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Grammatical constraints on language switching: Language control is not just executive control

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ABSTRACT

The current study investigated the roles of grammaticality and executive control on bilingual language selection by examining production speed and failures of language control, or *intrusion errors* (e.g., saying *el* instead of *the*), in young and aging bilinguals. Production of mixed-language connected speech was elicited by asking Spanish–English bilinguals to read aloud paragraphs that had mostly grammatical (conforming to naturally occurring constraints) or mostly ungrammatical (haphazard mixing) language switches, and low or high switching rate. Mixed-language speech was slower and less accurate when switch-rate was high, but especially (for speed) or only (for intrusion errors) if switches were also ungrammatical. Executive function ability (measured with a variety of tasks in young bilinguals in Experiment 1, and aging bilinguals in Experiment 2), slowed production and increased intrusion rate in a generalized fashion, but with little or no interaction with grammaticality. Aging effects appeared to reflect reduced monitoring ability (evidenced by a lower rate of self-corrected intrusions). These results demonstrate robust effects of grammatical encoding on language selection, and imply that executive control influences bilingual language production only after sentence planning and lexical selection.

Introduction

Some of the most impressive demonstrations of agility in the domain of spoken language production include the prosodic and expressive speech often exhibited by newscasters or storytellers, unusually rapid production in a single language (e.g., when sportscasters describe team sports action live), and fluid alternation back and forth between languages by bilingual or multilingual speakers. Indeed, language switching has become one of the most broadly studied topics in the field of research on bilingualism—without question, it has played a major role in shaping theories of control over bilingual language selection. With relatively few exceptions the bulk of research on this topic has focused somewhat narrowly on obligatory and intended switches in out of context speech, relatively little on switches in connected speech, and even less on *un*intended language switches, though these can provide a unique and powerful form of evidence on the cognitive mechanisms underlying bilingual language selection.

Bilingual language switching can be considered as a specific example of the more general problem of regulation and control of production processes, which may be driven by two general types of mechanisms. Language-specific knowledge clearly plays a role in controlling speech production. For example, word exchange errors (*I'm writing a mother to my letter*) overwhelmingly respect word class – or *part of speech* (i.e., nouns exchange with nouns, verbs with verbs, etc.; Garrett, 1975), suggesting that knowledge

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of syntactic properties helps control which lexical items are selected for production (because lexical items in different parts of speech serve distinct syntactic functions; see Dell, Oppenheim, & Kittredge, 2008, for review and discussion). In addition to such domain-specific knowledge, mechanisms that support goal directed behavior in non-linguistic cognitive domains might also support control of speech production. For example, the need to select from among competing response alternatives arises across many situations, and common mechanisms may subserve this function across these cases (e.g., Thompson-Schill, D'Esposito, Aguirre, & Farah, 1997). Few studies have considered how these two types of mechanisms might function jointly to control bilingual language selection, and fewer still have considered how language-specific and domain-general factors might modulate the control of both intended and *unintended* language switches in production of connected speech.

Factors modulating control of language switching in out-of-context speech

A great deal of the work in bilingual language control has examined single word production tasks. These have suggested a number of task properties that seem to facilitate switching between languages. Onset of speech in such studies is typically slower when speakers are cued to switch languages relative to when they are cued to continue speaking the same language they used on the previous trial. This difference is assumed to reflect *switch costs*, i.e., the processing cost associated with switching languages. Switch costs are smaller, but not eliminated entirely, when preceded by longer preparation times (e.g., Costa & Santesteban, 2004; Fink & Goldrick, 2015; Philipp, Gade, & Koch, 2007; Verhoef, Roelofs, & Chwilla, 2009), when they are predictable (Declerck, Koch, & Philipp, 2015), when bilinguals know exactly which words they will produce ahead of time (Declerck, Philipp, & Koch, 2013), and when they are voluntary (Gollan & Ferreira, 2009) rather than forced by an experimentally provided cue (Gollan, Kleinman, & Wierenga, 2014). Switch costs are found even when no overt switch is produced (e.g., when alternating between reading a word silently in one language and producing a word in the other; Peeters, Runnqvist, Bertrand, & Grainger, 2014). Cost free switches have been reported in just a few cases. In one study, switch costs were found in a task performed in both languages, but not for a task performed in just one language (e.g., digit naming in both languages, mixed with picture naming in just one language; Finkbeiner, Almeida, Janssen, & Caramazza, 2006). In another, cost free switches were found when bilinguals switched languages voluntarily, but with an experimental requirement to use each language about equally often which led switching to become the default behavior (Gollan & Ferreira, 2009, Experiment 2). Finally, cost free switches were also found in voluntary switching when a small set of pictures was presented repeatedly and bilinguals chose Gollan, Kleinman, et al. (2014) or were instructed (Kleinman & Gollan, in press) to use just one language to name each picture and then consistently used only that same language on all subsequent appearances of each picture. Together these studies reveal both the persistence of switch costs in a variety of experimental settings, thereby resembling the literature on non-linguistic task-switching, but also the possibility that language switches are sometimes as efficient as (if not more efficient than) using just one language. Such cost-free switches might be easier to observe when presented with contextual support, a property that might be easier to study in the domain of language.

Grammatical structure

Sentence contexts, and connected speech as it is produced when multiple sentences are strung together, include grammatical as well as semantic structure that may facilitate control of language selection. Studies of spontaneous code switching corpora have observed that grammatical properties constrain the distribution of naturally occurring language switches in connected speech (e.g., Muysken, 2000; Myers-Scotton, 1997, 2005, 2006; Poplack, 1980). However, experimental studies of language switches in sentence contexts have yielded inconsistent results. In one study, cued switches between sentences in unscripted connected speech (descriptions of actions shown in pictures) were found to be costly (Tarlowski, Wodniecka, & Marzecová, 2013). Another study revealed speech to be slower when preceding naturally occurring code-switches relative to single-language speech (while controlling part of speech and utterance length; Fricke, Kroll, & Dussias, in press). However, naturally occurring code-switches might sometimes be initiated to recover from access difficulties in one language, thereby masking the possibility that some switches are fully intentional and cost-free. In a different study, no switch costs were found but connected speech was not measured; sentence context was read silently, and only a single (highlighted) target word within each sentence was produced long after the language switch actually occurred (Gullifer, Kroll, & Dussias, 2013). Finally, another study had bilinguals (professional translators and highly proficient matched controls) read sentences one word at a time with self-paced button presses and exhibited switch costs only if they later had to repeat the sentence aloud (Ibáñez, Macizo, & Bajo, 2010).

Beyond simply asking participants to switch within sentences, some work has explicitly examined whether switch costs are modulated by the extent to which they match habitual, or henceforth *grammatical*, patterns of switching in natural language use. Some results suggest that the size of switch costs is influenced both by the exact location of the switch within the sentence, and the type of verb participating in the switch (Dussias, 2003). Specifically, faster reading times (measured in gaze duration times) were observed for switches that occurred at a syntactic boundary (i.e., before the auxiliary; *terroristas have injured*) than between the auxiliary and the main verb (*terroristas han injured*). However, this was found much more for closely bound syntactic elements (*haber + participle*), than for less closely bound elements (i.e., *estar + participle*). The former is more bound to the participle in that it cannot occur on its own but *estar* can, and there appear to be stronger restrictions on the occurrence of switches that