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Should I Stay or Should I Switch? A Cost–Benefit Analysis of Voluntary Language Switching in Young and Aging Bilinguals

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Abstract

Bilinguals spontaneously switch languages in conversation even though laboratory studies reveal robust cued language switching costs. The authors investigated how voluntary-switching costs might differ when switches are voluntary. Younger (Experiments 1–2) and older (Experiment 3) Spanish–English bilinguals named pictures in 3 conditions: (a) dominant-language only, (b) nondominant-language only, and (c) using “whatever language comes to mind” (in Experiment 2, “using each language about half the time”). Most bilinguals, particularly balanced bilinguals, voluntarily mixed languages even though switching was costly. Unlike with cued switching, voluntary switching sometimes facilitated responses, switch costs were not greater for the dominant language, and age effects on language mixing and switching were limited. This suggests that the freedom to mix languages voluntarily allows unbalanced and older bilinguals to function more like balanced and younger bilinguals. Voluntary switch costs reveal an expanded role for inhibitory control in bilingual language production and imply a mandatory separation by language in bilingual lexical selection.

Keywords

bilingualism; aging; voluntary switching; language switching; picture naming

Through knowing two languages, bilinguals have an obvious communicative advantage over monolinguals. They can communicate with a broader audience and function in a greater variety of language environments. When bilinguals converse with other bilinguals, they also have the flexibility of choosing whichever language most easily, uniquely, or sometimes privately expresses their intended thoughts. For this and other reasons (Heredia & Altarriba, 2001; Musyken, 2000; Myers-Scotton, 1997/1993), bilinguals commonly switch between languages even though in many cases nothing obvious compels such switches. On the other side of these bilingual advantages is the very basic challenge that bilinguals must face when speaking to monolinguals (or multilinguals with different language combinations), which is that they must use one language and not the other, even though in principle, both languages are usually about equally able to communicate their intended meanings.

A comparable challenge very occasionally faces monolinguals, when they try to produce synonyms (e.g., a speaker might want to say *sofa* instead of *couch*). Synonyms pose documentable difficulty for monolinguals (Jeschaniak & Schriefers, 1998; Peterson & Savoy, 1998), particularly when the two alternative names are low frequency (e.g., *limousine*, *limo*;

Spieler & Griffin, 2006; but see Griffin, 2001). For bilinguals, this challenge arises with almost every word they say, and certain strategies that monolinguals have (e.g., never say *sofa*) simply are not available to bilinguals who often must use one and not the other language. Evidence that bilinguals face a constant exercise in managing their two languages, controlling which language they use and when, is that bilinguals develop an unusually strong ability to resolve response conflict in nonlinguistic tasks. In such tasks, bilinguals display processing advantages over monolinguals (e.g., Bialystok, Craik, Klein, & Viswanathan, 2004; Costa, Hernandez, & Sebastián-Gallés, 2008). Conversely, in linguistic tasks (in which bilinguals must manage a burden that monolinguals do not have), bilinguals display subtle but significant fluency disadvantages relative to monolinguals (e.g., Gollan & Acenas, 2004; Gollan, Montoya, Cera, & Sandoval, 2008; Gollan, Montoya, Fennema-Notestine, & Morris, 2005; Gollan, Montoya, & Werner, 2002; Ivanova & Costa, 2008).

One way to seemingly alleviate the challenge associated with forcing bilinguals to use just one of their languages is to give them the option of using either language. Indeed, previous research reveals that this option improves bilingual fluency in some cases. For example, balanced Spanish–English bilinguals, both younger (Kohnert, Hernandez, & Bates, 1998) and older (Gollan, Fennema-Notestine, Montoya, & Jernigan, 2007), score significantly better on the Boston Naming Test (in which speakers name pictures; Kaplan, Goodglass, & Weintraub, 1983) if given credit for correct responses produced in either of their languages. Similarly, Hebrew–English bilinguals were able to correctly retrieve as many low-frequency names as monolinguals in a tip-of-the-tongue (TOT) study if credited for producing a name in either language (see “and-or scoring” in Gollan & Silverberg, 2001). In other circumstances, such as during timed category fluency, the option to use either language did not increase (though it also did not decrease) bilinguals’ verbal fluency scores (De Picciotto & Friedland, 2001; Gollan et al., 2002).

It is interesting to note that the broader cognitive psychology literature suggests that the option to use either language should be accompanied by a robust cost: If speakers exercise their option to use either language (e.g., saying *cat* and then *cochino*, the Spanish word for *pig*, during a category fluency trial), then they will have switched from one language to the other. Dozens of experimental studies have revealed *switch costs*—that is, participants take longer to respond when switching from one task to another than when repeating the same task from trial to trial (even when they do not repeat specific responses; see review by Monsell, 2003). Switch costs also occur in language switching; bilinguals are slower when cued to switch between languages than when cued to speak the same language as on the previous trial (e.g., Meuter & Allport, 1999).

However, language switch costs have been observed only with controlled, involuntary switching. In the cases discussed above, bilinguals had relatively more freedom regarding which language to use (Gollan et al., 2002), and this sometimes brought performance benefits (Gollan & Silverberg, 2001). This raises an intriguing alternative possibility, namely, that voluntary language switching, which is what bilinguals often do in everyday settings, does not incur switch costs. This would have implications for understanding why speakers code-switch in natural conversation and would clarify the previously observed “either” benefits. Prior findings of language switch costs could be explained by their nonvoluntary nature because these experiments required speakers to name particular pictures in one language or the other as directed by experimentally provided cues (i.e., switches were cued, forced, and required). Voluntary language switching might not be costly because bilinguals would no longer be forced to use a language that is relatively less accessible on any given trial. In addition, with voluntary switches, there would be no need to monitor and respond to a language cue. Thus, if bilingual control mechanisms afford the possibility of suspending the requirement to produce words in a particular language, then voluntary language switches should not be costly at all.

Quasivoluntary switch costs between nonlinguistic tasks have been documented when participants are asked to do each task about half the time (e.g., Arrington & Logan, 2004). However, the requirements to use each task half the time and to switch “randomly” without alternating on every trial reduce considerably the degree to which those switches were voluntary. Another reason that voluntary language switching might not be costly is that the definition of “task” might simply be “name the picture” when the instruction is to name pictures using either language. On this view, speakers would not be switching between different tasks any more than they would if given the option to speak loudly or quietly. Rather than a “task” that would need to be switched into and out of, language membership would simply be a parameter of the naming response. The fact that bilinguals switch languages frequently (sometimes even constantly) in natural conversation suggests the possibility that voluntary language switching is not costly, or only minimally costly. Thus, despite the robustness of cued switching costs, the situation could be different in voluntary language switching, and it is important to determine whether bilingual speakers experience switch costs even when they initiate the switches themselves.

In the present study, we shed new light on the mechanisms of bilingual control, age-related changes in control, and task switching by investigating the nature of language switching when bilinguals name pictures with an “either” instruction, inviting voluntary language switching. We first investigated in Experiment 1 whether voluntary language switching incurs any costs or benefits and then asked in Experiment 2 whether voluntary language switching differs from previous instantiations of voluntary task switching (e.g., Arrington & Logan, 2004). If voluntary language switches do not cause switch costs, then this would raise thorny issues for the task-switching literature, suggesting that the experimental setting may create switch costs that under more natural circumstances do not arise. Conversely, if voluntary switches are costly, then it would validate the experimental psychology literature on task switching by revealing that the switch costs it explores are robust even in a more naturalistic paradigm and would provide implicit empirical support for the assumption that naturally occurring codeswitches are driven primarily by pragmatic goals (Myers-Scotton, 2005, 2006) rather than by lexical accessibility (Clyne, 2003; Owens, 2005; Poplack, 1980).

An additional aim was to determine how voluntary switches might differ from previous reports of cued language switches. Existing work shows that cued language switch costs resemble nonlinguistic task-switching costs in more ways than not. For example, switch costs are present even when switches are completely predictable both in nonlinguistic (e.g., Meiran, 1996 e.g., Meiran, 2000; Rogers & Monsell, 1995) and in language switching (Hernandez & Kohnert, 1999). Of importance is that both in nonlinguistic switching (e.g., Allport & Wylie, 2000; Yeung & Monsell, 2003) and in language switches (Costa & Santesteban, 2004; Meuter & Allport, 1999), there is a counterintuitive asymmetry such that switches into easier tasks and the dominant language are more costly than switches into difficult tasks and the nondominant language. The switch-cost asymmetry has played a critical role in shaping models of bilingual language production and has often been interpreted as the signature of inhibitory control of the nontarget language (Abutalebi & Green, 2007; Costa & Santesteban, 2004; Costa, Santesteban, & Ivanova, 2006; Hernandez & Kohnert, 1999; Jackson, Swainson, Cunningham, & Jackson, 2001; Meuter & Allport, 1999; although alternative interpretations are possible, see Finkbeiner, Almeida, Janssen, & Caramazza, 2006; Yeung & Monsell, 2003). The role of inhibitory control is proposed to be more important for allowing switches into the nondominant language; bilinguals suppress the dominant language, and it subsequently suffers larger switch costs when inhibition must be released on a switch back into the dominant language. In contrast, the nondominant language need not be suppressed (or is inhibited much less) to speak the dominant language (Green, 1998).

If voluntary switches are costly, then it will also be of interest to see whether voluntary switch costs exhibit the asymmetry. The presence of a robust asymmetry, even in the context of voluntary switches, would confirm the hypothesis that bilingual language control entails turning inhibition on and off across switch and stay trials. In contrast, if no asymmetry is observed, then it would suggest that there are important differences between how bilinguals achieve language selection when switches are forced versus when switches are voluntary. In Experiment 3, we further considered the role of inhibitory control for bilingual language production by asking whether older bilinguals exhibit a different pattern of voluntary language switches than younger bilinguals. In cued-switching studies, older bilinguals exhibited greater language switching costs than younger bilinguals (Hernandez & Kohnert, 1999; for similar age effects in the context nonlinguistic switching, see Mayr, 2001; Salthouse, Fristoe, McGuthry, & Hambrick, 1998). The increased language switch costs in older bilinguals were interpreted as evidence that increased age impairs the ability to control activation of the nontarget language. On this view, when switches are voluntary, older bilinguals might choose to switch languages relatively less often than younger bilinguals, or if voluntary switches require less use of inhibitory control than cued switches, then voluntary language switching may reveal little or no age effect.

Finally, if fully voluntary switches are costly, then it would suggest that when bilingual speakers have the option of using either language, this simply shifts the challenges they face from the costs associated with using one language and not the other to the costs associated with choosing which language to speak. In addition, switch costs in voluntary language switching would create an interesting puzzle regarding why there might be “either benefits” in other tasks, such as the Boston Naming Test and in TOT studies. Whatever the solution is to that puzzle, is likely to provide fundamental insights into bilingual lexical representation, theories of bilingual control, natural code switching and of cognitive control.

Experiment 1: Voluntary Language Switching

A few key results characterize cued-language switching costs. First, *local* switch costs are found such that within mixed-language blocks (during which speakers are cued to name some pictures in one language and other pictures in the other language), naming times are faster on *stay* trials—when speakers name a picture in the same language as the previous picture—than on *switch* trials—when speakers name a picture in a different language from the previous picture (Costa & Santesteban, 2004; Costa et al., 2006; Hernandez & Kohnert, 1999; Meuter & Allport, 1999). Second, when one language is clearly dominant over the other, there is typically a local switch-cost asymmetry such that switching into the dominant language incurs a greater switch cost than switching into the nondominant language (Costa & Santesteban, 2004; Costa et al., 2006; Hernandez & Kohnert, 1999; Jackson et al., 2001; Meuter & Allport, 1999). Third, *global* switch costs are found such that between testing blocks, naming times are faster in pure blocks, when no language mixing is required, relative to when language mixing is required (Hernandez & Kohnert, 1999), even when only stay trials are considered in mixed blocks (to avoid including local costs in the calculation of global costs; e.g., Christoffels, Firk, & Schiller, 2007). Finally, in some studies language-mixing costs on the dominant language are so strong that language dominance reverses, such that naming times are slower in the dominant than in the nondominant language. Dominance reversal has been reported on both stay and switch trials (Christoffels et al., 2007; Costa & Santesteban, 2004), but in other studies, the reversal occurred only on switch trials (Meuter & Allport, 1999).

In Experiment 1, bilinguals switched languages voluntarily when naming pictures. If bilinguals can switch languages exclusively on the basis of lexical accessibility, producing whichever language comes to mind first, and simply using whichever language is more accessible for any given picture, then the rate of voluntary switching should depend on the extent of language

dominance. Though all bilinguals should use the dominant language more often than the nondominant language, relatively balanced bilinguals should choose to switch into the nondominant language more often than bilinguals with one strongly dominant language (because unbalanced bilinguals should be less likely than balanced bilinguals to have nondominant language names more accessible than dominant ones on any given trial).

In addition, if lexical accessibility alone can drive language switches, then a very different pattern of results should emerge for voluntary switches relative to that reported for cued switches (for a recent review of the different possible mechanisms of cued-switch costs, see Arrington & Logan, 2005). Specifically, a *lexical accessibility-only* account predicts that bilinguals should switch languages voluntarily only when that is easier than staying. Thus, across the three conditions tested in Experiment 1, naming times should be fastest overall in the either-language condition when compared with both language-selective conditions. Nondominant-only responses should be slower because in this condition, speakers are forced to retrieve pictures with names that are relatively less accessible than their translation equivalents. Dominant-only naming times should also be slower on average compared with the either-language condition on the assumption that bilinguals only switch languages when words in their nondominant language are more accessible than their corresponding dominant language translation equivalents. Thus, the accessibility-only account predicts that instead of the global language-mixing costs found in cued language-switching studies, we should find global facilitation effects for voluntary switches that resemble the above mentioned either-language benefits for bilinguals in untimed picture naming tasks. The absence of global language-mixing costs would imply that there is no burden associated with deciding what language to use when switching languages voluntarily and that the bilingual control mechanism can suspend monitoring of the language of output.

Comparing stay with switch trials within the either-language condition (locally), the accessibility-only account also predicts that there should be no voluntary language switch costs. In many studies on bilingualism, the primary theoretical question under investigation has been whether bilinguals can “turn a language off” and function effectively like monolingual speakers. In a sense, the either-language condition asks the mirror image of this question, which is whether bilinguals can “keep both languages available for response” without consideration of language membership. If so, then bilinguals should switch only when doing so will lead to faster response times overall, when switching is easier than staying, or at least as easy as staying, and consequently, no switch costs should be observed. Note that the accessibility-only account assumes that bilinguals can switch languages with no trial-to-trial executive decision or choice regarding what language to use.

Alternatively, if lexical accessibility alone cannot drive language switches, then (globally) there should be a cost associated with the burden of having to choose what language to use on each trial. In addition, comparing stay with switch trials (locally), if voluntary language switches reveal a switch cost, then this would imply that both cued and voluntary switches require time to reconfigure task goals from “name in language X” to “name in language Y,” effort to avoid the tendency to repeat previous stimulus–response mappings, and that cued-switch costs cannot be attributed entirely to forcing speakers to override their natural naming preferences or to monitoring and responding to experimentally provided cues.

