Risk Optimisation During Ongoing Movements: Insights From Movement and Gaze Behaviour in Throwing

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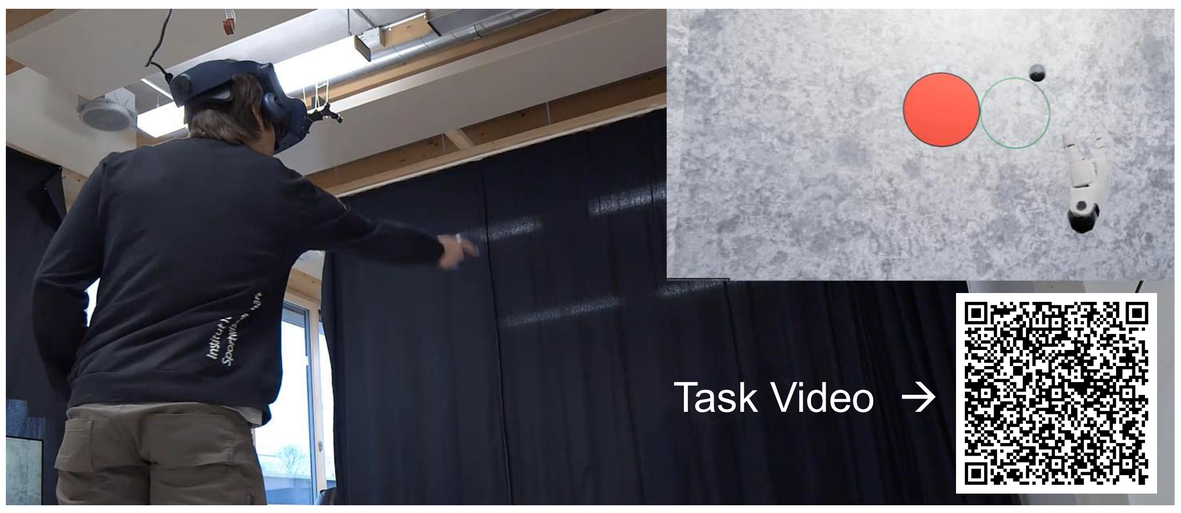
1. Introduction

Movement outcomes are inherently subject to variance. This variance should be considered in movement planning and control, especially in high-risk situations. Research on simple finger-pointing movements has shown that humans optimally adapt aim points based on their motor variance and penalties and rewards associated with outcomes (Trommershäuser et al., 2008). However, the question remains how this mechanism extends to more complex sensorimotor tasks.

2. Methods



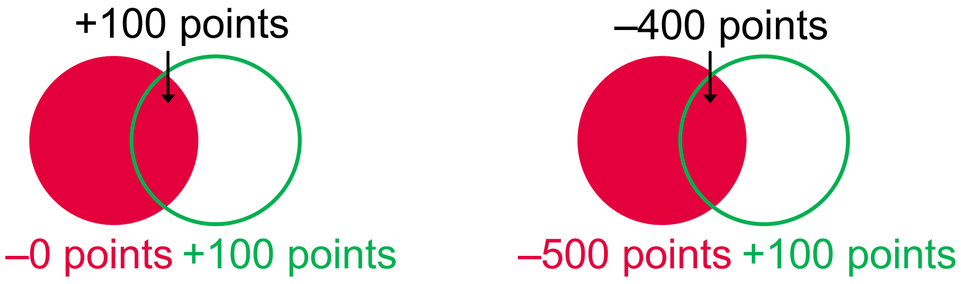
We investigated how humans handle motor variance in a VR throwing task under risk. Participants (N=20) had the task to throw balls into a green target circle with a 30 cm radius, gaining 100 points for each successful hit. The target circle was partially overlapped by a red penalty circle.

Dependent variables

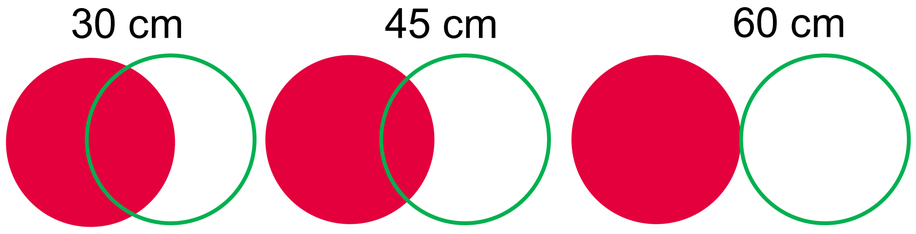
- Final gaze fixation before movement initiation
  → indicator of planned aim point before execution
- Ball's impact location
  → indicator of movement outcome

