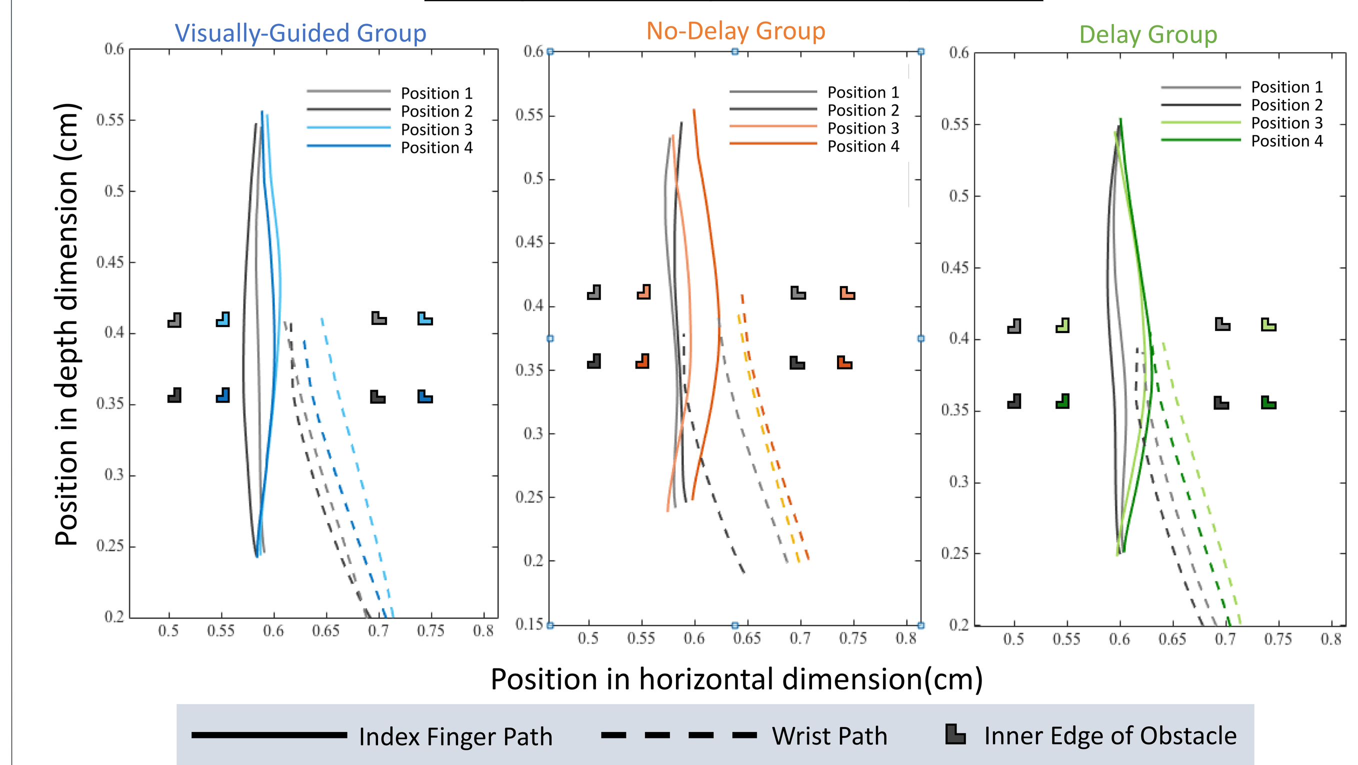
General Obstacle Avoidance

Performance was consistent with the *obstacle avoidance account of collision mitigation*[3], where obstacles on the same side as the reaching arm were most obtrusive to the reach path[4,5,6].

Successful obstacle avoidance and grasp performance was observed in all groups:

- Collisions with obstacles rarely occurred (**0.026% of trials**)
- Gaze was not often directed towards obstacles (**4.28% of trials**)
- Final fixations landed at the target object's horizontal COM

Average Index Finger/Wrist Trajectories



Conclusion

Different strategies emerged depending on the availability and timing of visual feedback. Obstacle avoidance behaviour, driven by our stored perceptual representations of a scene, does not seem to adopt an exaggerative strategy. Subjects reaching to remembered objects after a 2-s delay follow a "good enough" approach for avoiding obstacles.

References

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Acknowledgements

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