Method

Participants—Table 1 shows the participant characteristics broken down by type. Seventy-three Spanish–English bilinguals participated in the study for course credit. Participants completed a language-history questionnaire in which they rated their proficiency in each language. The 73 bilinguals were divided into two groups on the basis of whether they rated their ability to speak English as better than or equally as good as their ability to speak Spanish

($n = 57$) or their ability to speak English as weaker than their ability to speak Spanish ($n = 16$). The first group performed better in the English tasks below than in the Spanish tasks, and so this group was referred to as *English dominant*. Perhaps because of their immersion in an English-dominant environment, the second group performed about equally in the English and Spanish tasks, and so they were referred to as *balanced bilinguals*. Because of the relatively larger number of English-dominant bilinguals, the discussion was focused on their data, but the balanced bilinguals' data are also discussed in cases in which it proved useful for understanding the results.

Materials—One hundred thirty-two black-and-white line-drawn pictures were selected from Snodgrass and Vanderwart (1980) and other sources. Sixty items were taken from Griffin and Bock (1998), of which 5 had cognate names. Two other pictures were Spanish–English cognates. Pseudorandom assignment was used to divide the materials into three lists, each with 22 pictures with high- ($M = 142.3$) and 22 with low-frequency ($M = 8.3$) English names (Baayen, Piepenbrock, & Gulikers, 1995). For a list of the materials, see Gollan et al. (2008).

Procedure—Pictures were presented using PsyScope 1.2.5 (Cohen, MacWhinney, Flatt, & Provost, 1993) on a Macintosh computer with a 17-in. (43-cm) color monitor. Naming times were recorded using headset microphones connected to tape recorders and PsyScope response boxes. An experimenter recorded naming and voice key accuracy online and later verified coding against the recordings. Instructions were to name pictures “as quickly as you can without making mistakes.” Speakers named pictures in English in the English-only condition and in Spanish in the Spanish-only conditions. Instructions in the either-language condition were, “You can use either Spanish or English names. Just say whichever name comes to mind most quickly.” Each trial began with a 500-ms presentation of a central fixation point (“+”) that was immediately replaced by the picture. Participants initiated each trial by pressing the space bar. The picture disappeared when the voice key was triggered (or with a 3-s deadline) and was replaced by a minus sign that remained on the screen until the participant pressed the space bar to initiate the next trial. Lists were assigned to one of the three different conditions counterbalanced across participants, with condition order also counterbalanced across participants. Each bilingual saw each picture only once and named 44 pictures in English only, 44 pictures in Spanish only, and 44 pictures in either language. After naming the pictures, participants attempted to translate picture names from the English-only condition into Spanish and picture names from the Spanish-only condition into English. Pictures from the either-language condition were translated from the language participants designated as dominant into the nondominant language.

Results

To trim outliers, we discarded all reaction times (RTs) below 250 or above 5,000 ms; pictures disappeared after 3 s, but responses produced after the 3-s deadline were recorded, and we included correct naming times up to 5,000 ms in our analyses. For each bilingual, we then calculated the mean and standard deviation of RTs across all conditions for correct responses separately in the dominant and nondominant languages, and then for each language, we removed RTs that were more or less than 2.5 standard deviations above or below each participant's mean in that language. This trimmed 3.4% or less of correct response RTs from all conditions. In the analyses below, the degrees of freedom do not always match the number expected on the basis of the number of participants or items in each condition because each given bilingual or word was included in the analyses only if there were data points in all cells relevant to the comparison. For example, bilinguals who never switched languages would not be included in the analysis of switch costs (because they did not switch languages). For each analysis, we considered the means in the full data set as well (e.g., averaging into the English-stay trials all of the responses of the bilinguals who never switched languages), and the pattern

of results remained the same as that reported below. We report analyses by participants ($F1$) and items ($F2$), but note that in the either-language condition, in which different items do not contribute equally to each of the possible trial types (i.e., English stay, English switch, Spanish stay, Spanish switch), this reduces the extent to which $F1$ and $F2$ analyses are comparable. In addition, because of the small number of participants available for analysis, we report analyses on balanced bilinguals' data in less detail. Where we report comparisons of switching rates (e.g., comparing balanced and English-dominant bilinguals in Experiment 1 and younger and older adults in Experiment 3), we used both raw percents and arcsine-transformed values (Winer, 1971) as the dependent variable; however, the transformations did not change the pattern of significance in any of these analyses, and we report the values from the unadjusted analyses.

Language-dominance effects—Figures 1 and 2 show the mean RTs and error rates in the language selective (English-only, Spanish-only) and mixed language (either-language) conditions for the 36 English-dominant bilinguals and 13 balanced bilinguals, respectively, who produced at least one response in each of the four possible trial types in the either-language condition. Of importance is that English-dominant bilinguals named pictures almost 300 ms more slowly in the Spanish-only condition than in the English-only condition, $F1(1, 35) = 53.21$, $MSE = 26,957$, $\eta_p^2 = .60$, $p < .01$; $F2(1, 56) = 75.94$, $MSE = 30,053$, $\eta_p^2 = .58$, $p < .01$, and produced about twice as many errors in Spanish as in English in the only conditions, $F1(1, 35) = 11.05$, $MSE = .003$, $\eta_p^2 = .24$, $p < .01$; $F2(1, 56) = 13.27$, $MSE = .002$, $\eta_p^2 = .19$, $p < .01$ (see Figure 1). Thus, these bilinguals can be characterized as having one clearly dominant language (i.e., English). Balanced bilinguals demonstrated balanced knowledge of Spanish and English, with trends toward English dominance (see Figure 2). They named pictures slightly (about 21 ms) but not significantly more quickly in English than in Spanish ($F1 < 1$) and made significantly fewer errors in English ($M = 4.6$, $SD = 3.3$) than in Spanish ($M = 8.0$, $SD = 4.7$), $F1(1, 15) = 6.28$, $MSE = .001$, $\eta_p^2 = .30$, $p = .02$.

Choices within the either-language condition—The instruction to name pictures in whatever language comes to mind provides the opportunity (see Arrington & Logan, 2005) to consider the implications of choices bilinguals made in terms of what language to use and when to switch languages. Though switches were not required, most bilinguals (64/73) switched languages some of the time. Of interest, and consistent with the notion that voluntary switches are driven by lexical accessibility, English-dominant bilinguals switched languages significantly less often than balanced bilinguals (24% and 35% of the time, respectively), $F1(1, 71) = 4.40$, $MSE = .04$, $\eta_p^2 = .06$, $p = .04$. Switching rates, which were calculated as the total number of switches divided by the number of trials, are shown in Table 2.

Surprising from the perspective that switching is supposed to be more costly than staying, bilinguals clearly did not prefer stay over switch trials in all cases. One of the most frequent language-mixing patterns was what we term the *bail out* pattern, in which switches outnumbered stay trials but only in the less used language. Using English-dominant bilinguals as an example, the bail-out pattern entails a majority of stay-in-English trials, a small number of switch-into-Spanish trials, and an even smaller number of stay-in-Spanish trials. The different types of language-mixing patterns are shown in Table 3, and the number of bilinguals who chose each language pattern is shown in Table 4. Both Tables 3 and 4 also distinguish what language was used most often, or whether both languages were used about equally often (here, we allowed up to a difference of 6/44, or 14% more trials named in one than the other language). When bilinguals used one language more than 14% more often than the other language, we classified that language as the “Matrix Language” (e.g., Myers-Scotton, 2005,

2006; in natural code switches, the matrix language provides the morphosyntactic frame and often, but not always, also provides a majority of morphemes).

Bailing out of Spanish was the language-mixing pattern most preferred by English-dominant bilinguals; for these bilinguals, staying in Spanish was more difficult than switching back into English. This was especially true for bilinguals who switched languages with English as the matrix language; 31/(31 + 8), or 79% (i.e., 31 bilinguals bail out of Spanish, whereas only 8 bilinguals used a “stay > switch” pattern in both languages; see Table 4). Many balanced bilinguals also exhibited the bail-out pattern; however, some bailed out of Spanish (i.e., 4 with English as the matrix language, and 1 with no matrix language), and others bailed out of English (i.e., 6 with Spanish as the matrix language). The bail-out pattern was about two or three times more common than the “stay outnumber switch” pattern; 60% of English-dominant bilinguals [(31 + 1+2)/57] and 69% [(4 + 6+1)/16] of balanced bilinguals exhibited the bail-out pattern. In contrast, only 23% [(8 + 5)/57] of English-dominant and 18% (3/16) of balanced bilinguals exhibited the stay-outnumber switch pattern. In addition, most bilinguals (84% of English dominant, and 69% of balanced) chose a matrix language instead of using each language about equally often. In summary, bilinguals with more balanced accessibility of names in both languages switched languages more often than bilinguals with one more dominant language; however, both types of bilinguals preferred to use one language more often than the other, and the vast majority of bilinguals preferred switch over stay trials in the nondominant language.

Global language-mixing effects—To assess language-mixing effects, we carried out 2×2 analyses of variance (ANOVAs) on RTs, and errors with both language (English and Spanish) and condition (only vs. either) as repeated factors in both the participants’ and items analyses. For this analysis, we included just stay trials from the either-language block to assess global language-mixing effects independently from local switching costs (which are assessed separately below).

English-dominant bilinguals named pictures more quickly in English than in Spanish, $F(1, 39) = 10.14$, $MSE = 26,632$, $\eta_p^2 = .21$, $p < .01$; $F(1, 83) = 64.11$, $MSE = 54,444$, $\eta_p^2 = .44$, $p < .01$, and bilinguals exhibited some tendency to name pictures more slowly in language-mixed than in language-selective blocks ($F(1, 83) = 4.74$, $MSE = 30,160$, $\eta_p^2 = .05$, $p = .03$). However, both of these main effects were qualified by a highly robust interaction between language and mixing, such that language mixing slowed down English responses but sped up Spanish responses, $F(1, 38) = 70.38$, $MSE = 21,142$, $\eta_p^2 = .65$, $p < .01$; $F(1, 83) = 40.44$, $MSE = 30,432$, $\eta_p^2 = .33$, $p < .01$. Planned comparisons revealed significant language-mixing costs for English, $F(1, 38) = 37.01$, $MSE = 17,726$, $\eta_p^2 = .49$, $p < .01$; $F(1, 83) = 25.01$, $MSE = 10,686$, $\eta_p^2 = .23$, $p < .01$, but significant language benefits for Spanish, $F(1, 38) = 31.23$, $MSE = 26,813$, $\eta_p^2 = .45$, $p < .01$; $F(1, 83) = 22.17$, $MSE = 49,906$, $\eta_p^2 = .21$, $p < .01$. The language-mixing facilitation effect for Spanish represents a striking difference from mixing costs found in cued paradigms. In notable contrast, the balanced bilinguals did not exhibit these mixing facilitation effects; they named pictures more slowly in language-mixed than in language selective testing blocks in both languages (see Figure 2). There was no main effect of language ($F(1, 12) < 1$), a main effect of language mixing, $F(1, 12) = 8.67$, $MSE = 27,159$, $\eta_p^2 = .42$, $p < .01$, and no interaction ($F(1, 12) < 1$). Below (and in Experiment 2), we present analyses that suggest some (though importantly not all) of the global effects we observed should be attributed to “item-selection effects,” which is that English-dominant bilinguals monitor the overall accessibility of Spanish names, and make an executive decision to select Spanish names only when they are sufficiently accessible. (Note that this is different from the abovementioned lexical accessibility-only account, in which selection of a language would be made without

executive involvement, and solely on the basis of relative lexical accessibility of the two languages.)

In the analyses of error rates, the only significant effect was that English-dominant bilinguals made more errors in Spanish than in English, $F(1, 38) = 4.44$, $MSE = .006$, $\eta_p^2 = .11$, $p = .04$; $F(1, 83) = 4.80$, $MSE = .003$, $\eta_p^2 = .06$, $p = .03$, and there was some tendency toward fewer errors in the either-language condition than in language selective blocks, $F(1, 38) = 14.38$, $MSE = .003$, $\eta_p^2 = .27$, $p < .01$ ($F(2, 1) < 1$), and an interaction such that only Spanish benefitted from language mixing, $F(1, 38) = 9.78$, $MSE = .003$, $\eta_p^2 = .21$, $p = .01$; $F(1, 83) = 2.20$, $MSE = .003$, $\eta_p^2 = .03$, $p = .14$. Balanced bilinguals paid no global switch costs (both F s < 1), made more errors in Spanish than in English, $F(1, 12) = 7.47$, $MSE = .01$, $\eta_p^2 = .38$, $p = .02$, and though Figure 2 shows what looks like an interaction with Spanish showing a cost and English a benefit in the errors data, this interaction between language and mixing was not significant, $F(1, 12) = 2.23$, $MSE = .009$, $\eta_p^2 = .16$, $p = .16$.

Local switch costs within the either-language condition—To further consider whether voluntary language switching is costly, we carried out a 2×2 ANOVA, with language (English and Spanish) and trial type (stay vs. switch within the either-language condition) as repeated factors in both the participants' and items analyses. For these analyses, we included the 36 bilinguals and 57 pictures that yielded data in all four cells in the either-language condition. English-dominant bilinguals named pictures significantly more slowly on language switch trials than on stay trials, $F(1, 35) = 9.96$, $MSE = 23,050$, $\eta_p^2 = .22$, $p < .01$; $F(2, 56) = 14.29$, $MSE = 62,098$, $\eta_p^2 = .20$, $p < .01$, thus indicating significant costs associated with voluntary language switching. We also observed some indication of language-dominance reversal such that responses in English tended to be slower than those in Spanish, an effect that was significant by participants, $F(1, 35) = 13.97$, $MSE = 32,765$, $\eta_p^2 = .29$, $p < .01$ ($F(2, 1) < 1$). This resembles findings in studies of cued language switching in which dominance reversal has been reported on both switch and stay trials for balanced bilinguals (e.g., Christoffels et al., 2007).

In contrast with the pattern of results observed in studies of cued language switching in bilinguals with one clearly dominant language (e.g., Costa & Santesteban, 2004; Costa et al., 2006; Jackson et al., 2001; Meuter & Allport, 1999), the switch cost was not significantly greater in the dominant than in the less dominant language (as reflected by a nonsignificant interaction between language used and switching, $F(1, 1) < 1$), though there was a trend in the right direction in the items analysis, $F(2, 56) = 3.11$, $MSE = 64,908$, $\eta_p^2 = .05$, $p = .08$. Planned comparisons revealed significant switch costs within English alone, $F(1, 35) = 8.14$, $MSE = 12,976$, $\eta_p^2 = .19$, $p = .01$; $F(2, 56) = 13.17$, $MSE = 73,484$, $\eta_p^2 = .19$, $p < .01$, and some nonsignificant tendencies toward switch costs within Spanish alone, $F(1, 35) = 3.94$, $MSE = 31,546$, $\eta_p^2 = .10$, $p = .06$; $F(2, 56) = 2.27$, $MSE = 53,522$, $\eta_p^2 = .04$, $p = .14$.

