Independent Component Analysis Applied to Self-paced Functional MRI Paradigms

C. H. Moritz[1], J. D. Carew[1], M. E. Meyerand[1]
[1]University of Wisconsin-Madison Medical School, Madison, Wisconsin, United States

Self-paced fMRI paradigms, in which the task timing is determined by the subject's performance, can offer several advantages for clinical studies over commonly applied paradigms with predetermined stimulus timing. Independent component analysis (ICA) should be an advantageous method of deriving results from fMRI datasets with varying response timings and durations. This study reports preliminary results of ICA applied to self-paced motor and cognitive fMRI paradigms.

INTRODUCTION

Functional MRI (fMRI) studies usually use paradigms in which the timing of stimulus events is predetermined, with the resulting analysis presuming a fixed timing of responses. Self-paced fMRI paradigms have recently been attempted, and results determined by regression analysis with an estimated hemodynamic response model (1,2). In self-paced experiments, the BOLD response may not be constant from one part of the task to the next, and thus difficult to predict. The multivariate characteristics of spatial independent component analysis (ICA) should theoretically be relatively insensitive to differences between event timings of a self-paced paradigm (3). This study applies spatial ICA toward the determination and mapping of responses from self-paced motor and cognitive paradigms.

MATERIALS AND METHODS

Functional MRI paradigms were acquired with the following technical parameters: 1.5T scanner (Signa LX; GE Medical Systems, Milwaukee, WI); standard head coil; single-shot gradient-recalled echoplanar pulse sequence; TR/TE =2000/40msec; FOV=24cm; 64x64 matrix; 23 sagittal slice locations 5mm/1mm skip yielding whole brain coverage. Two fMRI paradigms were performed: 1) self-paced alternating-hand button presses with visual cues; & 2) self-paced arithmetic computation from visual presentations. Self-pacing of the paradigm cues was determined by the subject's button press responses during each of the task epochs: 20 button presses constituted a motor task epoch length; and the time the subject took to decide whether the given answers to 4 arithmetic problems was correct determined the timing of each cognitive task epoch. The button press timing intervals were recorded to a PC text file for each paradigm. All fMRI data was post-processed with spatial smoothing and motion correction, then analyzed with the Infomax algorithm of spatial ICA (4). Varying numbers of spatial ICA components (range: 81 to 116) were produced for each paradigm, since each paradigm's duration was determined by self-pacing. Spatial ICA component maps were overlaid on co-registered anatomical MRI images thresholded at $z > 2.0$, and inspected for spatial specificity to expected areas of task function. Related time courses from each task-related spatial component were inspected and compared to the time durations derived from the record of button press responses.

RESULTS

All subjects performed the tasks successfully. ICA of both paradigms produced spatial components in expected regions of functional response, with time courses that corresponded to the self-paced task intervals. The self-paced motor task yielded ICA spatial components that were specific to contralateral primary and supplementary motor areas (Fig. 1A) and ipsilateral superior cerebellum for each hand. Time courses from these components showed close correspondence to the button press intervals (Fig. 1B). The self-paced arithmetic task yielded a spatial component that mapped to regions of bilateral dorsolateral prefrontal cortex, superior parietal lobules, and visual association areas (Fig. 1C). The time course of this component closely corresponded to the self-paced task performance (Fig. 1D).

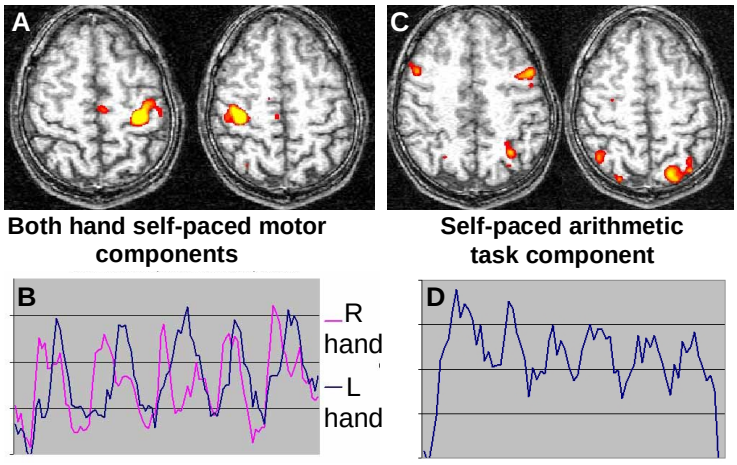

Figure 1. *Representative ICA spatial maps and time courses.*

DISCUSSION

These preliminary results suggest that ICA of self-paced fMRI paradigms can successfully identify spatial localization of task-related responses and corresponding time courses. Self-paced paradigms can offer important advantages over fixed timing : self-pacing is typically employed in behavioral/clinical neuropsychological testing; flexibility of task timing may allow impaired clinical subjects to perform fMRI paradigms. Further study is warranted to determine the sensitivity of ICA to varying self-pace rates of fMRI task performance, and paradigm design.

REFERENCES

1. Sander MD, *et al*., *Neuroimage,* **13**(6 Pt 1), 1113-1120, 2001.
2. Maccotta L, *Neuroimage,* **14**(5), 1105-1121, 2001.
3. McKeown, *et al, Hum Brain Mapp* ,**6**,160-188, 1998.
4. Bell & Sejnowski, *et al, Neural Comput,* **7**, 1129-1159, 1995.