How does false visual input affect learning in sensorimotor adaption?

Antonio Amaddio

FU-Berlin, Department of Psychology

1. Research Question

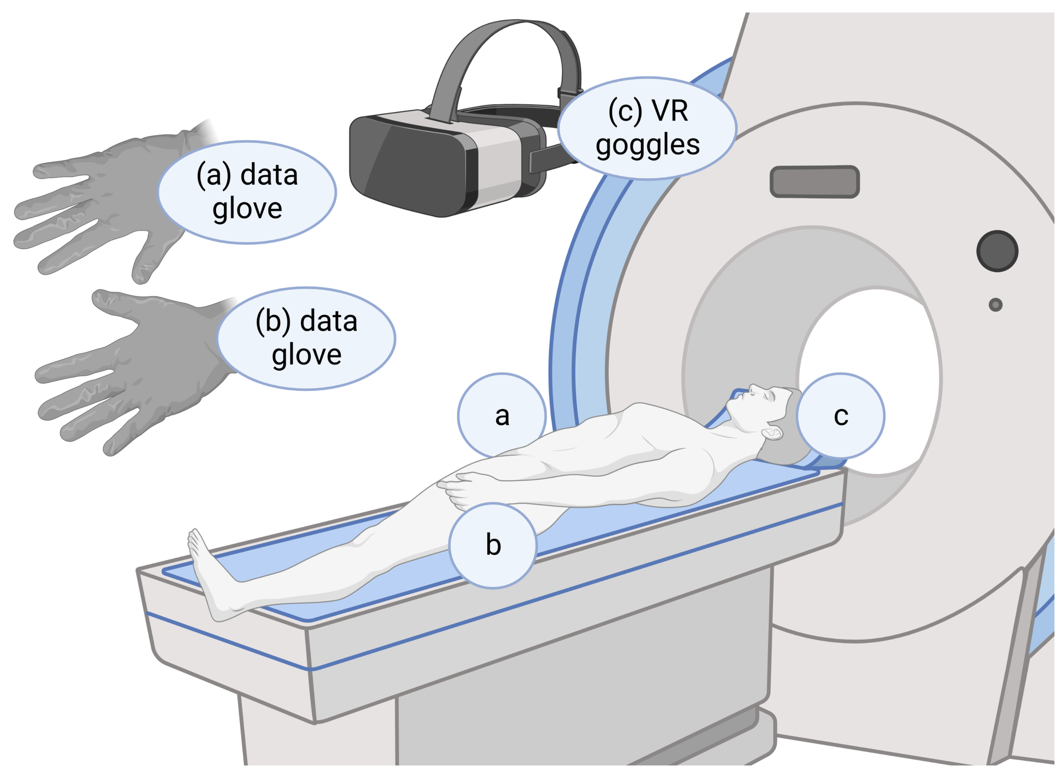
Sensorimotor Adaptation: Humans can learn/update a movement to adjust to changes from sensory input.

Learning of **motor actions** is driven by **error processing**. Feedback of information from proprioception and vision is integrated **when the two are congruent**.

Vision outweighs proprioception due to its higher spatial accuracy. But how does this mechanism affect the learning rate?

RQ: How well do humans learn a new movement when the visual feedback is wrong?

2. Experimental fMRI Set-Up



3. Experimental Task

A finger movement task where (healthy) subjects **perform better over time**, naturally.

