Brain & Language 123 (2012) 131–136

Contents lists available at SciVerse ScienceDirect

Brain & Language

journal homepage: www.elsevier.com/locate/b&l

Short Communication

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

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ARTICLE INFO

Article history:
Accepted 28 August 2012
Available online 8 October 2012

Keywords:
Self-monitoring
Conflict monitoring
Picture naming
Bilingualism
EEG
ERN
Speech production
Cognate
Gratton effect

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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http://dx.doi.org/10.1016/j.bandl.2012.08.008

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.

2.6. Data processing

Data processing involved automated procedures to first remove ocular then muscular artifacts on the entire dataset using a blind source separation algorithm on the basis of canonical correlation (BSS-CCA; de Clercq, Vergult, Vanrumste, van Paesschen, & van Huffel, 2006). This method separates muscle related artifact from the EEG signal based on the fact that muscular artifacts tend to have a much lower autocorrelation and much higher spectral power density at high frequencies than brain-generated EEG signal. This technique for automated removal provides a high signal–noise ratio, and has been validated across both clinical (de Clercq et al., 2006; Schlenck, Huber, & Willmes, 1987; Vidal, Hasbroucq, Grapperon, & Bonnet, 2000) and experimental (Riés et al., 2011) domains. In the present study EMG artifact by applying the BSS-CCC algorithm on successive windows of 3 s in length, with 2 s of overlap between each window. Frequencies above 15 Hz were considered for rejection, and artifacts were rejected if more than 1/10 of the spectral power was above this frequency (for details, see de Clercq et al., 2006).

Following automated removal of EMG artifacts the data were initially epoched according to picture onset, incorrect trials removed (M = 9.3%, SD = 5.9% of trials) and baseline corrected using the EEG signal 200 ms prior to picture onset. Following baseline correction, all epochs containing deflections of +/−75 μV were removed, and any remaining epochs with artifact (e.g. eye-blinks) were manually rejected (M = 12.2%, SD = 11.8% of trials). Finally, data were epoched to the onset of naming the picture, providing a window length of 250 ms.

3. Results

The timecourse and spatial distribution of the response-locked ERPs confirmed that a larger ERN-like component was present for cognates relative to non-cognates, but only in later time windows. In the first time window, 0–50 ms, the amplitudes for non-cognates were more negative compared to cognates (M_{COG} = 4.0 μV, SD = 2.9; M_{NCOG} = 3.41 μV, SD = 3.0). This effect just failed to reach significance (p = 0.053) and was short-lived (~50 ms)). In later time windows, however, a more consistent (and opposite) pattern appeared in which the amplitudes for cognates were more negative than non-cognates (see Fig. 1). The waveforms started to diverge about 100 ms after response onset, but only reached statistical significance at 150 ms continuing until 250 ms (see Table 1).

In the 150–200 ms time window, the amplitudes were more negative for cognates than for non-cognates at FCz (M_{COG} = 2.69 μV, SD = 3.4; M_{NCOG} = 3.38 μV, SD = 3.3; $F(1,20)$ = 4.95; MSe = 4.00; p = 0.03), were marginally different at Cz (M_{COG} = 2.91 μV, SD = 3.1; M_{NCOG} = 3.44 μV, SD = 3.1; $F(1,20)$ = 3.37; MSe = 3.56; p = 0.08), and were not different at CPz (M_{COG} = 2.39 μV, SD = 2.7; M_{NCOG} = 2.68 μV, SD = 2.7; $F(1,20)$ = 1.08; MSe = 3.38; p = 0.31). A similar pattern was observed at the 200–250 ms window. At FCz, cognates were more negative than non-cognates (M_{COG} = 4.03 μV, SD = 3.1; M_{NCOG} = 4.52 μV, SD = 2.9; $F(1,20)$ = 4.62; MSe = 2.16; p = 0.04), but this effect did not reach significance at the Cz and CPz electrodes ($F(1,20)$ = 1.78; MSe = 1.92; p = 0.19; F < 1, respectively).

