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The Gradient Effect of Context on Language Switching and Lexical Access in Bilingual Production

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Abstract

Previous research on bilingual language switching costs has demonstrated asymmetrical switch costs, driven primarily by language dominance, such that switches into a more-dominant language incur significantly greater reaction time delays than switches into a less dominant language. While such studies have generally relied on a fixed ratio of switch to non-switch tokens, it is clear that bilinguals operate not in a fixed ratio, but along a naturally occurring bilingual continuum of modes or contexts. Bridging the concepts of language switching and language context, the current study examines language switching costs through a cued-picture naming study with variable contexts or modes. Results demonstrate that switch costs are dependent upon both language dominance and language context, with asymmetrical costs found in more monolingual mode and symmetrical costs found in bilingual mode. Implications are discussed with respect to language mode and gradient inhibitory mechanisms of language selection.

1. Introduction

Perhaps one of the most remarkable facets of bilinguals' speech is their ability to separate their two languages. The two competing languages reside in one mind, and for highly proficient bilinguals, often in fully or partially overlapping brain territories (e.g. Chee, Tan, & Thiel, 1999; Illes et al., 1999; Hernandez et al., 2001). While previous research has generally supported the claim that bilinguals separate their two languages effectively (e.g. Hasselmo, 1970), excepting cases of cerebral trauma (e.g. Perecman, 1984) and 'slips of the tongue' (Poulisse, 2000), experimentally-based psycholinguistic research has demonstrated that language switching comes at a cost. Relative to non-switched performance, language switching incurs a small temporal cost, generally in the realm of tens of milliseconds (Kolers, 1966). Paradoxically, switching into the dominant language tends to incur greater switch costs than switching into the non-dominant language (e.g. Meuter & Allport, 1999). Yet the body of research investigating language switching costs and subsequent theories that have stemmed from this line of investigation seems to have ignored a potentially crucial variable: language context (i.e. language mode).

As has been previously noted, bilinguals operate along a continuum, from monolingual performance in one language to monolingual performance in the other (e.g. Grosjean, 1997). Along this continuum, driven by psychological, linguistic, and contextual factors, bilinguals must constantly evaluate how much of each language should be implemented in a given conversation. The result is a continuous, variable ratio of the quantity of language A to language B produced by bilinguals across a variety of contexts.

Given that the ratio of language A to language B varies with contextual and psychological factors, it is logical to posit that the relative accessibility of each language may also vary. It would seem inefficient for both languages to remain equally accessible throughout a conversation when it is clear that the discourse consists predominantly or exclusively of a single language. Yet, in a linguistically balanced discourse, in which both languages are represented equally, it may be most economical to maintain both languages equally accessible. To begin to approach the natural variation in bilingual switching patterns, the present study examines the effect of context on lexical access and language switching costs in L1-dominant bilinguals.

1.1 Language Switching and Switch Costs

In one of the first studies to consider the time cost of producing language switches, Kolers (1966) asked French-English bilingual subjects to perform a mixed-language read-aloud task, as well as a mixed-language free production task, and compared them to unilingual productions. Results indicated that subjects were slower when switching languages relative to monolingual, non-switched productions. Later study confirmed this effect with language neutral stimuli (i.e. digit naming), although subject to a moderating effect of predictability with switches in a regular pattern (i.e. ABABABAB) incurring less temporal costs than unpredictable switches (Dalyrmple-Alford, 1985; Macnamara, Krauthammer, & Bolgar, 1968; although for predictable language and concept see Declerck, Koch, & Philipp, 2014).

While these earliest studies sought to establish the overall delays associated with switching languages, more recent work has attempted to disentangle effects of the direction of switch (L1 to L2 vs. L2 to L1), proficiency, and multilingualism, as a means to provide a theoretical framework for bilingual language selection. Meuter & Allport (1999), in their seminal work, employed a digit-naming task in which the background color of a given numeral corresponded to one particular language; a change in color cued a change in language. Participants, all late bilinguals, reported using frequent and 'intentional' switches in everyday language use. Results for the naming task showed that subjects were significantly slower to name a numeral in a switched trial than in a non-switched trial, a reaction time delay referred to as the *switch cost*. Counter-intuitively, results indicated an asymmetry in switch costs, such that switches into the first language (L1) were slower than switches into the second language (L2). It should be noted that these results also closely parallel a fairly substantial body of literature in task switching (for review see Koch, Gade, Schuch, & Philipp, 2010).

Drawing on this work, Costa & Santesteban (2004) examined the naming latencies in a cued-picture naming study of late bilinguals, early balanced bilinguals and trilinguals with a significantly weaker L3. Their findings revealed that while the late, L1-dominant bilinguals demonstrated asymmetrical switching costs, the early, balanced bilinguals showed symmetrical switching costs. This finding extended even to early, balanced bilinguals (L1 & L2) switching into a significantly weaker L3, leading the authors to posit a distinct language switching mechanism in highly proficient bilinguals. Subsequent research, however, demonstrated that under certain conditions, such as switching between L3 and a weaker L4, highly proficient bilinguals can and do demonstrate asymmetrical switching costs (Costa, Santesteban, & Ivanova, 2006; see also Linck, Schwieter, & Sunderman, 2012). Conversely, several studies have also shown that under certain conditions, including longer inter-stimulus intervals (Verhoef, Roelofs, & Chwilla, 2009) and voluntary non-cued switching (Gollan & Ferreira, 2009), unbalanced bilinguals can show symmetrical switch costs (for review see Bobb & Wodniecka, 2013). Having concluded that a variety of factors do not impact asymmetrical switch costs, including age of acquisition, language similarity, and L2 proficiency, Schwieter and Sunderman (2008) investigated the possibility that proficiency, as measured through "lexical robustness" (e.g. Gollan, Montoya, & Werner, 2002), accounts for a shift from asymmetrical to symmetrical switch costs. They found that the degree of symmetry of switch costs is related to a measure of lexical robustness. Broadly, their conclusions imply that, at a specific threshold of proficiency (i.e. lexical robustness), bilinguals may transition from asymmetrical to symmetrical switching costs.

More recent work has centered on the question of the reach of switching costs when performing language-switching tasks. Results from an n-2 paradigm, in which speakers named images either in ABA or CBA language sequences (e.g. German$_{A}$/English$_{B}$/*German*$_{A}$ or French$_{C}$/English$_{B}$/*German*$_{A}$), revealed n-2 repetition effects, in which naming in an ABA sequence was slower than naming in a CBA sequence (Philipp, Gade, & Koch, 2007; Philipp & Koch, 2009). In addition, by varying the items to be named from one set to another, results indicated a more global process directly impacting the entire response language, as opposed to a smaller "response set" of target items (Experiment 2: Philipp & Koch, 2009).

Taken as a whole, this body of research indicates that language switching incurs a switch cost, with switched tokens taking longer to produce than non-switched tokens. In addition, the asymmetrical nature of such switch costs, with bilinguals incurring greater switch costs in their more dominant language than less dominant, has been widely replicated, although balanced bilinguals have been shown to evidence symmetrical switch costs.

1.2 Cognitive Mechanisms Governing Language Switching

Stemming from the above-detailed series of studies investigating switching costs, there has been an ongoing theoretical debate on the nature of the language selection and switching mechanism. Although seemingly obvious, given that bilinguals rarely experience unintentional switches (Dornic, 1979), there must be some mechanism that allows for the separation of a bilingual's two languages. And, once separated, given that bilinguals are able to switch languages when necessary, the mechanism posited must allow for switching and explain the switch costs found in the above research. While intentional control of language separation is clearly the norm, equally revelatory are cases in which different patterns of unintentional language switches are produced (for brain trauma: Aglioti & Fabbro, 1993; Alberta & Obler, 1978; Fabbro, Skrap, & Aglioti, 2000; Kutas, Moreno & Wicha, 2009; Paradis, 1977; Paradis, Goldblum, & Abidi, 1982; Perecman, 1984, 1985; Poulisse, 2000; although for a word of caution see Grosjean, 1985; for effects of aging: Gollan, Sandoval, & Salmon, 2011). Accounting for both normal and pathological behaviors, a language switching mechanism, separate from the languages themselves, has been proposed (e.g. Goldstein, 1948). This early work represented a very categorical view of the "language switch," with only one language able to be selected at a time (Penfield & Roberts, 1959). Subsequently Macnamara and

Kushnir (1971) amended the proposal to include both an input switch and an output switch, to account for the bilingual ability of simultaneous translation.

