A-magnetic optic-mechanical device to quantify finger kinematics for fMRI studies of bimanual coordination

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INTRODUCTION

During bimanual coordination tasks, phase transitions between different self-organized patterns may occur when critical values of the control variables are reached. Those rapid events should be monitored with adequate space and time resolutions. We describe a novel a-magnetic optic-mechanical device (AMOMeD) able to monitor fingers’ movements during fMRI acquisitions with resolutions sufficiently high to detect spontaneous pattern transitions and their neural correlates.

DEVICE DESCRIPTION

AMOMeD is built in PVC and Teflon. The mechanical part has two blocks (one for each hand) with rails having ± 2 mm space resolution. The rails, fixed to the fingers performing the coordination task, can slide along the vertical direction inside inflexible guides where four couples of optical fibers allow the acquisition of absolute and relative fingers’ positions. PowerLab 16/30 – ADInstruments is used for behavioral data acquisition with 1 kHz sampling frequency.

DATA COLLECTION

One healthy volunteer (25 years) performed an alternated bimanual index fingers’ flexion-extension movement during a blocked-trial paradigm (shown in the figure on the right). The subject was instructed to perform the movement at slow pace during the first two task blocks, while execution had to be at the highest possible oscillation frequency during the following 4 task blocks. If the alternated movement shifted to a parallel modality because of the high value of the oscillation frequency, it had not to be corrected. The paradigm was repeated twice. A Siemens Magnetom 1.5 T Vision system with a circular polarized head coil was used for MR imaging. The brain was imaged from the vertex to the cerebellum with an EPI-FID Mosaic sequence, and 15 volumes were acquired for each block. Behavioral data were simultaneously collected with AMOMeD.

RESULTS

No distortion was observed in the fMRI signals possibly due to AMOMeD. Dedicated software permitted to reconstruct the simultaneous fingers’ positions with ± 2 mm space resolution and 1 ms time resolution. Fingers’ oscillation amplitude, frequency, and relative phase was reconstructed; pattern transitions were also detected.

DISCUSSION

Until present, bimanual finger coordination has been monitored only using finger tapping protocols to measure the relative phase as the control variable. Our results show that a high space and time resolution can be reached to monitor fingers’ dynamics during fMRI imaging. This joint analysis of behavioral data and functional brain imaging may lead to detect the neural correlates of spontaneous phase transitions during bimanual coordination tasks.