Evidence that the Brain's Physics Engine Infers Physical Stability Based on Forward Simulations of What will Happen Next

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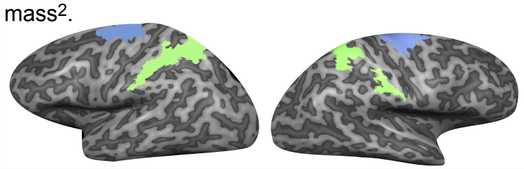
Background

Fronto-parietal regions in the human brain are strongly engaged in intuitive physical inference[1], and they contain invariant information about object mass[2].



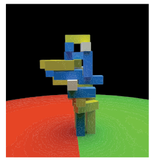
Questions

1. Does the brain's physics engine represent the physical stability of objects?
2. Do these regions infer stability based on forward simulations?

Intuitive Physics Localizer

Subjects made physical versus non-physical judgements on visually identical movie stimuli in an fMRI experiment.

Where will it fall? (physical)
or
More blue or yellow? (non-physical)

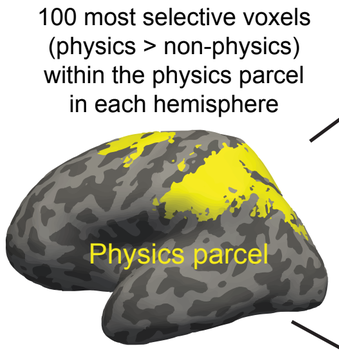


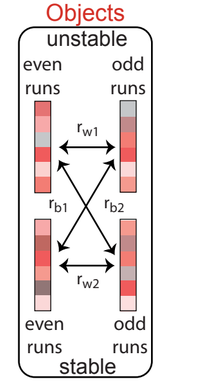
Stimulus and Experimental Design

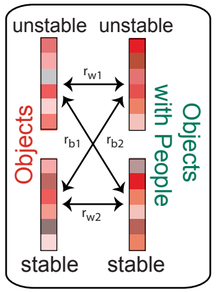
8 subjects; block design with 1-back task; 2 repeats of each condition per run; atleast 4 runs per subject; subjects fixated at the center throughout (confirmed with eyetracking)

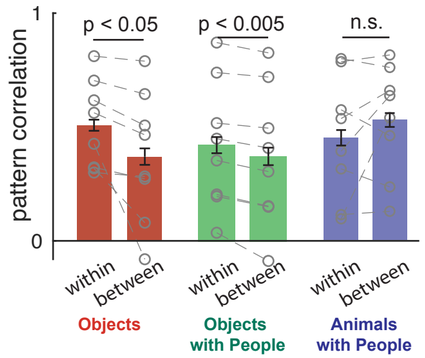
Q1. Does the brain's physics engine carry information about the physical stability of objects?

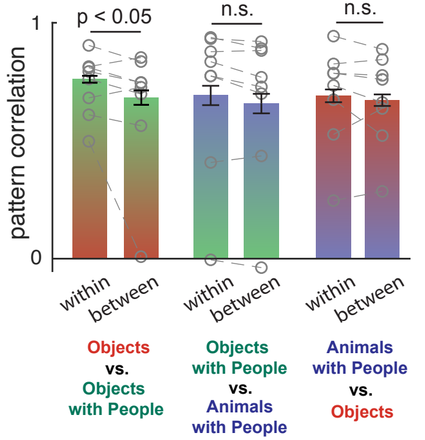
100 most selective voxels (physics > non-physics) within the physics parcel in each hemisphere





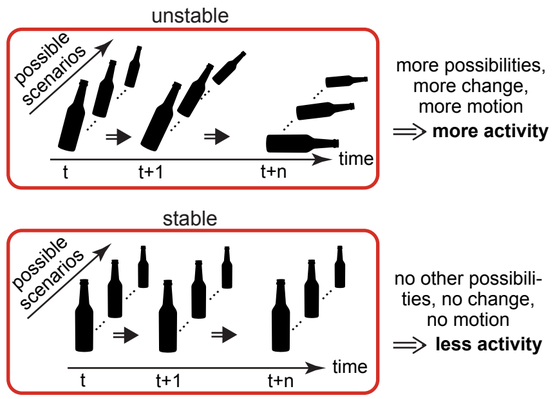




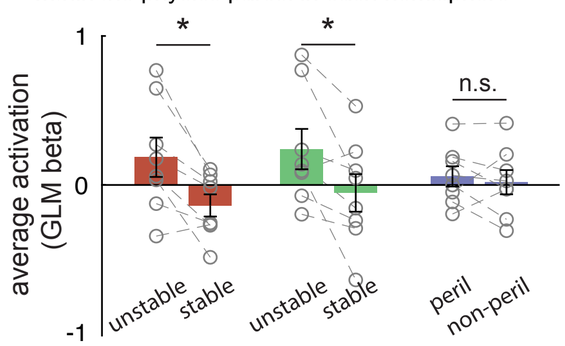


Physics regions have a generalizable representation of stability

Q2. Do these regions infer stability based on forward simulations?



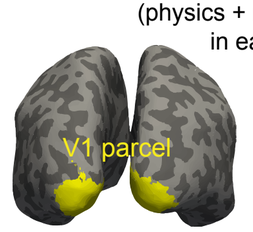
100 most selective voxels (physics > non-physics) within the physics parcel in each hemisphere

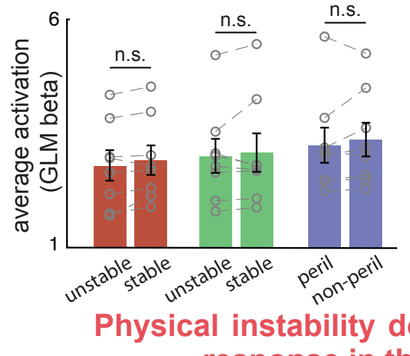


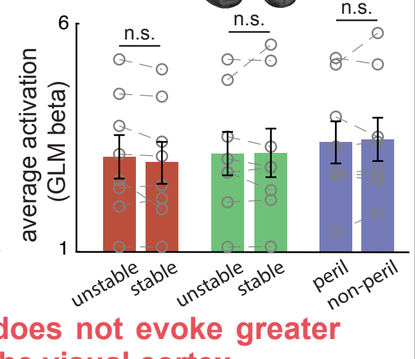
Physical instability evokes greater response consistent with the hypothesis that physics regions infer stability based on forward simulations

Is this also true in the visual cortex?

100 most selective visual voxels (physics + non-physics > fixation) in each hemisphere







Physical instability does not evoke greater response in the visual cortex

Conclusions

1. Fronto-parietal physics regions have a generalizable representation of physical stability.

2. Physical instability evokes greater response only in the physics regions consistent with the hypothesis that these regions infer stability through forward simulations. [We plan to test this directly in future experiments using high temporal resolution data from EEG/MEG/ECoG]

3. Our results are unlikely to be due to low level stimulus differences, eye-movements and attention.

Acknowledgements

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References

1. Fischer et. al. (2016). Functional neuroanatomy of intuitive physical inference. Proceedings of the national academy of sciences, 113(34), E5072-E5081.
2. Schwettmann et. al. (2019). Invariant representations of mass in the human brain. eLife, 8, e46619.