More recently, there are two main hypotheses that have been developed. The first explanation, and the framework that will be used predominantly throughout this study, relies on the use of inhibition to suppress the non-response language (e.g. Green, 1986, 1998). The second possibility, postulated predominantly for balanced bilingual populations, is that a language-specific selection mechanism, not suppression, is at play (e.g. Costa, 2005).[1]

Within the Inhibitory Control Model (ICM), the primary assertion is that when operating in a given language, other competing languages must be inhibited (Green, 1986, 1998; Kroll & Stewert, 1994). The initial model was based on three principles, mainly control, activation, and resource, and sought to account for both normal and pathological bilingual performance. Functioning by means of language specifying tags attached to each lexical entry, inhibition is applied to the non-target entries to facilitate access to the target language. Specifically, non-target entries are inhibited to a degree that is proportional to the activation that is sent to such targets. As such, it is proposed that targets in a more dominant L1 receive stronger activation, and subsequently, will necessitate greater inhibition to allow production in the L2. This model has found support in a variety of experimental paradigms, including the language switching paradigms discussed above, as well as neurolinguistic studies analyzing bilingual brain activity during linguistic tasks (see below).

With respect to the language switching findings, the general finding of asymmetrical switching costs, with greater costs incurred when switching into the L1, has been explained within the framework of asymmetrical inhibition (e.g. Meuter & Allport, 1999). Greater inhibition is required on the L1, as it is stronger and receives more activation, relative to the L2, and such inhibition persists into the next trial. As such, switching into the L1 involves overcoming greater levels of inhibition relative to L2, and greater switch costs result from greater inhibition. Similarly, effects of proficiency, with balanced bilinguals illustrating symmetrical switching costs (e.g. Costa & Santesteban, 2004), can be explained by roughly equal levels of inhibition required on languages that are equally dominant. In the n-2 paradigm, for example, greater n-2 repetition effects were found for the more dominant language (Philipp, Gade, & Koch, 2007), again fitting within the ICM expectations.

Additional support has been drawn from research on bilingual brain function, most notably event related potentials (ERP) and functional magnetic resonance imaging (fMRI) paradigms. ERP results have demonstrated a frontocentral negativity, associated with an N2 (Christoffels, Firk, & Schiller, 2007; Jackson, Swainson, Cunnington, & Jackson, 2001). The N2 response was equated with the N2 response found to be associated with no-go responses in a go/no-go paradigm (e.g. Kopp, Mattler, Goertz, & Rist, 1996). As such, language selection was correlated with the response inhibition mechanism. Most recently, Guo, Liu, Misra, and Kroll (2011) demonstrated inhibitory effects remaining long after switching languages (see also Verhoef, Roelofs, & Chwilla, 2010 for discussion of alternative interpretations). Similarly, fMRI results have shown consistent activation of the executive control function areas of the brain (frontal cortex, left anterior cingulate cortex) in language switching tasks relative to non-switching tasks (Abutalebi, Brambati, Annoni, Moro, Cappa, & Perani, 2007; Hernandez, 2009;

Hernandez, Dapretto, Mazziotta, & Bookheimer, 2001; Prince, Green, & von Studnitz, 1999). Furthermore, asymmetrical activation of the executive control regions have been found, with greater activation evidenced when switching into L1 relative to the L2 (Wang, Xue, Chen, Xue, & Dong, 2007). As such, these studies support not only an inhibitory account of language selection, but indicate that the mechanisms employed in language selection are not language-specific.

Another key component of the ICM is the assumption that the processes involved in language separation and selection are not specific to the domain of language (for early support see Dalrymple-Alford, 1985; Paradis, 1980). Meuter and Allport (1999), take this as a working assumption, claiming that the processes for bilingual language selection are "similar in kind to those responsible for the control of task set in other monolingual and/or non-language task domains" (p. 25). This assumption is well supported by comparisons between the language switching and task switching literature (for reviews see Kiesel, Steinhauser, Wendt, Falkenstein, Jost, Philipp, & Koch, 2010; Koch et al., 2010; Monsell, 1996, 2003). In brief, similar asymmetrical costs have been found for task switching, with greater switch costs, or *shift costs*, observed for more dominant tasks (i.e. easier) relative to weaker tasks (i.e. more difficult) (e.g. Allport, Styles, & Hsieh, 1994). While the parallel between task switching and language switching is clear, it is worth noting that a number of studies, specifically comparing task and language switching have found mixed results or marginal correlations (Calabria, Hernández, Branzi, & Costa, 2012; Klecha, 2013; Prior & Gollan, 2013; for aging effects see Weissberger, Wierenga, Bondi, & Gollan, 2012), leading to the acknowledgement that language switching is a complex phenomenon and its governing mechanisms may only partially overlap with the task switching mechanism. Similar parallels can be made with the neurolinguistic studies, in which activation of the executive control functions in language switching tasks (i.e. Abutalebi, Brambati, Annoni, Moro, Cappa, & Perani, 2007) is not found in language-specific brain areas.

While there has been a large body of work on switching costs, and growing support for an inhibitory framework, the experimental paradigms have yet to approach the natural variability found in bilingual language switching patterns, namely language context or language mode.

1.3 Language Mode and Language Context

In natural speech, bilinguals can operate either monolingually, speaking in one of their two languages, or bilingually, alternating between them. Yet, it is clear that such a division cannot be considered categorical. In discussing the various options available to bilinguals, Hasselmo (1970) notes that Swedish-English bilinguals alternate between three different norms or "modes" of speaking, English-only, English-Swedish, and Swedish-English, depending on the audience or interlocutors. Here, Hasselmo (1970) differentiates between monolingual communication and two different degrees of bilingual communication. Similar findings for Spanish-English bilinguals from the Puerto Rican community in New York have been detailed (Poplack, 1980), with different quantities of language switching found based on the context of the interaction (i.e. formal vs. vernacular).

The idea of various language norms, or *language modes*, has been further refined most notably by the work of Grosjean (Grosjean, 1985, 1997, 1998, 2001, 2008; Soares

& Grosjean, 1984). In summary, bilinguals have the ability to move along a continuum from monolingual to bilingual speech production. At any given point in an interaction, driven by both psychological and linguistic factors, a bilingual must decide "which language to use, and how much of the other is needed—from not at all to a lot" (Grosjean, 2001, p. 2). Crucial for the current study, language mode has been discussed in terms of activation levels of a language A and language B (for parallels between activation and inhibition, and reference to the Inhibitory Control Model, see Grosjean, 2008). When operating in monolingual mode of language A, language B is minimally activated. Operating in a truly bilingual mode, both languages receive similar amounts of activation. The relative degrees of activation are determined by a variety of internal and external factors including, interlocutors, situation/ linguistic environment, form and content of the message, and the function of the language act (Grosjean, 2001).

Placement along a bilingual continuum, with true monolingual endpoints excluded (e.g. Blumenfeld & Marian, 2007; Kaushanskaya & Marian, 2007), can be manipulated by controlling other factors impacting language mode. Relevant for the current project, Soares and Grosjean (1984) note that the place of a bilingual along such a continuum may have an impact on their language production patterns, and controlling for this variable is crucial in the study of code switching (see also Grosjean, 1997). Supporting this assertion are several studies that have indicated an effect of language mode on the frequency and types of language switching (Treffers-Daller, 1998; Lanza, 1992), as well as the phonetic production of code-switches (Khattab, 2003, 2009; Olson, 2012). Green (2011) presents a roughly parallel hypothesis, relying on the notion of the *ecology* of a bilingual speaker. Namely, speakers from communities that favor code-switching may perform language switching tasks and lexical access differently than speakers from communities in which code-switching is the marked choice. While Green's (2011) proposal focuses on a bilingual's ecology in terms of speech community or speaker background, such a proposal could extend to include notions of language mode, considering a single speaker interacting in varied speech contexts.

