On the Advantage of Data Driven Analysis in Aphasic Patients with Severe Language Latency

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Introduction

Since the discovery of the Blood Oxygen Dependent (BOLD) effect in 1990, functional Magnetic Resonance Imaging (fMRI) has developed from a pure experimental method for investigations of localized brain function, into a clinical tool for, in particular, presurgical planning. However, an increasing amount of clinical studies brings evidence that fMRI also could be used for other indications, *e.g.*, diagnosis of neurological diseases, prognosis, and assessment of treatment outcome [1]. One area of increasing interest for clinical fMRI is functional diagnosis and prognosis in patients with aphasia after left hemisphere lesion [2]. However, fMRI examinations of language performance of this patient group are exceptionally challenging. The patients do not only have language deficits but often also other kinds of cognitive impairments, such as reduced working memory and perception difficulties [3]. One consequence of this is that aphasia patients have latency in responding to cognitive tasks. Therefore it is expected that ordinary fMRI paradigms, which requires a time regulated task fulfilment, are badly suited for most aphasia patients. Using a data-driven approach, *e.g.,* Independent Component Analysis (ICA), might enable extraction of language networks even if the task is not performed at the intended pacing. In this study the neural correlates to word generation in aphasia patients was assessed by both model and data driven approaches.

Methods

Five patients (females/males = 1/4) with chronic aphasia after left hemisphere lesion were included in the study. The mean age was 53 years (range 26–74 years) and the mean time since lesion was 36 months (range 13–65 months). Four patients had left sided media infarction and one patient had a traumatic brain injury. All patients were right-handed before lesion. A training session for word generation ability (generate as many words beginning with A and F during one minute each) was administered before fMRI. Functional images were acquired using a BOLD-sensitive echo planar imaging (EPI) sequence on a Philips Achieva 1.5 T MR-scanner. Then a word generation paradigm, where the patients were asked to generate as many words as possible beginning with a given letter, was utilized. The letters were presented in blocks for 5 s each, using video-glasses in the scanner. In the control task a set of symbols were shown with the same frequency as the letters. Total task time was 5 minutes corresponding to 112 image volumes. Images were preprocessed and analyzed using SPM5 software (Wellcome Department of Imaging Neuroscience, University College, London, UK). All functional images were re-aligned to correct for movements during scanning, coregistered to the T1W anatomic images and smoothed using 8 mm Gaussian kernel. The thresholds were individually adjusted for each patient and each paradigm. The choice of individual thresholds was based on the best possible adoption to following criteria: 1) No spurious activation in non-cortical regions and 2) Visible activation clusters in frontal and temporal language areas. Data driven analysis was performed using an ICA InfoMax algorithm implemented in the GIFT Toolbox (http://icatb.sourceforge.net). The resulting ICA components were sorted in order to select components with temporal correlations to the paradigm

Results

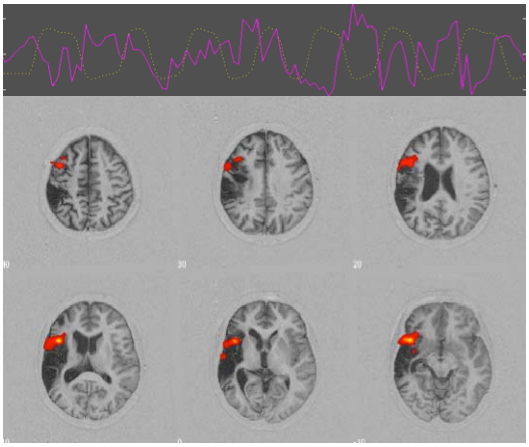

Fig. 1: *ICA time course of one component in perilesional language areas (purple) for one patient with moderate efferent motor aphasia. The dotted line is the modelled BOLD response according to the word generation paradigm. The neurological convention for R/L was used.*

The pre-fMRI word generation test showed that the patients had substantial difficulties in word generation. On average, they produced 3 words/minute. This is the production rate observed in healthy subjects during 5 s, which is the given time during fMRI.

The MODEL DRIVEN ANALYSIS did not result in language relevant activation for the majority of the patients. This was observed despite that an individual threshold was chosen. Only one patient elicited activation in fronto-temporal language areas. In contrast, the DATA-DRIVEN ANALYSIS revealed networks comprising perilesional language areas in all patients with mild or moderate aphasia. However, one patient with severe aphasia did not show networks in language related areas.

Two patients elicited networks in frontal and temporal perilesional regions that were positively correlated to the word generation paradigm. One of them also showed activation in the model driven analysis. These two patients scored highest in the pre-fMRI word generation test. In two patients, the ICA time-courses in language regions were anti-correlated to the paradigm (One of them is shown in Fig1), suggesting severe language latency.

Discussion

In the current study it was shown that conventional model driven analysis of fMRI data did not result in language related activation in the majority of the patients. When analysing the fMRI images using a data-driven approach, four out of five patients elicited language related networks. One explanation for this result is that aphasia patients are incapable to perform the task at the required pacing and therefore the following analysis with predefined task onsets failed. In two patients with severe language latency, the language related activation even appeared at an anti-correlated time course. It is concluded that language areas in patients with aphasia can be extracted using data driven analysis even if the conventional fMRI analysis fails.

References

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