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Research report

Electrophysiological correlates of different anomic patterns in comparison with normal word production

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ABSTRACT

Different forms of anomia are observed in aphasia, which can be related to impaired semantic, lexical or phonological processes. In the present study, we analysed electrophysiological correlates of different patterns of anomia in six aphasic speakers. Event-related potentials (ERPs) were recorded during picture naming in each anomic speaker and in 15 healthy controls. Waveform analysis and temporal segmentation indicated a difference between high and low frequency words in the control group between 270 and 330 msec after picture onset. The ERPs recorded in the patients were compared to the control group. The time-windows of divergent ERP correlates were very similar between successful and erroneous naming, but they were differently distributed in the 6 patients. Two patients with conduction aphasia and impaired phonological encoding had normal electro-cortical activity during the first 300 msec and abnormal patterns between 300 and 450 msec. Two patients with lexical-semantic impairment had earlier ERP abnormalities starting immediately after visual processes. The two patients with less severe anomia and preponderance of omission errors displayed abnormal ERPs between 280 and 350 msec. These results indicate that abnormal electro-cortical correlates of anomic profiles can be observed in different time-windows, which seem to correspond to the time course of the impaired encoding processes.

1. Introduction

The production of words during a picture naming task is a rapid activity spreading through several processing stages from visual recognition to articulation, through conceptual preparation, lexical retrieval, phonological and phonetic encoding. These processing are thought to have different time course during word production.

Changes in cortical activation over time during word production (from picture onset on screen to articulation) have been tracked in magnetoencephalography (MEG) studies with healthy speakers (Salmelin et al., 1994; Levelt et al., 1998; Vihla

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et al., 2006). These studies showed that activation proceeds from the occipital areas, linked to visual processing, to bilateral parietal and left temporal areas, then to pre-motor frontal areas during the first 400–500 msec following picture presentation. However, in most MEG studies on picture naming, the spatiotemporal analyses have been determined in function of pre-defined time-windows (Levelt et al., 1998; Sörös et al., 2003), which were based on the meta-analysis on the estimated time course of word production during picture naming by Indefrey and Levelt (2004) (Fig. 1). This estimation emanated from the comparison and subtraction procedures of ERP studies using go/no-go paradigms in monitoring tasks during tacit picture naming. In such tasks, subjects are asked to monitor for the presence of a linguistic unit. They have to answer by pressing a button either with the right or with the left hand. The response hand and whether or not the button should be pressed depend on the presence of the targeted linguistic information. Thus, the initial estimation of time course of word encoding processes was largely based on motor response preparation (Lateralised Readiness Potential – LRP – and N200).

The relative timing of semantic and phonological encoding has been analysed in a study comparing tasks implying phonological processes (monitoring phonological information and overt naming) and semantic categorisation tasks (Vihla et al., 2006). The difference between these two encoding processes has been identified at about 300 msec, suggesting that semantic encoding takes place before 300 msec and phonological encoding after this time-window. Evidence on the time course of semantic encoding has also been evaluated by Maess et al. (2002) with MEG by comparing semantic interference during picture naming. A difference was observed between the mixed-semantic categories condition and the same-semantic categories condition (interference) from 150 to 225 msec after picture onset.

Variable and diverging results have been reported with other paradigms, especially with tasks implying go/no-go and button press responses (Van Turennout et al., 1998; Schmitt et al., 2000; Abdel Rahman et al., 2003). These electroencephalographic (EEG) studies were especially concerned with an analysis of the serial versus parallel nature of the different encoding processes but the absolute time course of each encoding process can hardly be compared to the studies using other paradigms since the latency of the LRP reveals the moment at which the information, once available, is transmitted to pre-motor cortex, but not the moment at which the information is processed.

Impaired word production (anomia) in aphasic subjects can be ascribed to impairment at different levels of processing: semantic, lexical retrieval, or phonological. These different anomic patterns have been determined mainly on the basis of error distribution in picture naming (Kay and Ellis, 1987; Laine et al., 1998; Schwartz et al., 2006). If different anomic profiles indeed reflect impairment at different levels of word encoding processes, abnormal electrophysiological patterns should be found in the time-windows corresponding to the different encoding processes. Among the few electrophysiological studies investigating language encoding (production) with aphasic subjects, Dobel et al. (2001) used a semantic and syntactic monitoring task during silent picture naming. The ERPs differed in the aphasic subjects from a control group in the 300–600 msec time-window for both tasks. This period corresponds to the estimated time-window of phonological and phonetic encoding (Fig. 1) rather than to semantic or syntactic processes. However ERP correlates in monitoring tasks with a button press response reflect mainly the preparation of the motor response. Alternatively, the spatiotemporal correlates of anomia in aphasic speakers has been analysed with a delayed picture naming task in a MEG study by Cornelissen et al. (2003). The authors reported therapy-linked spatiotemporal changes in three chronic anomic patients in a time-window between 300 and 700 msec after picture onset. This time-window was interpreted according to the Indefrey and Levelt (2004) estimation as reflecting changes related to phonological encoding. Recently we also reported changes in ERP patterns linked to recovery from anomia in time-windows starting at about 300 msec after picture presentation in 3 aphasic patients, while a forth patient with semantic impairment displayed therapy-linked changes in an earlier time-window (Laganaro et al., 2008). These results suggested that these different time-windows of electrophysiological changes accompanying recovery from anomia might correspond to different encoding processes.

In the present study, we analysed the electrophysiological correlates of different anomic patterns. Specifically, we compared aphasic patients with different underlying anomic impairments to a control group. We expected to find abnormal electro-cortical activation depending on the anomic pattern.

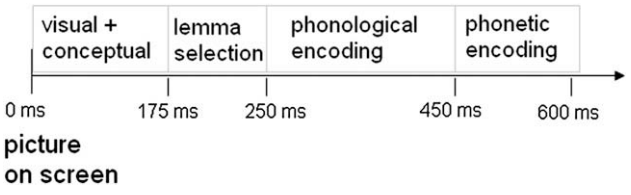

Fig. 1 – Estimated time course of word production in picture naming by Indefrey and Levelt (2004).

2. Methods

2.1. *Participants*

2.1.1. *Anomic patients*

Six aphasic patients were selected based on aphasia subtype and on performance and error distribution in naming tasks. They were all in a post-acute stage and presented anomia among other aphasic symptoms. Their demographic data, aphasia subtype and site of lesions are presented in Table 1 and Fig. 2.

The classification of aphasia was determined using the Montreal-Toulouse 86 Aphasia Battery (Nespoulous et al., 1992). In addition, semantic deficits were evaluated using the Pyramid and Palms trees test (Howard and Patterson, 1992) and an intracategorical word-to-picture matching task (French adaptation of Laiacona et al., 1993).

Patients P1 and P2 had typical conduction aphasia and produced phonological paraphasias in all output tasks (spontaneous, naming, reading, repetition). Auditory and written comprehension was unimpaired in the Montreal-Toulouse 86