While language mode is concerned with both the linguistic and sociolinguistic variables, *language context* focuses solely on the linguistic content of a production or paradigm (Olson, 2012). Language context, for the current study, is defined as the quantity of each language present in a given discourse or experimental paradigm. Language context can be conceptualized as falling within the over-arching umbrella of language mode, but with the understanding that many other factors also serve to induce differing language modes. In short, shifts in language context should result in corresponding shifts in language mode, but language context itself does not encompass all of the factors that also impact language mode. This distinction is crucial in the experimental setting, as variables such as linguistic environment, content of the message, interlocutors, and other social factors may be held constant across the different language contexts. In laboratory-based experiments, while it is possible to ask speakers to envision different interlocutors (e.g. Boston Study described in Grosjean, 1997), some paradigms may rely solely on the linguistic content or quantity of each language in the paradigm to trigger language mode (e.g. Olson, 2012).

While language mode has not been explicitly examined with respect to language switching costs, a relevant parallel can be made to the concept of global language mixing costs. Several language switching studies have examined *global language mixing costs*, defined as the difference in performance on non-switched trials in a mixed language block and non-switched trials in a pure (i.e. non-mixed) language block. Broadly, results have demonstrated a global cost associated with language mixing, such that non-switched trials in a mixed language block incur greater naming latencies than non-switched trials in a pure language block (Christoffels, Firk & Schiller, 2007; Declerck, Philipp, & Koch, 2013; Gollan & Ferreira, 2009; for differential activation see Wang, Kuhl, Chen & Dong, 2009). With respect to language mode, a pure language block may be representative of a monolingual mode while the mixed language block would be representative of a more balanced bilingual mode. Within this view, global language mixing costs may be taken as tacit support for the notion that language mode impacts lexical access.

It should be noted that studies of language switching costs (see above), have predominantly relied on a fixed switch-to-stay ratio (i.e. 30% of tokens are language switches, 70% are non-switches), albeit with all stimuli randomized. Similarly, much of the work on task switching has also followed such fixed ratios, although several notable exceptions have manipulated task ratios, with varied results (Bonnin, Gaonac'h, & Bouquet, 2011; Driesbach & Haider, 2006; Monsell & Mizon, 2006). And such results suggest a potential role of context in task switching. The fixed ratio generally employed in language switching tasks, while having been proven invaluable for this line of research, seemingly ignores the potential impact of language context.

1.4 Research Question

Bridging the previous research in language switching and language context, the current study seeks to investigate the impact of context on language switching costs.

Specifically, do language switching costs vary, depending on the context (more monolingual vs. bilingual)? Based on notions of language context and language mode, the working hypothesis is that switching costs may be subject to an impact of language context, and switching costs will be different at opposite ends of the language context continuum.

2. Methodology

To investigate the above research questions, a cued picture-naming task (e.g. Costa & Santesteban, 2004) was administered to L1-dominant bilingual participants. In this cued picture-naming task, participants named visually-presented pictures of common objects in both English and Spanish, depending on the background color of the picture. Following methodology implemented by Olson (2013), to better understand the role of context tokens were produced in both switched and non-switched conditions in three contexts: a predominantly English context, a predominantly Spanish context, and a balanced bilingual context. Analysis was conducted on reaction times, from the presentation of the picture to the onset of naming, as well as error rates.

2.1 Participants

A total of 18 Spanish-English bilinguals participated in the cued picture-naming study. Participants were recruited on the campus of the University of Texas at Austin, and all received a stipend for their participation in the study. All subjects reported normal speech and hearing, and normal or corrected to normal vision.

To control for any potential impact of language dominance and provide a balanced approach, nine participants were drawn from each of two language background categories: L1 English-dominant or L1 Spanish-dominant. Participants were grouped into these categories by means of a modified version of the Language Experience and Acquisition Questionnaire (LEAP-Q) (Marian, Blumenfeld, & Kaushanskaya, 2007), which employs a theoretical framework incorporating both language history and self-assessed language proficiency. Self-ratings have been used as a measure of linguistic ability (Bachman & Palmar, 1985; MacIntyre, Noels, & Clement, 1997; Shameem, 1998; Stefani, 1994), and have been shown to correlate reliably with linguistic performance (e.g. Flege, MacKay, & Piske, 2002). Additionally, such findings have been extended to the study of bilinguals, with results demonstrating that bilinguals are able to self-assess language proficiency in a manner that is highly correlated with behavioral performance (Chincotta & Underwood, 1998; Flege, Yeni-Komshian, & Liu, 1999; Flege, MacKay, & Piske, 2002; Jia, Aaronson, & Wu, 2002).

For the purposes of the current study, English-dominant participants ($n = 9$) are defined as those having learned English as a first language (L1), beginning acquisition of Spanish after the age of 12 ($M = 14.4$, $SD = 2.00$), and self-rating as more dominant in English than Spanish. Correspondingly, Spanish-dominant participants ($n = 9$) are defined as those having learned Spanish as an L1, starting acquisition of English after the age of 12 ($M = 15.3$, $SD = 4.00$), and self-rating as more dominant in Spanish than English. All English-dominant participants reported learning Spanish in the L2 classroom, as well as via immersion of various durations. All Spanish-dominant participants, although varying in L2 classroom experience, reported English-language immersion experience. Given the age of acquisition criteria, there was no potential overlap in subject categorization, with subjects not fitting these criteria eliminated in a pre-screening process. Addressing language abilities, subjects were asked to self-rate their skills in English and Spanish, for both speaking and comprehension, on a Likert scale of 1 to 9 (1= don't understand, 9= native speaker). English-dominant participants self-rated their English as stronger than Spanish in both speaking (English: $M = 8.9$, $SD = .33$; Spanish: $M = 7.1$, $SD = .60$) and comprehension (English: $M = 9$, $SD = 0$; Spanish: $M = 8.1$, $SD = .33$). Statistical analysis, employing paired two-tailed t-tests, confirms that English-dominant participants self-rated their English abilities significantly greater than their Spanish abilities (speaking: $t(8) = 8.00$, $p < .001$; comprehension: $t(8) = 8.00$, $p < .001$). Correspondingly, Spanish-dominant participants rated their Spanish as stronger than English in both speaking (English: $M = 6.3$, $SD = .71$; Spanish: $M = 8.9$, $SD = .33$) and comprehension (English: $M = 7.6$, $SD= .73$; Spanish: $M = 9$, $SD= 0$), with differences reaching statistical significance (speaking: $t(8) = -8.69$, $p < .001$; comprehension: $t(8) = -5.96$, $p < .001$). Similar trends were also found in reporting of current daily exposure, self-perceived accent, and other-perceived accent, as shown in Table 1 below.

Lastly, considering that not all bilingual communities and speakers engage in language switching, participants were asked to evaluate how often they switch languages, and how comfortable they are when others switch languages. Results showed that both groups of speakers switch languages with similar frequency and are equally comfortable when others switch languages (non-paired t-test: $t(33) = -.582$, $p = .565$). In short, all speakers are considered to be proficient Spanish-English bilinguals, dominant in their L1, and equally receptive to code switching. Given these shared backgrounds, and considering the preliminary statistical comparison by group (see section 3.1), the two groups were collapsed for analysis.

Table 1. *Language Experience and Acquisition Questionnaire results*

	Age of Acquisition		English Proficiency[a]		Spanish Proficiency[a]	
Language Background	English	Spanish	Speaking	Comprehension	Speaking	Comprehension
English-dominant	0.0 (.00)	14.4 (2.01)	8.9 (.33)	9.0 (.00)	7.1 (.60)	8.1 (.33)
Spanish-dominant	15.3 (4.00)	0.0 (.00)	6.3 (.71)	7.6 (.73)	8.9 (.33)	9 (.00)

a. Likert scale 1-9 (1= don't understand; 9= native speaker)

	Current Daily Usage[b]		Self-Perceived Accent[c]		Other-Perceived Accent[d]		Language Switching	
Language Background	Exposed	Speak	English	Spanish	English	Spanish	Self Switching[e]	Other Switching[f]
English-dominant	3.0 (1.00)	3.1 (1.05)	8.9 (.33)	5.7 (1.66)	7.7 (.70)	1.8 (2.37)	5.3 (1.50)	8.1 (.93)
Spanish-dominant	5.0 (1.20)	6.5 (1.41)	3.7 (1.94)	9.0 (.00)	1.4 (1.88)	9.0 (.00)	6.2 (1.64)	7.8 (1.3)