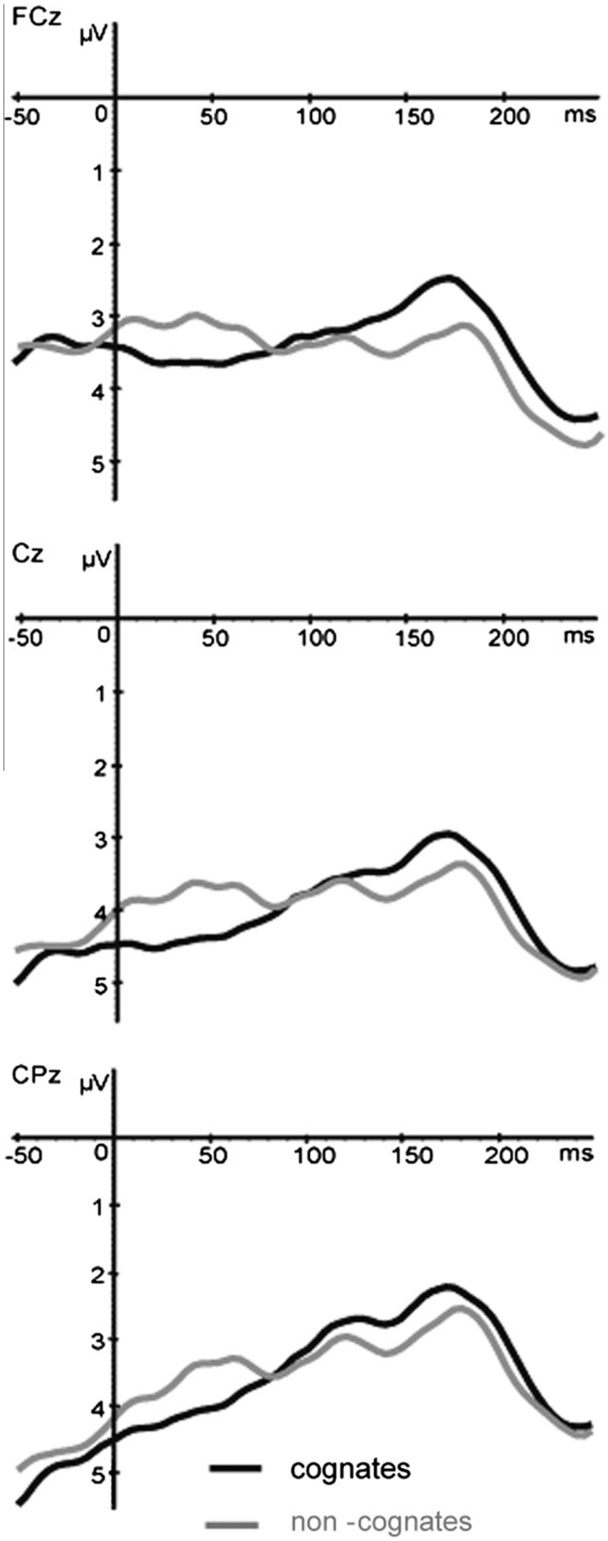

Fig. 1. Response-locked ERP waveforms for cognates and non-cognates at each of three central electrodes going from anterior (FCz) to posterior (PCz) scalp positions. Note that the ERPs begin above 0 due to a baseline before picture onset.

The electrophysiological results thus suggest that cognates did produce a larger ERN-like response than non-cognates at later time windows, and this in turn suggests they produced more response conflict. Research in the nonlinguistic domain has shown that there are downstream effects of such conflict as a result of engaging control systems in lateral prefrontal brain regions (i.e. conflict adaptation effects; Botvinick et al., 2001). For instance, in the Eriksen flanker task, the magnitude of the difference between conflicting and non-conflicting trials is reduced after a conflicting trial (i.e. the Gratton effect; Gratton, Coles, & Donchin, 1992). This interaction can show up in multiple ways, either as an increase in reaction times for non-conflicting trials as in the original Gratton et al. (1992) study, a decrease in reaction times for conflicting trials or

Table 1
Time course (ms) of the response-locked ERP effects as a function of block (block vs. non-switch), cognate (cognate vs. non-cognate), language (L1 vs. L2), and electrode (FCz, Cz, & CPz).

