Effects of immersive visual environment-change cues on motor learning during a virtual-reality target hitting task

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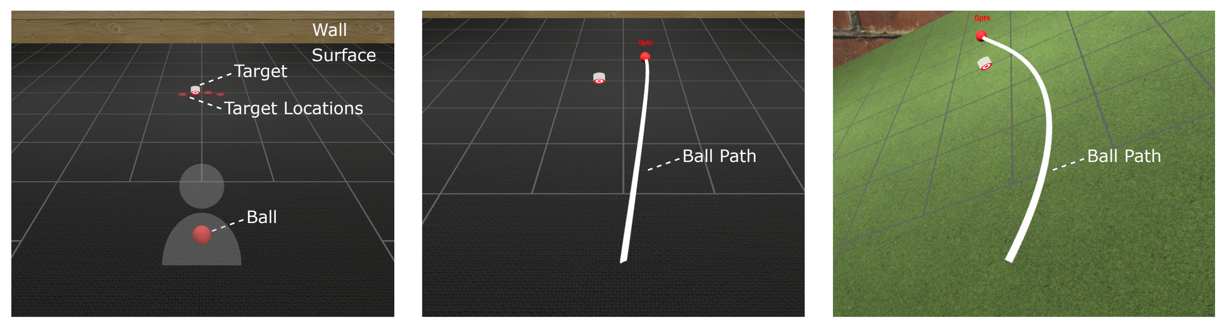
Internal model updating and switching during motor adaptation

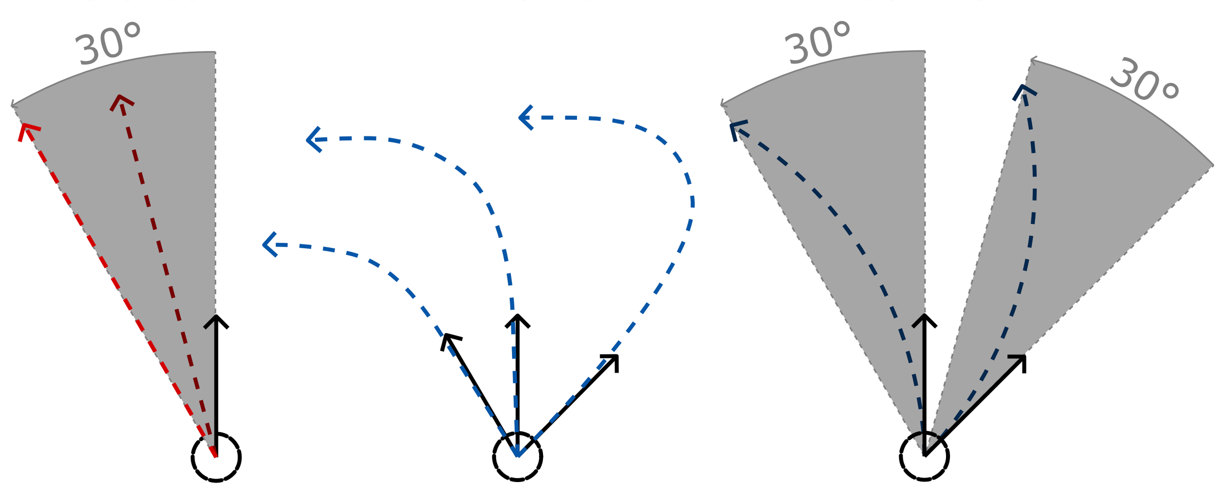
When adapting to motor errors, the human motor system may update internal models of interactions, or create and switch to new internal models. Visual feedback of the consequences of movements, and of environmental changes prior to movements can inform the decision of model updating, or model switching. In a ball-rolling task, we tested if perturbations cued by immersive visual changes in the environment (i.e., a tilt in the surface) or different feedback properties of task errors determine whether motor adaptation evolves via model updating or model switching.

