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How different immersive environments affect intracortical brain computer interfaces

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Introduction: Current methods for controlling a virtual or robotic limb using a brain computer interface (BCI) often involve decoding motor intent from primary motor cortex (M1) while a subject is working in a virtual environment. These virtual workspaces can differ in how immersed an individual feels while completing tasks and interacting with objects in that environment, yet more work is necessary to understand how varying the immersive properties of an environment impact overall BCI control [1].

Material, Methods and Results: We asked human participants implanted with intracortical multi-electrode arrays in M1 to perform a basic 3D grasp and carry motor imagery task in two different environments. In one setting, subjects wore a virtual reality (VR) headset allowing for complete immersion in the virtual environment. In the other setting the same task scene was presented; however, subjects interacted with this virtual environment by looking at a fixed view on a TV screen. We found that overall performance on the task was significantly better in the VR environment in participant C1 (73% vs. 62% success) with path lengths about half as long and faster movements during the carry phase (2.4 s vs. 4.0 s, $p<0.001$, Wilcoxon rank sum test), while participant P2 performed about equally in the two environments. We then trained separate offline linear decoders for each environment to decode hand velocity from neural activity and evaluated model performance using the fraction of variance explained (R^2) within and across environments. We found that R^2 values were similar for all conditions (Table 1).

train set / test set	**TV / TV**	**VR / VR**	**TV / VR**	**VR / TV**
Session 317	0.32	0.26	0.24	0.27
Session 331	0.18	0.08	0.21	0.19
Session 333	0.26	0.26	0.24	0.28

Table 1. *R^2 values for offline linear decoders trained to decode hand velocity in one environment and tested in the same or other environment (denoted as test / train in column headings) across three different experimental sessions for participant C1. Note the similarity in R^2 values across environments.*

Discussion: These results suggest that neural activity is similar across environmental setups despite any differences in immersion quality. While more immersive workspaces may provide better online performance metrics and be preferable as noted by participant C1, neural activity appears to be generalizable across environments.

Significance: Given the expanding future of BCIs and integration with VR technology, it is important to continue examining differences related to the types of environments in which BCIs are used as this will help develop better assistive devices and overall BCI control. Further, these results provide preliminary evidence that BCI control may generalize between 2D and immersive 3D environments.

References

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