PREDICTIVE CODING
AN INTRODUCTION

AARHUS
UNIVERSITET
INSTITUT FOR KLINISK MEDICIN

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BODY PAIN PERCEPTION LAB

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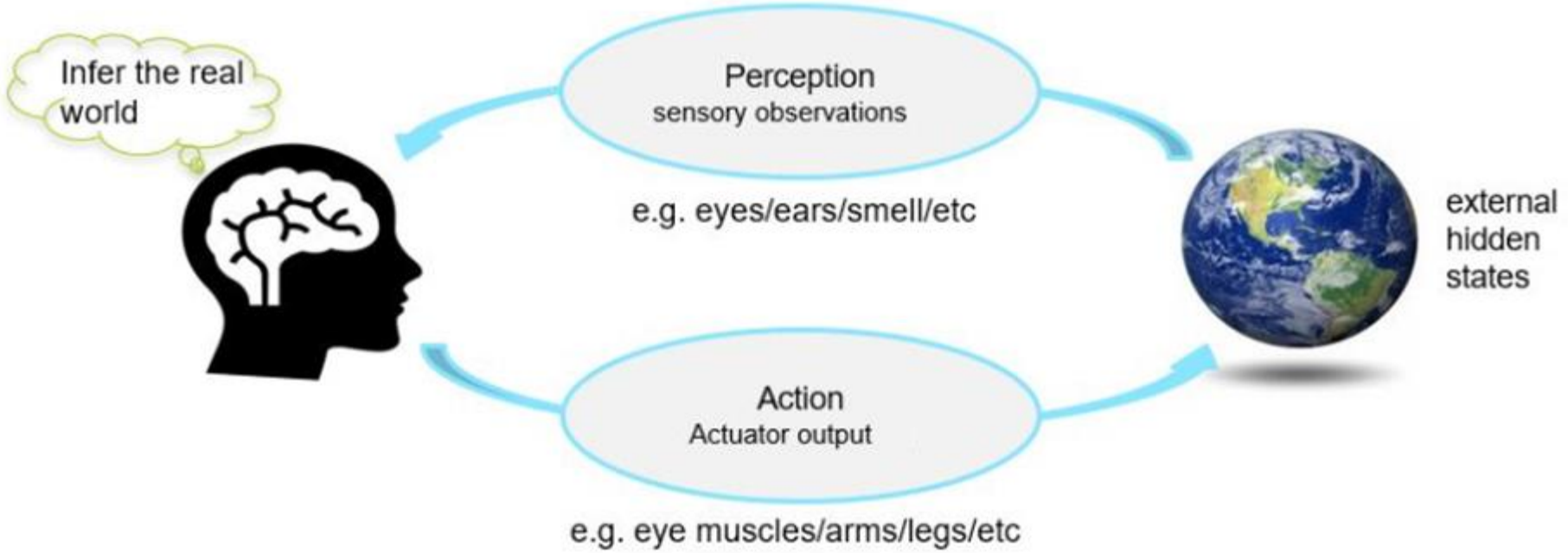
TERMS AND DEFINITIONS

(Friston et al., 2024)



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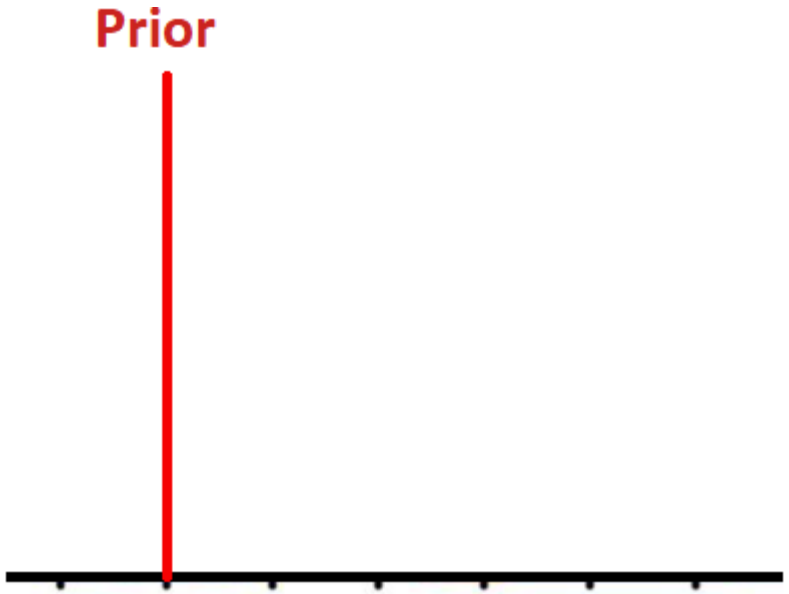

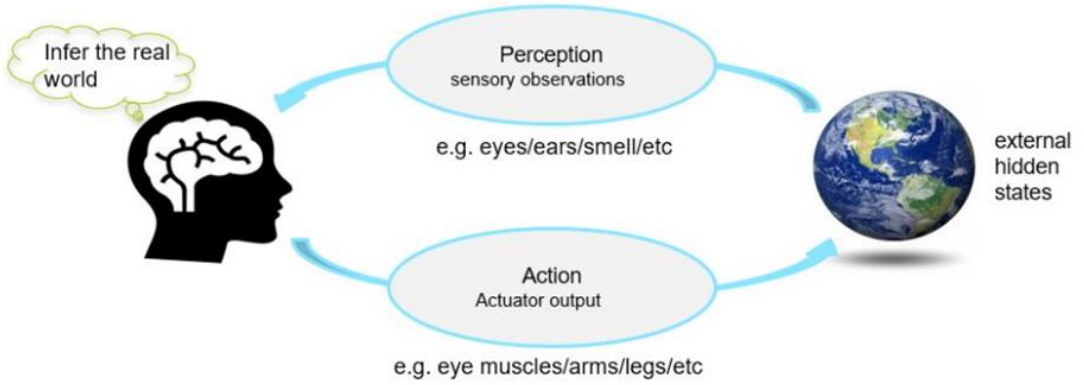

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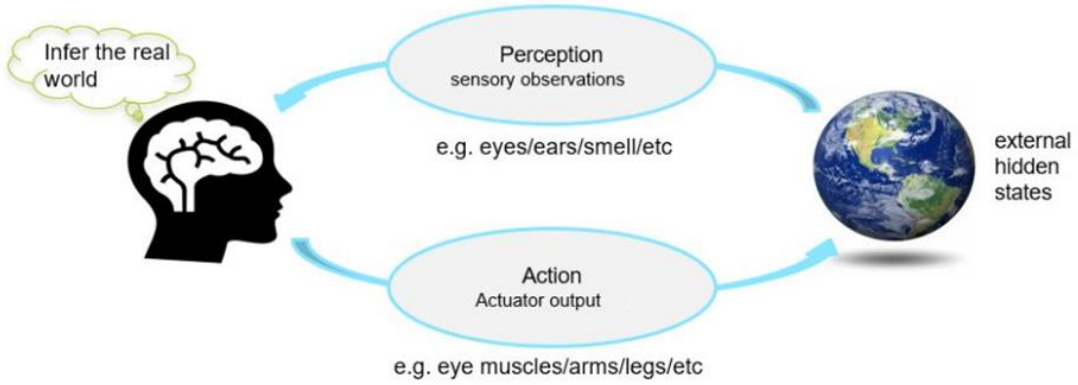

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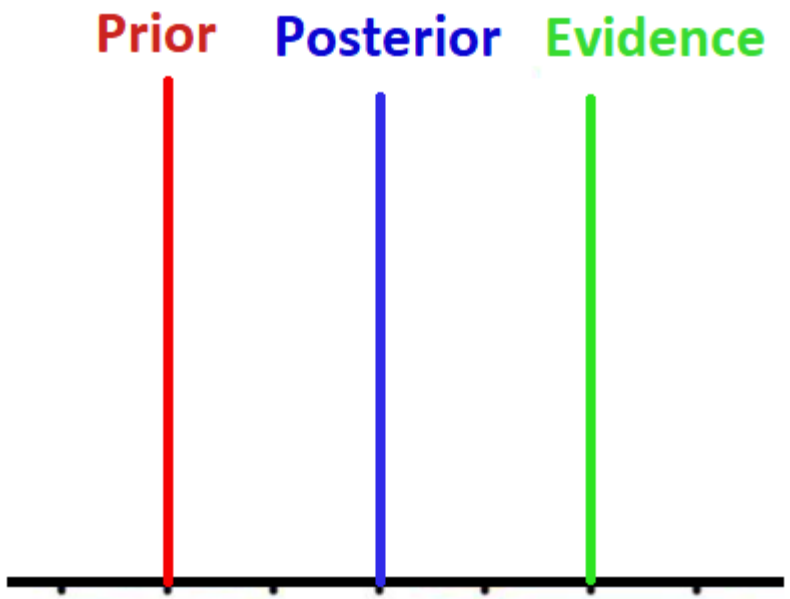