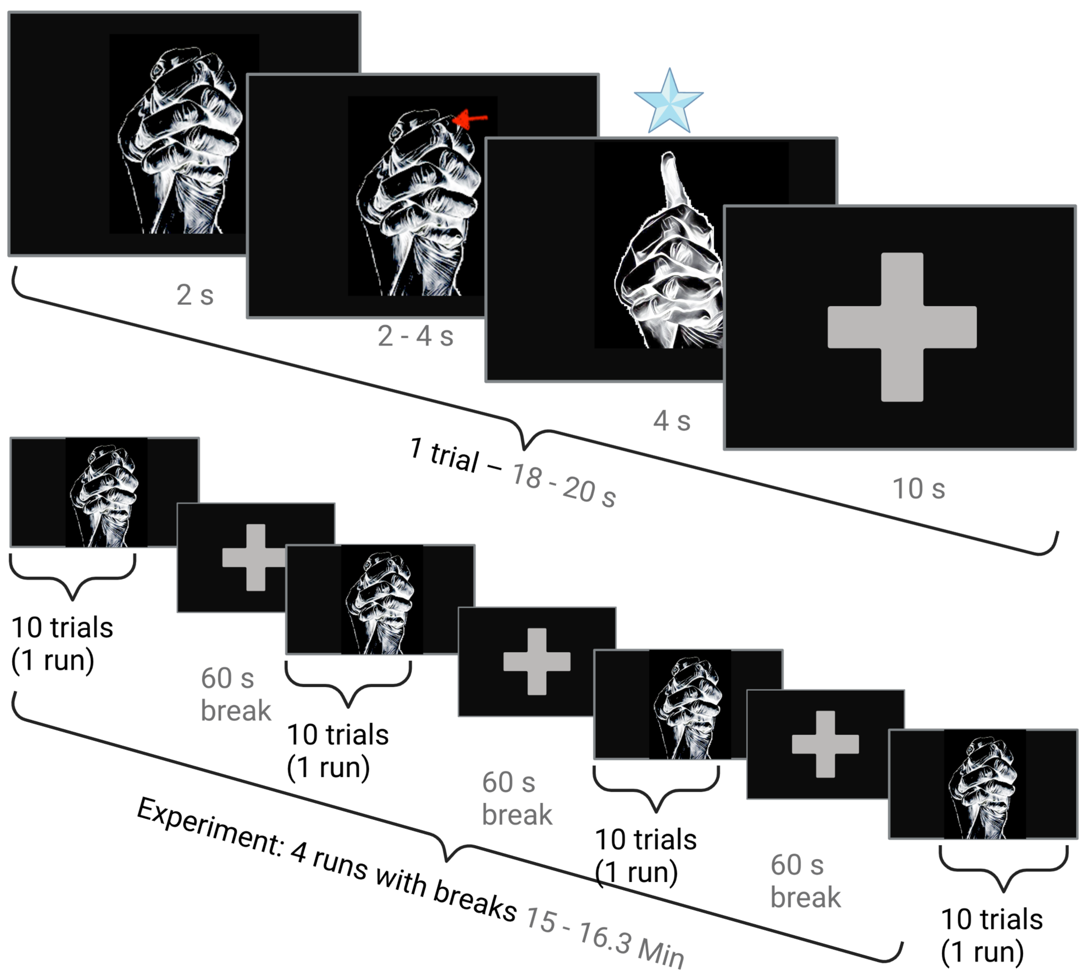
Preparation: (1) Cross hands, (2) grasp each other, (3) twist wrists vertically.

Instruction: Move finger arrow is pointing to (VR googles; see c above). **No correction** allowed.

Any finger can be randomly chosen ($p = .1$). Virtual observed 3D hands/fingers (Goggles; see c above) are synched with subject's limbs (Data glove; see a, b above).

4. Experimental Design

Learning will be **manipulated** experimentally by visual correct/incorrect feedback.



manipulation step: false finger moved (experimental trial) vs correct finger moved (control trial)
false: participants movement **not equal** to observed movement (vision and proprioception incongruence)
true: participants movement **equal** to observed movement (vision and proprioception incongruence)

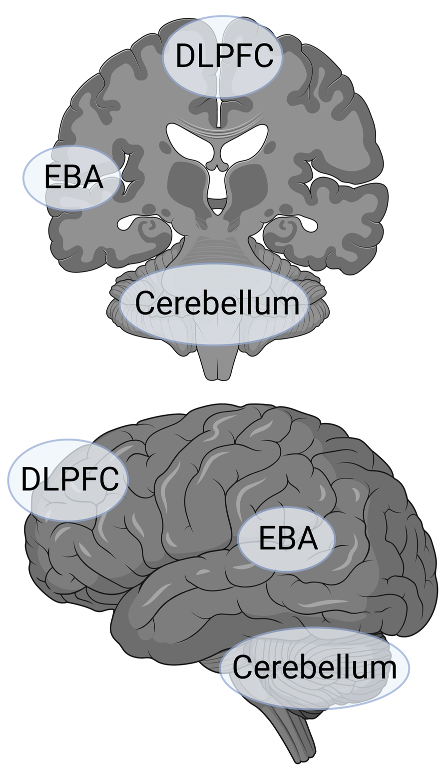
Sample: n = min. 4 subjects (estimate on params: $.\eta_p^2$=.156, α=.05, power = .9, age = 18 - 99, exclusion: finger and cerebral dysfunction.

5. Region of Interests

Extrastriate Body Area: Congruent versus incongruent visual and proprioceptive information. High vs low **prediction error**

Dorsolateral Prefrontal Cortex: Activated in early learning process. Shift from automatic to cognitive control. State: Consciously (implicitly) learning. High vs low **learning rate**

Cerebellum: Activated in late learning process. Shift from cognitive controlled to automatically retrieved motor action. State: Motor action has been learned. High vs low **learning rate**

