Research Reproducibility 2020
Educating for Reproducibility: Pathways to Research Integrity
University of Florida, Gainesville, FL, USA

Paradigm-based spatial navigation research as a model to enhance reproducibility in cognitive neuroscience

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ABSTRACT

Introduction: Reproducible science is a challenge in cognitive neuroscience, especially when studying complex constructs like spatial navigation. Experimenters must decide whether to use a paradigm that measures spatial navigation with high ecological validity (but low control over how subjects learn the environment) or to use a paradigm that reduces spatial navigation with high experimental control (but excluding much of what spatial navigation challenging in the real world). Spatial navigation is a paragon of this trade off, in part because of the high degree of involvement of many sensory and cognitive systems, but also because it is often not possible to replicate one real world experiment in a different spatial location. Here, I describe a paradigm-based approach to spatial navigation research in which a realistic virtual environment, designed with an identical spatial layout as a real-world college campus, has been shared on a web-based platform. To date, the paradigm has been used in over 30 experiments by over 14 different labs.
Methods: The experimental paradigm, called Virtual Silcton, is a realistic three-dimensional virtual environment designed in Unity 3D. Virtual Silcton consists of 2 learning modes (free exploration and route-based exploration) and has 4 tasks (onsite pointing, offsite pointing, model-building, distance estimation), which can be customized to the experimenter's use case.
Results: I will provide an overview of a sampling of results from several projects. First, I describe the range of individual differences, which are highly correlated with subjective self-report measures of navigation ability. Next, I show how these results have been replicated and extended, revealing the development of navigation ability, how navigation ability changes through interventions. Finally, I describe a large sample size, pre-registered experiment to test whether variability in navigation behavior relates to changes in cortical and subcortical volume.
Conclusion: Although using the same paradigm provides limits on the generalizability of the findings in some ways, this body of research reveals how building a strong foundation of basic cognitive findings can enhance robustness by measuring complex constructs in common ways across groups, while limiting the potential for spurious interactions.