Experimental conditions

(1) No-Penalty vs. Penalty



(2) Small vs. moderate vs. large distances between circles

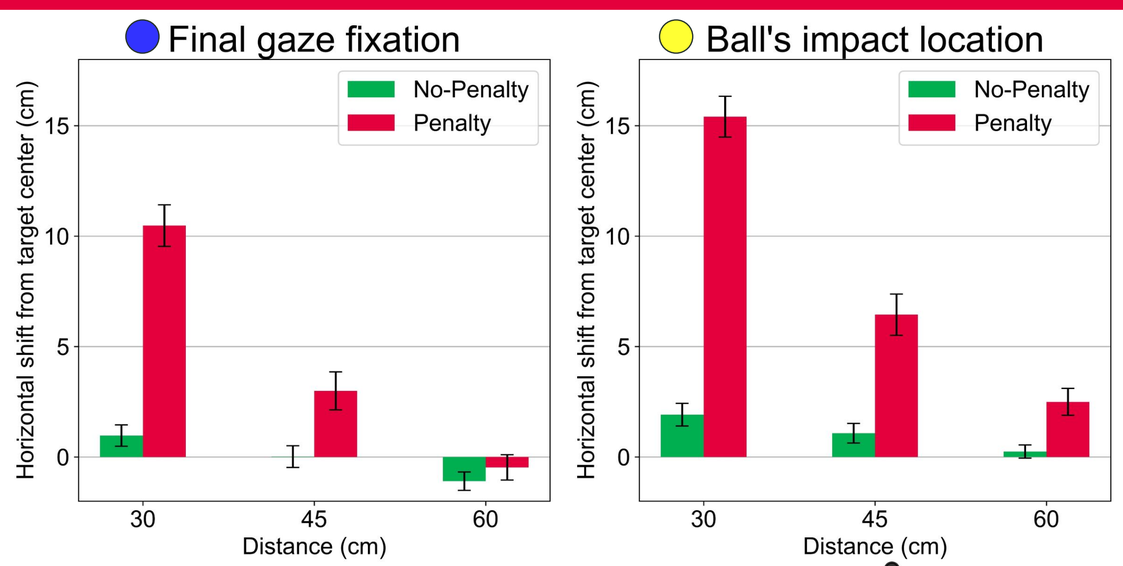


3. Results

Participants' behaviour was consistent with model-based predictions:

In the No-Penalty condition, the final gaze fixation before movement initiation and the ball's impact location were centred on the target circle.

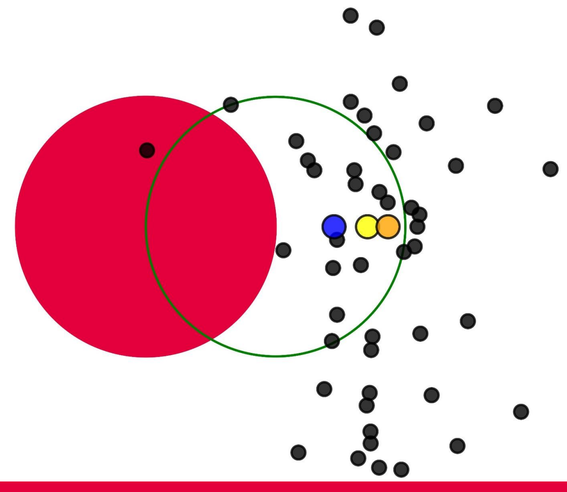
In the Penalty condition, both the gaze fixation and the ball's impact location shifted significantly farther away from the penalty circle as the distance decreased; Interaction gaze fixation: $F(2, 38) = 82.56$, $p < .001$, $\eta_p^2 = .81$; Interaction ball's impact location: $F(2, 38) = 102.79$, $p < .001$, $\eta_p^2 = .84$.



Noteworthily, the horizontal shifts in the ball's actual impact locations were larger than those in the fixations before movement initiation, $F(2, 38) = 3.61$, $p = .030$, $\eta_p^2 = .16$, and closer to the statistically optimal aim point to maximize expected gains given the individual's motor variance.

Exemplary data of an individual participant in the Penalty condition.

- Final gaze fixation
- Ball's impact location
- Optimal aim point



4. Discussion

Extending the findings from Trommershäuser et al. (2008), our results suggest that risk optimisation is not completed in a planning phase *before* movement execution but continues during ongoing movements. Follow-up experiments explicitly testing this online risk optimisation hypothesis are underway in our lab.

References

Trommershäuser, J., Maloney, L. T., & Landy, M. S. (2008). Decision making, movement planning and statistical decision theory. *Trends in Cognitive Sciences*, *12*(8), 291–297

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