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# How familiarization and repetition modulate the picture naming network

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ABSTRACT

A common strategy to reveal the components of the speech production network is to use psycholinguistic manipulations previously tested in behavioral protocols. This often disregards how implementation aspects that are nonessential for interpreting behavior may affect the neural response. We compared the electrophysiological (EEG) signature of two popular picture naming protocols involving either unfamiliar pictures without repetitions or repeated familiar pictures. We observed significant semantic interference effects in behavior but not in the EEG, contrary to some previous findings. Remarkably, the two protocols elicited clearly distinct EEG responses. These were not due to naming latency differences nor did they reflect a homogeneous modulation of amplitude over the trial time-window. The effect of protocol is attributed to the familiarization induced by the first encounter with the zmaterials. Picture naming processes can be substantially modulated by specific protocol requirements controlled by familiarity and, to a much lesser degree, the repetition of materials.



## 1. Introduction

Retrieving words from memory in order to express their thoughts is a key component of Humans' language production ability. According to the standard theoretical view, this process is one in which conceptual or semantic representations of the message to be conveyed drive the activation and selection of word-specific lexical representations (Caramazza & Hillis, 1990; Damasio, Tranel, Grabowski, Adolphs, & Damasio, 2004; Dell, Burger, & Svec, 1997; Indefrey, 2011; Levelt, 1992, 1993; Nickels, 2001). Laboratory research conducted to understand this process has made a widespread use of the picture naming task. Participants are presented with visual objects, usually one at a time, and they are asked to produce overtly the corresponding name (Alario et al., 2004; Bock, 1996; Glaser, 1992), an instruction that is presumed to trigger the activation of the semantic-to-lexical pathway above-described.

The cortical network underlying visual object naming has been described in detail on the basis of functional imaging data, complemented with some temporal evidence from neurophysiological studies. Oral picture naming recruits a widely distributed network of cortical areas, predominantly located in the left hemisphere. The network starts with occipital and ventro-temporal structures. From 200 ms onwards, temporal structures are engaged in lexico-semantic processing (activation of the meaning of the picture and its possible names). Somewhat later, inferior parietal cortex and posterior temporal lobe are associated with phonological encoding. The left inferior frontal gyrus is thought to resolve conflict among alternative representations, as well as syllabification processes. Finally, bilateral pre-motor and motor areas, as well as the inferior frontal gyri, are engaged for articulatory planning and articulation (for review see Damasio et al., 2004; Indefrey, 2011; Indefrey & Levelt, 2004; Llorens, Trébuchon, Liégeois-Chauvel, & Alario, 2011; Price, 2012).

Regarding timing, perhaps the most influential spatio-temporal model of word production has been proposed by Indefrey (2011, and previous versions). This proposal has two specific features. First, it is directly based on a cognitive processing model (Levelt, Roelofs, & Meyer, 1999) which has relatively strong modularity hypothesis, while alternative views have been defended (Rapp & Goldrick, 2000). Second, and related, the model describes the stages that are deemed necessary, *a priori*, for producing a word. It does not consider activities or modulations that may occur collaterally and that may be detectable in brain signals (we shall come back to this point).

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### 1.1. Using brain activity to test behavioral protocols

A strategy which is commonly used to reveal the components of this network is to test whether or not they are sensitive to psycholinguistic manipulations previously validated and interpreted in behavioral research (e.g. semantic or phonological relatedness; De Zubicaray & McMahon, 2009; see Riès, Janssen, Burle, & Alario, 2013 for a different approach based on the timing of the events). In addition to such manipulations of theoretical interest, the organization of the experimental protocols requires specific implementation details. For example, it is common place in behavioral experiments to familiarize participants with the materials (e.g. pictures) before the experiment proper or to present the target materials multiple times within and/or across conditions. To the extent that these "convenience manipulations" do not interact strongly with the effect of interest (for familiarization, see Alario et al., 2004; for repetition, see Fig. 10 in Levelt et al., 1999; for both, see Navarrete, Mahon, & Caramazza, 2010) they are typically not considered in detail. Yet, manipulations such as familiarization and repetition have been investigated in their own right in neurophysiological research. They have been shown to have substantial influences on brain activity, and on the processes engaged to perform a given task (Dhond, Buckner, Dale, Marinkovic, & Halgren, 2001; Marinkovic et al., 2003; McDonald et al., 2010). Given that neurophysiological research on language production is increasingly guided by psycholinguistic behavioral protocols. It is crucial to test whether and how parameters that may be deemed secondary in behavioral studies, such as familiarization and repetition modulate the neural networks underlying performance in these protocols.