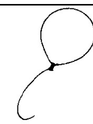
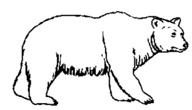
b. Likert scale 1-9 (1= only English; 9= only Spanish)
c. Likert scale 1-9 (1= very heavy accent; 9= no accent)
d. Likert scale 1-9 (1= always perceived as non-native; 9= never perceived as non-native)
e. Likert scale 1-9 (1= never switch; 9= frequently switch)
f. Likert scale 1-9 (1= confusing when others switch; 9= seems normal when others switch)

2.2 Stimuli

Target stimuli for the cued picture-naming study consist of 25 black and white line drawings of non-ambiguous objects taken from Snodgrass and Vanderwart (1980). The target names have an average of 3.92 phonemes in both English (*SD* = .86) and Spanish (*SD* = .64), and statistical analysis showed that there is no significant difference in number of phonemes between the two languages ($t(24) = .000$, $p = 1.00$). All tokens are considered to be of high frequency, among the 5000 most frequent words in each language, with no significant difference in frequency between the items in English (*M* = 1990.7, *SD* = 1544.8) and Spanish (*M* = 1905.1, *SD*= 1349.0) ($t(24) =.410$, $p = .685$) (for English: Davies & Gardner, 2010; for Spanish: Davies, 2005). All tokens are considered to be non-cognate, lacking an opposite language counterpart with similar meaning, orthography and phonology (e.g. de Groot, 1992)[2]. An additional 100 pictures (Snodgrass

& Vanderwart, 1980), also representing non-cognate names to minimize any cross-linguistic activation, were used as fillers. Table 2 below shows sample target pictures, with names in English and Spanish, as well as frequency and number of phonemes.

Table 2. *Sample stimuli*

English Name	English Frequency	English # of Phonemes	Spanish Name	Spanish Frequency	Spanish # of Phonemes	Stimuli Picture
Balloon	4764	5	Globo	3408	5	
Bear	1894	3	Oso	4555	3	

To investigate the effect of language context, each subject named the target pictures in 3 separate conditions. The *Monolingual English Context* consisted of 95% of tokens to be named in English and 5% to be named in Spanish. The *Monolingual Spanish Context* condition consisted of 95% of tokens to be named in Spanish and 5% to be named in English. Although not truly representative of monolingual, non-code-switched stimuli, the terms *Monolingual English* and *Monolingual Spanish* are used to imply that stimuli are representative of the more monolingual-end of the spectrum of language contexts. To facilitate discussion, the Monolingual English and Monolingual Spanish contexts are referred to as the *Monolingual Contexts*. The *Bilingual Context* condition consisted of exactly 50% of tokens named in English and 50% named in Spanish.[3] Stimuli presented in each of the contexts were randomized, such that the language of the following stimulus to be named was never predictable by the subject. Each condition was presented in a separate experimental session, administered on different days. The order of the sessions was counterbalanced across all participants, and all participants received a different randomized ordering.

Within each condition, stimuli were presented in trials consisting of a short list of pictures, varying from 6-14 pictures in length (*M* = 10), presented visually using SuperLab Pro 4.1.2 (Cedrus Corporation, 2010) experimental software. Targets were named in English and Spanish, both as switch and stay tokens. *Switch* tokens are defined as those in which the language of response was different from that used in the immediately preceding token. *Stay* tokens are those in which the language of response was the same as that used in the immediately preceding token. The first picture in a list was always a filler, and thus never analyzed as a switch or stay trial. In the Monolingual English Context, only pictures named in English as stay tokens and Spanish as switch tokens were included for analysis. In the Monolingual Spanish Context, pictures named in Spanish as stay tokens and English as switch tokens were analyzed. In the Bilingual Context condition, pictures named in both English and Spanish as stay and switch tokens were analyzed (e.g. Olson, 2013). Table 3 illustrates the distribution of the target tokens analyzed, in bold, by condition. *Switch costs* are defined as the difference between switch and stay target tokens (ms) in either the Monolingual or Bilingual Contexts. For example, switch costs for Spanish in the Monolingual Context are calculated as the difference in the Spanish stay tokens produced in the Spanish Monolingual context and Spanish switch tokens produced in the English Monolingual context. In total, there were 600 tokens per speaker and a total of 10,800 target tokens (25 stimuli × 2 language (Spanish/English) × 2 stimuli types (stay/switch) × 2 contexts (monolingual/bilingual) × 3 repetitions × 18 subjects = 10,800 tokens).

Table 3. *Target tokens by condition*

	Stay		Switch	
	English-**English**	Spanish-**Spanish**	English-**Spanish**	Spanish-**English**
Monolingual English Context (95% English; 5% Spanish)	X		X	
Monolingual Spanish Context (5% English; 95% Spanish)		X		X
Bilingual Context (50% English; 50% Spanish)	X	X	X	X

2.3 Procedure

The cued picture-naming study, based in part on previous research paradigms (Costa & Santesteban, 2004; Costa, Santesteban, & Ivanova, 2006, Meuter & Allport, 1999; Olson, 2013) was conducted in a quiet laboratory setting, with participants comfortably seated approximately 24" from a computer display. Through a series of instructional slides, participants were instructed to name pictures as "quickly and accurately" as possible, with the language of the token based on the color of the background, red or blue. The color-language pairings were counterbalanced across all participants, with half instructed that red indicated English and blue indicated Spanish. The remaining half of the participants received the inverse color-language pairing.

Each session began with presentation of instructions, with the language of the instructions corresponding to the predominant language of the session. For the Bilingual Context, half of the instructional slides were presented in English, half in Spanish. Following the instructions, participants were presented with a set of red and blue circles with the words *ENGLISH* and *ESPAÑOL* listed in the corresponding circles. Participants underwent a brief training, and 3 practice lists that were discarded from the analysis, to become familiar with the procedure and the color-language pairing. The switch-to-stay ratio used in the practice lists was identical to that in the following naming task. Each list began with a fixation cross, presented in the center of the screen for 500ms, followed by the first picture of the list. Each stimulus picture was presented in the center of a red or blue circle (800 x 800 pixels) and remained on the screen until triggered by onset and offset of the voice key or 2000ms passed. A blank interval of 700ms was then presented, followed by the next stimulus in the trial list. The end of a trial list was signaled by a series of asterisks ('*****'). Participants self-started the following trial list by pressing the spacebar, and the opportunity for short break was given after every 25 lists to limit fatigue. Figure 1 presents a schema for stimulus presentation in a given list.

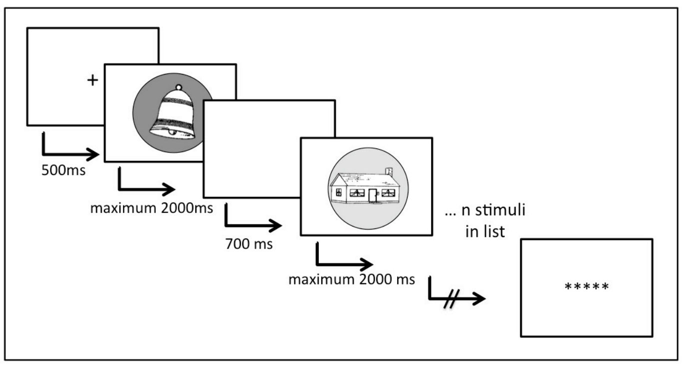


Figure 1. Schema of the time course of presentation of stimuli.

Naming latencies, or reaction times, were recorded using the Cedrus SV-1 Voice Key, with a 1ms resolution, and SuperLab Pro 4.1.2 (Cedrus Corporation, 2010). Gain levels for the voice key were set for each subject and used in all 3 experimental sessions.

3. Results

A total of 10,800 tokens were initially examined and coded for three different classes of errors: production errors, voice key failures, and outliers. Production errors included responses in the opposite language, false starts, and fillers. Voice key errors consisted of responses that were not registered by the voice key, generally the result of vocal productions not surpassing the set threshold. Lastly, outliers, those responses more than 3 standard deviations from the mean for each individual were eliminated. In total 12.46% of the responses were eliminated, with 2.55% from production errors, 8.38% from voice key failures, and 1.54% from outliers, resulting in a total of 9454 total tokens included in the statistical analysis. The total number of tokens eliminated from each subject was similar for both the English-dominant and Spanish-dominant groups, as demonstrated by a one-way ANOVA ($F < 1.00$, $p = 0.639$).