To increase the ability to detect a switch-cost asymmetry, we analyzed the data using a generalized linear mixed effects model. We used the lme4 package (Bates, 2007) in the statistical software R (Version 2.5.0; R Development Core Team, 2007), with significance assessed using Markov chain Monte Carlo sampling using 10,000 samples (Baayen, 2007). This statistical technique addresses a number of shortcomings with traditional ANOVA analyses (for discussion, see Baayen, 2004, 2008; Baayen, Davidson, & Bates, 2008; Pinheiro & Bates, 2000; Richter, 2006). Most critical here, it is robust to missing values in data sets, and so we can conduct analyses including all participants and items regardless of whether they

contribute observations to all experimental conditions. To investigate the interaction, we included language (English or Spanish) and switch behavior (switch or stay) as fixed effects, and participants and items were simultaneously treated as random effects. To investigate the main effects, we carried out a separate analysis excluding the interaction term.

In the complete data set, bilinguals named pictures in English after switching 192 ms slower than on stay trials (1,249 ms vs. 1,057 ms). In Spanish, bilinguals named pictures on switch trials 79 ms slower than on stay trials (1,140 ms vs. 1,061 ms). However, this difference in switch costs between languages did not approach significance ($b = 7.6$, $SE = 38.1$, $t = 0.20$, $p = .72$). Bilinguals named pictures significantly more slowly on switch than on stay trials ($b = 70.5$, $SE = 18.0$, $t = 3.91$, $p = .001$), but naming times were equivalent in English and in Spanish ($b = 41.6$, $SE = 20.3$, $t = 2.05$, $p = .12$). Thus, even when all participants are analyzed, robust evidence for a switch-cost asymmetry was not observed.

Discussion

Experiment 1 revealed that voluntary language switches are costly but that they also differ from cued language switching costs, and these provide information about the nature of bilingual control mechanisms. The clearest evidence that voluntary language switching is costly comes from our observation of significant local switch costs. Within the either-language condition, naming times were significantly slower on switch trials than on stay trials in both languages. This implies that speakers need time to reconfigure the goals from naming in one language to naming in the other language and that voluntary language switches are not driven purely by lexical accessibility (i.e., some higher order decision to switch or stay is required). Additional evidence that voluntary switches are costly was that balanced bilinguals exhibited slower naming times in language-mixed than in language selective blocks (see Figure 2). Such global (language-mixing) costs imply that maintaining the option to use either language entails a burden associated with choosing what language to use on each trial.

The absence of a clear overall benefit for naming times in the either-language condition contrasts notably with previously observed benefits from the option to use either language in untimed naming tasks (e.g., Gollan et al., 2007; Gollan & Silverberg, 2001; Kohnert et al., 1998). It is interesting that despite the clear costs associated with voluntary language switching, nearly all bilinguals chose to switch languages in the either-language condition. Assuming that choices to switch despite the costs do not exclusively reflect speakers' response to experimental task demands, this implies that all bilinguals prefer to maintain the option to use either language and that in some naturally occurring circumstances, this option is beneficial. The higher switching rate in bilinguals with more balanced knowledge of the two languages is consistent with prior studies, which showed a greater benefit from the option to use either language for balanced than for unbalanced bilinguals (Gollan et al., 2007; Kohnert et al., 1998). The switching rate difference between bilingual types is also consistent with the notion that voluntary switches are driven at least in part by lexical accessibility and that the voluntary-switching paradigm is sensitive to naturally occurring differences in proficiency level between bilinguals.

A few characteristics clearly differentiated voluntary language switching from previous reports of cued language switching. First, unlike cued language switches, within the either-language condition, bilinguals who were strongly English dominant when naming pictures in language selective blocks (see Figure 1) exhibited symmetrical switch costs and a trend toward slower naming times in English than in Spanish. This pattern of results (symmetrical switch costs and dominance reversal) has been reported previously only in balanced bilinguals (e.g., Christoffels et al., 2007; Costa & Santesteban, 2004). Thus, it seems that when switches are voluntary, bilinguals with one clearly dominant language choose to mix languages in a way that leads their naming times to exhibit a pattern that in cued paradigms is seen only in more balanced

bilinguals. The appearance of the balanced pattern in unbalanced bilinguals implies important differences between cued and voluntary switches and suggests (as we argue below) that the most efficient strategy for language mixing is to inhibit the dominant language equally and steadily on stay and switch trials. Equal application of inhibition on stay and switch trials leads to symmetrical switch costs and reversed language dominance. When switches are cued, this strategy is possible only for balanced bilinguals, but when switches are voluntary, even unbalanced bilinguals have sufficient processing resources to effect this strategy.

It might be suggested that we could find a significant asymmetry in voluntary switch costs if we added more bilinguals to our experiment. Although there was no hint of a switch-cost asymmetry by *FI*, and the asymmetry did not approach significance in a mixed effects analysis (see Baayen, 2004, 2008; Baayen et al., 2008; Pinheiro & Bates, 2000; Richter, 2006), we did observe a marginally significant interaction in the items analysis. Though it is always possible that adding more participants will change the data pattern, it would still be the case that the asymmetry is considerably less robust in voluntary than in cued switching studies. For example, in previous studies, the cued switch-cost asymmetry was robust (at the $p = .01$ level) with only 12 bilinguals participating (one group of 12 Korean–Spanish and another group of 12 Spanish–Catalan bilinguals; Costa & Santesteban, 2004, Experiment 1), whereas we tested 57 English-dominant bilinguals in Experiment 1. As such, we interpret the lack of a clear asymmetry in our data as reflecting the emergence of a more balanced bilingual pattern in bilinguals with one clearly dominant language when switches are voluntary.

A second aspect of voluntary language switching that differs from previous reports of cued language switching (Christoffels et al., 2007; Hernandez & Kohnert, 1999) was that language mixing was not consistently more costly than language selective production. Also, language mixing had a robust effect on nondominant language production, which in cued switching showed relatively weak mixing effects (Christoffels et al., 2007; Hernandez & Kohnert, 1999). That is, strikingly, for the English-dominant bilinguals, language mixing facilitated production in Spanish (i.e., they named pictures in Spanish more quickly in the either-language than in the Spanish-only condition). A possible explanation for this result is that speaker's choices of what pictures to name in the nondominant language masked the costs of language mixing. To consider this possibility, we examined the types of pictures bilinguals most often chose to name in the nondominant language in the either-language condition and the distribution of stay and switch choices in each language.

A majority of both balanced and unbalanced bilinguals chose one matrix language (i.e., they used one language more often than the other, supporting Myers-Scotton, 2005, 2006), and most bilinguals also preferred to briefly dip into and quickly bail out of the nonmatrix language (switching back into the matrix language). This pattern of stay versus switch choices implies that language dominance can have a powerful influence on when bilinguals choose to mix languages voluntarily and is surprising from the perspective that task switches are supposed to be more difficult than staying in the same task. Specifically, the bail-out pattern implies that a lack of ready lexical accessibility of translation equivalents can compel switches from the nondominant language into the dominant one, apparently even in balanced bilinguals. This supports the view that code switches are motivated by lexical accessibility (Clyne, 2003; Owens, 2005; Poplack, 1980) and places some limits on the notion that natural language switches are driven only by pragmatic factors (e.g., Myers-Scotton, 2005, 2006). Pragmatic reasons for language switching are inherently limited within the experimental setting we used (i.e., outside of a discourse situation in which switching can serve an expressive function such as reiteration, personalization, addressee specification, and the like; Gumperz, 1982). Nevertheless, in the present context, pragmatic factors are supported indirectly because something other than lexical accessibility is needed to explain why bilinguals switched into

the nondominant language at all given that they would have named pictures more quickly if they had not switched.

Table 5 shows the characteristics of pictures that bilinguals never, sometimes, and often named in the nondominant language. The table demonstrates that bilinguals selected the easiest pictures (e.g., higher frequency, shorter in number of phonemes, and faster and less error prone in the language selective conditions) to name in the nondominant language. Thus, the apparent language-mixing facilitation effect on the nondominant language likely reflected speakers' strategy of using the nondominant language only with relatively accessible responses. This strategy may have masked the presence of global switch costs into the nondominant language. Because pictures that were easy in the nondominant language tended to also be easier in the dominant language, and this also meant that the dominant language was left to name the remaining difficult pictures in the either-language condition thereby magnifying the size of the global mixing costs for the dominant language.

Further clues as to when bilinguals choose to switch languages when not required to can be derived from comparing the characteristics of English and Spanish names in Table 5, looking in particular at pictures that bilinguals often chose to name in Spanish. Pictures that English-dominant bilinguals frequently chose to name in Spanish were not pictures that were more accessible in Spanish than in English. In fact, in the language selective conditions, the same English names were produced more rapidly (881 ms) than the Spanish names (1,089 ms). However, the error rates for the pictures named often in Spanish were extremely low in both languages (i.e., 1%) and equally so ($t < 1$). This suggests that bilinguals are willing to pay the small cost in time to keep the less dominant language active in the either-language condition. This willingness may stem from their awareness that it will ultimately be useful to have both languages available, and though switches may cost some time, bilinguals are not willing to pay a cost in accuracy (i.e., they do not switch languages if such switches will increase their error rate). Conversely, bilinguals may be particularly likely to switch languages if switching will allow them to name more pictures correctly. Supporting this notion, the pictures that the balanced bilinguals chose to name in English frequently in the either-language condition were pictures that they could name with significantly fewer errors in English ($M = 4\%$, $SD = 11\%$) than in Spanish ($M = 8\%$, $SD = 13\%$) in the language selective conditions, $t(178) = 2.16$, $p = .03$.

A question that arises, then, is whether all voluntary switch costs should be attributed to item selection (i.e., speakers naming easy pictures in Spanish and hard pictures in English). Of importance is that local switch costs cannot be attributed to item selection, which is equally possible on stay and switch trials. That is, for all data points (every trial) in the either-language condition, speakers are free to choose which language to use. As such, to an equal extent on both stay and switch trials, speakers can choose to use the nondominant language only to name relatively easy pictures. Similarly, regardless of trial type (switch or stay), speakers can choose to use the dominant language only to name relatively difficult pictures. The only way to explain local switch costs with item selection would be to propose that within each language, speakers assign relatively more difficult pictures to be named on switch trials and relatively easier pictures to be named on stay trials. However, this seems rather unlikely because when holding language constant, staying should be easier than switching (or if lexical accessibility alone drives switches, then staying should be equally difficult as switching). Of course when switching between languages, speakers might be more likely to switch out of the nondominant language on difficult trials, but within each language, it is difficult to see why speakers would choose to name more difficult pictures on switch than on stay trials. Thus, the presence of local switch costs in Experiment 1 confirms that voluntary switches cannot be driven exclusively by lexical accessibility and indicates a cost associated with voluntary language switching.

Concerning global switch costs, it might seem that significant items analyses rule out the possibility that item selection effects alone can explain global mixing effects (because each picture contributes equally to all conditions in items analyses). However, when speakers choose what pictures to name in each condition, item selection effects could still apply because the rank ordering of item difficulty for each language is likely to be different across speakers, and bilinguals who choose to name certain pictures in the nondominant language voluntarily may be speakers who happen to be able to access those pictures more easily in the nondominant language.

To obtain an estimate of the magnitude of item selection effects on the pattern of results shown in Figure 1, we considered whether the pattern of global effects (facilitation for Spanish and a cost for English) holds when bilinguals produced relatively easy-to-name items (thereby taking the more difficult-to-produce items out of the English-stay mean and removing some of the influence of item selection on the observed language-mixing costs). Figure 3 shows the participant means for global effects in each language after dividing the materials based on the cutoffs in Table 5 for pictures that were never, sometimes, and often named in Spanish in the either-language condition. This division reveals that mixing costs (see the top panel of Figure 3) were not driven exclusively by item difficulty (here using frequency of naming in Spanish as a measure of difficulty). Bilinguals named pictures of all difficulty levels more slowly on English-stay trials than in the English-only condition (a main effect of trial type), $FI(1, 13) = 13.34$, $MSE = 21,109$, $\eta_p^2 = .51$, $p < .01$; and most slowly for never-named-in-Spanish and most quickly for often-named-in-Spanish items (a main effect of difficulty), $FI(1, 35) = 8.14$, $MSE = 12,976$, $\eta_p^2 = .19$, $p = .01$. More important, although the global cost to English was numerically smaller for pictures named often in Spanish (93 ms) relative to the other items (about 127 ms), there was no indication of an interaction ($F < 1$).

Additionally, the bottom panel of Figure 3 suggests that facilitation effects for Spanish were also not driven exclusively by item selection, as facilitation was robust in both often- and sometimes-named-in-Spanish items. Bilinguals named pictures more quickly on Spanish-stay trials than in the Spanish-only condition, $FI(1, 13) = 6.34$, $MSE = 51,645$, $\eta_p^2 = .33$, $p = .03$, and more quickly for often-named-in-Spanish items than for sometimes-named-in-Spanish items, $FI(1, 35) = 30.52$, $MSE = 32,606$, $\eta_p^2 = .70$, $p < .01$, and global facilitation effects were similarly sized for pictures named often in Spanish (144 ms) as for pictures sometimes named in Spanish (162 ms), with no indication of an interaction ($F < 1$). The presence of a language-mixing facilitation effect for Spanish even for items that were often named in Spanish in the either-language condition suggests that these effects were not driven exclusively by the burden of naming difficult pictures in Spanish in the Spanish-only condition and speakers' freedom to select out only easy items to name in the Spanish-stay mean.

In Experiment 2, we further investigated the influence of item selection by requiring bilinguals to name pictures in each language about 50% of the time, thus reducing the degree to which they can use the nondominant language only to name easy pictures. The requirement to use each language 50% of the time also reduces the extent to which switches were voluntary, thereby further highlighting differences between voluntary and forced-language switches.

Experiment 2: Quasivoluntary Language Switching

Experiment 2 was designed to test the idea that item selection effects influenced the pattern of results obtained in Experiment 1 and to contrast voluntary switching with previous instantiations of quasivoluntary switching (Arrington & Logan, 2004, 2005). Of particular interest was whether the apparent facilitation effect of language mixing for producing the less dominant language (a highly unusual result given previous reports of cued language-mixing

costs) resulted from bilinguals' choice to name only easy pictures in their less dominant Spanish. Also of interest was to determine whether the item selection benefit on Spanish contributed to the global mixing cost for English (i.e., the effect of speakers naming the harder pictures in English). To these ends, we replaced the either-language condition in Experiment 2 with a fifty-percent condition in which we asked bilinguals to use each language about half the time.

To the extent that global facilitation effects (for Spanish) reflected item selection effects, we should observe the facilitation effect on Spanish to be smaller in Experiment 2 than it was in Experiment 1. This is because the requirement to use each language about half the time leaves bilinguals less free to name only very easy pictures in Spanish and requires them to name at least some more difficult (perhaps medium difficulty) items in Spanish as well. Conversely, the global cost to English might be greater in Experiment 2 than it was in Experiment 1; if bilinguals choose to name all the easy pictures in Spanish, and also some medium difficulty pictures in Spanish, then they would then be reserving their use of English even more exclusively (than they did in Experiment 1) for naming very difficult pictures.