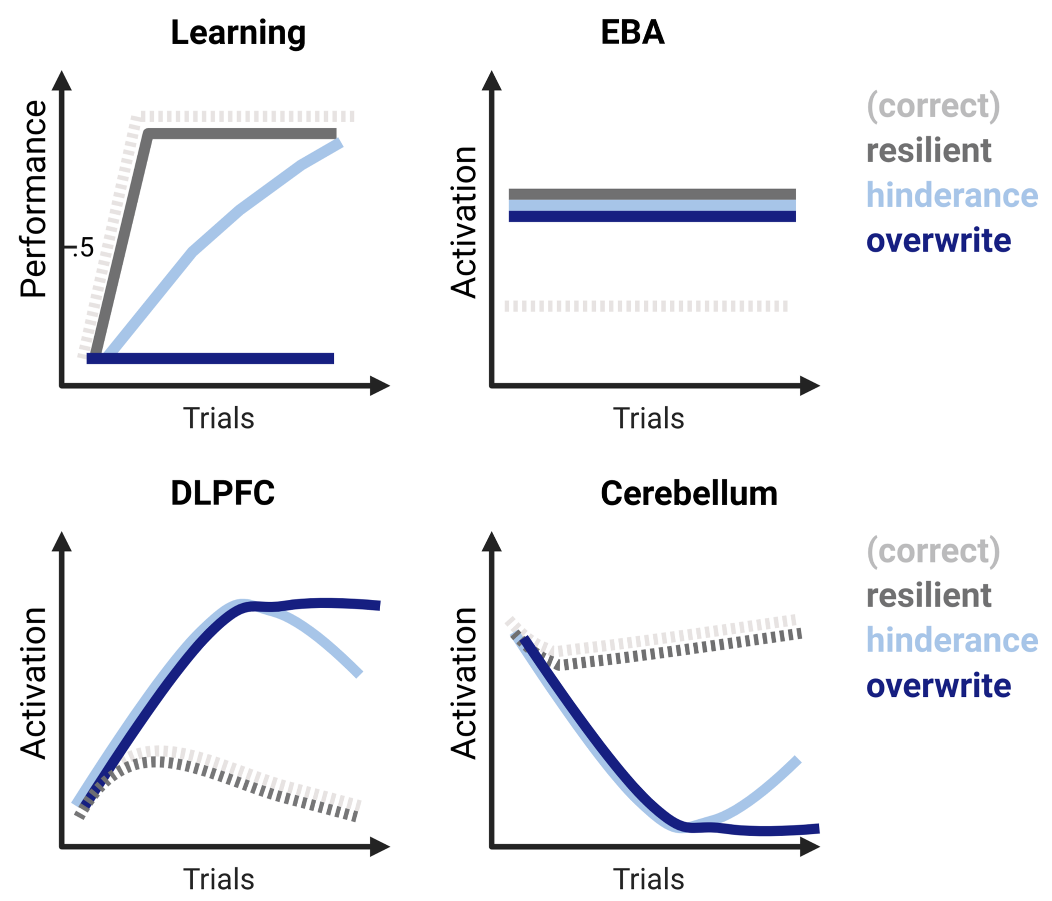


6. Expected Learning Model

Expected learning rates when the visual feedback **is false**. Learning = move correct finger. Humans learn ...

- slower (**Hinderance**),
- not at all (**Overwrite**),
- uninhibited (**Resilience**).

7. Neural Correlates and Learning



Update rule $V_{t+1}(S_t) = (1-\alpha)V_t(S_t) + \alpha r_t$
$V : value$
$t : trial$
$S : stimulus$
$\alpha : learning\ rate$
$r : reward$

The model differs in its $learning\ rate$.
overwrite : $\alpha = 0$
hinderance: $\alpha = .5$
resilient: $\alpha = 1$

8. Hypotheses

- **H1**: Congruency effects task performance (learning).
  - Performance (negative error) significantly different for trials after correct vs incorrect feedback.
  - **Resilient** learning model can not explain subject's performance significantly.
- **H2**: Visual input can outweigh proprioceptive information.
  - **Overwrite** and/or **Hinderance** learning model can explain subject's performance best.

9. Implication

Results show how **strong** false feedback from vision can **impede** or even **block** sensorimotor based learning.

References

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[2] Jakub Limanowski and Felix Blankenburg. Integration of visual and proprioceptive limb position information in human posteri[illegible] extrastriate cortex. *Journal of Neuroscience*, 36:2582–2589, 3 2016. ISSN 0270-6474. doi: 10.1523/JNEUROSCI.3987-15.2016. URL https:/[illegible]ci.org/content/36/9/2582 https://www.jneurosci.org/content/36/9/2582.abstract.

[3] Jakub Limanowski, Evgeniya Kirilina, and Felix Blankenburg. Neuronal correlates of continuous manual tracking under varying visual movement feedback in a virtual reality environment. *NeuroImage*, 146:81–89, 2 2017. ISSN 1053-8119. doi: 10.1016/J.NEUROIMAGE.2016.11.009.

[4] Rachael D Seidler, Bryan L Benson, Nathaniel B Boyden, and Youngbin Kwak. Motor skill learning 20. *The Oxford Handbook of Cognitive Neuroscience, Volume 1: Core Topics*, 1:416, 2013.

Contact information:
antonio.amaddio@fu-berlin.de