Three main factors were considered in the initial analysis of the dependent variable of *Naming Latency*: (1) *Language Context* (Monolingual Context vs. Bilingual Context), (2) *Response Type* (Switch vs. Stay token), and (3) *Response Language* (L1 vs. L2). *Naming Latency* was defined as the delay between the visual presentation of the picture stimuli and the onset of vocal production of the target token, and *Naming Latency* values were subjected to a square-root transformation to normalize the distribution of raw naming latencies for statistical analysis (e.g. Baayen, 2008). In addition, results make reference to the *switch cost*s, defined as the difference between naming a given token in a Stay condition vs. a Switch condition. Subsequent statistical analysis was conducted using R statistical software, version 2.6.2 (The R Foundation for Statistical Computing, 2013), and employed the LME4 statistical package. The significance criterion was set at $|t| = 2$. As complementary to the naming latency data, error rates are presented for the L1 and L2.

3.1 Naming Latency Results

Initial statistical analysis for the combined subjects group[4] was conducted using a linear mixed model with fixed factors of *Language Context*, *Response Type,* and *Response Language*, with *Subject* and *Item* as random factors with both random intercepts and slopes for each of the main factors and their interactions (see Barr, Levy, Scheepers, & Tily, 2013). Results for all fixed effects are found in Table 4. For completeness, results for random effects are included in Appendix A. The results reveal a significant effect of *Response Type,* specifically between the intercept (Switch in L1 of Monolingual Context) and Stay (Stay in L1 of Monolingual Context: β = -1.909, t = -5.65), with significantly slower naming latencies for switch tokens compared to stay tokens. The two-way interaction for *Response Type* × *Language Context* (β = 1.00, t = -2.86) was significant, as well as the two-way interaction for *Response Type* × *Response Language* (β = 2.002, t = 4.35). From this interaction, we can conclude that in the Monolingual Context, the difference between Switch and Stay is dependent on the L1 and L2. Finally, the 3-way interaction between *Response Language, Response Type,* and *Language Context* was significant (β = -2.01, t = -3.82), suggesting that the 2-way *Response Language* × *Response Type* interaction may differ between the Monolingual Context and Bilingual Context.

To assess the contribution of each of the above fixed factors, three subsequent models with were conduced, each eliminating one of the fixed effects. The first model (LogLik = -26410) was then compared with each of the subsequent models. Results indicated that inclusion of each of the factors significantly improved the overall fit of the model: *Response Language* (LogLik = -26422, $\chi^2(1)$ = 23.68, p

< .001), *Response Type* (LogLik = -26425, $\chi^2(1) = 29.75$, $p < .001$), and *Language Context* (LogLik = -26419, $\chi^2(1) = 16.71$, $p = .002$).

Table 4. *Fixed effects of linear mixed effects model*

	Estimate	Std. Error	t-value	Left CI	Right CI
Intercept	32.43	0.38	84.43	31.67	33.19
Stay	-1.92	0.34	-5.65	-2.60	-1.24
L2	-1.56	0.37	-4.29	-2.30	-0.82
Bilingual Context	-0.27	0.35	-0.77	-0.97	0.43
Switch: L2	2.00	0.46	4.35	1.08	2.92
Switch: Bilingual Context	1.00	0.35	2.86	0.30	1.70
L2: Bilingual Context	0.47	0.44	1.05	-0.41	1.35
Switch: L2: Bilingual Context	-2.01	0.52	-3.82	-3.05	-0.97

Note: Fixed effects are response type (switch, stay), response language (L1, L2), and language context (bilingual context, monolingual context). CI, Confidence interval. L2, second language.

To better understand the interactions between the main factors, it is worth considering the data in the Monolingual and Bilingual Contexts separately. As such, separate linear mixed effects models were conducted for the Monolingual and Bilingual Context data with fixed factors of *Response Type* and *Response Language*, and *Subject* and *Item* as random factors with both random intercepts and slopes for each of the main effects and their interactions (Barr et al., 2013).

Results of the model conducted for the data in the Monolingual Context (Table 5) reveal a significant difference between the intercept (Switch in L1) and Stay (Stay in L1) ($\beta = -1.92$, $t = -5.86$) (for random effects see Appendix B). However, as demonstrated by the interaction of *Response Type* × *Response Language* ($\beta = 2.00$, $t = 4.35$), the effect of language switching was different in the L1 and L2. A preliminary observation of the raw naming latencies for Monolingual Context, illustrated in Figure 2a, highlights the difference in the effect of language switching between the L1 and L2. Specifically, while there was a large difference between the Switch (M = 1061 ms, SD =249.2) and Stay (M = 945 ms, SD = 265.6) tokens in the L1, these differences were minimal in the L2

(Switch: *M* = 963 ms, *SD* = 237.6; Stay: *M* = 976 ms, *SD* = 279.1) Thus, in the Monolingual Context, switch costs were asymmetrical, with greater switch costs observed in the L1 relative to the L2. This result replicates the asymmetrical switch costs found in previous language switching paradigms (e.g., Meuter & Allport, 1999).

Table 5. *Fixed effects of linear mixed effect model for monolingual context*

	Estimate	Std. Error	t-value	Left CI	Right CI
Intercept	32.43	0.38	85.59	31.67	33.19
Stay	-1.92	0.33	-5.68	-2.58	-1.26
L2	-1.56	0.34	-4.53	-2.24	-0.88
Stay: L2	2.00	0.46	4.35	1.08	2.92

Note: Fixed effects are response type (switch, stay) and response language (first language, second language). CI, Confidence interval; L2, second language.

Similar analysis for Bilingual Context (Table 6) reveals a different pattern (for random effects see Appendix C). While results of the LME model revealed significant effect of both *Response Type* (β = -.91, *t* = -4.46) and *Response Language* (β = -1.10, *t* = -3.49), there was no interaction between *Response Type* and *Response Language* (β = -.01, *t* = -.02). Figure 2b highlights these finding, showing that naming latencies were greater for *Switch* tokens relative to *Stay* tokens in both L1 (Switch: *M* = 1050 ms, *SD* = 293.0; Stay: *M* = 986 ms, *SD* = 275.9) and L2 (Switch: *M* = 979 ms, *SD* =271.1; Stay: *M* = 922, *SD* =252.6). Most importantly, these results show that, in contrast to the Monolingual Context, there is no difference in the effect of language switching between the L1 and L2.

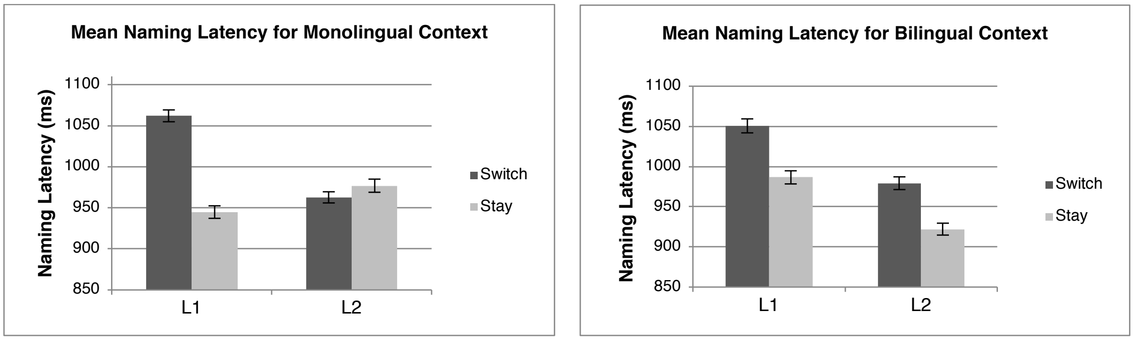


Figure 2. Raw naming latencies in the Monolingual Context (2a) and the Bilingual Context (2b). Error bars represent ± 1 standard error.

Table 6. *Fixed effects of linear mixed effect model for bilingual context*

	Estimate	Std. Error	t-value	Left CI	Right CI
Intercept	32.16	0.49	65.47	31.18	33.14
Stay	-0.91	0.21	-4.46	-1.33	-0.49
L2	-1.10	0.31	-3.49	-1.72	-0.48
Stay: L2	-0.01	0.29	-0.02	-0.59	0.57

Note: Fixed effects are response type (switch, stay) and response language (first language, second language). CI, Confidence interval; L2, second language.