Task

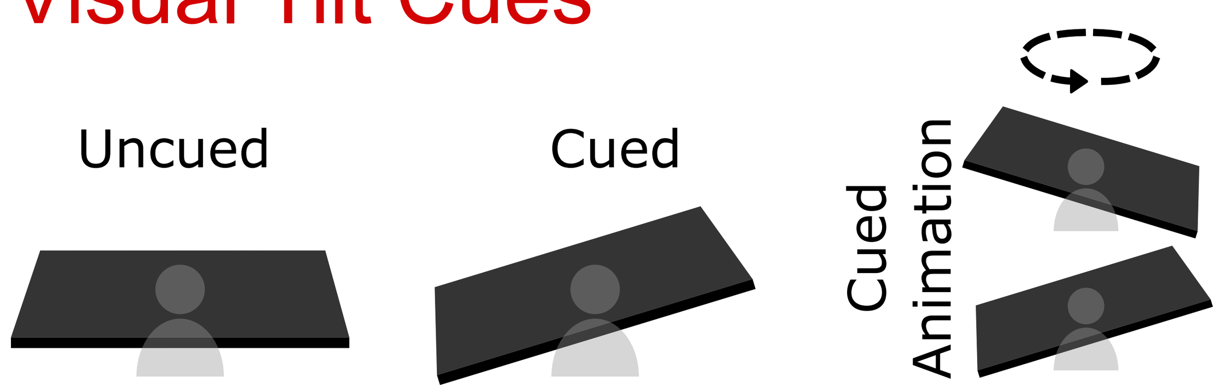
Using throwing movements, participants rolled a ball towards visual targets in an immersive virtual reality environment



Perturbations



Visual Tilt Cues

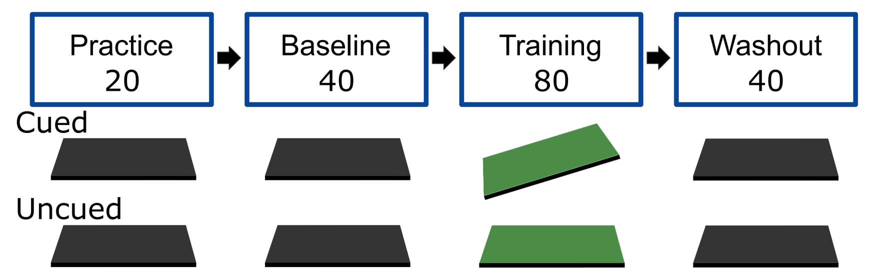


169 participants were placed into 8 groups with differing perturbations and visual cues.

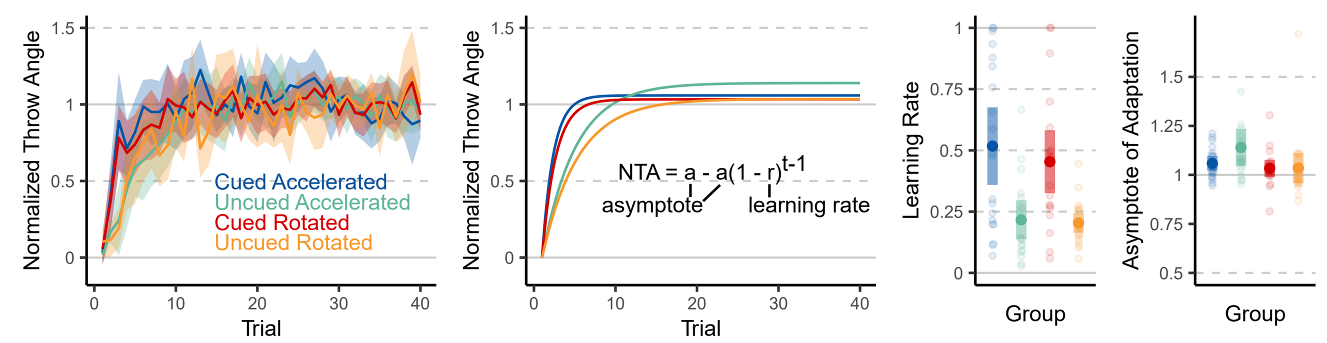
Groups

Perturbation	Visual Cue	Perturbation	Visual Cue
Rotated - 30°	Cued	Rotated - 15°	Cued
Rotated - 30°	Uncued	Rotated - 15°	Uncued
Accelerated	Cued	Curved - 30°	Cued
Accelerated	Uncued	Curved - 30°	Uncued

