Behavioral/Cognitive

Eliminating Direction Specificity in Visuomotor Learning

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The generalization of learning offers a unique window for investigating the nature of motor learning. Error-based motor lea
reportedly cannot generalize to distant directions because the aftereffects are direction specific. This direction specificity is o
garded as evidence that motor adaptation is model-based learning, and is constrained by neuronal tuning characteristics in the
motor cortices and the cerebellum. However, recent evidence indicates that motor adaptation also involves model-free learn
explicit strategy learning. Using rotation paradigms, here we demonstrate that savings (faster relearning), which is closely re
model-free learning and explicit strategy learning, is also direction specific. However, this new direction specificity can be abolish
the participants receive exposure to the generalization directions via an irrelevant visuomotor gain-learning task. Control ev
indicates that this exposure effect is weakened when direction error signals are absent during gain learning. Therefore, the d
specificity in visuomotor learning is not solely related to model-based learning; it may also result from the impeded express
model-free learning and explicit strategy learning with untrained directions. Our findings provide new insights into the mecha
underlying motor learning, and may have important implications for practical applications such as motor rehabilitation.

[illegible] learning specificity; motor adaptation; motor generalization; motor learning

Significance Statement

Motor learning is more useful if it generalizes to untrained scenarios when needed, especially for sports training and mo
rehabilitation. However, as a form of motor learning, motor adaptation is typically direction specific. Here we first show tha
savings with motor adaptation, an index for model-free learning and explicit strategy learning in motor learning, is also directio
specific. However, the participantsÕ additional exposure to untrained directions via an irrelevant gain-learning task can enabl
complete generalization of learning. Our findings challenge existing models of motor generalization and may have import
implications for practical applications.

Introduction

[illegible]

Experimental design

Experiment 1 (generalization without exposure). [illegible]

Experiment 2 (generalization enabled by visuomotor gain learning). [illegible]

Washout controls (savings after washout). [illegible]

Experiment 3 (relevant factors in the exposure task). [illegible]

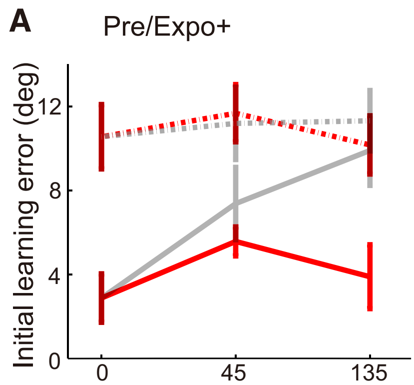
[illegible]

$$[illegible] = \sqrt{\left(\sum_{i=1}^{n}\Delta x^2 + \sum_{i=1}^{n}\Delta y^2\right)/n},$$

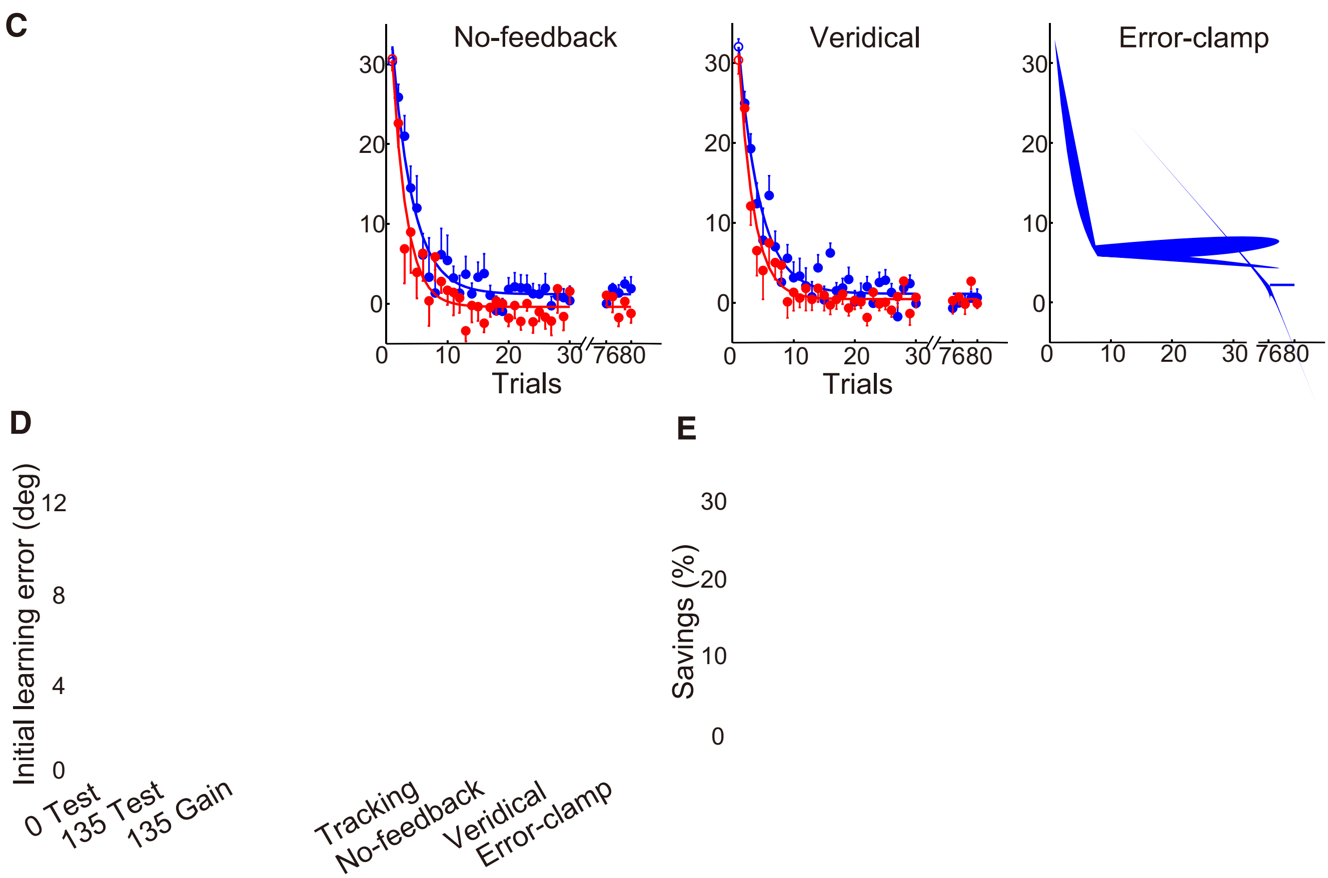
[illegible] Δx [illegible] Δy [illegible] x- [illegible] y [illegible]

Data analysis

[illegible]



Discussion


C
No-feedback
Veridical
Error-clamp
Trials
Trials
D
Initial learning error (deg)
0 Test
135 Test
135 Gain
Tracking
No-feedback
Veridical
Error-clamp
E
Savings (%)

References

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[illegible]

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[illegible]

[illegible]

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