A second motivation for conducting Experiment 2 was that the "half-the-time" instruction more closely resembles previous instantiations of voluntary task switching (i.e., Arrington & Logan, 2004, 2005) and thus allowed us to consider how voluntary switches may differ when involving switches between more naturally occurring alternative tasks (i.e., between languages instead of between judging numbers as even or odd vs. > 5 or < 5). To anticipate the results, the fifty-percent instruction led to some highly unexpected local switching effects, which we attempt to understand with exploratory analyses. These analyses suggest that the fifty-percent instruction introduces unusual task strategies that altered considerably the extent to which language switches were voluntary. Thus, we focused our discussion of Experiment 2 primarily on the global language-mixing effects (given that these are relevant for testing the notion of item selection effects) and briefly discuss the broader implications for understanding the difference between cued and voluntary switching in linguistic and nonlinguistic contexts.

Method

Participants—Table 1 shows the characteristics of the 44 bilinguals who participated in Experiment 2 for course credit. Participants completed the same language-history questionnaire used in Experiment 1. In the analyses and discussion, the authors chose to focus exclusively on the 37 bilinguals who we classified as English dominant (in the same way as we did in Experiment 1). The remaining 7 bilinguals rated their ability to speak Spanish as better than their ability to speak English. Because of their relatively small number, we do not discuss their data.

Materials—These were the same as in Experiment 1.

Procedure—The procedure was the same as in Experiment 1 except that in the language-mixed condition, bilinguals were instructed as follows:

You can use either Spanish or English names, but try to name about half of the pictures in Spanish and half in English. You don't have to switch back and forth between languages on every other picture, just try to name about half in English and half in Spanish overall as you go along.

Results

In our analyses of RT data, we trimmed outliers in the same way as in Experiment 1, removing $\leq 4.8\%$ of correct response RTs from all conditions.

Language-dominance effects—Figure 4 shows the mean RTs and error rates in the language selective (English-only, Spanish-only) and mixed language (fifty-percent) conditions for the 35 bilinguals who produced at least one response in each of the four possible trial types for the fifty-percent condition. As in Experiment 1, the bilinguals classified as English dominant in Experiment 2 were quite clearly English dominant; they named pictures almost 332 ms more slowly in Spanish only than in English only, $F(1, 36) = 90.12$, $MSE = 22,629$, $\eta_p^2 = .72$, $p < .01$; $F(1, 124) = 144.36$, $MSE = 94,440$, $\eta_p^2 = .54$, $p < .01$, and produced over twice as many errors in Spanish as in English (in the “only” conditions), $F(1, 36) = 30.08$, $MSE = .002$, $\eta_p^2 = .46$, $p < .01$; $F(1, 131) = 25.73$, $MSE = .007$, $\eta_p^2 = .16$, $p < .01$ (see Figure 4).

Choices within the fifty-percent condition—In their attempt to meet the requirement of using each language about half the time, bilinguals increased their switching rate from 24% in Experiment 1 to 52% in Experiment 2 (see Table 2), and they named 44% ($SD = 7\%$) of the pictures in Spanish (compare with $M = 22\%$, $SD = 19\%$ from Experiment 1). A majority of the bilinguals (70%) in Experiment 2 did not choose a matrix language (in contrast with Experiment 1; see Table 4). Interestingly, bilinguals’ forced increased use of Spanish in Experiment 2 also had a dramatic effect on language-mixing patterns. Specifically, a large number of bilinguals in Experiment 2 (38%) switched languages more often than they stayed in the same language in both languages (compared with only 4% in Experiment 1). This suggests that bilinguals use qualitatively different strategies when mixing languages voluntarily versus less voluntarily (i.e., with the either-language option vs. with a 50% requirement). Apparently, the requirement to use each language equally often led many bilinguals to mix languages with a pattern that is usually not preferred when switches were voluntary.

Global language-mixing effects—To assess the effects of language mixing, we carried out a 2×2 ANOVA, with language (English and Spanish) and condition (only vs. fifty percent) as repeated factors in both the participants’ and items analyses. As in our analyses of global mixing effects in Experiment 1, for these analyses we included just stay trials (to distinguish local from global effects). Within each language, we also carried out planned comparisons to determine whether the size of global mixing effects (on English and Spanish separately) were similar or different across Experiments 1 and 2. Briefly summarized (see Figures 1 and 4), global mixing effects were qualitatively similar across experiments except, as predicted, the size of the cost to English was bigger in the fifty-percent condition than it was in Experiment 1, and conversely the size of the facilitation for Spanish was smaller in the fifty-percent condition than it was in Experiment 1.

Bilinguals exhibited some overall tendency to name pictures in English more quickly than in Spanish ($F(1, 79) = 6.09$, $MSE = 139,740$, $\eta_p^2 = .07$, $p = .02$, and they named pictures more slowly on stay trials in the fifty-percent condition than in language selective “only” conditions, $F(1, 34) = 26.68$, $MSE = 65,514$, $\eta_p^2 = .44$, $p < .01$; $F(1, 79) = 22.86$, $MSE = 131,679$, $\eta_p^2 = .22$, $p < .01$. However, as in Experiment 1, both of these main effects were qualified by a highly robust interaction between language and mixing, such that language mixing slowed down English responses but sped up Spanish responses, $F(1, 34) = 78.24$, $MSE = 46,806$, $\eta_p^2 = .70$, $p < .01$; $F(1, 79) = 72.06$, $MSE = 95,311$, $\eta_p^2 = .48$, $p < .01$. Planned comparisons revealed significant language-mixing costs for English, $F(1, 34) = 62.00$, $MSE = 84,437$, $\eta_p^2 = .65$, $p < .01$; $F(1, 79) = 75.77$, $MSE = 125,204$, $\eta_p^2 = .49$, $p < .01$, and (in line with our predictions) the language-mixing facilitation effect for Spanish that had been robust in Experiment 1 was just significant in the items analysis in Experiment 2, $F(1, 34) = 6.28$, $MSE = 27,881$, $\eta_p^2 = .16$, $p = .02$; $F(1, 79) = 3.85$, $MSE = 101,787$, $\eta_p^2 = .05$, $p = .05$.

To directly compare item selection effects across experiments, we compared the magnitude of language-mixing effects across Experiments 1 and 2 separately within each language. Across experiments, RTs in Spanish were faster in language-mixed blocks, $F(1, 73) = 28.43$, $MSE = 28,456$, $\eta_p^2 = .28$, $p < .01$, and were faster in Experiment 1 than in Experiment 2, $F(1, 73) = 11.96$, $MSE = 82,471$, $\eta_p^2 = .14$, $p < .01$. Of greatest interest, there was a significant interaction such that the global facilitation effect in nondominant Spanish was larger in Experiment 1 than in Experiment 2, $F(1, 73) = 4.77$, $MSE = 28,456$, $\eta_p^2 = .28$, $p < .01$. This interaction supports our proposal that voluntary language-mixing facilitation effects reflect speakers' choices to use Spanish only to name easy pictures; when forced to name at least some more difficult pictures in Spanish (in the fifty-percent condition), facilitation effects were weaker. Also in line with the notion of item selection effects, the language-mixing cost to dominant English was significantly larger in the fifty-percent than in the either-language condition. Across experiments, response times in English were slower in language-mixed blocks, $F(1, 91) = 120.33$, $MSE = 41,671$, $\eta_p^2 = .57$, $p < .01$; were slower in Experiment 2 than in Experiment 1, $F(1, 91) = 21.98$, $MSE = 141,713$, $\eta_p^2 = .20$, $p < .01$; and there was a significant interaction such that the global cost to dominant English was larger in Experiment 2 than in Experiment 1, $F(1, 91) = 45.94$, $MSE = 41,671$, $\eta_p^2 = .34$, $p < .01$.

As in Experiment 1, the only significant effect in Experiment 2 in the analyses of error rates was that bilinguals made more errors in Spanish than in English, $F(1, 35) = 14.17$, $MSE = .004$, $\eta_p^2 = .29$, $p < .01$; $F(1, 97) = 7.07$, $MSE = .01$, $\eta_p^2 = .07$, $p < .01$. There were no significant effects of language mixing and no interaction between language and trial type (all F s ≤ 1.52).

Local costs within the fifty-percent condition—To consider whether language switching is costly when bilinguals are given the instruction to use each language about 50% of the time, we carried out a 2×2 ANOVA, with language (English and Spanish) and trial type (stay vs. switch within the fifty-percent condition) as repeated factors in both the participants' and items analyses. For these analyses, we included the 35 bilinguals and 57 pictures that yielded data in all four cells in the fifty-percent condition. Within the fifty-percent condition, we observed a robust reversed language-dominance effect such that English-dominant bilinguals produced faster naming times in Spanish than in English, $F(1, 34) = 13.03$, $MSE = 103,900$, $\eta_p^2 = .28$, $p < .01$; $F(1, 56) = 6.70$, $MSE = 127,142$, $\eta_p^2 = .11$, $p = .01$.

In contrast with Experiment 1, and also contrary to previous reports of cued and voluntary-switching costs, we found no significant switch costs, and if anything, responses tended to be slower on stay trials than on switch trials, $F(1, 34) = 2.43$, $MSE = 61,968$, $\eta_p^2 = .08$, $p = .13$; $F(1, 56) = 1.76$, $MSE = 169,164$, $\eta_p^2 = .03$, $p = .19$ (see Figure 3). In addition, there was some indication that the "stay cost" was more robust in English than in Spanish (i.e., there was a stay-cost asymmetry), $F(1, 34) = 7.48$, $MSE = 57,664$, $\eta_p^2 = .19$, $p = .01$; $F(1, 56) = 1.11$, $MSE = 129,457$, $\eta_p^2 = .02$, $p = .30$. Planned comparisons revealed some indication of stay costs for English, $F(1, 34) = 9.73$, $MSE = 57,374$, $\eta_p^2 = .22$, $p < .01$; $F(1, 56) = 2.38$, $MSE = 178,698$, $\eta_p^2 = .04$, $p = .13$, but not for Spanish (both F s < 1).

Exploratory analyses suggested that the tendency toward a stay cost resulted from a strategy in the fifty-percent condition in which bilinguals attempted to switch languages on as many trials as possible, choosing to stay in English only when switching into Spanish was extremely difficult. This required them to abandon the plan to name the picture in Spanish and instead create a new goal to name the picture in English on some of the stay-in-English trials. Although

we instructed bilinguals that they did not need to alternate between Spanish and English on every trial, there were some bilinguals who nevertheless seemed to try to alternate languages frequently to meet the fifty-percent instruction. Confirming this speculation, there was a significant correlation between switching rate (including all the English-dominant bilinguals tested in Experiment 2) and stay costs both in English ($r = .46, p < .01$) and in Spanish ($r = .36, p = .03$), suggesting that bilinguals who switched more often exhibited stay costs because they changed task goals at some point during the trial on many stay trials.

Discussion

The results of Experiment 2 confirm the hypothesis that bilinguals' choices to name only easy pictures in Spanish (item selection effects) in Experiment 1 influenced the magnitude and direction (i.e., facilitation vs. a cost) of language-mixing effects and provide further insights into differences between voluntary and forced-language switches. To meet the requirements of the fifty-percent instruction, bilinguals switched languages more often, and many more bilinguals switched languages with no clear choice of a matrix language, with an unusual mixing pattern in which switch trials outnumbered stay trials in both languages. The contrast between experiments demonstrates important differences between voluntary and forced-language switches and suggests that when speakers switch voluntarily, language-mixing costs are masked to some degree by speakers' choices of what pictures to name in what language.

To further examine the effects of item selection on voluntary language mixing, Figure 5 shows the mean frequency of names produced in each language in each experiment. The mean frequency of items in the language selective (i.e., "only") conditions reflect our selection of materials for study and therefore do not differ between languages and are the same in Experiments 1 and 2. However, in the language-mixed conditions in both experiments, bilinguals chose to use English for naming more of the pictures with lower frequency names and Spanish to name more of the pictures with higher frequency names. The language-mixing facilitation effect on Spanish was especially strong in Experiment 1 in which bilinguals were completely free to use Spanish only when they chose to, and was significantly less robust in the fifty-percent condition (Experiment 2), which forced bilinguals to name at least some relatively more difficult pictures in Spanish. Conversely, the language-mixing (global) cost to English (again, in naming times as reported above) was especially strong when bilinguals made some effort to avoid staying in English and therefore produced even fewer relatively easier pictures in English in the fifty-percent condition than they had in Experiment 1 (particularly on stay trials; see Figure 5). These points imply an effect of item selection in both experiments.

Our observation of trends toward stay costs (see Figure 3), in which responses in the dominant language (English) were slower on stay than on switch trials within the fifty-percent condition in Experiment 2, is a highly unusual result that requires some explanation (see also Steinhauser & Hübner, 2006). Stay costs are difficult to interpret given prior observations of switch costs (in Experiment 1 and in the literature), given theories of cognitive control, and given that robust switch costs were observed with analogous instructions to those used in the fifty-percent condition for switching between two nonlinguistic tasks (Arrington & Logan, 2004, 2005). One difference that could have produced the stay costs in the present study is that English was clearly dominant over Spanish, whereas in prior studies in which the fifty-percent instruction were used, participants switched between two tasks of approximately equal difficulty.

To meet the requirements of the fifty-percent instruction in Experiment 2, bilinguals may have tried to switch languages whenever they were able to switch. With this strategy, bilinguals would choose to stay in English only when it was impossible or extremely difficult for them to switch into Spanish. On this view, stay-in-English trials would involve a highly costly series of controlled processes, beginning with an attempt to retrieve a Spanish name, a decision that this attempt will probably fail, followed by a change in plans from switching into Spanish to

a new plan to stay in English, followed by (finally) a successful (though by now rather slow) retrieval of the English word. This series of processes would take more time than executing an already prepared plan to switch. Supporting this speculation, a post hoc exploratory analysis revealed a correlation between switching rates and stay costs such that bilinguals who switched languages more often showed stronger stay costs than bilinguals who switched languages less often.

Other results from within the mixed language conditions in Experiments 1 and 2 together provide further insights into how completely voluntary switches differ from less voluntary switches. Our observation of fully reversed language dominance in Experiment 2 with the fifty-percent instruction could reflect our increased power for observing this effect (in Experiment 1, reversed language dominance was significant by participants but not by items, perhaps because bilinguals did not use the less dominant language very often with the either-language instruction). A more interesting possibility is that the appearance of significantly reversed language dominance in the fifty-percent condition suggests that bilinguals modify the degree to which their dominant language is prepotent to allow language mixing and that they do this to a greater extent when more switches are required.

To summarize, the results of Experiment 2 demonstrated important differences between voluntary and quasivoluntary switching and reveal that unusual strategies emerge when bilinguals are forced to switch languages more often than they choose to voluntarily. The contrast between experiments also confirms the item selection hypothesis that bilinguals work around some of the costs associated with language mixing by selecting out easy pictures to name in the nondominant language when switches are voluntary. In addition, the appearance of fully reversed language dominance could be taken as evidence of a greater role of inhibitory control in bilingual language selection when switches are less voluntary (and a smaller role for inhibitory control when switches are relatively more voluntary). In Experiment 3, we further investigated the role of inhibitory control for bilingual language selection, while also informing models of age-related changes in cognitive control.