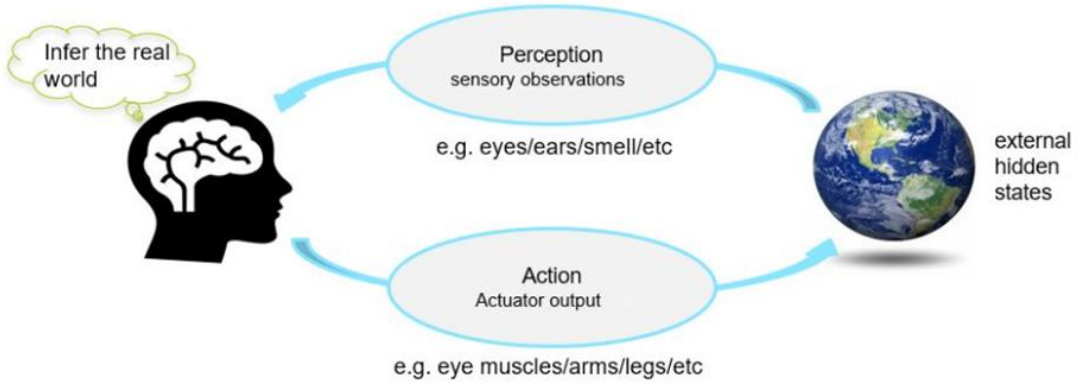

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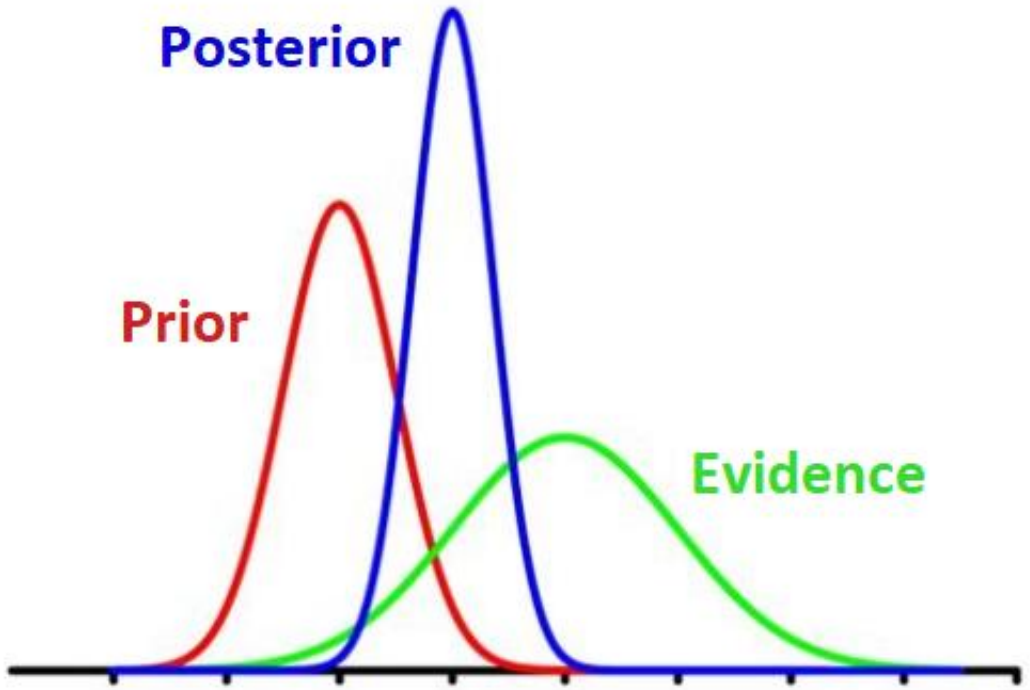

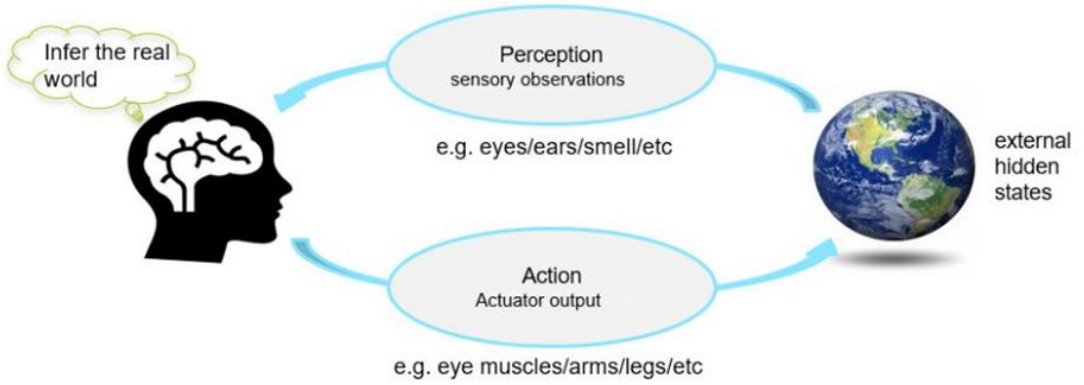

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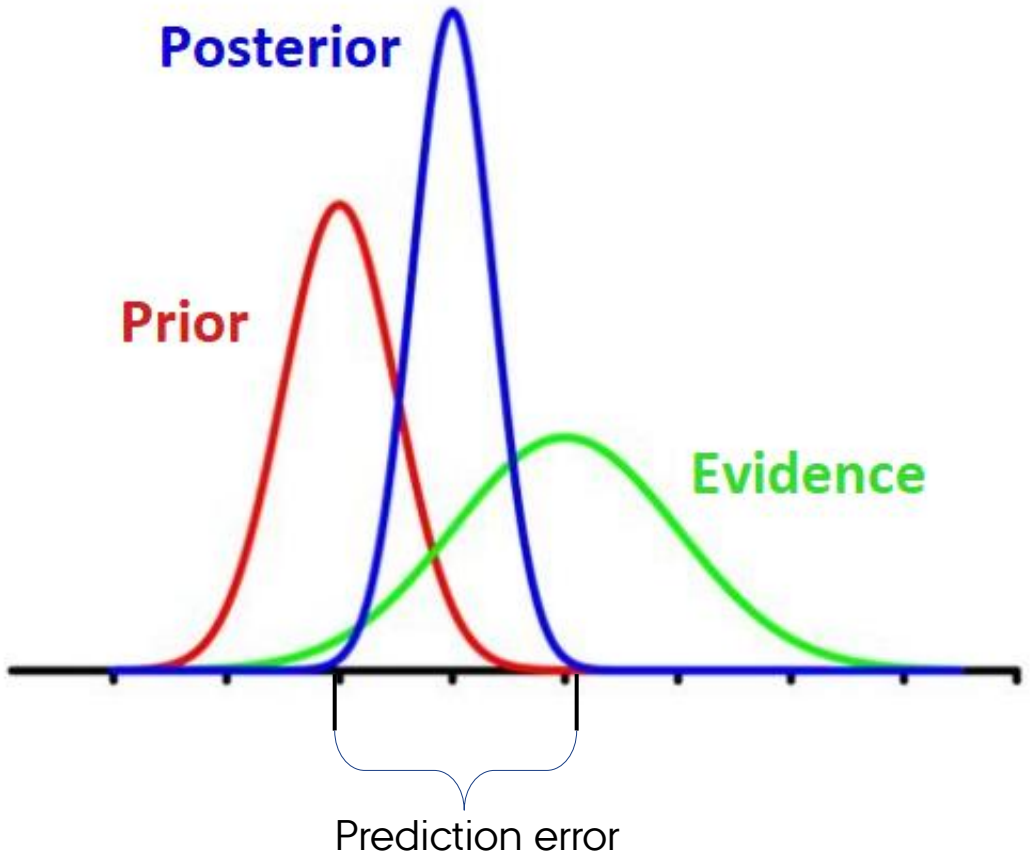
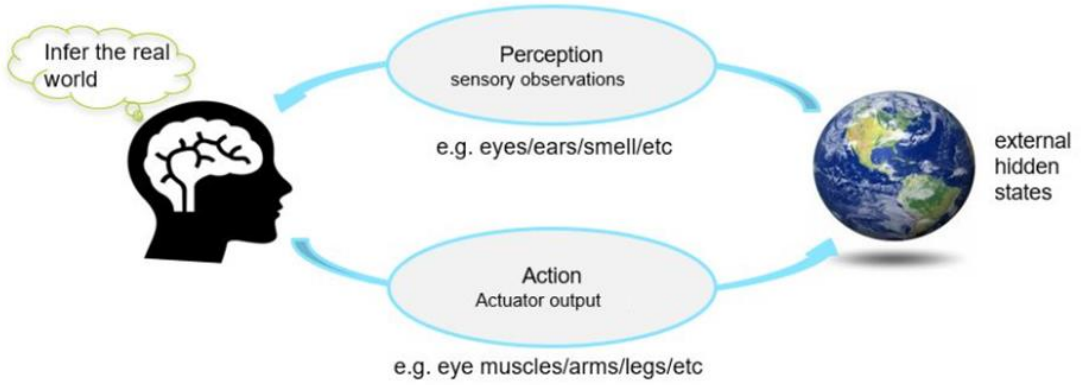