Task Schedule



Training Phase

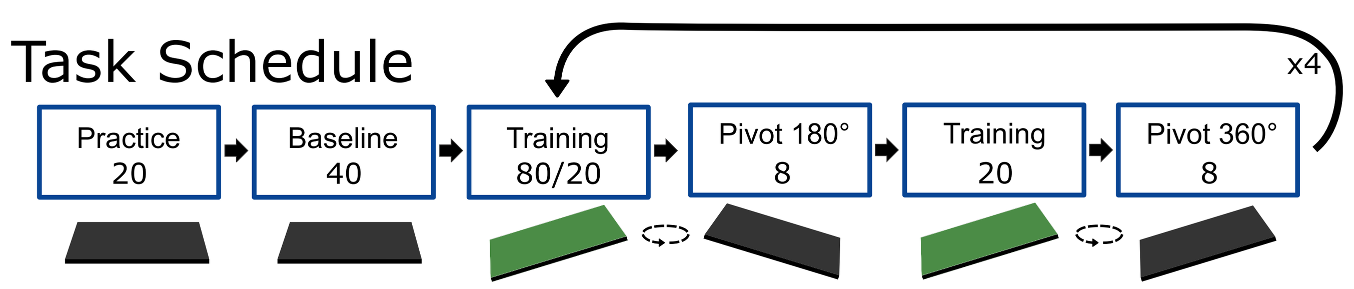


The visual tilt cue enables faster adaptation.

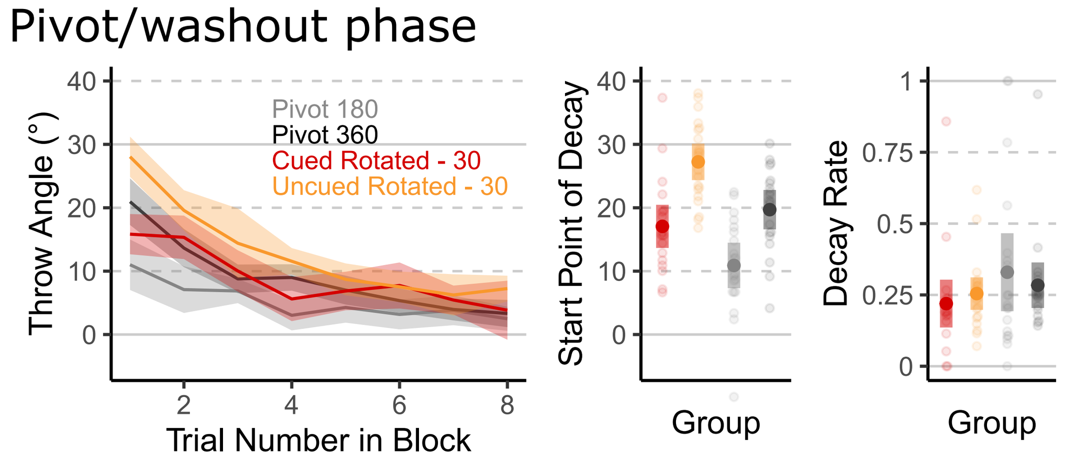
Pivot Experiment

Are updated internal models affected by immersive visual properties of the environment?