Here we address this issue based on two implementations of the picture naming task that are amongst the most popular in language production research. We will refer to those as the "sequential" and "blocked cyclic" picture naming protocols. The first protocol involves naming a sequence of pictures belonging to multiple semantic categories. Typically, these pictures are presented for naming only once, and participants are not familiarized with them (Howard, Nickels, Coltheart, & Cole-Virtue, 2006). The second protocol involves naming repeatedly, within a block, a few pictures after participants have been familiarized with them (e.g., Damian, Vigliocco, & Levelt, 2001; Roelofs, 2006).

### 1.2. Research based on the sequential and blocked naming protocols

Up to now, the sequential and blocked naming protocols have been used quite interchangeably to investigate processing stages involved in word production. For example, semantic interference effects are thought to reflect lexical selection processes. When words are produced in response to sequentially presented objects or definitions, performance decreases with the number of previously named items from the same semantic category (Howard et al., 2006). In the blocked protocol, performance also decreases if the items within a block belong to same category, compared to when they are semantically heterogeneous (Damian & Als, 2005; Damian et al., 2001; McCarthy & Kartsounis, 2000; note that performance increases when the items are phonologically rather than semantically related: Roelofs, 2006).

These two manifestations of semantic interference are most often construed as instances of the same phenomenon. That is, an increase in the duration or difficulty of semantically driven lexical retrieval, within the same processing pathway leading from object recognition to word articulation. Most notably, Oppenheim, Dell, and Schwartz (2010) explicitly hypothesize the semantic interference effect stems from the same processing mechanisms in these two protocols. They more tentatively suggest that semantic interference could be tied to a single underlying cortical network involving the left inferior frontal gyrus (LIFG) and/or the left temporal lobe. This hypothesis has been recently challenged. Most notably, Belke and Stielow (2013) concluded a review of the behavioral evidence by noting important differences between these two protocols. In particular, they highlight differences in the relative involvement of top-down processes across blocked and sequential naming.

Most of the empirical work discussed above on the sequential and blocked naming paradigms has relied on behavioral measures (in healthy and impaired speakers). Few studies have explored the neurophysiological signature of these protocols and effects. Costa, Strijkers, Martin, and Thierry (2009) measured the event related potentials (ERPs) in the sequential naming protocol, and their modulation by semantic context. They reported an amplitude modulation of the ERPs on posterior electrodes bilaterally, which was correlated to the magnitude of behavioral semantic interference during a time window between 200 and 400 ms approximately. We are not aware of other imaging or neurophysiological published studies of this protocol. There are more studies that have tested the blocked naming protocol. Using cortical source reconstruction from magneto-encephalographical (MEG) data, Maess, Friederici, Damian, Meyer, and Levelt (2002) reported that semantic interference was associated with the left temporal region during a time window similar to that mentioned above. This is also reported by the ERP study of Aristei, Melinger, and Abdel Rahman (2011), although the responses they observed were bilateral. Also using ERPs, Janssen, Carreiras, and Barber (2011) reported that semantic interference was associated with an amplitude modulation, mostly observed in anterior electrodes, occurring between 220 and 450 ms. These authors link this effect to input processes (e.g. visual and semantic identification of the picture) rather than word retrieval per se. Schnur et al. (2009) and Schnur, Schwartz, Brecher, and Hodgson (2006) tested the same protocol in fMRI with a group of Broca's aphasics, as well as healthy speakers. Their results link semantic interference and phonological facilitation effects with temporal regions, but only semantic interference was associated with the LIFG. The authors highlighted the involvement of the LIFG in solving the conflict between semantically-related candidate words. Finally, an fMRI study conducted by Hocking, McMahon, and De Zubicaray (2008) showed a greater activation in the left middle to posterior superior temporal gyrus as well as in the hippocampus, bilaterally, for the homogeneous than for the heterogeneous context.

Together, the studies of the blocked naming protocol broadly reveal a fronto-temporal network. This network is closely related to the standard network of picture naming (Damasio et al., 2004; Indefrey, 2011; Price, 2012), thought to be engaged in the sequential protocol. This could suggest that, across the sequential and the blocked naming protocols, the same cortical network is similarly engaged in naming processes (e.g., lexical selection) as has been implicitly or explicitly assumed in previous research (with the notable exception of Belke & Stielow, 2013). However, the data do not provide a definite test of this hypothesis, particularly because the two protocols have never been directly compared with imaging or neurophysiological methods.

### 1.3. The current study

The goal of the current study was to test the hypothesis that the naming protocols under discussion reflect the same processes with the same time course. The alternative is that these two tasks rely, at least in part, on different processes and hence produce distinguishable electro-physiological signatures. To evaluate this alternative, we implemented and tested standard versions of the sequential and blocked naming protocols with a single pool of native speakers, all within the same experimental session. The