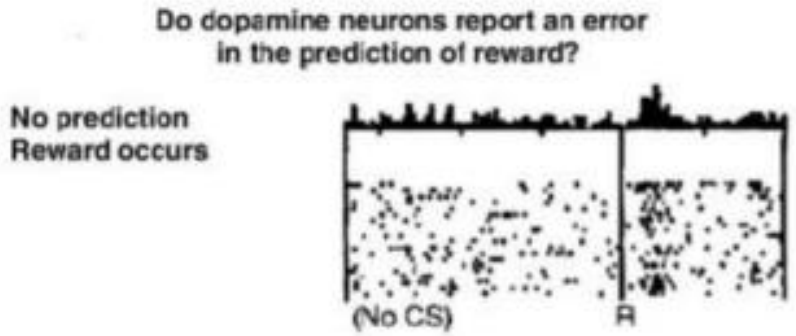
Usefulness and falsification

(Bowman et al., 2023)

Evidence

(Kishida & Sands, 2021)

(Schultz et al., 1997)



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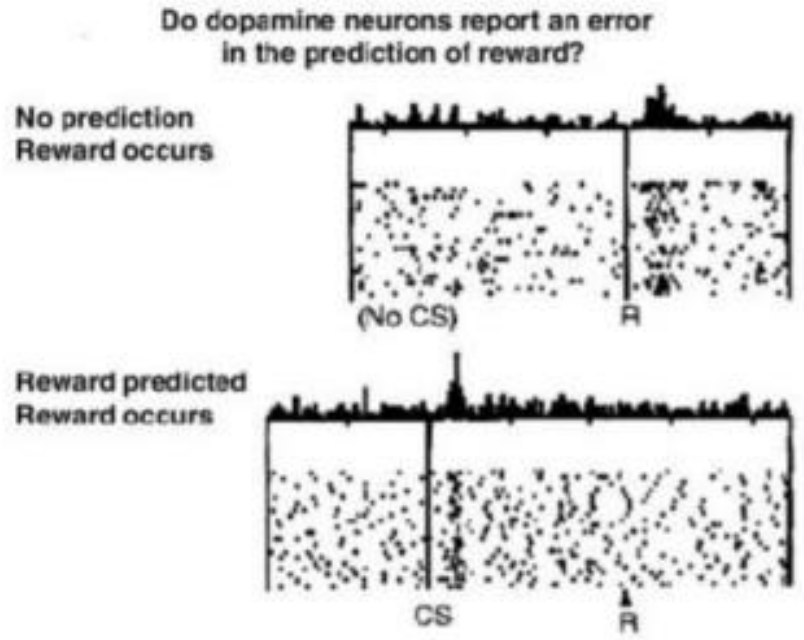

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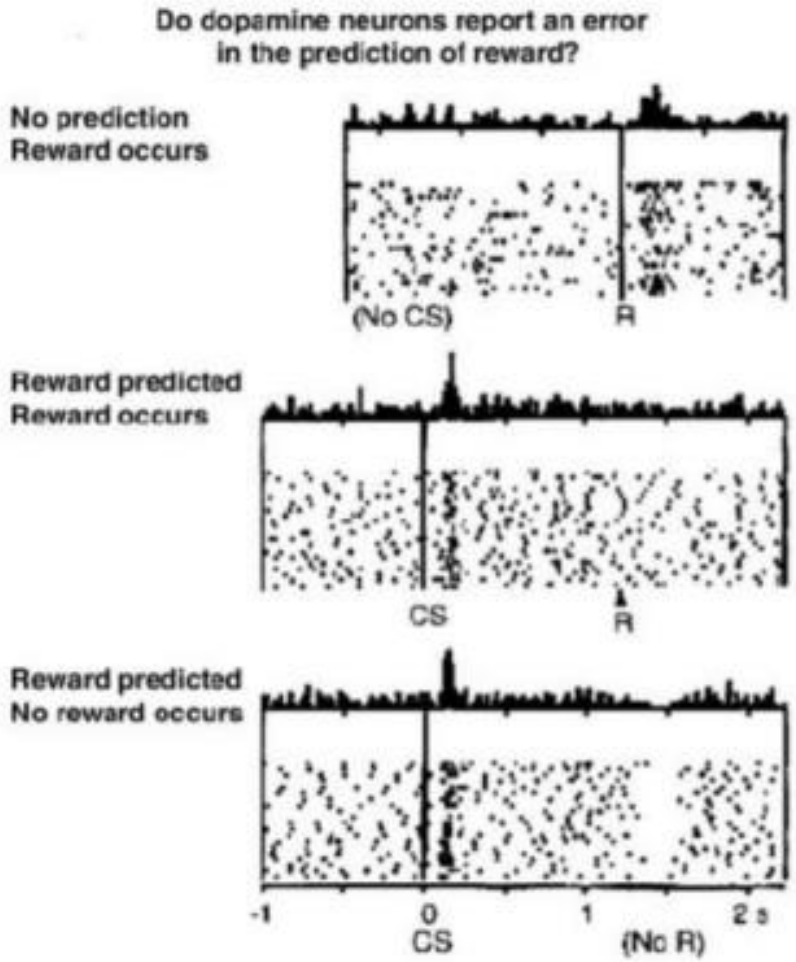

