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Form overrides meaning when bilinguals monitor for errors

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ABSTRACT

Bilinguals rarely produce unintended language switches, which may in part be because switches are detected and corrected by an internal monitor. But are language switches easier or harder to detect than within-language semantic errors? To approximate internal monitoring, bilinguals listened (Experiment 1) or read aloud (Experiment 2) stories, and detected language switches (translation equivalents or semantically unrelated to expected words) and within-language errors (semantically related or unrelated to expected words). Bilinguals detected semantically related within-language errors most slowly and least accurately, language switches more quickly and accurately than within-language errors, and (in Experiment 2), translation equivalents as quickly and accurately as unrelated language switches. These results suggest that internal monitoring of form (which can detect mismatches in language membership) completes earlier than, and is independent of, monitoring of meaning. However, analysis of reading times prior to error detection revealed meaning violations to be more disruptive for processing than language violations.

Introduction

Bilinguals are mental jugglers, and skilled ones, too: They easily switch languages when they want to but rarely switch languages by mistake (Gollan, Sandoval, & Salmon, 2011; Poulisse, 1999). Unintentional language switches might be rare in part because they are filtered out by an internal monitor prior to overt production (Postma, 2000). But how difficult is it to detect unwanted language switches (e.g., *perro* instead of *dog*) relative to within-language semantic errors (e.g., *cat* instead of *dog*)? Translation equivalents might be easier to detect, because they do not belong to the target language, or harder to detect, because they match the intended meaning exactly.

To produce an utterance, speakers need to plan their intended message at a conceptual level, access the relevant abstract lexical representations (*lemmas*) of the concepts forming the message and insert them into a structural frame, plan and retrieve the morphological, phonological and phonetic structure of the utterance and ultimately articulate it (Dell, 1986; Levelt, Roelofs, & Meyer, 1999). At some point before articulation, monitoring mechanisms ensure that these steps have been performed correctly, in accordance with the speaker's intentions and the rules of the language (Hartsuiker & Kolk, 2001; Laver, 1980; Levelt, 1989; MacKay, 1987). Evidence for the existence of an internal monitor comes from observations that some errors are corrected too quickly (within approximately 150 ms) for this to happen after listening to one's overt speech (e.g., Blackmer & Mitton, 1991). Also, errors can still be detected when overt speech cannot be monitored because of noise masking, suggesting that planned speech can be monitored internally (Lackner & Tuller, 1979; Postma & Kolk, 1993; Postma & Noordanus, 1996; for other evidence, see Oppenheim & Dell, 2008; Severens, Janssens, Kühn, Brass, & Hartsuiker, 2011). Finally, even when

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experimentally-elicited Spoonerisms which would result in taboo words (e.g., the Spoonerism of *hit shed*) are *not* produced, they elicit elevated galvanic skin responses, suggesting that they are generated and comprehended internally but barred from overt production by the internal monitor (Motley, Camden, & Baars, 1982).

A major proposal in models of language production is that the internal monitor operates through the comprehension system (the Perceptual Loop theory: Hartsuiker & Kolk, 2001; Levelt, 1983, 1989). Once the utterance has been assembled by the language production system, the comprehension system comprehends inner speech to perform internal inspection of the production system's output – in the same way it analyzes the utterances of others – and transfers the outcome to a central monitor. If this were so, internal monitoring should show the same perception-specific effects found during comprehension of overt speech, such as perceptual uniqueness (e.g., Marslen-Wilson, 1990). Accordingly, Özdemir, Roelofs, and Levelt (2007) showed that, similarly to auditory comprehension, *internal* phoneme monitoring was faster when the phoneme which made a word unique came early in the word than when it came late (but see Huettig & Hartsuiker, 2010; Marshall, Rappaport, & Garcia-Bunuel, 1985).