Conditions	0–50	50–100	100–150	150–200	200–250
Block	–	–	–	–	–
Cognate	**$F(1,20) = 4.61$; $MSe = 11.01$; $p = 0.053$**	–	–	$F(1,20) = 3.01$; $MSe = 10.98$; $p = 0.09$	$F(1,20) = 1.92$; $MSe = 5.96$; $p = 0.18$
Language	–	–	–	–	–
Electrode	–	–	–	–	–
Blocking × Cognate	–	–	–	–	–
Blocking × Cognate × Language	–	–	–	–	$F(1,20) = 1.66$; $MSe = 12.29$; $p = 0.21$
Cognate × Language	–	–	–	–	–
Blocking × Electrode	$F(2,40) = 1.30$; $MSe = 1.02$; $p = 0.27$	$F(2,40) = 2.18$; $MSe = 1.52$; $p = 0.15$	$F(2,40) = 1.82$; $MSe = 1.53$; $p = 0.19$	$F(2,40) = 1.68$; $MSe = 096$; $p = 0.21$	–
Cognate × Electrode	$F(2,40) = 1.17$; $MSe = 0.25$; $p = 0.30$	$F(2,40) = 1.74$; $MSe = 2.60$; $p = 0.20$	$F(2,40) = 1.21$; $MSe = 0.28$; $p = 0.30$	**$F(2,40) = 12.55$; $MSe = .19$; $p = 0.001$**	**$F(2,40) = 6.80$; $MSe = 0.32$; $p = 0.01$**
Language × Electrode	–	–	–	–	–
Cognate × Language × Electrode	$F(2,40) = 1.25$; $MSe = 0.35$; $p = 0.29$	$F(2,40) = 2.01$; $MSe = 0.44$; $p = 0.16$	–	–	–
Blocking × Cognate × Electrode	$F(2,40) = 2.93$; $MSe = 0.20$; $p = 0.09$	–	–	–	–
Blocking × Language × Electrode	–	–	–	–	$F(2,40) = 1.62$; $MSe = 0.46$; $p = 0.22$
Blocking × Cognate × Language × Electrode	–	–	$F(2,40) = 1.84$; $MSe = 0.42$; $p = 0.18$	–	–

The reported *F* values are Huyhn–Feldt corrected. Significant effects are marked in bold; – indicates $F < 1$.

both (see Nieuwenhuis et al., 2006). In the context of the present investigation, we predicted that if higher conflict is present for the naming of cognates, then the magnitude of the cognate facilitation effect should be smaller after naming a cognate relative to naming a non-cognate.

With this prediction in mind, we re-analyzed the speech onset data while coding for whether the named picture was preceded by a cognate or a non-cognate (see Fig. 2). As with the analyses above, we did not include switching trials, and due to some positive skewing in the distribution, the data was log transformed prior to analysis. Speech onset times were subject to a 2 (Cognate) X 2 (Language) X 2 (Follow Cognate), repeated-measures ANOVA. The effects of cognate status and language mirror analyses that were reported in Christoffels et al. (2007), hence we focus on effects following the naming of a cognate or non-cognate picture.

The results of ANOVA showed no overall main effect of the Follow Cognate nor a Language X Follow Cognate interaction ($Fs < 1$). Interestingly, there was a significant Cognate X Follow Cognate interaction ($F(1,20) = 13.53$, $p < 0.001$), with the three-way interaction Cognate X Language X Follow Cognate approaching significance ($F(1,20) = 3.61$, $p = 0.08$). The nature of the Cognate X Follow Cognate interaction is exactly in line with what was predicted based on the Gratton effect: The magnitude of the cognate facilitation effect was smaller after naming a cognate ($M_D = -50.9$ ms, $SD = 46.6$; $t(20) = -5.00$, $p < 0.001$) relative to after naming a non-cognates ($M_D = -68.5$ ms, $SD = 46.6$; $t(20) = -6.74$, $p < 0.001$). In light of the nearly significant three-way interaction, closer inspection of the data revealed that this reduction of the cognate facilitation effect was driven by naming in L1 ($M_D = -14.2$ ms, $SD = 48.2$; $t(20) < 1$), whereas the effect remained strong for L2 ($M_D = -82.5$ ms, $SD = 81.9$; $t(20) < -2.81$, $p < 0.05$). Thus, in addition to physiological effects, the Gratton-like effect also suggests that cognates produced response conflict.

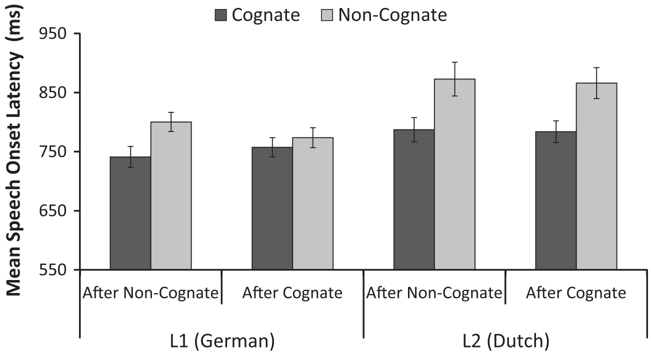

Fig. 2. Mean speech onset latencies before and after naming cognates for each language and picture type.