Experiment 3: Aging and Voluntary Language Mixing

Models of cognitive aging predict that switching should become more difficult with increased age on the assumptions that control processes entail frontal lobe (especially prefrontal cortex) functioning (Mesulam, 2002) and evidence that prefrontal cortex declines earlier, and more rapidly, than other parts of the brain as part of the normal aging process (see reviews in Raz, 2000; West, 1996). Consistent with these predictions are observations of an age-related increase in cued task-switching costs (see review by Mayr & Liebscher, 2001) and an age-related increase in both cued language-switching (local) and language-mixing (global) costs (Hernandez & Kohnert, 1999; see also Hernandez, 1997). The older bilinguals' increased language-switching costs were strongest when switches were frequent, which led Hernandez and Kohnert (1999) to conclude that older bilinguals have an age-related difficulty with disengaging from the previously used language (in line with the idea that language switch costs reflect "task-set inertia"; Allport, Styles, & Hsieh, 1994). This interpretation is consistent with the notion that both local and global switch costs in younger bilinguals reflect inhibition of the dominant language when speaking the less dominant language (e.g., Green, 1998; Meuter & Allport, 1999). An aspect of the aging data that is particularly compelling is that, when cued to switch, older bilinguals were much more likely to mistakenly fail to switch languages than were younger bilinguals (Hernandez & Kohnert, 1999). Thus, the age-related increase in switch costs is unlikely to be explained merely by generalized slowing in older age (e.g., Cerella, 1990; Salthouse, 1996).

To the extent that the age-related increase in switch costs can be attributed to particular processing mechanisms, any differences in age effects across cued versus voluntary switches will provide an indication of what processing mechanisms are involved. For example, if cued switches demand more processing resources than voluntary switches, then older bilinguals might fare better when they switch languages voluntarily than they would when switches are cued and therefore more demanding of inhibitory control mechanisms. This prediction assumes that aging reduces the ability to apply inhibitory control in language-processing tasks (Connelly, Hasher, & Zacks, 1991; Logan & Balota, 2003; Spieler, Balota, & Faust, 1996; Spieler & Griffin, 2006; Taylor & Burke, 2002, Experiment 1; Zacks & Hasher, 1994).

Conversely, if older adults show increased switch costs (relative to younger adults) even when given the freedom to name pictures in whatever language comes to mind, this would allow for the same explanation for the age-related increase in cued and voluntary switching. For example, in both cases, the task goals must be changed from “name in language X” to “name in language Y.” In particular, one view of the age-related switching deficit is that older adults have difficulty keeping two different task goals available, or more specifically, “... a problem with maintaining distinct representations of what ought to be done in the face of competing representations of what could be done in principle” (Mayr & Liebscher, 2001, p. 47). This hypothesis can be broken down into two parts that each make different predictions about whether there should be an age effect on voluntary language switching: (a) whether older adults have trouble keeping two tasks available in general and (b) whether older adults have trouble ensuring that they perform the correct task. If it is difficult for older adults to keep two different task goals available, then (after matching younger and older bilinguals for proficiency in both languages) we should find that older bilinguals prefer not to mix languages voluntarily as much as younger bilinguals. Some data that support the notion of reduced voluntary-switching rates in older adults is that older monolinguals switched between subcategories (from *domestic* to *wild animals*) less often than younger monolinguals during category fluency generation (Troyer, Moscovitch, & Winocur, 1997). In addition, when older bilinguals do exercise the option to use both languages, they should show larger voluntary-switching costs than younger bilinguals. Conversely, if older adults have difficulty maintaining a representation of what “ought to be done” on each trial in the context of cued switching, then the age-related increase in switch costs should disappear when switches are voluntary because it would no longer be necessary to keep track of what language ought to be used once the requirement of naming each picture in one (but not the other) language has been removed.

Method

Participants—Table 6 shows the characteristics of the 25 cognitively healthy older Spanish–English bilinguals who participated in Experiment 3 and 25 matched younger bilinguals (taken from Experiment 1). Older bilinguals were recruited for participation from the University of California, San Diego’s (UCSD) Alzheimer’s Disease Research Center (ADRC; see Gollan et al., 2007, 2008, for further details about the elderly bilingual population at the ADRC). Participants were diagnosed as cognitively intact by two senior staff neurologists using criteria developed by the National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer’s Disease and Related Disorders Association (McKhann et al., 1984), and based on medical, neurological, and neuropsychological evaluations as well as a number of laboratory tests (to rule out dementia). Six additional Spanish–English bilinguals (3 were spouses of ADRC participants, and 3 were recruited from a senior center) also participated and were assumed to be cognitively intact on the basis of high levels of reported functioning in daily life and Dementia Rating Scale (Mattis, 1988) and Mini Mental State Examination (Folstein, Folstein, & McHugh, 1975) scores.

The 25 bilinguals in each group were matched for reported language dominance and degree of reported language dominance (i.e., degree of difference between rating for spoken English and spoken Spanish proficiency). Despite this matching, the older bilinguals reported using English less often ($p < .01$), translated about 10% fewer picture names into English, and also tended toward later age of acquisition of English ($p = .06$) than younger bilinguals. As such, the focus of the discussion is on a subset of *proficiency-matched* older ($n = 15$) and younger ($n = 15$) bilinguals who were matched for ability to translate into English and into Spanish (as well as for education level). Because they were useful for understanding the overall pattern of age effects, separate analyses considering all bilinguals tested are also reported, and of age effects within the remaining participants who were termed *strong-Spanish* bilinguals ($n = 10$ in each age group) for their better ability to translate into Spanish than the proficiency-matched groups. Note that the strong-Spanish older bilinguals had less education and were less proficient in English than the younger strong-Spanish bilinguals (see Table 6 and the *Does age predict local switch costs with other variables controlled?* section).

Proficiency-matched younger and older bilinguals were matched for education level ($p = .64$), ability to translate into Spanish ($p = .74$), and ability to translate into English ($p = .20$). To determine education level, the degree level completed was used (e.g., 12 years for high school, 16 years for a bachelor of arts degree, 18 years for a master's degree, and so on), or if a degree was not completed, the number of years completed was used. Older bilinguals rated their ability to speak both languages as lower (on average) than proficiency-matched younger bilinguals. This difference may reflect older adults' higher standard of excellence than that of younger adults or their subjective sense of age-related decline in spoken language proficiency ratings (in previous studies, older monolinguals also rated their ability to speak English lower than matched younger monolinguals; see Gollan et al., 2008). Absolute rating level aside, younger and older bilinguals were matched ($p = .75$) for degree of rating difference (just over 1.0 on a scale ranging from 1 (*little to no knowledge*) to 7 (*being like a native speaker*)) between ability to speak each language.

Materials—These were the same as in Experiments 1 and 2.

Procedure—The procedure was the same as in Experiment 1 except that older bilinguals were tested in their homes using a Macintosh G3 PowerBook with a 14-in. (11-cm) screen. Pictures were adjusted so that the size on the laptop matched those shown in Experiment 1.

Results

Outlier RTs were trimmed as in Experiment 1, removing $\leq 5.1\%$ of correct response RTs from all conditions. Figure 6 shows the subject means for the proficiency-matched bilinguals' data, and Figure 7 shows the subject means for the strong-Spanish bilinguals' data. To consider the possibility of age effects on voluntary language switching, we carried out separate $2 \times 2 \times 2$ ANOVAs for proficiency-matched and strong-Spanish bilinguals, with age group (older and younger) as a between-participants factor and language (English and Spanish) and trial type (only vs. stay trials for global mixing effects, and stay vs. switch in the either-language condition for local costs) as repeated factors in the participants' analyses. As in Experiment 1, for all analyses we included participants who yielded data in all cells being compared (but the pattern of results did not change when we included the data from all participants). We do not report items analyses in Experiment 3 because there were insufficient data (only seven items with data in all eight cells) to consider age effects on local and global switch costs.

Language-dominance effects—Proficiency-matched bilinguals in Experiment 3 were English dominant, as they named pictures more quickly in English than in Spanish, $F(1, 28) = 31.95$, $MSE = 40,301$, $\eta_p^2 = .53$, $p < .01$, and made fewer errors in English than in Spanish in

the English-only and Spanish-only conditions, $F(1, 28) = 18.12$, $MSE = .004$, $\eta_p^2 = .39$, $p < .01$. In addition, older bilinguals named pictures more slowly than younger bilinguals, $F(1, 28) = 5.04$, $MSE = 131,054$, $\eta_p^2 = .15$, $p = .03$, and older bilinguals made more errors than younger bilinguals, $F(1, 28) = 6.15$, $MSE = .006$, $\eta_p^2 = .18$, $p = .02$. Our procedure of matching younger and older bilinguals for offline translation accuracy (see Table 6) was largely successful in that errors analyses showed an equivalent degree of English dominance in younger and older bilinguals (no interaction between language and age; $F(1, 28) < 1$). In the RT data, younger bilinguals were slightly (though not significantly) more English dominant than older bilinguals, $F(1, 28) = 2.55$, $MSE = 40,301$, $\eta_p^2 = .08$, $p = .12$.

Strong-Spanish bilinguals displayed a more balanced profile overall in their picture naming data. They named pictures about equally quickly in Spanish and English with a tendency toward Spanish dominance in RTs (slightly but not significantly more quickly in Spanish), $F(1, 18) = 2.47$, $MSE = 43,003$, $\eta_p^2 = .12$, $p = .13$, and similar error rates in Spanish and English, but this time with a tendency toward English dominance (slightly but not significantly fewer errors in English than in Spanish) in the English-only and Spanish-only conditions, $F(1, 18) = 3.80$, $MSE = .002$, $\eta_p^2 = .17$, $p = .07$. There was no overall age-related disadvantage; older balanced bilinguals named pictures about equally quickly as younger balanced bilinguals, $F(1, 18) = 1.41$, $MSE = 75,234$, $\eta_p^2 = .07$, $p = .25$, and older bilinguals did not make significantly more errors than younger bilinguals, $F(1, 18) = 3.07$, $MSE = .003$, $\eta_p^2 = .15$, $p = .09$. However, there was a trend toward an interaction such that older bilinguals tended to be less balanced (more Spanish dominant) in their naming times in each language than younger bilinguals, $F(1, 18) = 3.98$, $MSE = 43,003$, $\eta_p^2 = .18$, $p = .06$, though the groups were similarly balanced in terms of error rates (there was no interaction between age and language in error data; $F(1, 18) < 1$).

The absence of age-related slowing in the strong-Spanish groups likely reflects the older bilinguals' relatively stronger knowledge of Spanish when compared with the younger balanced bilinguals (see Table 6). Below, we argue that the degree of balanced knowledge of both languages seemed to be more important for predicting switching rate than age. Note that by some standards, the younger strong-Spanish bilinguals (in Table 6) were the most balanced bilinguals in Experiment 3 (e.g., they translated 80% or more of the target picture names in both translation directions, reported using both languages frequently in daily use). The next most balanced bilinguals were older bilinguals from the proficiency-matched groups (i.e., they had a similar ability to translate in both directions, though not as high as 80%). In contrast, bilinguals in the other two groups (i.e., younger bilinguals from the proficiency-matched groups and older strong-Spanish bilinguals) had one more clearly dominant language, as measured by translation direction, and used one language at least 80% of the time in daily language use.

Choices within the either-language condition—As in Experiment 1, most bilinguals chose to switch languages at least some of the time (see Table 2). Only 1 younger English-dominant bilingual never switched languages, and the remaining bilinguals switched languages between 2% and 52% of the time. Of great interest, older bilinguals did not choose to switch languages less often than younger bilinguals in all comparisons. Within the proficiency-matched groups, older bilinguals switched languages marginally more often (33%, $SD = 16\%$) than younger bilinguals (22%, $SD = 15\%$), $F(1, 28) = 3.75$, $MSE = .02$, $\eta_p^2 = .12$, $p = .06$. This tendency of older bilinguals to switch relatively more than younger bilinguals is particularly surprising from the perspective that switching is supposed to be harder for older bilinguals and suggests that the degree to which knowledge of both languages is balanced is more important

than age for predicting voluntary-switching rates. Consistent with the idea that balanced bilinguals switch language more often voluntarily, older strong-Spanish bilinguals switched languages significantly less often (25%) than the more balanced younger strong-Spanish bilinguals who switched languages more often than any subgroup within Experiment 3 (37%, see Table 2), $F(1, 18) = 4.25$, $MSE = .02$, $\eta_p^2 = .19$, $p = .05$. In summary, the choices of language-mixing patterns in Experiment 3 (see Table 4) suggest that degree of language balance is more important for predicting the pattern of voluntary language mixing than age; more balanced bilinguals (i.e., including older proficiency-matched and younger strong-Spanish bilinguals) switched languages more often than less balanced bilinguals (i.e., including the younger proficiency-matched and older strong-Spanish bilinguals).

Global language-mixing effects—There was no evidence for an age-related increase in language-mixing effects. In the proficiency-matched comparison, bilinguals named pictures marginally more quickly in English than in Spanish, $F(1, 21) = 4.14$, $MSE = 34,077$, $\eta_p^2 = .17$, $p = .06$; about equally quickly in the language selective (“only”) conditions as on stay trials in the either-language condition, $F(1, 21) = 1.29$, $MSE = 35,603$, $\eta_p^2 = .06$, $p = .27$; and older bilinguals named pictures significantly more slowly than younger bilinguals, $F(1, 21) = 5.61$, $MSE = 334,046$, $\eta_p^2 = .21$, $p = .03$. As in Experiment 1, the dominant language (English) displayed language-mixing costs, whereas the nondominant language (Spanish) displayed mixing benefits; this interaction between language and mixing effects was significant, $F(1, 21) = 12.45$, $MSE = 45,346$, $\eta_p^2 = .37$, $p < .01$.

There was a trend toward an interaction between age group and language-mixing effects, $F(1, 21) = 2.42$, $MSE = 35,603$, $\eta_p^2 = .10$, $p = .14$, such that older bilinguals showed some tendency toward an overall language-mixing cost, whereas younger bilinguals displayed little difference between only and stay trials overall (when collapsed across language). However, post hoc comparisons (2×2 ANOVAs looking at age effects and language-mixing effects separately in each language) revealed no hint of an age-related increase in global mixing costs for English ($F < 1$) and also no age-related increase in global facilitation effects for Spanish, $F(1, 21) = 1.44$, $MSE = 50,676$, $\eta_p^2 = .06$, $p = .24$. Two- and three-way interactions were not significant (all $F_s \leq 1.11$, all $p_s \geq .30$), suggesting no age-related increase in global mixing effects. Similarly, in the errors analyses, the English-dominant bilinguals made marginally more errors in Spanish than in English, $F(1, 23) = 3.86$, $MSE = .01$, $\eta_p^2 = .14$, $p = .06$, and older bilinguals made more naming errors than younger bilinguals, $F(1, 23) = 12.45$, $MSE = .01$, $\eta_p^2 = .29$, $p = .01$, but there were no other significant main effects or interactions ($F_s \geq 1.53$, all $p_s \geq .23$).