Task Schedule

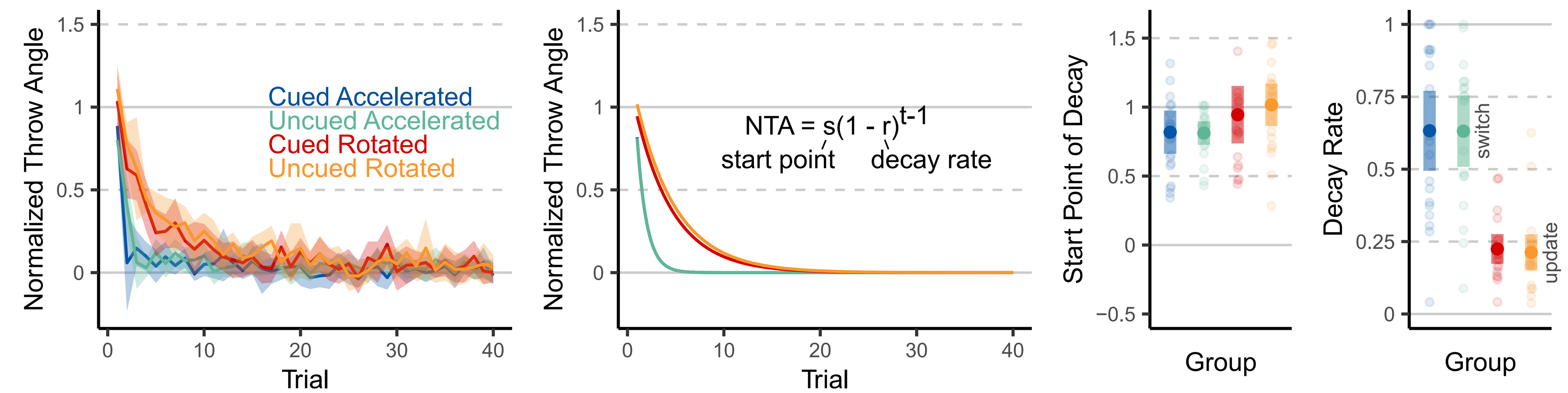


Pivot/washout phase



Visual environment properties affected the decay of learned behaviour when models are updated. The updated models are likely interaction models.

Washout Phase

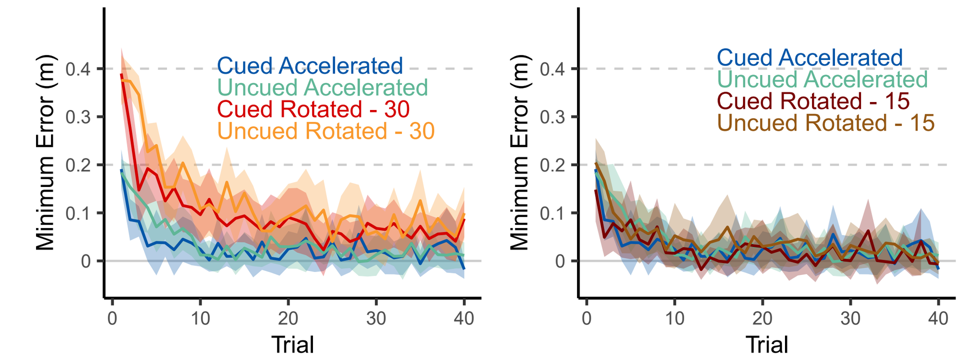


The perturbation type alone affected if new internal models are created or existing internal models are updated.

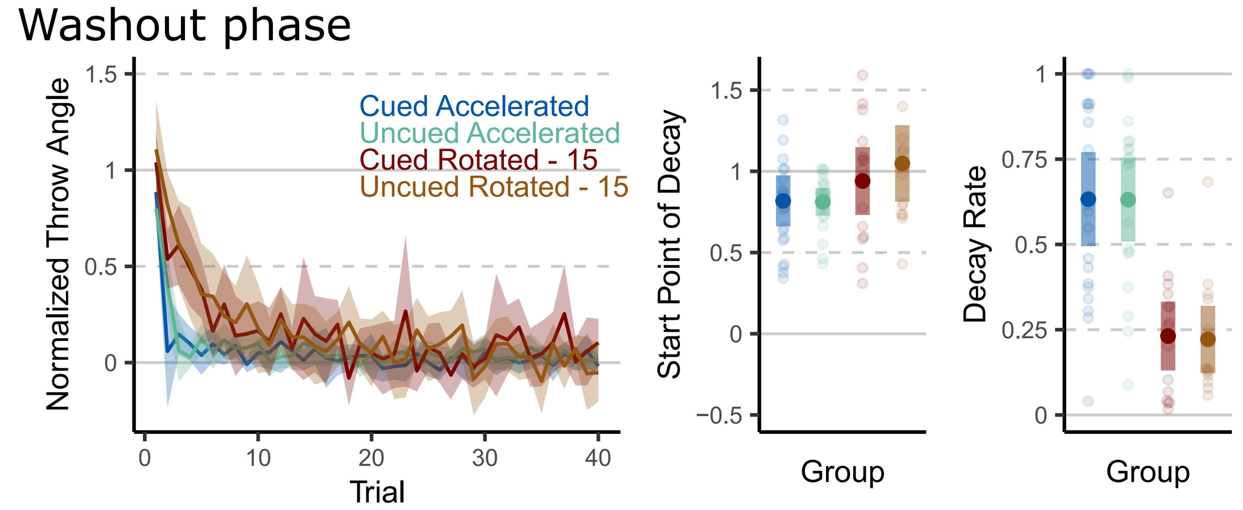
Sensory prediction errors present at the moment of release in Rotated perturbations may drive the updating of existing internal models of motor control, while errors that emerge following release, like in Accelerated or Curved perturbations, lead to model switching.