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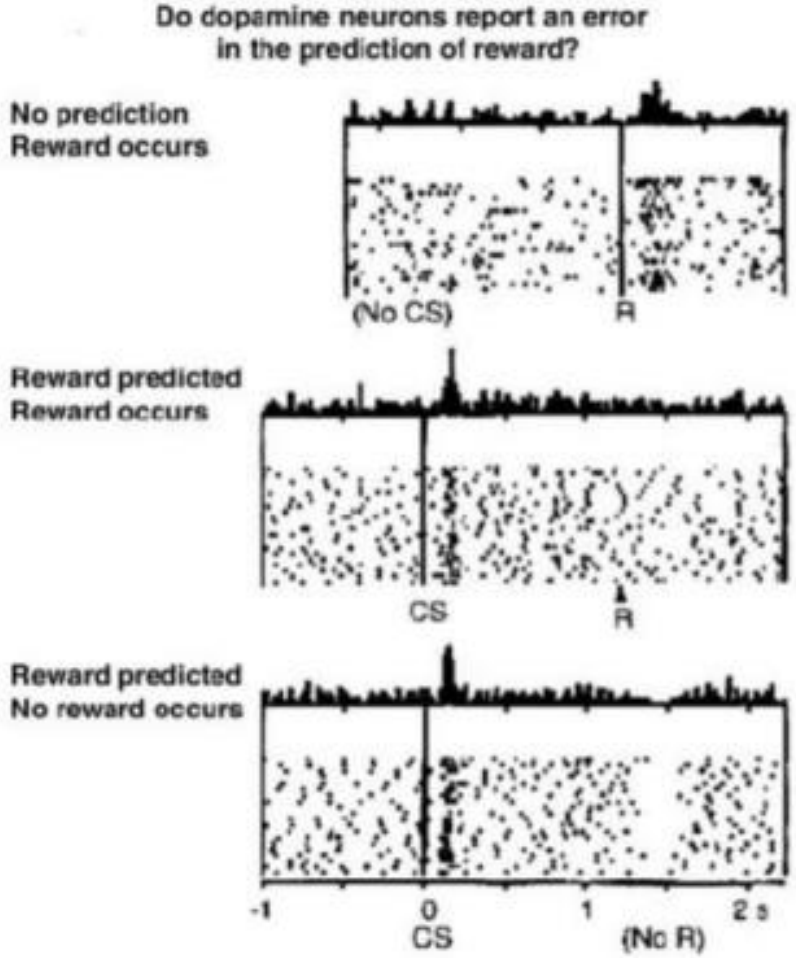
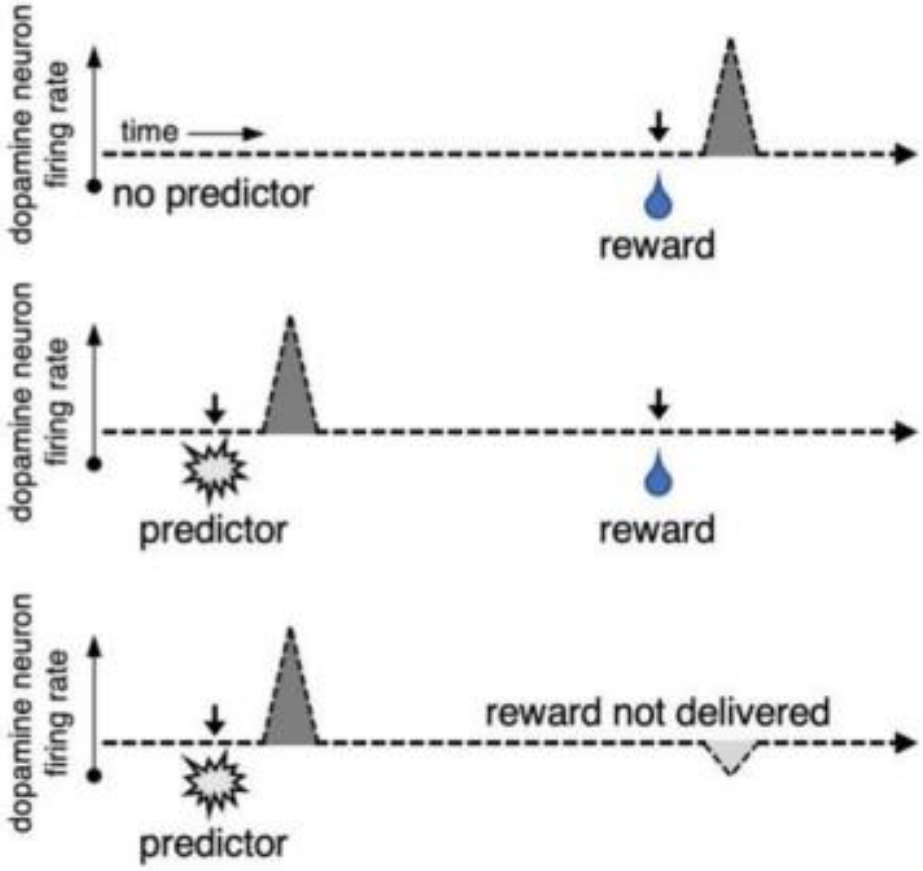
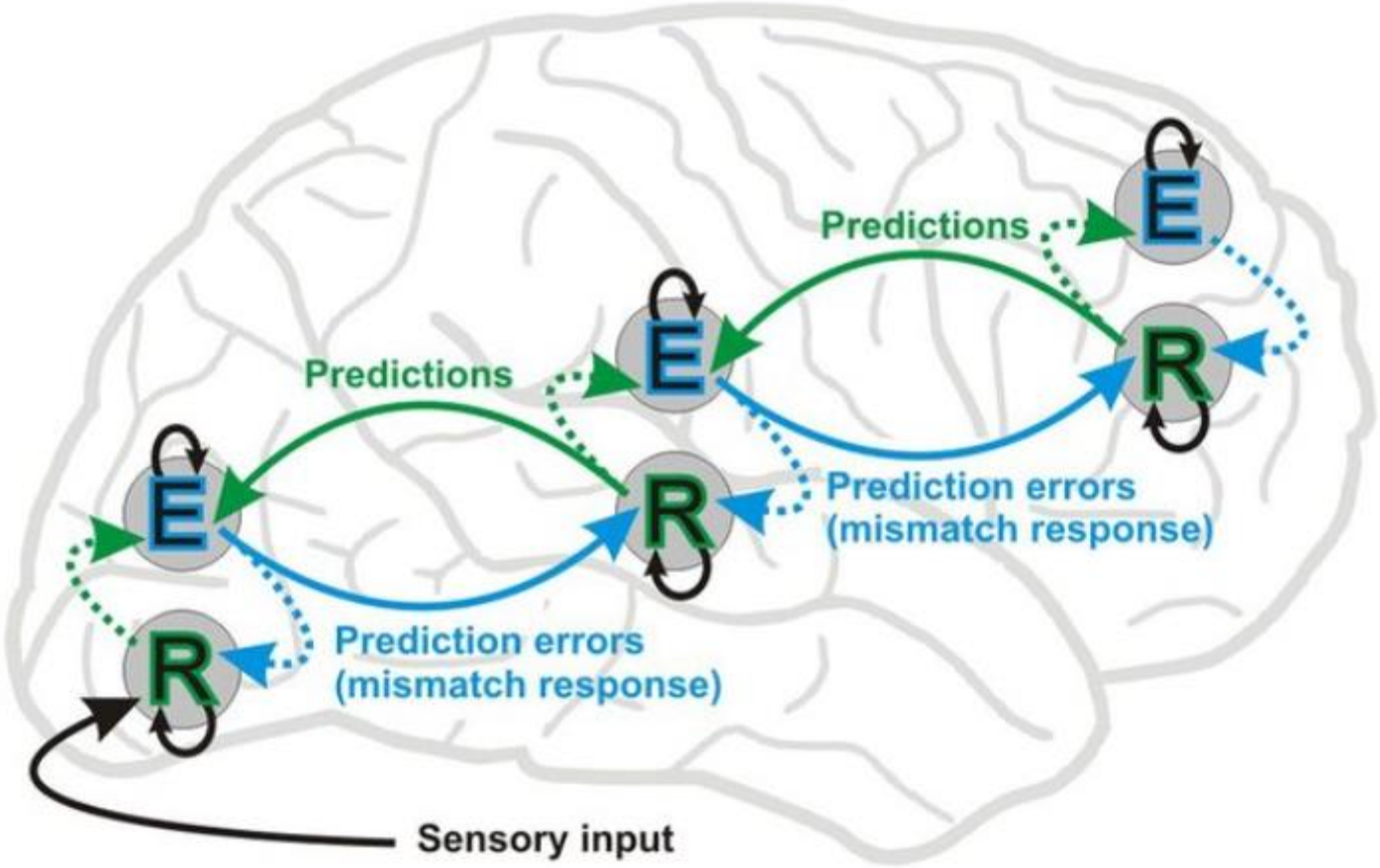




Evidence

(Stefanics et al., 2014)

(Rao & Ballard, 1999)



Bottom-up signals

(Mitchell et al., in prep)

