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Short Communication

Conflict monitoring in speech production: Physiological evidence from bilingual picture naming

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ABSTRACT

Self-monitoring in production is critical to correct performance, and recent accounts suggest that such monitoring may occur via the detection of response conflict. The error-related negativity (ERN) is a response-locked event-related potential (ERP) that is sensitive to response conflict. The present study examines whether response conflict is detected in production by exploring a situation where multiple outputs are activated: the bilingual naming of form-related equivalents (i.e. cognates). ERPs were recorded while German-Dutch bilinguals named pictures in their first and second languages. Although cognates were named faster than non-cognates, response conflict was evident in the form of a larger ERN-like response for cognates and adaptation effects on naming, as the magnitude of cognate facilitation was smaller following the naming of cognates. Given that signals of response conflict are present during correct naming, the present results suggest that such conflict may serve as a reliable signal for monitoring in speech production.

1. Introduction

Producing speech is one of the most common motor acts in which humans engage. The process of production involves the generation of a pre-linguistic message, the selection of lexical items which must be grammatically and phonologically encoded prior to articulation, all while constantly monitoring performance (Levelt, 1989). This latter stage is often overlooked in production research, despite the fact that fluent production requires the ability to monitor ourselves and subsequently adapt our production behavior when faced with multiple ways of saying the same message or when the system is about to produce an error. Although a substantial amount of behavioral and electrophysiological work has been conducted to elaborate the processes of lexical selection, as well as grammatical and phonological encoding, significantly less electrophysiological work has addressed monitoring processes (for a review see Ganushchak, Christoffels, & Schiller, 2011). Part of the reason for avoiding electrophysiological studies of monitoring in production is a practical one: overt production necessarily produces motor artifacts in EEG. Recent advances in EEG analysis have allowed researchers to clean motor artifact using automated procedures, thus allowing for the investigation of response-locked ERP components during production (Riés, Janssen, Dufau, Alario, & Burle, 2011). The present work takes advantage of these advances to explore the neurophysiological correlates of monitoring during correct naming.

Monitoring in production can occur prior to and during actual articulation. The most prominent theory of monitoring, the perceptual loop hypothesis, posits that monitoring occurs via a comparison process in which an intended utterance is compared against input from language comprehension that itself receives input from three different stages of production planning: message retrieval, phonological encoding and articulation (see Levelt, 1989). The perceptual loop hypothesis is attractive in its simplicity as monitoring in production does not require additional mechanisms beyond those responsible for comprehension. However, criticism of this hypothesis has emerged because the central prediction, that monitoring in comprehension and production occur via the same mechanism, is not born out in behavioral, neuropsychological or electrophysiological studies (Nozari, Dell, & Schwartz, 2011; Postma, 2000). Other researchers have therefore proposed that monitoring may occur within the production system itself either through independent monitors at each stage of production planning (e.g. Laver, 1980) or monitoring via the differences in the expected feedback received from later to earlier stages of production planning (Postma & Kolk, 1993). These production-based models have been criticized either for making incorrect predictions or for not being computationally explicit, hence some recent accounts

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hypothesize that monitoring may occur by detecting when multiple responses are simultaneously active (i.e. response conflict; Ganushchak & Schiller, 2008; Nozari et al., 2011). From this perspective, monitoring in production is a specific instantiation of the sort of monitoring hypothesized to occur within action and perception systems more generally. Monitoring for response conflict thus represents a very different mechanism than previous proposals in language production research as there is no explicit comparison between an expected and actual response.

In the action monitoring literature much emphasis has been placed on the detection of errors, and in particular, the error-related negativity (ERN), a negative going ERP that peaks approximately 100 ms after an error (Falkenstein, Hohnsbein, Hoormann, & Blanke, 1991; Gehring, Goss, Coles, Meyer, & Donchin, 1993). The ERN has been associated with activity in the dorsal anterior cingulate cortex (ACC) or pre-supplementary motor area (pre-SMA), regions which are broadly connected to motor planning and control systems (Dehaene, Posner, & Tucker, 1994; Debener et al., 2005; Margulies et al., 2007). In addition to responding to explicit errors, however, activity within the ACC and the ERN show sensitivity to situations with high amounts of response conflict, such as the Stroop and Eriksen flanker tasks (Botvinick, Braver, Barch, Carter, & Cohen, 2001). These findings suggest that we have systems dedicated to monitoring response conflict across a number of modalities, and that the ERN may be a sensitive marker of these monitoring activities.