Differences in minimum error

Training phase

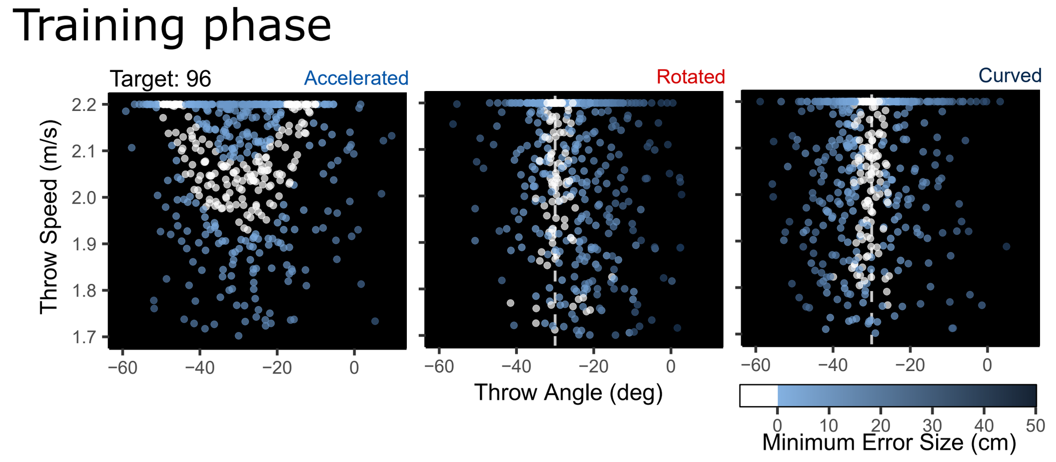


Washout phase

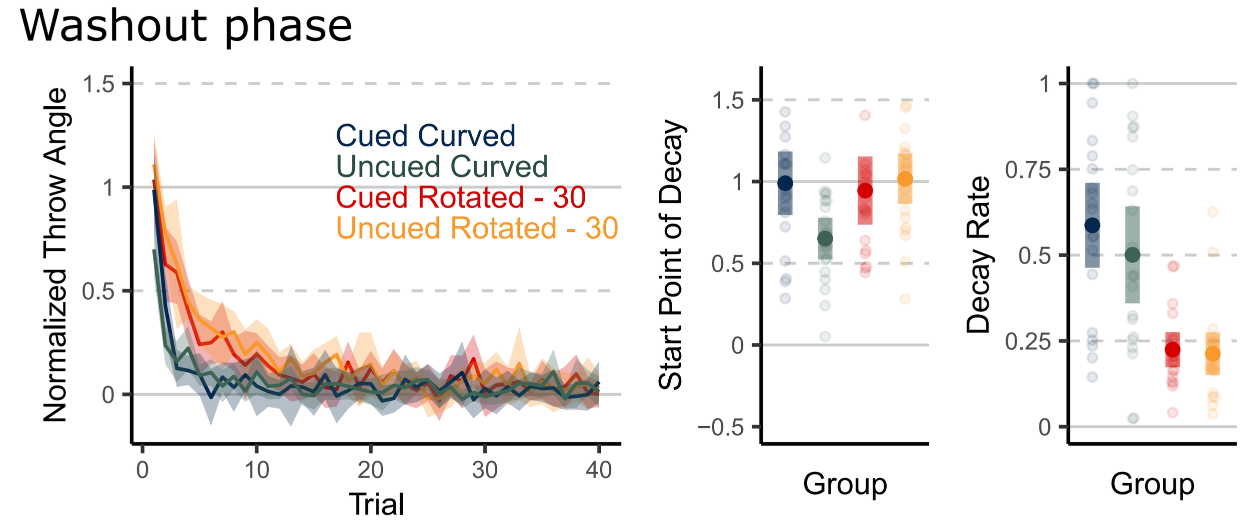


Differences in the solution space

Training phase



Washout phase



Our findings were not affected by the error sizes or the solution space of the task during training.

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