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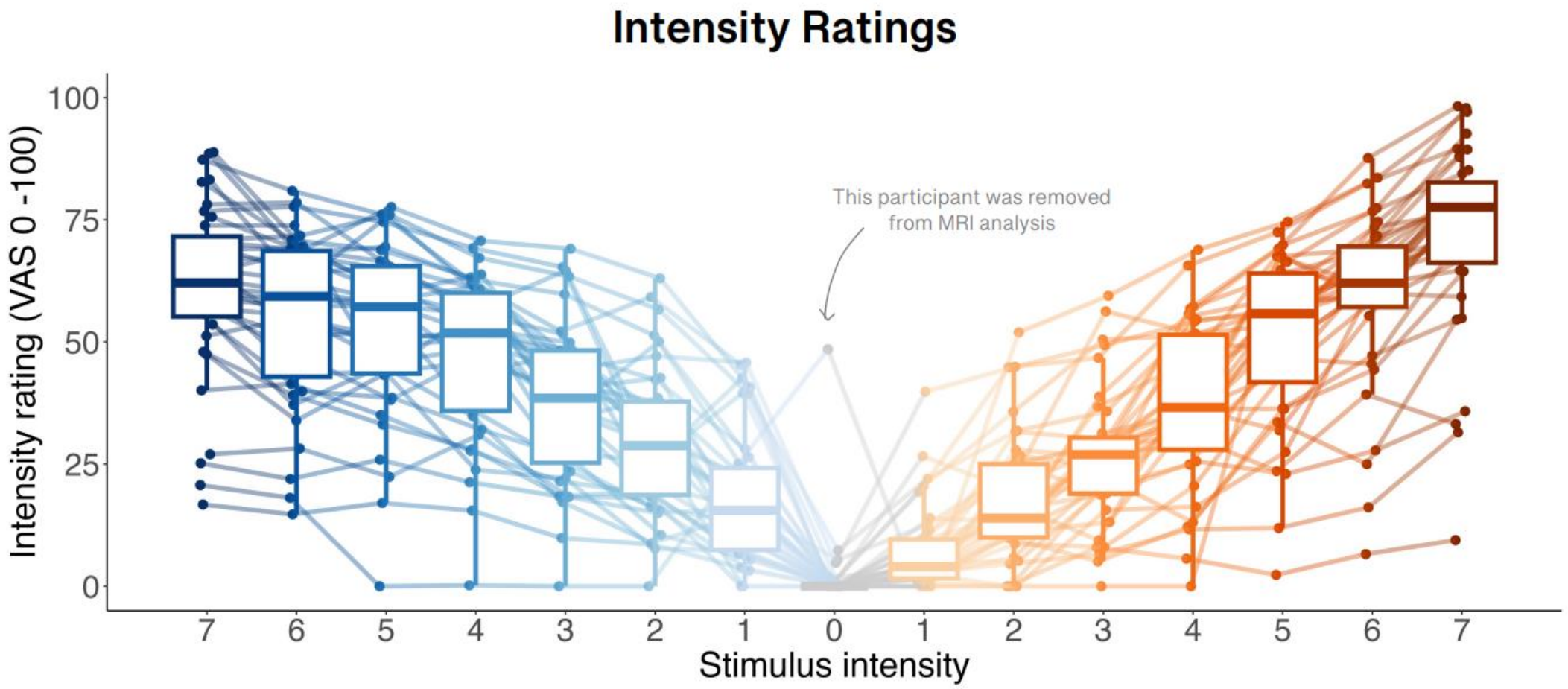

Expectations (top-down signals)

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Experimental manipulation of expectations

Learning

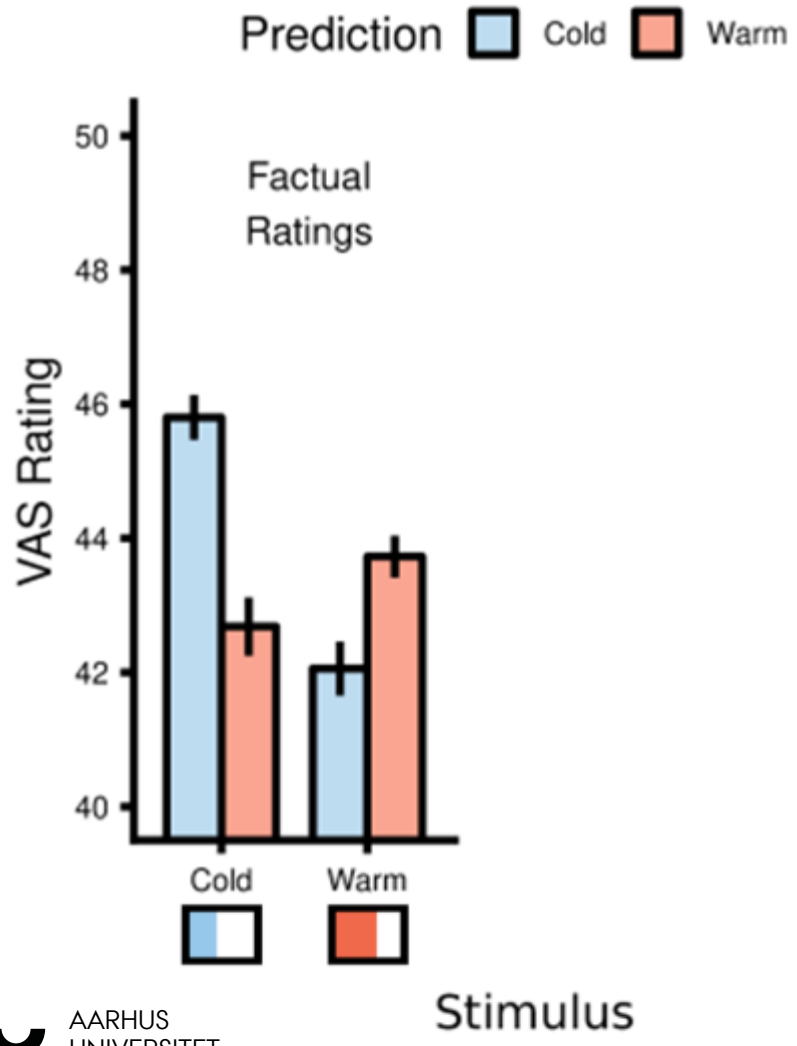
Conditioning

Instructions

Social / cultural cues

Expectations thermosensation

(Ehmsen et al., in prep)