Alternatives to the Perceptual Loop theory assume instead that internal monitoring does not function through the comprehension system but is a process internal to the production system itself. Thus, a major difference between the perceptual-loop monitor and production-based monitors is that the latter have access to production-internal information before the speech plan has been fully assembled (Laver, 1980; MacKay, 1987; Nozari, Dell, & Schwartz, 2011; Pickering & Garrod, 2014; see Postma, 2000, for a review). For example, Laver (1980) proposed multiple specialized monitors examining the output of each component of the production system (e.g., conceptual processing, lemma selection) immediately after its completion. MacKay's (1987) Node Structure Theory differs in that monitoring is not based on comparisons between intended and actual output but relies instead on statistical sensitivity to unfamiliar patterns of information flow throughout the production system. More recently, Nozari et al. (2011) proposed that speech-production monitoring is a domain-general conflict-monitoring system engaging a frontal brain region, which operates by detecting conflict between intended and produced language. A different account was put forward by Pickering and Garrod (2014), who proposed that speakers construct forward models of their to-be-produced utterances, and monitoring involves evaluating the discrepancy between such predicted (on the basis of the forward models) utterances and the actual utterances. Internal monitoring in the present study was operationalized as perceptual loop monitoring and the study was not designed to constrain monitoring theories (but see Declerck, Lemhöfer, & Grainger, 2016). However, any monitoring theory needs to include mechanisms for detection of unwanted language switches in bilingual production, and thus our study is relevant for internal monitoring in general.

A monolingual perceptual-loop monitor would detect lexical speech errors by examining at least two aspects of the words in the pre-articulatory speech plan: their form and their meaning. Additionally, the bilingual internal monitor needs to ensure that the words in the speech plan belong to the intended language, and not to another language (which may not be understood). Broadly, the bilingual monitor could cope with this task in two ways. Unintended language switches could be detected through the examination of form, with no additional mechanism responsible for wrong-language detection. Assuming monitoring is performed over inner speech (Levelt, 1989), the monitor would detect language switches specifically by examining words' phonetic make-up. Detection would be possible because even closely related languages mismatch in certain phonetic properties (e.g., /b/ is a stop in English but a fricative or approximant in Spanish; English has vowel reduction while Spanish does not; etc.). Thus, wrong-language words would at least partially mismatch in phonetic characteristics with intended-language words. Alternatively or in addition, a form-examining monitoring component could determine whether words in their entirety belong to the intended-language lexicon (e.g., the answer to "Is the word *bolsa* an English word?" is "no"). Such a mechanism – one that examines the lexical status of words – has been proposed to account for the greater likelihood of phonological substitution errors that result in existing words than in non-words (the *lexical bias effect*; Baars, Motley, & MacKay, 1975; see also Hartsuiker, Corley, & Martensen, 2005).

It is also possible that the bilingual monitor includes a separate component detecting language membership through a direct examination of words' language tags (Green, 1998; van Heuven, Dijkstra, & Grainger, 1998). Note, however, that an entirely comprehension-based monitor such as the perceptual loop monitor, which does not have access to intermediate representations in the language production system, will necessarily encounter words' form first, before being able to activate any internal properties of words such as language tags. In other words, the only way for the perceptual-loop monitor to activate the Spanish language tag of the word *bolsa* would be, at a minimum, to detect that the initial "b" is a bilabial fricative, which does not exist in English. For this reason, in the following we assume that unintended language switches are detected by the bilingual internal monitor through the examination of form (either directly or through the subsequent activation of a language tag); we return to the possibility of a form-independent language-detection monitoring component in section 'General Discussion'.

Note that bilinguals are thought to restrict production to the target language by means of language control mechanisms, which regulate the activation of the two languages to ensure the target language is activated to a greater extent than the non-target language. According to the most well-established proposal (Green, 1998), bilinguals inhibit the non-target language to avoid interference with the target language (but see Costa & Santesteban, 2004; Verhoef, Roelofs, & Chwilla, 2009). However, language control mechanisms may occasionally fail (as may any component of the language production system); it is then up to the monitoring mechanism to detect and correct the errors.