Analysis of Switch Costs

Analysis of the switch costs serves to highlight the asymmetrical differences between *Switch* and *Stay* tokens in the L1 and L2 and the modulating effect of *Language Context*. Again, switch costs are defined as the difference in the naming latency between a switch token and a stay token. Specifically, in Monolingual Context, subjects showed a greater switch cost for the L1 (M = 116 ms) than for the L2 (M = -13 ms). For statistical analysis, switch costs were calculated for each switch token by subtracting the mean naming latency for stay tokens in a given response language and language context from each individual switch token in the same response language and language context. Subsequently, a two-sample t-test, with unequal variance, comparing L1 and L2 switch costs in the Monolingual Context, confirmed the statistical significance of the asymmetry

($t(2403) = 13.256$, $p < .001$, $d = .54$). In the Bilingual Context, however, subjects showed much smaller differences in the switch costs between L1 ($M = 64$ ms) and L2 ($M = 57$ ms), with subsequent analysis showing no significant difference in the L1 and L2 switch costs ($t(2272) = .588$, $p = .557$, $d = .02$). Figure 3 highlights the asymmetrical nature of the switching costs in L1 and L2, and the effect of *Language Context* on switch costs. The difference between switch costs in L1 and L2 is greater in Monolingual Context than in Bilingual Context.

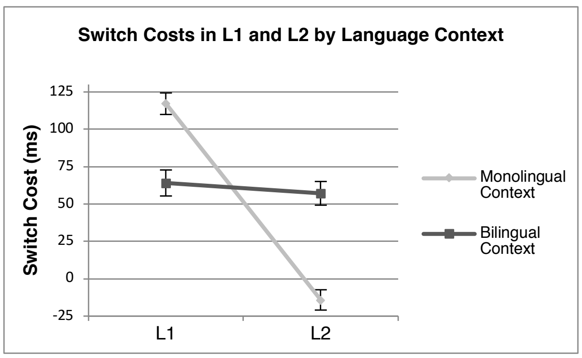


Figure 3. Effect of Language Context on switch costs in L1 and L2. Error bars represent ± 1 standard error.

In summary, in the Monolingual Context, bilinguals showed the expected asymmetrical switching costs, with switches into the L1 incurring greater switch costs than switches into the L2. These asymmetries, however, were neutralized in the Bilingual Context, with similar switch costs being incurred in both L1 and L2.

3.2 Error Rates

Tokens containing errors were eliminated from the analyses of the naming latencies, given that they constituted speech errors and thus are not representative of normal naming latencies, yet an examination of the pattern of errors sheds light on some of the difficulties of lexical access in a cued language-switching paradigm. The analysis of error rates focuses on the production errors, accounting for 2.6% of total responses (276 tokens), as such errors most clearly correlate with subject performance. Production errors were categorized as: (1) responses in the opposite language, (2) false starts in the opposite language, (3) false starts in the target language, and (4) fillers (Table 7). Given the limited number of total tokens, analysis centers on observation of error rates and patterns as opposed to statistical analysis.

Table 7. *Production error examples*

Category	Target Word	Production Error Example
Opposite Language	'house'	*casa*
False Start in Opposite Language	'house'	*ca... house*
False Start in Target Language	'house'	*hou... house*
Filler	'house'	*eeh... house*
		um... house

In considering the total number of errors, bilinguals made more errors on switch tokens (69.8%) relative to stay tokens (30.2%). In addition, participants made more errors in their L1 (65.8%) relative to their L2 (34.2%). Interestingly, a majority of errors consisted of productions in the opposite language (responses in the opposite language = 51.5%; false starts in the opposite language = 24.7%). However, of most interest are the asymmetries found in the error rates between L1 and L2 and the effect of Language Context on these asymmetries.

As with the reaction time data, error rates can be discussed in terms of *error switch costs*, here defined as the number of errors made when switching into a given language minus the number of errors made when staying in the same language. In the Monolingual Context, participants demonstrated a substantial asymmetry, with greater error switch costs in their L1 (cost= 60 additional errors) relative to their L2 (28 errors). In the Bilingual Context, in contrast, the error switch costs were much more similar between the dominant (7 errors) and non-dominant languages (11 errors). Importantly, these findings for the switch costs errors pattern with the switch costs found for the reaction time data. Figure 4 illustrates the total switch costs in errors by language context.

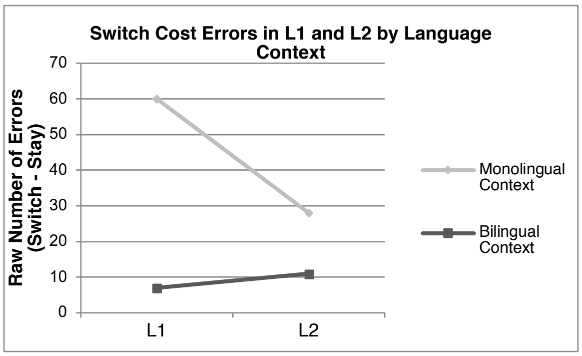


Figure 4. Switch cost errors in L1 and L2.

4. Discussion

The main goal of the current study was to examine the effect of language context on language switching costs. Results, drawing primarily on naming latencies, demonstrate a significant impact of language context on switch costs. Specifically, L1-dominant bilinguals showed asymmetrical switching costs in the Monolingual Context, such that they incurred significantly greater costs switching into their more dominant language relative to the non-dominant language. However, in the Bilingual Context, symmetrical switch costs were found, with no significant difference in the switch costs incurred in the dominant and non-dominant languages for either of the L1-dominant bilingual groups. Error rates, assessed for general trends and taken as complementary results to the main analysis of naming latencies, patterned after the naming latency switch cost findings. In the Monolingual Context, both groups demonstrated greater error switch costs in their dominant language relative to the non-dominant language. In the Bilingual Context, the switch cost in terms of errors was roughly the same in the dominant and non-dominant languages.

Stemming from these results, the remainder of the discussion will be dedicated to discussing the implications for an Inhibitory Control framework, drawing support from current and previous results, as well as notions of global reactivity.

4.1 The Effect of Language Context

The results presented above, most particularly in the Monolingual Context, first serve to replicate previous findings, albeit with a more extreme switch-to-stay ratio. The findings are in line with the asymmetrical switching costs that have been reported in Spanish-Catalan (Costa & Santesteban, 2004), Spanish-Korean (Costa & Santesteban, 2004), and even English-dominant learners of Spanish (Schwieter & Sunderman, 2008). In tandem with similar results found in other language pairings, the results for English-dominant and Spanish-dominant bilinguals in the current study add to the view of a universal nature of the language switching mechanism. In addition, given that they pattern closely after previous findings, the results found in the Monolingual Context serve to validate the methodology and stimuli used in the current experiment.

One of the key findings in the current study is the effect of language context on naming latencies and switch costs. Language mode (e.g. Grosjean 1985), akin to language context, has been described as a continuum along which bilinguals operate, extending from monolingual in language A, through balanced bilingual, to monolingual in language B. In experimental paradigms examining the effect of language mode, there have been several studies confirming that bilinguals' placement along the language mode or language context continuum impacts production, primarily limited to the domain of phonetics and pragmatics in code-switching (Khattab, 2003; Lanza, 1992; Olson, 2012; Treffers-Daller, 1998; Weil, 1990 as cited in Grosjean, 2008). While issues in lexical access may often be obscured in discourse, in part by utterance pre-planning (Swerts & Geluykens, 1994), the cued-picture naming study employed here offers an ideal paradigm to examine the effects of language context on lexical access.