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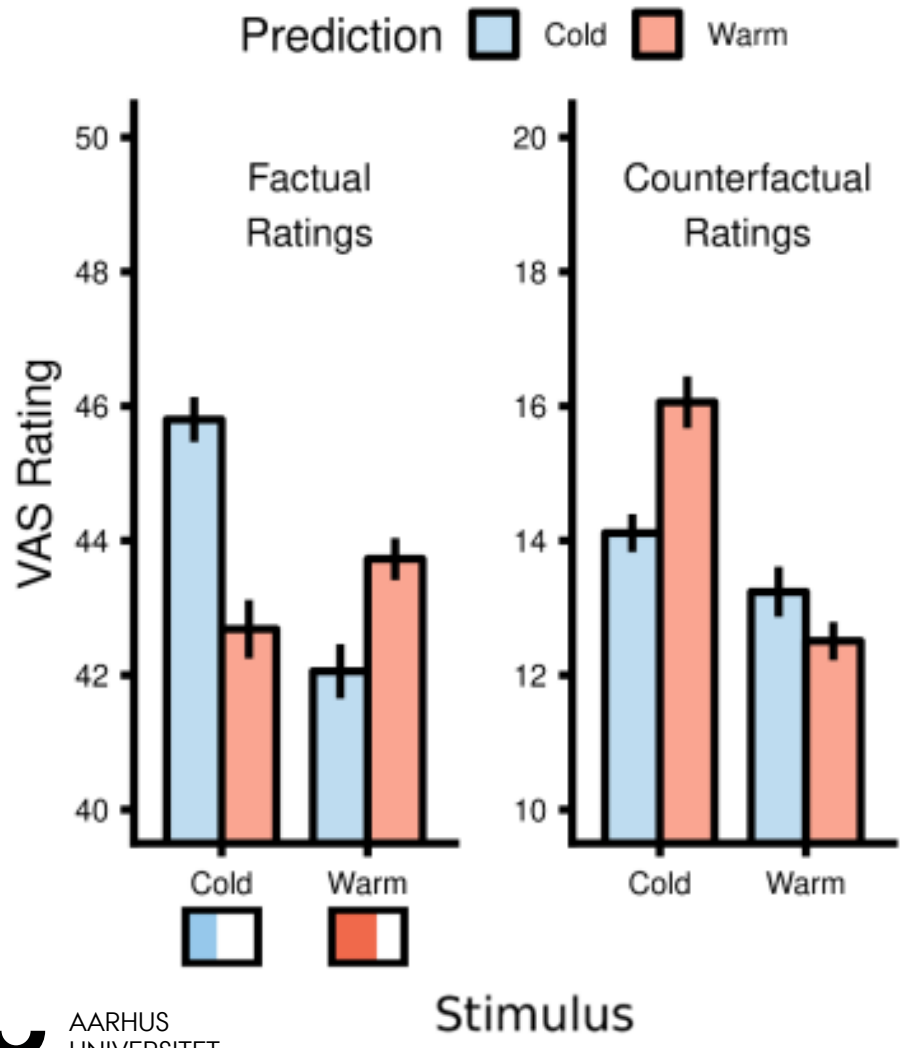
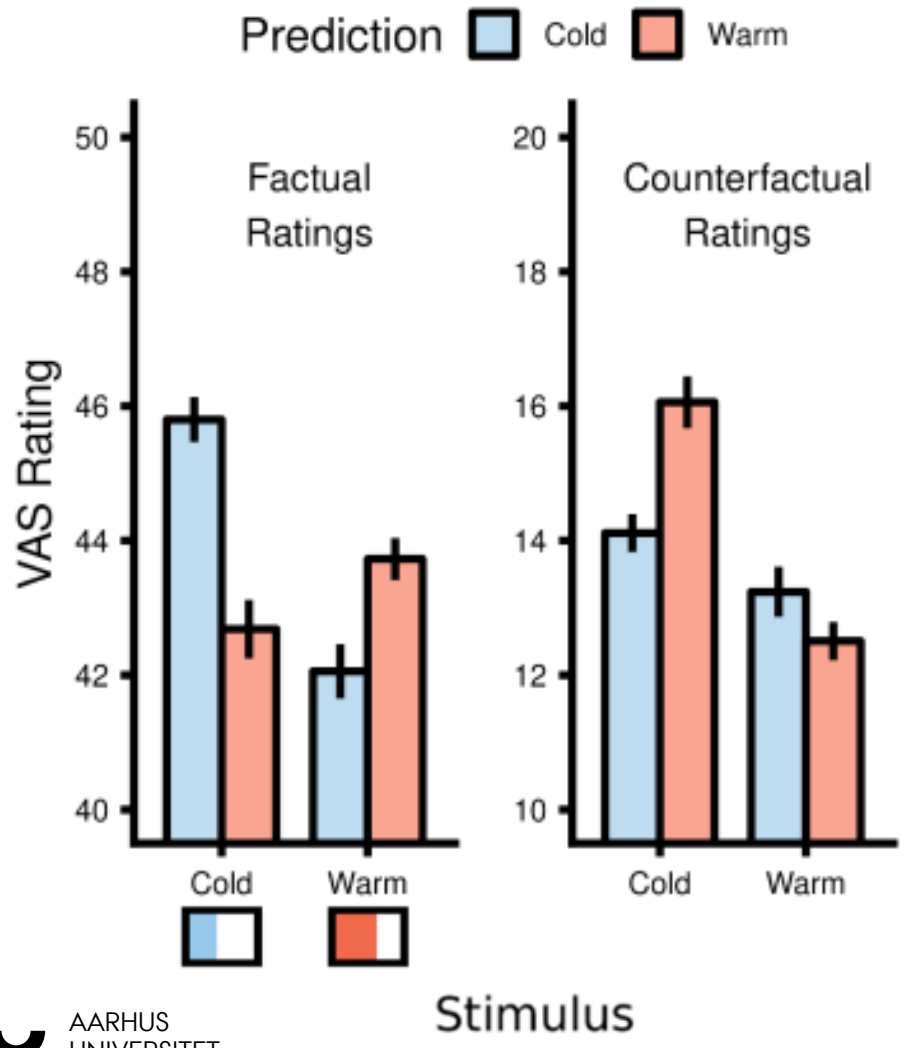
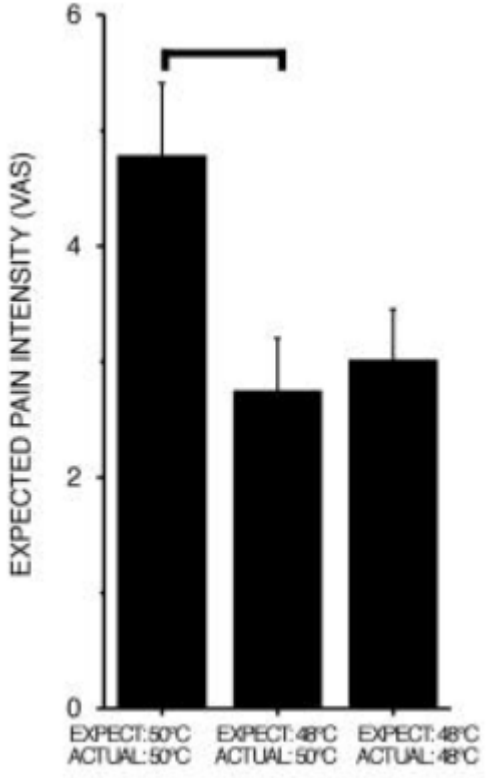


Expectations thermosensation

(Koyama et al., 2005)