4. Discussion

The present investigation utilized the bilingual naming of cognates to study the monitoring of response conflict in language production. The results provide clear evidence that such operations are occurring. Cognates were named faster, suggesting that both L1 and L2 phonological forms were activated. Although very early after naming non-cognates showed a larger and broadly-distributed negativity relative to cognates, a later ERN-like component emerged which was larger for cognates than non-cognates, suggesting that the co-activation of multiple lexical or phonological features produced a form of response conflict. This conflict had downstream effects on people's naming performance, as the magnitude of the cognate facilitation effect was reduced after naming cognates relative to non-cognates.

These somewhat counterintuitive results nonetheless have precedence in the field. An fMRI study of the picture-word interference paradigm conducted by de Zubicarray and colleagues showed that although orthographically and phonologically-related distractors sped picture naming relative to unrelated distractors, they *increased* activation in the ACC (de Zubicaray, McMahon, Eastburn, & Wilson, 2002). Furthermore, a recent EEG study examining the picture-word interference effect in bilinguals showed that presentation of a phonologically-related distractor word in L1 slowed picture naming in L2 (Hoshino & Thierry, 2011), suggesting that co-activated phonological representations across languages can slow naming performance.

There are two patterns in the current study that bear some consideration. The first is that immediately after naming began, non-cognates showed a larger negativity than cognates, a pattern which mirrors the timecourse observed of the ERN-like component in an earlier EEG study of picture naming (Riés et al., 2011). Although this effect could be interpreted as non-cognates producing a larger ERN-like component than cognates, we disfavor this interpretation for two reasons. First, the scalp distribution of this effect was broadly distributed. Although the ACC has a somatotopic organization, all studies of the ERN in vocal responding have shown a frontal-central distribution similar to that observed for the later ERN-like component. Second, although non-cognates were slower to name, the Gratton-like effect observed for cognates suggests that the latter produced more response conflict.

An important question to ask, then, is how cognates could have been named faster yet still produced response conflict, especially in light of previous research using manual responding which shows that conflict leads to slowing. One explanation for these differences is that there are two factors at play in speech that differ from studies of response conflict using manual responding. First, the response conflict in manual tasks is often between two completely different choices, whereas in speech, there may be more similarity in responding. Second, the motor acts of speech unfold over time in a way that manual responses do not. Cognates are defined by their close form equivalence between two languages, and this equivalence almost always comes at the beginning of a word (100% of cognates in this study shared onset phonemes and syllables); it is only later that the two pronunciations diverge. Thus, the detection of conflict may be delayed for cognates, leading to the later ERN-like component in the present investigation. This interpretation suggests that even after initiating naming, phonological representations from both L1 and L2 continue to be active, and that although the interaction between lexical and phonological representations may initially benefit naming, later differences lead to conflict. If this account of continuous conflict monitoring is true, it suggests that there should be situations where the speech durations for cognates will be slower than matched non-cognates.

The current investigation has important methodological implications as it confirms that the ERN can be observed on correct trials during picture naming (e.g. Riés et al., 2011). The ability to detect this effect clearly hinged on the ability to remove unwanted motor artifact from the EEG signal using of the BSS-CCA algorithm developed by de Clercq et al. (2006). The present study thus provides an important affirmation of the data cleaning method, and opens up the possibility for future ERP investigation of overt language production, an area which to date has remained virtually unexplored.

The present results have theoretical implications for language production research broadly, and bilingual language research more specifically. First, our results suggest that response conflict may be one of the primary signals that the production system uses for monitoring performance (e.g. Nozari et al., 2011). This is a very different mechanism for monitoring than accounts that explicitly compare actual to desired output. It is important to note, however, that the current results do not necessarily speak against the perceptual loop hypothesis, and it seems quite likely that some form of monitoring via the comprehension system occurs. Still, if the response conflict account is correct, than a number of predictions can be made about what should be observed in language production when response conflict is present.