Although previous cued-picture naming studies have demonstrated asymmetrical switch costs for L1-dominant bilinguals (Costa & Santesteban, 2004; Costa, Santesteban, & Ivanova, 2006; Meuter & Allport, 1999; Philipp, Gade, & Koch, 2009; Philipp & Koch , 2009), it should be noted that all of the previously-cited studies employed a fixed switch-to-stay ratio, generally 30% switch-70% stay. Thus, while these results have been consistent, they represent roughly similar positions along the language context continuum. The current study, varying the switch-to-stay ratio (5% switch-95% stay to 50% switch-50% stay), showed a clear effect of language context on both switch costs and error rates, with the asymmetrical switch costs in the Monolingual Context differing significantly from the symmetrical switch costs in the Bilingual Context for L1-dominant bilinguals. These results also reflect previous findings in the task switching literature, in which varied switch ratios led to differing shift costs (Bonnin, Gaonac'h, & Bouquet, 2011; Driesbach & Haider, 2006; Monsell & Mizon, 2006), as well as findings for global language switching costs, in which naming latencies for non-switched trials vary depending on the context (i.e. pure vs. mixed language blocks) (Christoffels, Firk &

Schiller, 2007; Declerck, Philipp, & Koch, 2013; Gollan & Ferreira, 2009; Wang et al., 2009).

Considering the language context continuum, it is clear that when operating towards the monolingual ends of the language context continuum, subjects demonstrate asymmetrical switching costs. Towards the mid-point of the language mode continuum, however, language switching costs were symmetrical. Thus, changes in a speaker's position along the language context continuum result in changes in the temporal costs and accuracy associated with language switching and lexical access.

These results add empirically-based evidence to the discussion of language context and language mode (e.g. Grosjean, 1985), and expand on Green's (2011) proposal for the role of speaker ecology in language selection. Specifically, while previous research has demonstrated an impact of language context on the type, number, and phonetic production of code-switches produced in a naturalistic code-switched discourse, the current results show that language context plays an integral role in lexical access itself. When speakers are operating in a Monolingual Context, a language switch into the more dominant language is more costly, both in terms of reaction times and error rates, than when they are operating in a Bilingual Context. More specifically, language context not only impacts the language from which a given lexical item is selected, it also affects the speed and accuracy with which a lexical entry is selected and produced.

In addition to adding to the discussion of language context and language mode, these results have substantial implications for ongoing research on bilingual lexical access. Specifically, the current results demonstrate an impact of language context on switch costs, and serve to illustrate the flexible nature of language switching costs and lexical access. While previous research has demonstrated asymmetrical switch costs for L1-dominant speakers (e.g. Meuter & Allport, 1999; Costa & Santesteban, 2004), it is clear that this is not always the case. The results in the current study confirm that L1-dominant bilinguals may produce symmetrical switch costs in certain language contexts, a finding more strongly associated with balanced bilinguals (e.g. Costa, Santesteban, & Ivanova, 2006; for L1-dominant bilinguals see Christoffels, Firk, & Schiller, 2007). This finding is not without precedent, as a number of studies have found specific conditions under which L1-dominant bilinguals may produce symmetrical switch costs, including long inter-stimulus interval (Verhoef, et al., 2009) and non-forced switching (Gollan & Ferreira, 2009), yet these findings indicate that a contextual factor may serve to manipulate switch costs even in a cued-switching paradigm. Thus, switch costs are not only affected by language dominance, with speakers incurring greater switch costs in their more dominant language, they are also subject to effects of language context, a previously unattested factor. As such, although current theories regarding the cognitive mechanism governing language switching have accounted for the effect of language dominance, the present findings suggest that they must also account for the effect of language context.

4.2 Language Context and a Gradient View of Inhibition

Given the demonstrated effect of language context on lexical access, theories concerning the cognitive mechanisms governing bilingual language selection and language switching must be able to account for these effects. In early models of bilingual language selection, language selection was described in terms of a binary language switch (e.g. Penfield & Roberts, 1959). In order for a bilingual to operate in language A, language A must be “on”, while language B remains “off”. Later models, accounting for performance in simultaneous translation tasks, proposed input and output switches which could be differentially set to on/off positions (Macnamara & Kushnir, 1971), but the general principle remained unchanged. Within this framework, language selection occurs in a categorical manner, according to which if a language is selected, the competitor language must be non-selected.

More recently, the Inhibitory Control Model (ICM) (Green 1986, 1998) posits language selection as the product of selective inhibition. Broadly, targeting language-specific tags attached to each lexical entry, inhibition is applied to lexical entries of the non-target language, resulting in selection of the target language. Support for the ICM has been drawn from a number of areas, including pathological switching (Alberta & Obler, 1978; Fabbro, Skrap, & Aglioti, 2000; Paradis, 1977; Paradis, Goldblum, & Abidi, 1982), ERP and neuroimaging (Abutalebi, Brambati, Annoni, Moro, Cappa, & Perani, 2007; Christoffels, Firk, & Schiller, 2007; Guo, Liu, Misra, & Kroll, 2011; Hernandez, 2009; Hernandez, Dapretto, Mazziotta, & Bookheimer, 2001; Jackson, Swainson, Cunnington, & Jackson, 2001; Prince, Green, & von Studnitz, 1999; Wang, Xue, Chen, Xue, & Dong, 2007), and, most relevant for the current study, cued language-switching paradigms (Costa & Santesteban, 2004; Costa, Santesteban & Ivanova, 2006; Meuter & Allport, 1999; Linck, Schwieter & Sunderman, 2012; Philipp, Gade & Koch, 2007; Philipp & Koch, 2009). Results from the cued language-switching paradigms, particularly for L1-dominant bilinguals, have consistently evidenced asymmetrical switching costs (although see Gollan & Ferreira, 2009; Verhoef, et al., 2009). In accounting for the asymmetrical switch costs found in previous studies, it has been proposed that different degrees of inhibition are required on the dominant and non-dominant languages.

This interpretation certainly accounts adequately for the asymmetrical costs and impacts of language dominance found in the previous studies and may also account for the effect of language context. While previous results have pointed to inter-speaker variability in inhibition driven by proficiency, the current study suggests a gradient interpretation of inhibition as illustrated by intra-speaker variability by language context. The switch costs in the more Monolingual Contexts were asymmetrical, implying different levels of inhibition applied to the L1 and L2. In contrast, the switch costs in the Bilingual Contexts were symmetrical, such that switching into dominant and non-dominant languages incurred similar costs. If, as described within the IC framework, switching costs result from the amount of inhibition on each language, then switching languages in a Balanced Context must entail roughly similar levels of inhibition on each competing lexical entry. Thus, the different patterns of switch costs found in the Monolingual Context and the Bilingual Context may be the product of different degrees of inhibition applied to the L1 and L2 in the two contexts. As such, inhibition cannot be viewed as categorical, with an item being either inhibited or not. Rather, the fact that inhibition patterns are different in the two contexts leads to, at minimum, two differing levels of inhibition applied to each language.

Complementary to the analysis of the naming latencies, the error rates found in the current study parallel the findings for switching costs. Within an inhibitory approach, the asymmetrical error rates (Monolingual Context) may be indicative of greater inhibition on the L1 than the L2, resulting in more opportunities for unintended productions in the

L2. As such, the difference in the error rate patterns between the Monolingual and Bilingual context provide further support for, at minimum, two differing levels of inhibition applied to each language.

Drawing on the notion of language context as a continuum, it is reasonable to posit a continuum of inhibition applied to each language, resulting in a continuum of relative inhibition. Operation in a monolingual context in language A would require maximal inhibition on language B, with that maximum determined by a bilingual's language proficiency profile (i.e. greater inhibition on L1 relative to L2). Operation in a bilingual context, however, would require roughly equal levels of inhibition applied to language A and B. Intermediary points on the continuum would then evidence differing, gradient degrees of inhibition relative to their position on the continuum.

While the current results point to an effect of language context on switch costs, potentially owing to gradient degrees of inhibition, language context may be only one of many possible factors affecting the degree of inhibition. Encompassed within the notion of language mode is the assertion that there are a variety of factors that affect position along the language mode continuum, including linguistic, contextual, and psychological factors (Soares & Grosjean, 1984; Grosjean, 1985, 1997, 1998, 2001, 2008). The current experiment manipulated only language context; however it is reasonable to posit that language mode, not solely language context, is key for modulating the amount of inhibition applied to each language.