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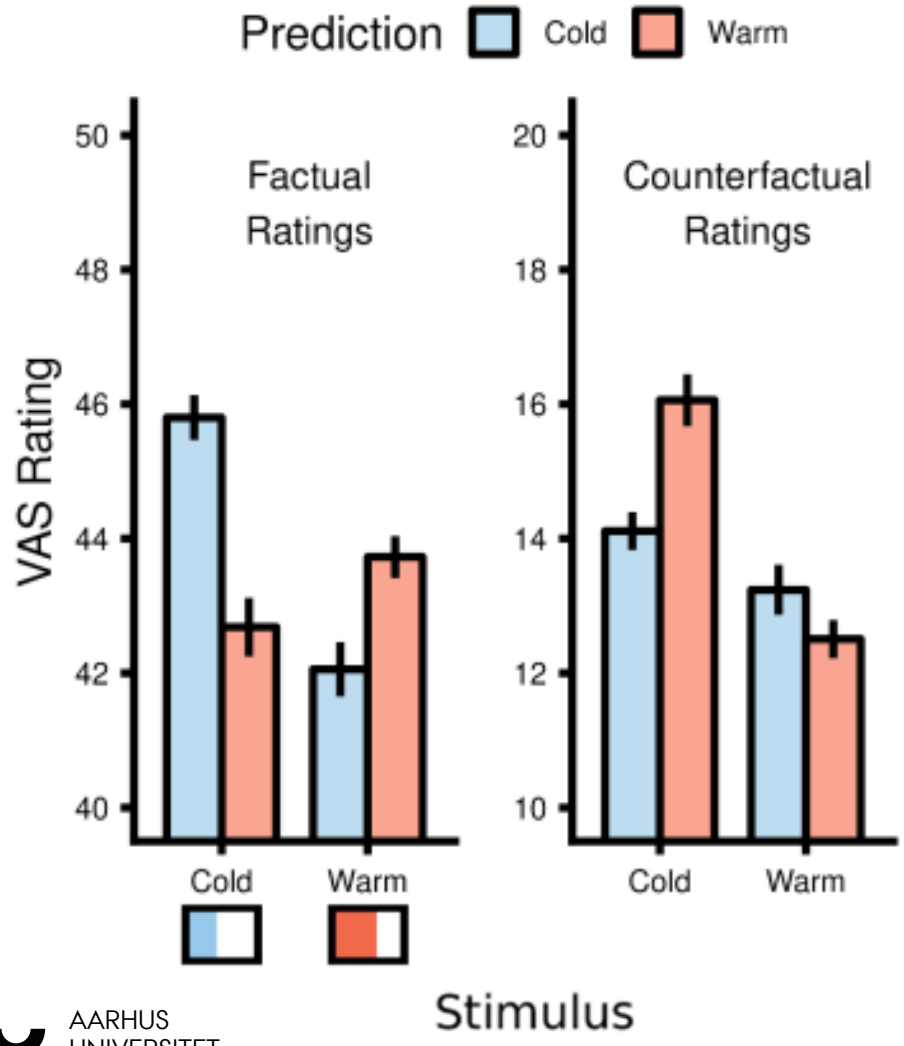
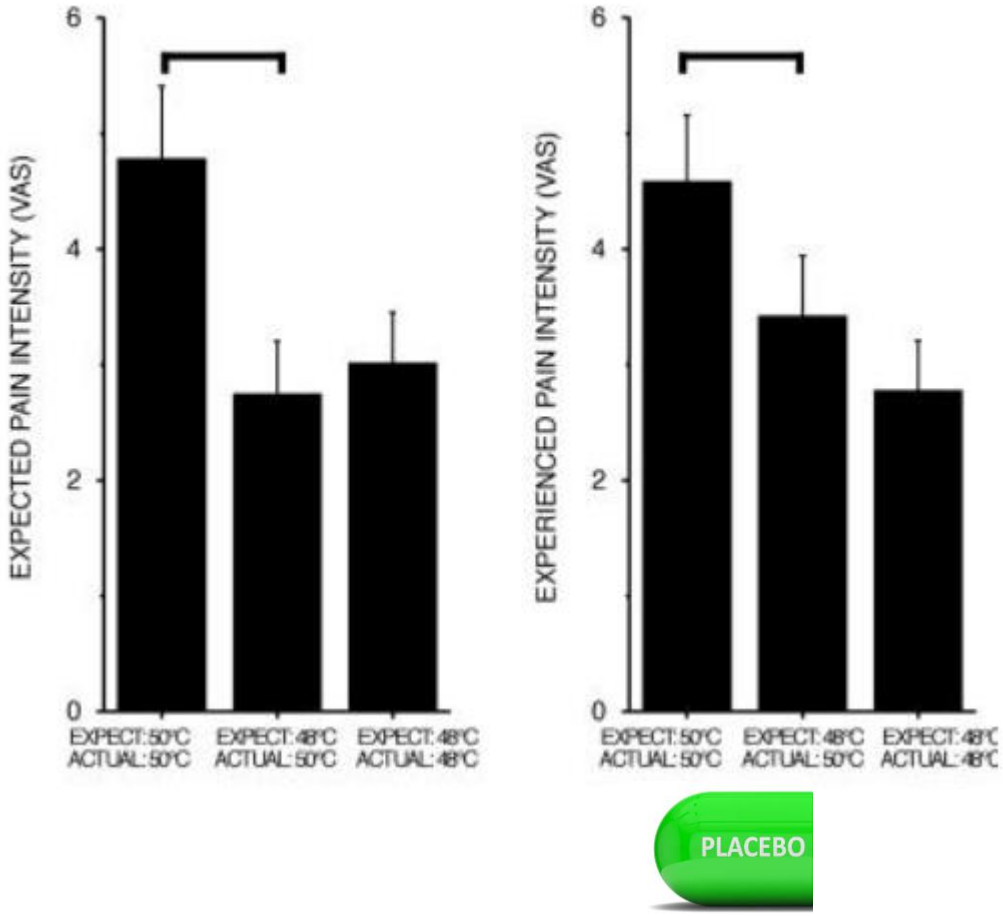
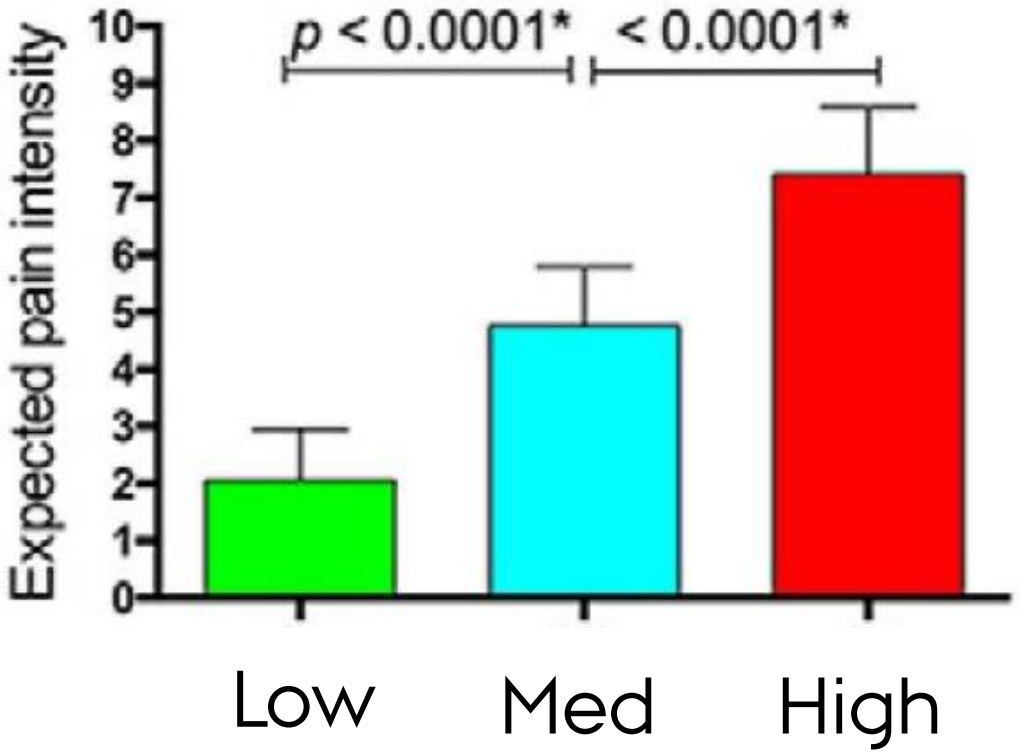




Expectations on pain

(Shih et al., 2019)



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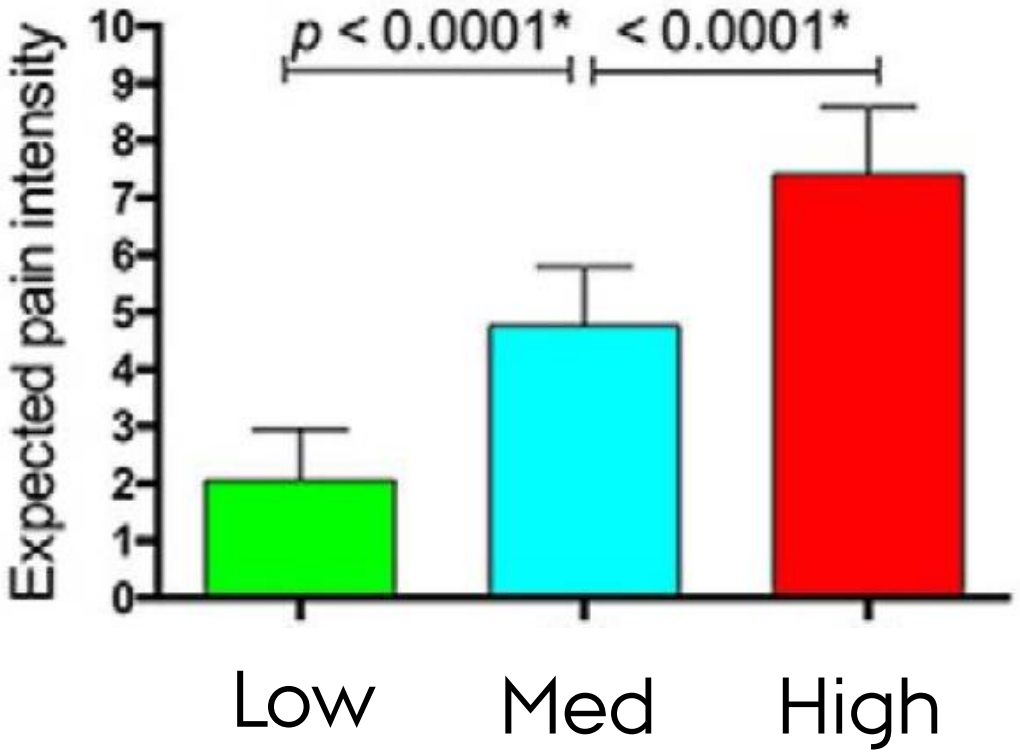

