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Brain Research

Research Report

The fox and the *cabra*: An ERP analysis of reading code switched nouns and verbs in bilingual short stories

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ARTICLE INFO

Article history:
Accepted 4 February 2014
Available online 14 February 2014

Keywords:
Code switching
Bilingualism
Discourse processing
Word class
LAN
LPC

ABSTRACT

Comprehending a language (or code) switch within a sentence context triggers 2 electrophysiological signatures: an early left anterior negativity post code switch onset – a LAN – followed by a Late Positive Component (LPC). Word class and word position modulate lexico-semantic processes in the monolingual brain, e.g., larger N400 amplitude for nouns than verbs and for earlier than later words in the sentence. Here we test whether the bilingual brain is affected by word class and word position when code switching, or if the cost of switching overrides these lexico-semantic and sentence context factors. Adult bilinguals read short stories in English containing 8 target words. Targets were nouns or verbs, occurred early or late in a story and were presented alternately in English (non-switch) or Spanish (switch) across different story versions. Overall, switched words elicited larger LAN and LPC amplitude than non-switched words. The N400 amplitude was larger for nouns than verbs, more focal for switches than non-switches, and for early than late nouns but not for early than late verbs. Moreover, an early LPC effect was observed only for switched nouns, but not verbs. Together, this indicates that referential elements (nouns) may be harder to process and integrate than relational elements (verbs) in discourse, and when switched, nouns incur higher integration cost. Word position did not modulate the code switching effects, implying that switching between languages may invoke discourse independent processes.

1. Introduction

Bilingualism is a dynamic phenomenon that can affect language production and comprehension, as well as generate constructs not experienced by monolinguals. One experience unique to bilinguals is the ability to switch between languages during a conversation, referred to as code switching. Code switching is the integration of more than one language

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http://dx.doi.org/10.1016/j.brainres.2014.02.009
0006-8993

in a single communicative exchange (Heller, 1988). This subject has been studied from diverse perspectives (e.g. Bullock and Toribio, 2009; Gardner-Chloros, 2009). Some have focused on the cognitive and neural processes underlying code switching, especially with regard to the representation of two languages in bilingual memory and the bilingual brain (See for more information in Kutas et al., 2009). The present study employs event-related potentials (ERPs) to examine the temporal dynamics of comprehending a language switch in short stories, with the goal of understanding the role of *word class* and *discourse context* (in terms of amount of preceding co-text) in bilingual comprehension of code switched words.

1.1. *Code switching*

The few ERP studies that have analyzed code switching in a sentence context have observed a code switching effect on the left anterior negativity (LAN) or N400 amplitude, where switched words elicited larger negative amplitude than non-switched words (Moreno et al., 2002; Proverbio et al., 2004; van Der Meij et al., 2011).

Moreno et al. (2002) observed a LAN – a negative-going ERP component over left anterior electrode sites – in English-Spanish bilinguals who read English sentences containing a Spanish word. The effect was attributed to increased working memory load arising from integrating the Spanish morphological cues into an English context. Similarly, van Der Meij et al. (2011) observed a LAN for Spanish-English bilinguals reading switched words in English sentences, but the effect was limited to higher proficiency bilinguals. The authors argued that this effect resulted from 'the difficulty of integrating the different grammatical rules of both languages' (p. 52). These arguments are consistent with the monolingual literature, where the LAN has been argued to reflect increased working-memory load (Kluender and Kutas, 1993). Others, however, have argued that the LAN is related to syntactic processes observed in word categorization and morphosyntactic violations (Gunter et al., 2000; Neville et al., 1991; Osterhout and Mobley, 1995).

In contrast, both high and low proficiency bilinguals in van Der Meij et al. (2011) showed an N400 effect at the switched word, which was argued to reflect 'the activation costs of the specific lexical forms in the less active language' (p. 52). The N400, which overlaps in time and polarity with the LAN, is a negative-going ERP component with peak latency around 400 ms (Kutas and Hillyard, 1984). It differs from the LAN based on its central-parietal distribution, and is thought to reflect access to meaningful information from memory (Kutas and Federmeier, 2000). The N400 amplitude is inversely related to the semantic fit of a word in preceding context, such that it decreases as the semantic fit of a word increases (van Petten, 1993; van Petten and Kutas, 1990, 1991). A N400 effect was also observed for switched words in Italian-English interpreters reading Italian and English sentences (Proverbio et al., 2004). The position of the switch in these sentences was completely predictable, indicating that the N400 switching effect is not simply an effect of surprise. In addition, the switching direction modulated the amplitude of the N400: second-language English words embedded in Italian sentences elicited a larger N400 than first-language Italian words embedded in English sentences (cf., switching from second language to first language can be more costly in single-word presentation paradigms in Meuter and Allport, 1999). The authors attributed this difference in the N400 effect based on the switching direction to greater difficulty of accessing conceptual knowledge when using a second, and later learned, language. Therefore, the N400 effect can result from processing a less active lexical form (van Der Miej et al., 2011) or accessing meaning through a language that has weaker connections to conceptual knowledge (Proverbio et al., 2004).

It is possible that code switching in sentences incurs a higher cognitive load at both syntactic and semantic level, given that a switch requires the application of different grammatical rules and integration of different semantic attributes. The presence of the LAN in high proficiency bilinguals could indicate that these bilinguals are more likely than low proficiency bilinguals to apply syntactic rules of the two languages in a mixed-language context (cf. Osterhout et al., 2008). In addition, the N400 difference based on the switching direction may indicate that it is easier to integrate the lexico-semantic features of words from a stronger than a weaker language into the ongoing context.

The LAN/N400 is followed by a Late Positive Component (LPC), which is sometimes equated with the P600. The LPC is a large positive deflection with maximum amplitude over right posterior recording sites, beginning around 500 ms post-stimulus onset and lasting up to several hundred milliseconds. Both Moreno et al. (2002) and van Der Meij et al. (2011) observed an LPC for language switching, with larger amplitude to switched than non-switched words.[2]

In Moreno et al. (2002), the LPC was argued to reflect the processing cost of code switches in decision-making stages, which seems to refer to the increased cognitive load involved in processing an unexpected or improbable event (cf. Kolk and Chwilla, 2007). Code switches are therefore treated more as a change in form than as a change in meaning (Moreno et al., p. 204). LPC amplitude was negatively correlated with an individual's vocabulary size in Spanish – a measure of proficiency, with increased Spanish vocabulary resulting in a smaller LPC. This finding is to a certain extent contrary to that of van Der Meij et al. (2011), who observed a larger switching effect at the early phase of the LPC (450–650 ms) for high than low proficiency learners. The authors attributed this effect to more second language (L2) grammatical processing (the context language was the L2 of the bilinguals) by these learners, given that the LPC has been linked to repairing a syntactic anomaly (Hagoort et al., 1993). This finding about two phases of the LPC was also consistent with those of the previous studies (Carreiras et al., 2004; Hagoort and Brown, 2000). The two accounts for the LPC by Moreno et al. (2002) and van Der Meij et al. (2011) need not be incompatible, because a syntactic anomaly is an unexpected event that needs further processing for integration. van Der Meij et al. (2011) emphasized the linguistic processes for repair while Moreno et al. (2002) stressed the general cognitive processes for comprehending an unexpected occurrence.

[2] Proverbio et al. (2004) did not report statistical analyses for the LPC time window.