The ERN has been observed in language production when individuals make overt errors (Masaki, Tanaka, Takasawa, & Yamazaki, 2001; Moller, Jansma, Rodriguez-Fornells, & Munte, 2007). Few studies, however, have shown an ERN under conditions of response conflict in production. The two exceptions to this are a study by Ganushchak and Schiller (2008), who showed an increased ERN during semantic blocking in picture naming, and a recent study by Severens et al. who showed an ERN prior to the production of a taboo word (Severens, Janssens, Kuhn, Brass, & Hartsuiker, 2011). Part of the reason that the ERN may have remained elusive in production research is that typical data processing involves severe low-pass filters (e.g. filtering all data above 12 Hz). Recently, however, an algorithm designed to clean high-frequency motor artifact in EEG has been used, and a small but reliable ERN-like component was observed during correct picture naming (Riés et al., 2011).

If response conflict is one of the main mechanisms by which the production system monitors performance, then the combination of the result from the production literature and the action monitoring literature suggests that an ERN-like component should be present under conditions of response conflict. Such conflict naturally arises in production as there are multiple possible ways to convey the same message, such as choosing different word orders (e.g. active vs. passive constructions), or even different words (e.g. couch vs. sofa). In the present study, we assess whether the production system might monitor for response conflict by exploring a situation in which multiple outputs are simultaneously active: bilingual naming. More specifically, we focus on the naming of cognates, which are items with a close form-equivalent between different languages (e.g. *house*-English, *haus*-German and *huis*-Dutch). Previous results have shown that proficient bilinguals are faster to name cognate relative to non-cognates, a result which has been attributed to accessing phonological features from both languages simultaneously (Christoffels, de Groot, & Kroll, 2006; Costa, Caramazza, & Sebastian-Galles, 2000). Despite faster naming, activation of the phonological properties of both languages might lead to more response conflict, as producers must continuously monitor whether their phonological output is appropriate given the naming environment (e.g. naming in L1 or L2). A recent fMRI study is consistent with this hypothesis, as activation of pre-SMA increased for Dutch–English homographs (i.e. words with the same written form but different meanings) when subjects made decisions about whether a stimulus was an English word (van Heuven, Schriefers, Dijkstra, & Hagoort, 2008).

In the present investigation we re-analyzed a bilingual naming study by Christoffels, Firk, and Schiller (2007) to explore whether the correct naming of cognates might lead to a larger ERN-like response than non-cognates. Participants named both cognate and non-cognate pictures in their first (L1; German) and second-languages (L2; Dutch). Pictures were presented either in blocked format (all picture had to be named in one language), or in a mixed language format, where participants occasionally switched between L1 and L2. In order to avoid interacting effects with switching, we focus analysis on blocked naming and non-switch trials from the mixed language condition.

2. Methods

All methods for the current investigation were previously reported in Christoffels et al. (2007). Below we report details that are relevant to the current investigation, but we refer the reader to the original publication for more detailed information.

2.1. Participants

Twenty-four undergraduate students of Maastricht University participated in the study (mean age: 23.6 years). Due to technical problems, three participants were excluded from the analyses. All participants were native German speakers and participated in an intensive Dutch course prior to their undergraduate studies in the Netherlands.

2.2. Materials

Forty-eight simple white-on-black line drawings were used. Half of the picture names were German–Dutch cognates and the other half had non-cognate names.

2.3. Design

The experiment consisted of blocked and mixed language conditions. In the blocked language condition, participants were asked to name all the pictures once in L1 (German) and once in L2 (Dutch). The order of languages was counterbalanced across participants.

In the mixed language condition, participants were asked to name pictures in their L1 (German) or L2 (Dutch). On switch trials, response language alternated between L1 and L2 (i.e. L1–L2 and L2–L1). On non-switch trials, response language on two consecutive trials was the same (i.e. L1–L1 and L2–L2).

2.4. Procedure

First, participants were familiarized with the pictures. During the blocked and mixed language naming tasks, participants were asked to name pictures with the names learned during familiarization.

2.5. Apparatus and recoding

The electroencephalogram (EEG) was recorded from 29 scalp sites (extended version of the 10/20 system) using tin electrodes mounted in an electrode cap. Electrode impedance was kept below 5 kΩ.