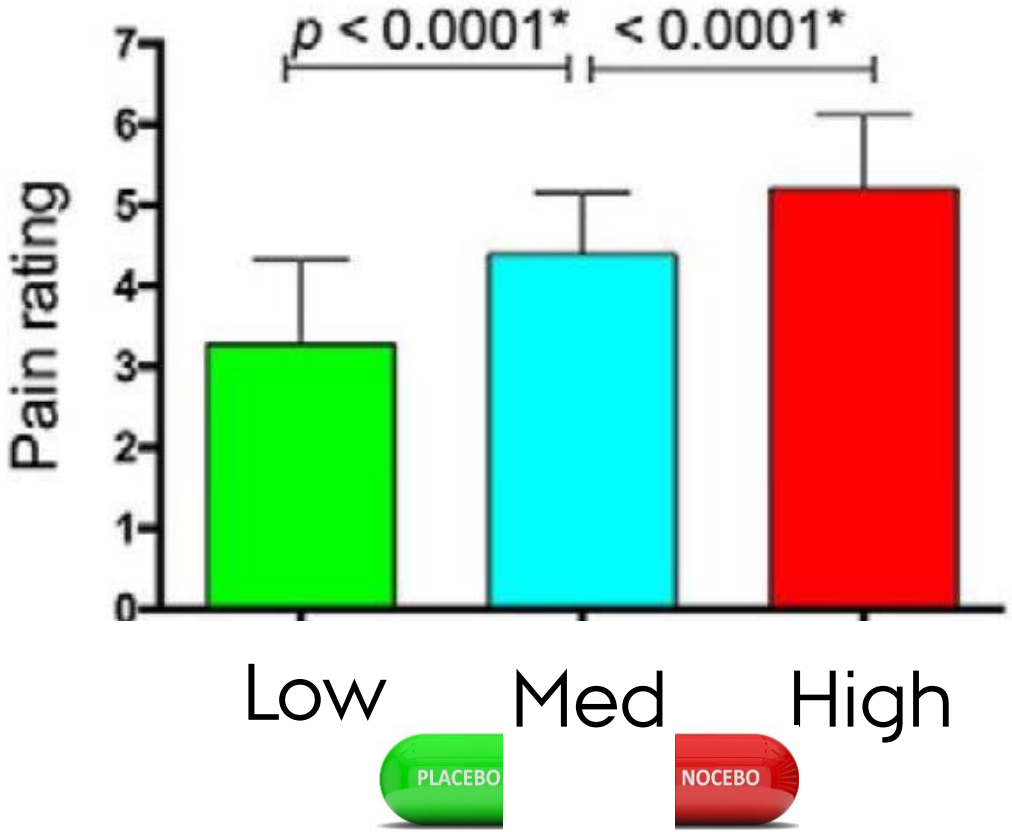

Relevance

(Sterzer et al., 2018)

Chronic pain

Psychosis

Schizophrenia

hallucinations

Relevance

(Tegner et al., 2018)

Quality Assessment						No. Patients		
No of Studies	Study Design	Risk of Bias	Inconsistency	Indirectness	Imprecision	Neurophysiological Pain Education	Effect (95% CI)	Quality
Pain (follow-up: median 4 wk)								
Pain measured on a VAS scale from 0-10 (10 worst) (5 studies)	Randomized trials	Serious*†	Not serious	Not serious	Not serious	106/212 (50.0%)	WMD −1.03 (−1.52 to −0.55)	⊕⊕⊕○ Moderate
Pain (follow-up: median 3 mo)								
Pain measured on a VAS scale from 0-10 (10 worst) (3 studies)	Randomized trials	Serious‡§	Not serious	Not serious	Serious‖	62/116 (53.4%)	WMD −1.09 (−2.17 to 0.00)	⊕⊕○○ Low
Disability (follow-up: median 4 wk)								
Disability measured on various different scales and transformed to NRS scale from 0-10 (10 worst) (6 studies)	Randomized trials	Serious*†	Not serious	Not serious	Serious‖	127/253 (50.2%)	WMD −1.00 (−1.72 to −0.29)	⊕⊕○○ Low
Disability (follow-up: median 3 mo)								
Disability measured on various different scales and transformed to NRS scale from 0-10 (10 worst) (4 studies)	Randomized trials	Serious*†	Not serious	Not serious	Serious‖	90/178 (50.6%)	WMD −0.82 (−1.56 to −0.05)	⊕⊕○○ Low
Behavioral attitude (Tampa Scale of Kinesiophobia) (follow-up: median 4 weeks)								
Behavioral attitude measured on Tampa Scale of Kinesiophobia (17-68) (68 worst) (3 studies)	Randomized trials	Serious*¶#	Serious**	Not serious	Serious‖	56/112 (50.0%)	WMD −5.73 (−13.60 to 2.14)	⊕○○○ Very low
Tampa Scale of Kinesiophobia (follow-up: median 3 mo)								
Behavioral attitude measured on Tampa Scale of Kinesiophobia (17-68) (68 worst) (2 studies)	Randomized trials	Serious *#	Not serious	Not serious	Serious‖	50/100 (50.0%)	WMD −0.94 (−6.28 to 4.40)	⊕⊕○○ Low

*Selective reporting bias: no registered protocol, unclear in choice of reported results.
†Concealment bias: explanation of the concealment missing.
‡No blinding of outcome assessors.
§Other sources of bias: baseline difference between groups.
‖Wide 95% CI.
¶Other sources of bias: high dropout.
#No blinding of assessor.
**High heterogeneity.
CI indicates confidence interval; VAS, Visual Analog Scale; WMD, weighted mean difference.

References

- Tegner, H., Frederiksen, P., Esbensen, B. A., & Juhl, C. (2018). Neurophysiological Pain Education for Patients With Chronic Low Back Pain: A Systematic Review and Meta-Analysis. *The Clinical Journal of Pain*, *34*(8), 778. https://doi.org/10.1097/AJP.0000000000000594

- Sterzer, P., Adams, R. A., Fletcher, P., Frith, C., Lawrie, S. M., Muckli, L., Petrovic, P., Uhlhaas, P., Voss, M., & Corlett, P. R. (2018). The Predictive Coding Account of Psychosis. *Biological Psychiatry*, *84*(9), 634–643. https://doi.org/10.1016/j.biopsych.2018.05.015

- Stefanics, G., Kremláček, J., & Czigler, I. (2014). Visual mismatch negativity: A predictive coding view. *Frontiers in Human Neuroscience*, *8*, 666. https://doi.org/10.3389/fnhum.2014.00666

- Shih, Y.-W., Tsai, H.-Y., Lin, F.-S., Lin, Y.-H., Chiang, C.-Y., Lu, Z.-L., & Tseng, M.-T. (2019). Effects of Positive and Negative Expectations on Human Pain Perception Engage Separate But Interrelated and Dependently Regulated Cerebral Mechanisms. *The Journal of Neuroscience*, *39*(7), 1261–1274. https://doi.org/10.1523/JNEUROSCI.2154-18.2018

- Schultz, W., Dayan, P., & Montague, P. R. (1997). A neural substrate of prediction and reward. *Science (New York, N.Y.)*, *275*(5306), 1593–1599. https://doi.org/10.1126/science.275.5306.1593

References

- Rao, R. P. N., & Ballard, D. H. (1999). Predictive coding in the visual cortex: A functional interpretation of some extra-classical receptive-field effects. Nature Neuroscience, 2(1), 79–87. https://doi.org/10.1038/4580 Schultz, W. (2016). Dopamine reward prediction error coding. Dialogues in Clinical Neuroscience, 18(1), 23–32.

- Koyama, T., McHaffie, J. G., Laurienti, P. J., & Coghill, R. C. (2005). The subjective experience of pain: Where expectations become reality. Proceedings of the National Academy of Sciences of the United States of America, 102(36), 12950–12955. https://doi.org/10.1073/pnas.0408576102

- Kishida, K. T., & Sands, L. P. (2021). A Dynamic Affective Core to bind the contents, context, and value of conscious experience. In Affect dynamics (pp. 293–328). Springer Nature Switzerland AG. https://doi.org/10.1007/978-3-030-82965-0_12

- Friston, K. J., Ramstead, M. J. D., Kiefer, A. B., Tschantz, A., Buckley, C. L., Albarracin, M., Pitliya, R. J., Heins, C., Klein, B., Millidge, B., Sakthivadivel, D. A. R., Smithe, T. S. C., Koudahl, M., Tremblay, S. E., Petersen, C., Fung, K., Fox, J. G., Swanson, S., Mapes, D., & René, G. (2024). Designing Ecosystems of Intelligence from First Principles. Collective Intelligence, 3(1), 26339137231222481. https://doi.org/10.1177/26339137231222481

References

- Bowman, H., Collins, D. J., Nayak, A. K., & Cruse, D. (2023). Is predictive coding falsifiable? *Neuroscience & Biobehavioral Reviews*, *154*, 105404. https://doi.org/10.1016/j.neubiorev.2023.105404

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