Strong-Spanish bilinguals named pictures equally quickly in English and in Spanish ($F < 1$), with no age-related slowing ($F_s < 1$), and, resembling balanced bilinguals in Experiment 1, there was a significant overall language-mixing cost such that both languages showed mixing costs, $F(1, 17) = 7.47$, $MSE = 25,751$, $\eta_p^2 = .31$, $p = .01$. There were no other significant interactions (all $F_s \geq 1.22$, all $p_s \geq .29$). In the errors analyses, bilinguals made significantly more errors in Spanish than in English, $F(1, 17) = 9.30$, $MSE = .002$, $\eta_p^2 = .35$, $p = .01$; older bilinguals made marginally more naming errors than younger bilinguals, $F(1, 17) = 3.09$, $MSE = .005$, $\eta_p^2 = .15$, $p = .10$; and error rates were significantly higher in the language selective conditions than in the either-language condition, $F(1, 17) = 10.83$, $MSE = .0004$, $\eta_p^2 = .39$, $p < .01$. However, there were no significant interactions ($F_s \geq 1.4$, all $p_s \geq .25$), suggesting no age-related increase in global mixing effects for strong-Spanish bilinguals.

Local switch costs within the either-language condition—Within the proficiency-matched bilinguals, older bilinguals named pictures more slowly than younger bilinguals, $F(1, 19) = 6.14$, $MSE = 475,928$, $\eta_p^2 = .24$, $p = .02$, and as in Experiment 1, bilinguals named pictures significantly more slowly on language switch trials than on stay trials, $F(1, 19) = 4.35$, $MSE = 33,763$, $\eta_p^2 = .19$, $p = .05$. Also as in Experiment 1, there was a trend toward reversed language dominance, $F(1, 19) = 2.73$, $MSE = 67,380$, $\eta_p^2 = .13$, $p = .12$, and there was no switch-cost asymmetry ($F < 1$). Of most interest was that there was no age-related increase in voluntary language switching costs ($F < 1$), and none of the other two- or the three-way interactions were significant. There were no significant effects in the errors analyses (all F s < 1) with the exception that older bilinguals made significantly more errors than younger bilinguals, $F(1, 22) = 14.83$, $MSE = .01$, $\eta_p^2 = .40$, $p < .01$. Thus, within the proficiency-matched comparison, we obtained no evidence of an age-related increase in local switch costs even though proficiency-matched older bilinguals switched languages more often than their matched younger counterparts.

Within the strong-Spanish groups, bilinguals named pictures more slowly on switch trials than on stay trials, $F(1, 17) = 7.69$, $MSE = 31,509$, $\eta_p^2 = .31$, $p = .01$; older and younger bilinguals named pictures about equally quickly, $F(1, 17) = 1.88$, $MSE = 180,611$, $\eta_p^2 = .10$, $p = .19$; and there was no effect of language dominance ($F < 1$). Of interest, older bilinguals paid greater switch costs than younger bilinguals (a significant Age Group $\times$ Switch Costs interaction), $F(1, 17) = 5.76$, $MSE = 31,509$, $\eta_p^2 = .25$, $p = .03$, and as in Experiment 1, there was no switch-cost asymmetry ($F < 1$), and none of the other two-way or the three-way interactions were significant. In the errors analyses, there were more errors on switch than on stay trials, $F(1, 17) = 6.56$, $MSE = .007$, $\eta_p^2 = .28$, $p = .02$, and older bilinguals made more errors than younger bilinguals, $F(1, 17) = 6.24$, $MSE = .01$, $\eta_p^2 = .27$, $p = .02$. The interaction effect between age and switch costs on errors, $F(1, 17) = 2.82$, $MSE = .007$, $\eta_p^2 = .14$, $p = .11$, and the switch-cost asymmetry, $F(1, 17) = 2.18$, $MSE = .01$, $\eta_p^2 = .11$, $p = .16$, were not significant. Planned comparisons testing for a switch-cost asymmetry within the older balanced bilinguals alone demonstrated no hint of a switch-cost asymmetry ($F < 1$). The pattern of local switch costs within the strong-Spanish bilinguals thus constitutes the first and only evidence for an age-related increase in voluntary switch costs.

Does age predict local switch costs with other variables controlled?—Our observation of a significant age-related increase in voluntary local switch costs within the strong-Spanish bilinguals demonstrates that there is sufficient power in the present study to observe age effects on local switch costs. Of importance is that the age-related increase in switch costs could not be attributed to differences in switching rate; age and voluntary-switching rate were not correlated in Experiment 3 ($r = .10$, $p = .49$), and the older bilinguals who showed increased switch costs also switched languages significantly less often than younger bilinguals (in prior work, higher switch rates were associated with a greater age effect; Hernandez & Kohnert, 1999). However, in Experiment 3, age was negatively correlated with education level ($r = -.40$, $p < .01$) and positively correlated with several measures of proficiency (particularly English), including self-reported English use, English-only RTs, translation into English scores, and ratings of spoken English and Spanish proficiency (all r s $\geq .35$, all p s $\leq .01$), introducing the possibility that the age-related increase in switch costs should instead be attributed to one of these variables. To consider this possibility, we conducted a number of exploratory analyses.

First, because we only observed an age effect in the strong-Spanish bilinguals on local switch costs in English, it was of interest to determine whether age was a significant predictor with all 50 bilinguals tested in Experiment 3. A linear regression analysis, with age coded categorically as a dummy predictor variable, showed that age was just significant ($\beta = .29, p = .05$) as a predictor of local switch costs in English (i.e., English-switch minus English-stay RTs). To determine whether age was still a significant predictor of local switch costs in English after controlling for differences in education level and proficiency in English, we repeated our regression analysis simultaneously entering age (again coded categorically), years of education, and translation-into-English scores as predictor variables. Of all the English proficiency measures, we used translation because it is less subjective than self-ratings and more independent from switch costs than naming times. In this analysis, age was a significant predictor ($\beta = .36, p = .04$), but education ($\beta = .05, p = .75$) and translation into English ($\beta = .13, p = .42$) were not. These analyses imply that lower levels of education and English proficiency did not spuriously introduce an age effect on switch costs, and therefore increase our confidence in the association between older age and larger voluntary switch costs.

Predicting voluntary language-switching rate—The absence of an age effect on switching rate raises a question as to what leads bilinguals to choose to switch languages more often, and whether anything besides older age predicts the magnitude of switch costs. To explore possible answers to this question, we considered whether bilinguals were more likely to switch languages in the either-language condition if they had first completed the Spanish-only condition, and we also correlated total switching rates and local switch costs in English with several predictor variables, including (a) age, (b) education, (c) a number of proficiency measures (i.e., mean RTs from the language selective conditions, translation scores in both languages, spoken proficiency ratings in each language, self-reported current degree of English use), and (d) a number of language-dominance measures (e.g., the absolute value of the difference between English-only RTs and Spanish-only RTs). The results of these analyses suggest two factors that influence the rate of voluntary language switching, which are shown in Figures 8 and 9.

None of the proficiency measures or education level predicted the magnitude of local switch costs in English in Experiment 3 (all r s $\leq .14$, all p s $\geq .34$) or in Experiment 1 (all r s $\leq .17$, all p s $\geq .20$). Surprisingly, switching rate was negatively correlated with local switch costs in Experiment 3 ($r = -.30, p = .04$), implying that bilinguals who switch frequently paid smaller switch costs. However, this correlation was not present in Experiment 1 ($r = .04, p = .75$), implying that the apparent relationship between switching rate and switch costs in Experiment 3 depended on the older bilinguals who showed unusually large switch costs and also switched languages relatively less often. We thus conclude that there is no relationship between local switch costs and voluntary switch rates in younger bilinguals.

A significant predictor of switch rate was the relative accessibility of the two languages (see Figure 8). Bilinguals with similar naming times in the English-only and Spanish-only conditions chose to switch languages voluntarily more often than bilinguals who named pictures much more quickly in one language than in the other language. Switching rate was negatively correlated with the RT difference between the two languages—significantly so in the 50 bilinguals tested in Experiment 3 ($r = -.35, p = .01$) (revealing a tendency in this direction when including only the 25 older bilinguals tested in Experiment 3, $r = -.31, p = .13$); the effect was also significant in the 73 bilinguals tested in Experiment 1 ($r = -.27, p = .02$) and was robust when including all 98 bilinguals (older and younger) tested in the either-language condition in both Experiments 1 and 3 ($r = -.28, p = .01$). These analyses demonstrate a continuous relationship between the degree of balanced bilingualism and the frequency of choices to switch languages and confirm our conclusions on the basis of group comparisons

in which balanced bilinguals switched languages more often than unbalanced bilinguals in Experiment 1.

Another significant predictor of switch rate was testing order (see Figure 9). Bilinguals who completed a block of Spanish-only picture naming switched languages more often than bilinguals who did not name pictures in Spanish only until after completing the either-language condition. Completion of a Spanish-only testing block prior to the either-language condition elevated switching rates in English-dominant and older bilinguals to about the rate (roughly 30% language switches) seen in balanced bilinguals in Experiment 1. This testing order effect on switch rate was significant for younger English-dominant bilinguals in Experiment 1, $F(1, 55) = 17.92$, $MSE = 0.03$, $\eta_p^2 = .25$, $p < .01$, and for older bilinguals in Experiment 3, $F(1, 23) = 4.32$, $MSE = 0.02$, $\eta_p^2 = .16$, $p = .05$, but not for younger balanced bilinguals in Experiment 1 ($F < 1$). Of importance is that testing order did not affect the magnitude of age effects in Experiment 3 (all F s < 1), language-dominance effects for English-dominant bilinguals in Experiment 1 ($F < 1$), local switch costs in Experiment 1 (all F s < 1), or global language-mixing effects (all F s ≤ 1.08), with one nonsignificant exception of a tendency toward greater global costs to English after naming pictures in Spanish, $F(1, 55) = 2.16$, $MSE = 16,087$, $\eta_p^2 = .04$, $p = .15$.

Discussion

The results of Experiment 3 provide some confirmation of prior reports of an age-related increase in language switching costs while also demonstrating some clear differences between age effects in cued and voluntary language switching. Described in general terms, age effects appear to be much less robust in voluntary language switching than they were in previous reports of cued switching. Perhaps most impressive in this regard was the absence of an age-related increase in language-mixing costs (global costs). This is surprising given the robust age effect on mixing costs in cued language switching (Hernandez & Kohnert, 1999) and given that age effects on global costs (task-mixing costs) are generally considered to be more robust than age effects on local switching costs (Kray & Lindenberger, 2000; Mayr, 2001; Reimers & Maylor, 2005; Verhaeghen & Cerella, 2002).

Also surprising was the absence of a clear relationship between age and the frequency of choice to switch languages, a finding that supports the idea that lexical accessibility influences voluntary language switching. If language switching were more difficult for older bilinguals, then they should have switched languages less often than younger bilinguals. Although the strong-Spanish bilingual groups confirmed this pattern, within the proficiency-matched groups older bilinguals actually chose to switch languages (marginally significantly) more often than younger bilinguals. The age-related increase in switching rate among proficiency-matched bilinguals may have reflected the tendency of older bilinguals to be more balanced than proficiency-matched younger bilinguals. Although we matched younger and older English-dominant bilinguals as much as possible for proficiency in both languages, there was some evidence that the older bilinguals had relatively stronger knowledge of Spanish than the younger bilinguals. For example, age-related slowing was slightly larger for English than for Spanish (the Language $\times$ Age Group interaction was marginally significant; see Figure 6), and older bilinguals reported using English slightly less often (and therefore Spanish slightly more often) than younger bilinguals (see Table 6). Conversely, the lower switching rate in older relative to younger strong-Spanish bilinguals may reflect the fact that these older bilinguals were slightly less balanced (more Spanish dominant) than the younger bilinguals (e.g., the older bilinguals translated more items into Spanish than into English, whereas the younger bilinguals translated more items into English more successfully than into Spanish; see Table 6). Confirming the notion that language balance predicts voluntary language-mixing rates, in

both Experiments 1 and 3 there was a significant and continuous relationship between the degree of language balance and switch rates.

The presence of some age-related increase in voluntary-switching costs implies that age-related switching deficits in prior studies did not exclusively reflect the burden of executing required switches on the basis of experimentally provided cues. Strong-Spanish older bilinguals showed increased local switch costs in English. Exploratory analyses indicated significant age effects on local switch costs in English in all 50 participants tested in Experiment 3 even after controlling for between-age group differences in education level and English proficiency. We consider further implications of the age effects we obtained in the General Discussion section.

General Discussion

The experiments reported here revealed several main points that characterize voluntary language switches as follows:

1. Most bilinguals choose to switch languages voluntarily even though switches entail local (i.e., on switch vs. stay trials) and global costs (e.g., balanced bilinguals showed mixing costs in both languages), and even though they would have named pictures more quickly had they not switched.
2. When switches are voluntary, most bilinguals choose to use one language more often than the other (i.e., with enough of a difference in use between the two languages to suggest selection of a matrix language).
3. Choices to switch versus stay indicated that switches are not universally more difficult than staying in the same language (i.e., many bilinguals used the bail-out pattern in which switch choices outnumbered stay choices in the nondominant language).
4. Bilinguals avoided some of the costs of language mixing by choosing to name only very easy pictures in the nondominant language (i.e., item selection effects).
5. Bilinguals are willing to pay switch costs in time but not in accuracy, and balanced bilinguals switch languages to improve naming accuracy.
6. Voluntary-switching rate was predicted by the relative speed of accessibility of naming responses in the two languages such that balanced bilinguals switched more often than less balanced bilinguals, and for unbalanced bilinguals by testing order such that bilinguals who recently named pictures in Spanish only switched languages more often than bilinguals who had not yet named a block of pictures in Spanish only.
7. Voluntary-switching rate was not predicted by aging.

The experiments reported also reveal several important differences between required and voluntary switches as follows:

1. Less voluntary switches (in the fifty-percent condition in Experiment 2) introduce some strategies that are not used or are infrequently used when switches are relatively more voluntary (e.g., switches outnumbering choices to stay in both languages).
2. Standard patterns of switch costs are severely disrupted when bilinguals are required to switch more frequently (i.e., the appearance of “stay costs” in Experiment 2).
3. Voluntary switching and mixing has robust effects on the nondominant language (e.g., an apparent “mixing benefit”), whereas in cued paradigms, the nondominant language is relatively unaffected by mixing.
4. Unbalanced bilinguals resemble balanced bilinguals when switches are voluntary, exhibiting symmetrical switch costs and reversed language dominance

5. Older bilinguals resemble younger bilinguals when switches are voluntary; they mixed languages as easily as younger bilinguals (i.e., there was no age-related increase in global costs), and the age-related increase in local switch costs was limited to English.

These results highlight powerful differences between the mechanisms underlying voluntary and cued switches and have implications for understanding bilingualism, aging, and cognitive control.

Is Voluntary Language Switching Costly?