The first prediction is that there should be downstream effects of such response conflict on behavioral performance and ERP responses (e.g. the Gratton effect). Indeed, in the present investigation, the magnitude of the cognate facilitation effect was reduced after naming cognates. Such an effect in behavior should also be present in ERPs in the form of a reduction in the ERN-like response. There was not enough data in the present study to test this hypothesis, thus it remains an important place for future experimentation. It should be noted that Gratton-like effect on naming times was driven by naming in L1. Part of the reason for this difference between languages may be that individuals exert more control over L1, their dominant response language. Such an explanation is consistent with behavioral research showing smaller cognate facilitation effects for L1 relative to L2 (Costa et al., 2000), and that in bilingual language switching studies, switch costs are greater for L1 than L2 (e.g. Meuter & Allport, 1999) or responses in L1 may become slower than L2 in mixed language settings for proficient speakers (e.g. Christoffels et al., 2007). This Gratton-like effect is particularly noteworthy because it demonstrates the generality of conflict adaptation on action performance. In the flanker task, subjects are responding to the same stimuli (arrows), often pointing in the same direction using the same motor effectors (fingers), leading some researchers to conclude that the Gratton effect may be a result of priming due to stimulus repetition rather than reflecting adaptation to conflict via the recruitment of cognitive control (e.g. Mayr, Awh & Laurey, 2003; Nieuwenhuis et al., 2006). In contrast, detection of conflict for naming cognates led to a slowdown in naming completely different words with different configurations of motor effectors. Coupled with findings of conflict adaptation effects in other paradigms (e.g. the Stroop and Simon tasks; see Nieuwenhuis et al., 2006), the current results suggest that adaptation emerging from conflict is unlikely to only reflect response priming and perhaps points to the need for future research to use a larger response set then is typically employed in the action monitoring literature.

The second prediction is that evidence of response conflict should also be present prior to responding in the form of an N2 difference, the pre-response equivalent to the ERN (Folstein & van Petten, 2008). This prediction comes directly from the conflict-monitoring hypothesis in which previous research has shown that conflict during correct performance on non-verbal tasks is reflected in the N2 (Yeung, Botvinick, & Cohen, 2004). This leads to the prediction that an increased N2 should be present in production in instances where multiple lexical or phonological representations are available, a result which has been observed in the context of a bilingual picture word interference study (Hoshino & Thierry, 2011).

Although the present study points to the viability of response conflict as a signal to increased monitoring, what has yet to be determined is whether conflict more generally might also serve this purpose. Representational conflict lies at the heart of production-internal monitoring mechanisms that have been proposed (e.g. Nozari et al., 2011), but previous neuroimaging evidence suggests that representational conflict alone is not enough to engage the ACC/pre-SMA (van Veen, Cohen, Botvinick, Stenger, & Carter, 2001). Van Heuven et al. (2008), for instance, failed to find activation of these medial prefrontal regions when subjects were presented with English–Dutch homographs in the context of a simple lexical decision task, although increases in lateral prefrontal regions were observed. Critically, the pre-SMA was engaged when subjects made decisions about whether a word was English, a situation that produced response conflict for homographs. This research thus highlights that a distinction should be made between representational- and response conflict, and that ability to monitor conflict is likely to involve a network of brain regions responsible both for representation and control. Delineating the respective contributions of these brain regions to monitoring and control operations in production remains an important area for future investigation. The present research suggests that a fruitful means of assessing these operations will be to manipulate the co-activation of multiple representations (e.g. semantic, lexical, phonological) during production planning.

Finally, the current study has two important implications for bilingual research. First, the present results suggest continued activation and monitoring of both languages even after production has been initiated. Second, the combination of the above-described results offers a clear physiological and processing explanation as to why bilinguals may have better executive abilities than monolinguals (Bialystok, Craik, Klein, & Viswanathan, 2004). To date, a primary explanation of these effects has focused on the fact that bilinguals may benefit from repeated switching between languages. The present results suggest that bilinguals would also gain more experience in training their monitoring systems. Whether the ERN/N2 reflect the detection of response conflict or the inhibition of information (e.g. Verhoef, Roelofs, & Chwilla, 2009), the monitoring and control systems engaged are hypothesized to be domain general. Hence, when bilinguals engage in speech production, they train the use of these domain-general systems, which would then extend to non-linguistic domains as well.

5. Conclusion

The present investigation provides an important link between studies of monitoring and control in language production, non-linguistic action, and bilingualism. Both electrophysiological and behavioral results indicate that despite being faster to name, cognates produce more response conflict that non-cognates. Even in correct naming, the production system appears to be quite sensitive to such conflict, lending credence to the idea that response conflict may be one of the primary signals the production system uses to monitor itself.

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