Local and Global Reactivity

While the effect of inhibition has been described as reactive, applied after activation of a given lemma (e.g. Green, 1998), the current results highlight a globally-driven interpretation of reactivity, as opposed to solely local. Considering the cued picture-naming experiment, if inhibition were applied only after the language cue were presented (i.e. at a local level), then one would expect consistent naming latencies and switch costs, regardless of position along the language context continuum. However, if degree of inhibition applied to a given set of lexical entries or tags were driven by the language context or language mode, established throughout an experimental paradigm or discourse, we may expect different local switch costs in different contexts. In addition, the proposal of a global interpretation of inhibition is not without precedent in the ICM. Green (1998) claims that "inhibition is assumed to be reactive though previous episodes of suppression may exert their effects, since it takes time for the effects of prior inhibition to be overcome" (p. 72). Given the above-demonstrated effect of language context on switch costs, there must be a process by which the preceding discourse or paradigm is assessed in order to shift local switch costs and the degree of inhibition accordingly.

A globally-driven interpretation of the reactive nature of inhibition finds support in studies of global language mixing costs (Christoffels, Firk & Schiller, 2007; Declerck, Philipp, & Koch, 2013; Gollan & Ferreira, 2009; Wang et al., 2009), in which longer latencies are found for non-switch tokens in mixed language blocks relative to pure language blocks. Given that response times for stay tokens (i.e. tokens with identical local environments) change depending on the characteristics of the larger block (i.e. global), there is existent evidence for a global effect of language switching on lexical access. Furthermore, such findings can be couched within the discussion of language mode, with greater non-switched latencies found in a more bilingual mode relative to a monolingual mode. In short, global language mixing costs, potentially subject to language mode, appear to be impacted by broader contextual factors, indicative of a globally reactive system.

In addition to accounting for global language mixing costs, the interpretation of the reactive nature of inhibition seems to account for the current results for local switch costs as well. While asymmetrical switch costs (i.e. local switch costs) were found in the Monolingual Context, symmetrical switch costs were found in the Bilingual Context. In short, the local switch costs were modulated by the global context. While this interpretation still allows for a reactive interpretation of inhibition, such that inhibition is applied after activation of a given lexical item, the degree of inhibition applied may be modulated by the global context.

5. Conclusion

While bilinguals are generally very proficient at separating their two languages, language switching also occurs to varying degrees, dependent on the context. As such, the mechanisms governing language switching must permit this wide range of performance. The current study, employing a cued picture-naming paradigm that varied language context, demonstrated significant effects of language context on lexical access in L1-dominant English-Spanish and Spanish-English bilinguals. These results were accounted for within a gradient interpretation of the Inhibitory Control Model, drawing on notions of language mode (i.e. language context) and a globally-driven reactive nature of inhibition. Within this gradient IC framework, the degree of inhibition applied to a given lexical set is modulated by the broader language context. To accomplish this, inhibition must operate at the global level, such that the degree of inhibition to be applied to a given lexical set is determined by the preceding context. Thus, contexts consisting of a balance of L1 and L2 constituents will drive roughly equal levels of inhibition on the two languages. This gradient interpretation accounts for previous results of asymmetrical switching costs, as well as the current results for both temporal and accuracy switch costs.

While the results from the current paradigm may be explained within an inhibitory framework, it is recognized that it may not be the only way to account for such results. Future research should address different proposals, as well as account for the performance of balanced bilinguals in cued-switching paradigms.

Appendix A

Random of linear mixed effects model

Subject	Variance	Std. Dev	Corr						
Intercept	0.69	0.83							
Bilingual Context	0.07	0.26	-0.21						
Stay	0.44	0.66	-0.15	0.41					
L2	0.43	0.65	-0.69	0.73	0.41				
Bilingual Context: Stay	0.15	0.38	0.56	-0.78	-0.39	-0.99			
Bilingual Context: L2	0.28	0.53	-0.22	-0.88	-0.53	-0.46	0.56		
Stay: L2	0.70	0.84	0.18	-0.05	-0.88	-0.34	0.30	0.20	
Bilingual Context: Stay: L2	0.54	0.74	-0.45	0.43	0.60	0.85	-0.84	-0.35	-0.71

Item	Variance	Std. Dev	Corr						
Intercept	1.92	1.38							
Bilingual Context	1.71	1.31	0.00						
Stay	1.29	1.13	-0.25	0.61					
L2	1.63	1.28	-0.29	0.64	0.90				
Bilingual Context: Stay	1.16	1.08	0.30	-0.71	-0.98	-0.86			
Bilingual Context: L2	2.39	1.54	0.45	-0.79	-0.71	-0.76	0.77		
Stay: L2	2.40	1.55	0.49	-0.76	-0.90	-0.90	0.94	0.90	
Bilingual Context: Stay: L2	2.71	1.65	-0.75	0.55	0.79	0.75	-0.85	-0.84	-0.93

Note: Fixed effects are response type (switch, stay), response language (first language, second language), and language context (bilingual context, monolingual context). Subject and Item are declared as random intercepts and slopes for each of the main effects and their interactions. L2, Second language.

Appendix B

Random effects of linear mixed effects model for monolingual context

Subject	Variance	Std. Dev	Corr		
Intercept	0.63	0.79			
Stay	0.41	0.64	-0.13		
L2	0.09	0.31	-0.95	0.44	
Stay: L2	0.81	0.90	0.13	-0.79	-0.38

Item	Variance	Std. Dev	Corr		
Intercept	1.91	1.38			
Stay	1.31	1.14	-0.24		
L2	1.64	1.28	-0.29	0.90	
Stay: L2	2.35	1.53	0.50	-0.91	-0.90

Note: Fixed effects are response type (switch, stay) and response language (first language, second language). Subject and item are declared as random intercepts and slopes for each of the main factors and their interactions. L2, Second language.

Appendix C

Random effects of linear mixed effects model for bilingual context

Subject	Variance	Std. Dev	Corr		
Intercept	0.65	0.81			
Stay	0.32	0.56	0.18		
L2	0.40	0.63	-0.94	-0.44	
Stay: L2	0.29	0.54	-0.07	-0.95	0.39

Item	Variance	Std. Dev	Corr		
Intercept	3.62	1.90			
Stay	0.03	0.16	-0.04		
L2	1.01	1.00	-0.04	1.00	
Stay: L2	0.34	0.58	-0.96	-0.25	-0.26

Note: Fixed effects are response type (switch, stay) and response language (first language, second language). Subject and item are declared as random intercepts and slopes for each of the main factors and their interactions. L2, Second language.

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[1] An alternative framework to the ICM is that of a language-specific selection mechanism (Costa 2005; Costa, Santesteban, & Ivanova, 2006; Finkbeiner, Almeida, Jannsen, & Caramazza, 2006; Finkbeiner, Gollan, & Caramazza, 2006; for the Direct Access Hypothesis see Paradis, 1980, 2004), in which only lexical nodes of the target language are activated. This framework has been driven by findings of symmetrical switch costs in balanced bilinguals (i.e. Costa & Santesteban, 2004), although subsequent proposals have considered duel mechanisms, language-specific and inhibitory (Costa, Santesteban, & Ivanova, 2006). However, given that the bilinguals in the current study are L1 dominant, not balanced, the language-specific hypothesis will be left aside at present.

[2] Previous research has demonstrated faster and more accurate lexical access for cognates relative to non-cognates (Costa, Caramazza, & Sebastian-Galles, 2000; de Groot, Borgwaldt, Box & Van den Eijnden, 2002; for Spanish-English see Schwartz & Kroll, 2006).

[3] Driven by the experimental design, there was an average of 19 stay trials between each switch trial in the Monolingual Contexts, and an average of one stay trial for each switch trial in the Bilingual Context. It should be noted that, given the use of fillers, an equal number of the target tokens were analyzed for each response type (stay/switch) in each context (Monolingual/Bilingual).

[4] Given the similar language backgrounds and proficiency profiles, English-dominant and Spanish-dominant groups were combined into a single sample for analysis. Preliminary statistical analysis confirmed that there were no differences between the groups with respect to naming latency. Results from a preliminary

ANOVA, with *Language Background*, *Response Type*, *Response Language,* and *Language Context* as main factors, reveal that when *Response Language* is coded as English or Spanish, the four-way interaction between all the main factors, as well as each of the main factors, was found to be significant (*Language Background* × *Response Type* × *Response Language* × *Language Context*: $F(1, 9438) = 32.03$, $p < .001$, $\eta_p^2 < .001$). When representative of the L1/L2 of each individual speaker, the repeated analysis was found to be not significant $F(1, 9438) = .002$, $p = .969$, $\eta_p^2 = .003$).

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