Risk Optimisation in Action: Differences Between Fixated Aim Points and Movement Outcomes in VR Throwing

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Movement outcomes are inherently subject to variance. Dealing with this variance is crucial to action planning and control, especially in risky situations. Research on simple finger-pointing movements has shown that humans adapt strategies to their own motor variance to optimise penalties or rewards of potential outcomes (Trommershäuser et al., 2008). However, the question remains whether this mechanism extends to more complex tasks. In three experiments, we thus investigated how humans handle risks in a VR throwing task. In Experiment 1, 20 participants had the task of throwing balls on a green target circle, gaining 100 points for each hit. The target was partially overlapped by a red penalty circle. We manipulated the consequences of hitting the penalty circle (no-penalty = 0 points vs penalty = -500 points) and the distance between both circles (30 cm vs 45 cm vs 60 cm). We assessed participants' final gaze fixation before movement initiation—as an indicator of their planned aim point before execution—and the ball's impact location. In the no-penalty condition, the final fixation and the ball's impact location were centred on the target. In the penalty condition, both the mean final fixation and the ball's mean impact location shifted significantly farther away from the penalty circle as the distance decreased. Interestingly, the shifts in the ball's impact locations were larger – and closer to the statistically optimal location – than those in the fixated aim points. Extending Trommershäuser et al., our results suggest that risk optimisation is not finalized in a planning phase before action execution but continues during ongoing movements. Experiment 2 confirmed the results and ruled out saliency effects. Experiment 3, including an additional -2000 penalty condition, replicated the findings and added that participants adapt their strategies to increasing penalty levels. Experiments testing the online risk optimisation hypothesis further are underway in our lab.