We demonstrated in Experiments 1 and 3 two costs of exercising the flexibility to use both languages: First, there were local switch costs. These demonstrate that voluntary language switches are not driven exclusively by lexical accessibility and likely reflect the time needed to reconfigure the cognitive system from the goal of “Name in language X” to “Name in language Y.” We also observed language-mixing (global) costs for the dominant language in English-dominant bilinguals and for both languages in balanced bilinguals such that naming times were faster in language selective testing blocks than on stay trials in the either-language condition. We demonstrated in Experiment 2 that the global mixing costs were partly caused by an item selection strategy. When bilinguals are free to use the nondominant language only at their discretion, they choose to speak the nondominant language only to name relatively easy pictures, and this leaves the dominant language with a greater number of difficult pictures to be named. More important, local switch costs cannot be attributed to this strategy because item selection is equally possible on stay and switch trials (see the *Discussion* section in Experiment 1). In addition, it is unlikely that global mixing costs exclusively reflected item selection strategies because mixing costs were robust across three levels of item difficulty (see Figure 3). Voluntary language-mixing costs likely reflect the consequences of maintaining more than one language available for response in the either-language condition and rule out an accessibility-only account of voluntary language switches.

Voluntary language-switching costs confirm reports of cued switching costs and suggest that such costs occur between natural alternative tasks independently of the experimentally imposed requirement of naming some pictures in the less preferred language. Because bilinguals named pictures out of context, it remains possible that naturally occurring language switches are not costly (because grammatical constraints could lessen the cost of switching; Poplack, 1980). However, although switch costs have been eliminated in some testing situations (Finkbeiner et al., 2006), they are rarely eliminated completely. For example, nonlinguistic switch costs have been reduced but not eliminated when switches are predictable, with a longer lag between presentation of the cue and the switch, when each stimulus is clearly associated with one but not with the other task (for a review, see Monsell, 2003).

The observation of voluntary switch costs also supports the analogy between “language choice” and “task choice,” an analogy that was not obvious a priori given some compelling differences between nonlinguistic switching and language switching. Whereas task switching typically involves responses that are virtually always accessible (e.g., classifying colored shapes on the basis of their shape or their color; e.g., Mayr, 2001), in language switching a different string of phonemes must be produced to name each picture, and in some cases those names are inaccessible, or even unknown.

The mixing benefits for English-dominant bilinguals in Spanish are more difficult to interpret and were less robust in that balanced bilinguals did not exhibit mixing benefits (they exhibited mixing costs to both languages). A possible explanation for the mixing benefits relates to “frequency blocking” effects in which relatively difficult items are named more quickly when they are mixed together with relatively easier items (for a recent review, see Kinoshita & Mozer,

2006). This view requires that all Spanish names can reasonably be classified as “relatively difficult” for English-dominant bilinguals, and is plausible given that English-dominant bilinguals name pictures with high-frequency names in Spanish more slowly than pictures with low-frequency names in English (Gollan et al., 2008). Although this explanation is highly speculative, it is interesting to note that frequency-blocking studies also show that relatively easy items are named more slowly when mixed together with difficult items, and as such the same kind of explanation could explain part of the global costs to English in English-dominant bilinguals. This account also suggests that frequency-blocking effects may be obtained in language production (not only in lexical decision and reading aloud).

The Lure of Voluntary Mixing: “Switch Now, Pay Later” and the Role of Lexical Accessibility

Given that voluntary language switching is costly, an obvious question is why bilinguals nevertheless switch and pay a switch cost. The present results validate the literature on naturally occurring code switching by providing evidence that voluntary language switches are driven both by pragmatic factors (Myers-Scotton, 2005, 2006) and by lexical accessibility (Clyne, 2003; Owens, 2005; Poplack, 1980). Our results indirectly support pragmatic motivations for switching despite the costs because voluntary language switches in our study could not have been driven exclusively by the relative accessibility of names in each language. Specifically, we observed local switch costs and therefore a cost associated with the decision to switch languages. Also notable was that the choice to switch languages was ultimately inefficient in terms of time spent in the experiment. For English-dominant bilinguals in particular, the English-only condition always yielded the fastest RTs in each experiment. This suggests that if bilinguals had stayed in English for the entire block, then they would have completed the experiment more quickly. Bilinguals’ choices to switch into the nondominant language despite the costs may have reflected their implicit assumption that the experimenter wants to see at least some use of both languages. Our observation of higher switching rates in bilinguals who completed the voluntary-switching (either-language) condition after the Spanish-only condition could be taken as evidence to support the idea that lexical accessibility drives switch rates. This view would require that a block of naming pictures in Spanish would lead to an increase in the relative accessibility of Spanish names. However, because testing order did not affect language dominance (i.e., the extent to which English was more accessible than Spanish; see also Gollan et al., 2008), or any of the other effects we reported, we suggest instead that the effects of testing order on switching rate may originate outside the language system in the form of an increased rate of executive decisions to switch languages despite the costs.

Although we did not obtain evidence for an accessibility-only account of voluntary switches, some aspects of our data imply a role for lexical accessibility. Specifically, balanced bilinguals switched languages more often than unbalanced bilinguals, bilinguals did not switch languages if such a switch would lead them to name a picture incorrectly (see Table 5), and bilinguals selected out easy pictures to name in the nondominant language and bailed out of the nondominant language back into the dominant language to name difficult pictures. Here we suggest the operation of a “switch now, pay later” principle, whereby bilinguals are tempted to switch into the nondominant language by its apparent relative accessibility on easy trials (i.e., switch now) and are later compelled to make costly switches on difficult trials (i.e., pay later) back into the dominant language. On this view, when bilinguals switched into the nondominant language voluntarily, they likely did not anticipate that the *inaccessibility* of upcoming difficult names in the nondominant language would force additional (costly) switches back into the dominant language and did not anticipate that staying in the nondominant language would then be more difficult than switching. In other words, bilinguals considered immediate, but not upcoming, switch costs in planning what language to use (and so limited how far they “looked ahead” when deciding whether to switch languages). Thus, although

bilinguals switch languages for reasons independent of accessibility (e.g., for a recent review, see Basnight-Brown & Altarriba, 2007), lexical accessibility clearly also plays a strong role.

A different reason why bilinguals may choose to switch despite the cost in time is that the ultimate benefits that using either language confers may be more obvious and important to them than the relatively smaller costs (time in milliseconds) incurred by language mixing. A benefit of using both languages is that bilinguals are ultimately able to label more concepts if they can use words from either language (because bilinguals can produce some words in their otherwise less dominant language that they do not know in their usually more dominant language). In prior studies, this either-language benefit was more robust in balanced bilinguals (Gollan et al., 2007; Kohnert et al., 1998), but the fact that strongly English-dominant bilinguals chose to switch languages voluntarily suggests that in some contexts (maybe with very low-frequency targets; e.g., Gollan & Silverberg, 2001), relatively unbalanced bilinguals would also demonstrate a significant benefit from the option to use either language.

The contrast between timed (costly) versus untimed (beneficial) “either” consequences suggests that bilinguals may be relatively less aware of switch costs (i.e., delays) than they are of the ultimate advantages and flexibility that using both languages affords. These assumptions seem reasonable given that a cost in terms of milli-seconds should be much less apparent than, for example, completely failing to name a picture. In tasks in which production is not timed on a trial-by-trial basis (e.g., verbal fluency with an either-language instruction), the costs of switching and language mixing may balance out the benefits of using both languages so that no difference is observed between language selective and language-mixed fluency (e.g., Gollan et al., 2002). Finally, a more general implication of the contrast between timed versus untimed “either” results is that switch costs are speed bumps but not road blocks; switching requires additional time but does not reduce the probability of successfully accessing the lexicon.

What Is the Role of Inhibitory Control in Bilingual Language Production?

In studies of cued language switching, a signature of inhibitory control—specifically, control of the dominant language on switch trials—has been the switch-cost asymmetry whereby local switch costs are bigger for switching into the dominant language than they are for switching into the nondominant language (Abutalebi & Green, 2007; Costa & Santesteban, 2004; Costa et al., 2006; Hernandez & Kohnert, 1999; Jackson et al., 2001; Meuter & Allport, 1999; but see Finkbeiner et al., 2006). In the present study, we did not obtain strong evidence of a local switch-cost asymmetry—this is despite the fact that a significant asymmetry was observed in the same population as tested in the present study, when language switches were cued (Hernandez & Kohnert, 1999) and the asymmetry was obtained in several other bilingual populations who (like the English-dominant bilinguals tested in the present study) had one language clearly dominant over the other (e.g., Costa & Santesteban, 2004, Experiment 1; Meuter & Allport, 1999). In our study, switch costs were symmetrical, as previously found only in highly proficient bilinguals (Costa & Santesteban, 2004, Experiments 2–5; see also exploratory analysis by Meuter & Allport, 1999 and Christoffels et al., 2007, who obtained symmetrical switch costs in bilinguals with about 100 ms quicker naming times in the dominant language than in the nondominant language). Also notable is that in cued studies and in our data, symmetrical switch costs occur together with reversed language dominance (Christoffels et al., 2007; Costa & Santesteban, 2004; Costa et al., 2006).

In prior work, symmetrical switch costs were interpreted as evidence that proficient bilingual control mechanisms operate without inhibition (Costa & Santesteban, 2004; Costa et al., 2006). But note that the reversal of language dominance (which was found in these same studies) is itself powerful evidence for inhibitory control of the dominant language (Kroll, Bobb, Misra, & Guo, 2008). As such, we suggest that all bilinguals (even balanced ones) rely on inhibitory control for producing the nondominant language and that the absence of a robust

switch-cost asymmetry, and fully switched language dominance in the either-language condition (see Figures 1 and 4), reflect the application of consistent inhibition of the dominant language on all trials (both stay and switch; Costa et al., 2006, briefly consider but then discount this possibility). Note that because balanced bilinguals are relatively proficient in their nondominant language, they do not have to inhibit the dominant language as strongly to produce their nondominant language. This allows balanced bilinguals to apply this inhibition to the dominant language at a consistent level across the entire task, accounting for why dominance is reversed (the dominant language is weakly, but consistently, inhibited) and why costs are symmetric (inhibition was not withdrawn for stay trials).

On this view, voluntary switching allows unbalanced bilinguals to function more like balanced bilinguals (exhibiting faster naming times in the usually less dominant language and symmetrical switch costs). In particular, under voluntary instructions, unbalanced bilinguals as well can apply just a small amount of inhibition to their dominant language, allowing just relatively accessible nondominant responses to be spoken. Because they need only apply a small amount of inhibition to the dominant language, that level of inhibition can be applied both on switch and on stay trials, yielding the balanced pattern—reversed dominance and symmetric switch costs. In contrast, when unbalanced bilinguals are in a cued-switching study, they are forced to produce weakly accessible names in the nondominant language, requiring a high level of inhibition of the dominant language. This higher level of inhibition may be difficult to maintain or may lead speakers to find production of the dominant language to be unacceptably slow, and this in turn leads speakers to withdraw inhibition upon switching into the dominant language.

This discussion implies that bilinguals (or task switchers in general) avoid applying inhibition when possible (see also Emmorey, Borinstein, Thompson, & Gollan, 2008). When they do apply inhibition, they try to apply as little as is needed to allow responses in both languages, and if the degree of inhibition is small enough, then that degree of inhibition is maintained at a constant level across the task context (yielding reversed dominance and symmetric switch costs). This suggests that, generally, the most efficient strategy for allowing language mixing (whether voluntary or cued) is to (approximately) equalize the accessibility of both languages by applying steady inhibition to the dominant language. However, if needed, bilinguals apply higher levels of inhibition, even though doing so requires inhibition to be throttled on a trial-by-trial basis, yielding switch-cost asymmetries (here, we assume that trial-by-trial adjustment of inhibition is more difficult than steady application of a small amount of inhibition, but less difficult than steady application of a large amount of inhibition). It might be asked why dominance was reversed if the goal was to equalize the relative accessibility of the two languages. Here, we speculate that inhibition is “over-applied” to the lexicon as a whole because of the difficulty of equalizing the two languages exactly (e.g., more inhibition would be needed to equalize low-frequency than high-frequency translation equivalents; Gollan et al., 2008).

Ironically, because cued studies were designed to test the notion of inhibitory control, if our interpretation is correct, it suggests that the use of experimentally provided cues to elicit switches may have led to the underestimation of the extent to which bilinguals use inhibitory control in natural circumstances. Our interpretation clarifies and expands the role of inhibitory control in bilingual language production as being operational in both balanced and unbalanced bilinguals, and on switch and stay trials, and dispenses with the notion of the switch-cost asymmetry as the signature of inhibitory control (see also Yeung & Monsell, 2003). Language mixing (both voluntary and cued) becomes easier with increased proficiency because less inhibition of the dominant language is needed to make both languages relatively equally accessible. In principle, our interpretation leaves open the possibility that mechanisms other than inhibition produced reversed dominance and symmetrical switch costs, so long as both

balanced and unbalanced are stipulated as capable of using this mechanism (contra Costa & Santesteban, 2004, who proposed a special mechanism for language mixing in balanced bilinguals). However, it is not immediately apparent how some of these alternative accounts can explain why making switches voluntary (instead of required) allows unbalanced bilinguals to function more like balanced bilinguals and older bilinguals more like younger bilinguals. One alternative mechanism that makes the less dominant language more available for response is to raise the selection threshold of the dominant language so that a greater amount of activation is required to produce it (Costa & Santesteban, 2004; Costa et al., 2006). This account, however, provides no explanation for why unbalanced bilinguals are able to adjust their selection threshold when switches are voluntary but not when switches are cued; that is, threshold adjustment should be an all-or-none change that is independent of the requirement or lack thereof to switch languages.

Other accounts that were proposed specifically to explain asymmetrical language switch costs face different challenges in explaining the present data. For example, Finkbeiner et al. (2006) proposed that the dominant language shows larger switch costs because on switch trials, speakers become suspicious of responses that are available too quickly. Similarly, Yeung and Monsell (2003) proposed that task repetition priming effects are greater for the weaker task and that the weaker task competes with the stronger task relatively little unless considering specifically the switch trials. Such accounts cannot explain the fully reversed language-dominance effects and symmetrical switch costs that we observed. Noninhibitory accounts also cannot explain other evidence for the role of inhibition in bilingual language control. Particularly convincing in this regard is a recent study (Phillip, Gade, & Koch, 2007) in which trilinguals switched between three languages (ABC) and exhibited a greater cost for switches back to a just-used language (ABA) compared with switches to the third language (CBA). This “n-2 repetition cost” is also found in non-linguistic task switching (e.g., Mayr & Keele, 2000).

Thus, although noninhibitory accounts of the switch-cost asymmetry (in which it is obtained) and fully reversed language dominance are possible, we suggest that the simplest explanation of the results observed across task switching, language switching, and age effects, in both voluntary and cued settings, is that some form of inhibition of the dominant task/language is applied to equalize the relative accessibility of the dominant and nondominant responses. Having used the same mechanism (inhibitory control) to explain both local and global mixing costs (see also Meuter & Allport, 1999), we caution that ultimately this approach may fail to capture some important aspects of bilingual language control mechanisms. Indeed, some researchers have proposed that local and global switch costs are produced by (at least partially) non-overlapping mechanisms in studies of language switching (Christoffels et al., 2007; Costa & Santesteban, 2004) and in nonlinguistic switching (Monsell, 2003). For example, global, but not local, costs are sensitive to stimulus ambiguity (for which the same stimulus could activate two different responses; Kray & Lindenberger, 2000). In addition, it is important to note that inhibition alone cannot be the sole mechanism used to explain both reversed dominance and how switches are carried out on a trial-to-trial basis. If switches were to occur solely on the basis of what language is more active (inhibition or release of inhibition), then reversed dominance should be found to occur with a reversed asymmetry of switch costs (i.e., with bigger switch costs in the nondominant language rather than with symmetrical costs). Instead, it appears that some other independent mechanism ultimately implements selection of the desired language.

Implications of Age Effects for Models of Bilingual Control and Cognitive Aging

Voluntary switching necessarily requires an act of cognitive control in the form of a decision “to switch or not to switch” on each trial (Arrington & Logan, 2005), and there seems to be

universal agreement that increased age leads to increased difficulty with cognitive or “executive” control mechanisms (e.g., Moscovitch & Winocur, 1992; Verhaeghen, Kliegl, Mayr, 1997). As such, it is quite surprising that voluntary language switching was not clearly more difficult for older than for younger bilinguals. Switching rate was more determined by the degree to which both languages are equally accessible more than it was by age, and there were no age effects on language mixing (global costs). The contrast between age effects on language mixing observed in cued (increased costs) and voluntary (no effect) switching supports the proposal that older adults have more difficulty keeping track of what response ought to be produced on any given trial when switches are cued (Mayr & Liebscher, 2001). By making either language appropriate as a response, the age-related mixing deficit disappeared. In addition, older bilinguals have relatively intact mechanisms for maintaining available two potentially competing and confusable response sets, and, assuming inhibition is the mechanism that allows this to occur, older adults also have sufficiently intact inhibitory control mechanisms to allow voluntary language switching without increased switch costs (for a review of inhibitory deficits in aging, see Lustig, Hasher, & Zacks, 2007). Thus, when switches are voluntary instead of cued, older bilinguals function more like younger bilinguals. In addition to intact mechanisms related to maintaining the option to use either language, the absence of an age effect on global language-mixing costs suggests intact mechanisms in older age for deciding what language to use on each given trial.

Of importance is that we did obtain some evidence for increased local switch costs with increased age, and these could not be attributed to between-age group differences in education level or proficiency in English. The finding of significant age-related increase in local switching costs implies that something common to cued and voluntary language switching explains age effects in both cases. One possible explanation is that older bilinguals experience greater priming from previously executed goals to currently possible alternative goals (i.e., larger “positive response repetition effects” on stay trials; Mayr & Liebscher, 2001). Consistent with this proposal, where we did obtain an age-related increase in switch costs (see Figure 7), there appeared to be no age-related slowing for stay trials, but there was significant age-related slowing on switch trials. The age-related increase in voluntary local switch costs also seems consistent with the notions of inhibitory control of the two languages and age-related deficits thereof. However, it must be noted that the notion of age-related inhibitory deficits has been questioned (for a recent review, see Burke & Osborne, 2007) particularly in the task-switching literature (e.g., Mayr, 2001, demonstrated that older adults show stronger inhibition than younger adults in switching between two categories in the verbal fluency task).

Conclusions

Voluntary language-switching costs differed from previous reports of cued language-switching costs in a number of ways that provide insights into the mechanisms of language control and as to what leads bilinguals to choose to switch languages voluntarily in spontaneous conversation. Bilinguals switch languages despite the small costs in time, only when nondominant-language responses are relatively accessible and only when switches do not compromise accuracy, or if such switches improve accuracy. In addition, when switches are voluntary, bilinguals can work around some of the costs associated with language switching. Thus, most bilinguals, including unbalanced and older bilinguals, prefer to keep and exercise the option to use either language perhaps because when speakers are not forced into overriding their natural naming preferences by language cues, the costs associated with keeping both languages accessible are relatively small, whereas the potential benefits of switching are quite obvious.

Models of language control must be able to explain cued and voluntary language switches in bilinguals of all proficiency levels. The use of cued language switching to understand bilingual

control mechanisms may have led to the underestimation of the role of inhibitory control and exaggerated the functional differences between unbalanced versus balanced bilinguals, as well as between younger and older bilinguals. By implication, in natural conversation, bilinguals of different types (unbalanced/balanced, younger/older) may be more similar to each other than they are different, thereby reducing the need for special mechanisms that operate only in highly proficient (Costa & Santesteban, 2004), younger, and “perfect” bilinguals. At the same time, the presence of voluntary switch costs imply that bilingual language control mechanisms cannot be suspended to allow production of whichever language is more accessible. Even when switches are voluntary, some form of executive decision must be made with respect to which language will be produced (there is mandatory separation by language in bilingual lexical selection, as argued by Costa et al., 2006).

Our findings not only revealed the robustness of switch costs but also highlighted the importance of determining what causes naturally occurring switches, how they affect behavior outside the context of more controlled cued switches, and the ability of speakers to avoid paying some of the costs associated with switching when switches are not cued.

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Figure 1.

Mean reaction times (RTs; top panel) and error rates (bottom panel) for responses in the dominant-only, nondominant-only, and either-language picture-naming conditions for English-dominant bilinguals in Experiment 1. Responses in the either-language condition are shown separately by response language and by whether the response entailed a switch (based on the language bilinguals chose to use on the previous trial). Error bars show standard errors.

Balanced Bilinguals

Figure 2.

Mean reaction times (RTs; top panel) and error rates (bottom panel) for responses in the dominant-only, nondominant-only, and either-language picture-naming conditions for balanced bilinguals in Experiment 1. Responses in the either-language condition are shown separately by response language and by whether the response entailed a switch (based on the language bilinguals chose to use on the previous trial). Error bars show standard errors.

English global language mixing costs for English-dominant bilinguals by item type

Spanish global facilitation effects for English-dominant Bilinguals by item type

Figure 3.

Mean reaction times (RTs) for English-naming times (top panel) and Spanish-naming times (bottom panel) in language selective conditions versus stay trials from the either-language condition for pictures that were often named in Spanish (easy), sometimes named in Spanish (medium difficulty), and never named in Spanish (difficult) in the either-language condition. Error bars show standard errors. Voluntary language-mixing costs to English, and mixing facilitation to Spanish, were similarly sized across easy-, medium-, and difficult-to-name pictures.

English-dominant bilinguals

Figure 4. Mean reaction times (RTs; top panel) and error rates (bottom panel) for responses in the dominant-only, nondominant-only, and fifty-percent picture-naming conditions for English-dominant bilinguals in Experiment 2. Error bars show standard errors.

Figure 5.

Mean CELEX frequency of picture names produced in the dominant language (English; top panel) and in the nondominant language (Spanish; bottom panel) for responses in language selective and language-mixed conditions of Experiment 1 (either-language) and Experiment 2 (fifty-percent). Error bars show standard errors.

Figure 6. Mean reaction times (RTs; top panel) and error rates (bottom panel) for responses in the dominant-only, nondominant-only, and either-language picture-naming conditions for proficiency-matched younger and older English-dominant bilinguals in Experiment 3. Error bars show standard errors.

Figure 7.

Mean reaction times (RTs; top panel) and error rates (bottom panel) for responses in the dominant-only, nondominant-only, and either-language picture-naming conditions for strong-Spanish younger and older bilinguals in Experiment 3. Error bars show standard errors.

Figure 8.

The relationship between language-switching rates and the degree of language dominance as measured by reaction time (RT) difference scores. The x -axis represents the difference between mean RTs in the nondominant language minus mean RTs in the dominant language from the language selective conditions. Smaller differences (farther to the left) indicate more similar naming times in the two languages. The y -axis represents voluntary language-switching rates from the either-language condition. Older bilinguals' data (from Experiment 3) are shown with circles and the solid regression line. Younger bilinguals' data (from Experiment 1) are shown with triangles and the dotted regression line. The figure shows that bilinguals with more similar naming times in the two languages switched languages more frequently than bilinguals with one clearly dominant (faster) language.

Figure 9.
Mean voluntary language-switching rates for bilinguals tested in the either-language condition before and after the Spanish-only condition.

Table 1
Means and Standard Deviations of Participant Characteristics in Experiments 1 and 2

Participant characteristic	Experiment 1: English-dominant bilinguals (<i>n</i> = 57)		Experiment 1: Balanced bilinguals (<i>n</i> = 16)		Experiment 2: English-dominant bilinguals (<i>n</i> = 37)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Age	19.9	2.5	22.8	4.1	19.8	1.5
Percentage of daily use of English ^a	88.1	11.4	59.8	28.2	87.8	12.9
Age first exposed to English	2.3	2.4	8.9	5.0	2.9	2.3
Age exposed to Spanish	0.4	1.5	0.4	0.6	0.4	0.8
English self-rated speaking ^b	6.8	0.5	5.5	0.7	6.7	0.7
Spanish self-rated speaking ^b	5.7	1.3	6.9	0.5	5.6	1.2

^aPercentage of daily Spanish use is 100 minus the amount reported in this row.
^bProficiency level based on self-ratings using a scale ranging from 1 (*little to no knowledge*) to 7 (*being like a native speaker*).

Table 2

Switching Rates for Each Bilingual Type and Instruction Type in Experiments 1–3

Instruction type	Experiment	Bilingual type	<u>Switching rate</u>	
			<i>M</i>	<i>SD</i>
Either-language	Experiment 1	English-dominant ($n = 57$)	24	19
Either-language	Experiment 1	Balanced ($n = 16$)	35	20
Fifty-percent	Experiment 2	English-dominant ($n = 37$)	52	13
Either-language	Experiment 3	Older proficiency-matched ($n = 15$)	33	16
Either-language	Experiment 3	Younger proficiency-matched ($n = 15$)	22	15
Either-language	Experiment 3	Older strong-Spanish ($n = 10$)	25	14
Either-language	Experiment 3	Younger strong-Spanish ($n = 10$)	37	11

Note. Data reflect 44 trials. The first naming response was counted as a “stay” trial.

Table 3

Average Number of Trials in Each of the Four Cells in the Either-Language Condition for Each Language-Mixing Pattern in Experiments 1 and 3

Matrix language	Language-mixing type	English		Spanish	
		Stay	Switch into	Stay	Switch into
English	Bail out of Spanish (stay > switch only in English)	30.7	5.2	2.8	5.3
English	Stay > switch in both languages	27.6	5.3	6.4	4.7
English	No switches	44	0	0	0
English	Switch ≥ stay in both languages ^a	12	14	4	14
Spanish	Bail out of English (stay > switch only in Spanish)	3.8	6.6	26.9	6.7
Spanish	Stay > switch in both languages	9.8	5.3	23.5	5.5
None	Bail out of English (stay > switch only in Spanish)	8.7	11	13.3	11
None	Bail out of Spanish (stay > switch only in English)	13.2	10.8	9	11
None	Stay > switch in both languages	14.1	8.3	13.2	8.4
None	Switch ≥ stay in both languages	7	14.7	7.3	15

Note. Data reflect 44 trials. The first naming response was counted as a “stay” trial.

^aThis mixing pattern occurred only once with English as the matrix language, and only in Experiment 2.

Table 4

The Number of Bilinguals Who Used Each Language-Mixing Pattern

Instruction type	Bilingual type & exp.	English matrix language			Spanish matrix language			No matrix		
		Bail out of Spanish	Stay > switch	No switch	Switch ≥ stay	Bail out of English	Stay > switch	Bail out of English	Bail out of Spanish	Switch ≥ stay
Either-language	English-dominant: Exp. 1 (<i>n</i> = 57)	31	8	8	0	1	0	2	0	2
Either-language	Balanced: Exp. 1 (<i>n</i> = 16)	4	0	1	0	6	0	0	1	1
Fifty-percent	English-dominant: Exp. 2 (<i>n</i> = 37)	9	1	0	1	0	0	0	6	13
Either-language	Older proficiency-matched: Exp. 3 (<i>n</i> = 15)	6	2	0	0	0	0	1	2	0
Either-language	Younger proficiency-matched: Exp. 3 (<i>n</i> = 15)	9	4	0	0	0	0	0	0	0
Either-language	Older strong-Spanish: Exp. 3 (<i>n</i> = 10)	3	0	0	0	2	3	0	1	0
Either-language	Younger strong-Spanish: Exp. 3 (<i>n</i> = 10)	3	0	0	0	2	1	0	1	0

Note. Switching rate is the total number of trials involving a change in language relative to the previous trial divided by the number of trials (i.e., 44). Exp. = experiment.

Characteristics of Picture Names Never, Sometimes, and Often Named in Spanish by English-Dominant Bilinguals in the Either- Language Condition in Experiment 1

Table 5

Characteristic of picture name	Proportion of time used Spanish (the nondominant language) in the either-language condition			
	Never (0%) (n = 22)	Sometimes (5%–39%) (n = 86)	Often (43%–67%) (n = 24)	p
CELEX English name frequency/million	27	58	182	4.24 < .01
Number of phonemes in English name	3.95	4.26	3.38	1.25 .13
Number of phonemes in Spanish name	5.77	5.95	4.67	2.40 .02
Mean RT in English-only condition	1,052	1,017	881	3.79 < .01
Mean RT in Spanish-only condition	1,655	1,407	1,089	5.05 < .01
Error rate in English-only condition	0.08	0.04	0.01	2.95 < .01
Error rate in Spanish-only condition	0.20	0.10	0.01	6.04 < .01

Note. RT= reaction time.

^adf = 44.

^bDifference between “Never” and “Often” columns.

Table 6

Means and Standard Deviations of Participant Characteristics in Experiment 3

Participant characteristic	Older mixed dominance (<i>n</i> = 25)		Younger mixed dominance (<i>n</i> = 25)		Older proficiency-matched (<i>n</i> = 15)		Younger proficiency-matched (<i>n</i> = 15)		Older strong-Spanish (<i>n</i> = 10)		Younger strong-Spanish (<i>n</i> = 10)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Age	74.5	7.4	20.4	2.8	75.6	8.0	19.3	1.4	72.8	6.6	22.2	3.6
Education	12.2	3.0	14.2	1.6	13.2	2.4	13.5	1.3	10.7	3.2	15.3	1.4
Percentage of daily use of English ^a	52.4	34.6	78.4	22.0	76.4	20.8	87.2	12.0	18.7	16.8	65.2	27.3
Age exposed to English	7.9	7.5	4.6	4.6	3.5	4.2	1.8	2.1	14.5	6.5	8.7	4.5
Age exposed to Spanish	0.3	1.5	0.6	2.1	0.5	1.9	1.0	2.6	0	0	0.1	0.3
English self-rated speaking ^b	5.2	1.4	6.4	0.8	5.9	1.0	6.9	0.3	4.2	1.3	5.7	0.7
Spanish self-rated speaking ^b	5.4	1.2	6.2	1.2	4.8	1.0	5.7	1.3	6.3	0.8	7.0	0
Percentage translated into English	71.6	15.2	81.8	7.0	74.5	13.0	79.5	7.2	67.3	17.8	85.4	5.1
Percentage translated into Spanish	72.6	10.1	72.1	11.5	67.4	9.0	66.2	10.8	80.5	8.1	80.9	5.3

^aPercentage of daily Spanish use is 100 minus the amount reported in this row.^bProficiency level based on self-ratings using a scale ranging from 1 (*little to no knowledge*) to 7 (*like a native speaker*).