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Research Article

Losing Access to the Native Language While Immersed in a Second Language

Evidence for the Role of Inhibition in Second-Language Learning

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ABSTRACT—*Adults are notoriously poor second-language (L2) learners. A context that enables successful L2 acquisition is language immersion. In this study, we investigated the effects of immersion learning for a group of university students studying abroad in Spain. Our interest was in the effect of immersion on the native language (L1), English. We tested the hypothesis that immersion benefits L2 learning as a result of attenuated influence of the L1. Participants were English-speaking learners of Spanish who were either immersed in Spanish while living in Spain or exposed to Spanish in the classroom only. Performance on both comprehension and production tasks showed that immersed learners outperformed their classroom counterparts with respect to L2 proficiency. However, the results also revealed that immersed learners had reduced L1 access. The pattern of data is most consistent with the interpretation that the L1 was inhibited while the learners were immersed.*

An important discovery in recent studies of language processing in bilinguals and second-language learners is that the native language (L1) and the second language (L2) appear to be active simultaneously during reading, listening, and speaking (e.g., Dijkstra & Van Heuven, 2002; Kroll, Sumutka, & Schwartz, 2005; Marian & Spivey, 2003). It is surprising that cross-language activity occurs in speaking because the initiation of the plan for a spoken utterance is under the control of the speaker (e.g., Kroll, Bobb, & Wodniecka, 2006). But it is even more surprising that the parallel activity of the bilingual's two languages extends to languages that are as dissimilar as English and Japanese (e.g., Hoshino & Kroll, 2008), to spoken and signed languages (e.g., Emmorey, Borinstein, Thompson, & Gollan, 2008), and to the most proficient bilinguals (Christoffels, De Groot, & Kroll, 2006). Cross-language activation has been documented extensively at the level of the lexicon (for a review, see Dijkstra, 2005), but it also affects grammar (e.g., Dussias & Sagarra, 2007).

If both languages are always active and speakers have no simple mechanism to turn off one of the languages when using the other, then bilinguals must solve a cognitive problem in order to use the intended language, to code-switch at will with other similar bilinguals, and to avoid random errors involving the unintended language. Recent evidence suggests that the skill acquired in negotiating cross-language competition may confer positive cognitive consequences in the realm of executive function (e.g., Bialystok, Craik, & Ryan, 2006; Colzato et al., 2008; Costa, Hernandez, & Sebastián-Gallés, 2008). Although little direct evidence provides a causal link between the competitive nature of cross-language processing and the cognitive advantages attributed to bilingualism, these advantages may arise, at least in part, through the expertise that bilinguals develop in response to the need to negotiate the parallel activity of the two languages.

Adult learners often struggle to acquire any level of proficiency in a second language. The past literature has focused on constraints on L2 acquisition that have been hypothesized to

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result from a biologically sensitive period for language learning (e.g., Johnson & Newport, 1989). However, given the observation that it may be difficult or nearly impossible for adult L2 learners to turn off their highly dominant L1 when processing the L2, the observed effects of age of acquisition may in fact be driven by competition between the two languages (e.g., Jia, Aaronson, & Wu, 2002). One context that seems to promote adult L2 acquisition in face of this competition is the immersion environment. There is limited but encouraging evidence that studying abroad may enhance the learning process (e.g., Freed, 1995), but little is known about the dynamics of the cognitive system of the learner within such a context. The study we report tested the hypothesis that immersion facilitates L2 learning because it enables adult learners to attenuate the activity of the L1.

Using the retrieval-induced forgetting paradigm, Levy, McVeigh, Marful, and Anderson (2007) showed that increased use of the L2 was associated with subsequent inhibition of the L1. In that study, increased use of the L1 or L2 was achieved by having participants repeatedly name pictures in one language or the other. When participants were later presented a phonological cue in the L1 (e.g., "break—s___" to cue "snake"), they generated significantly fewer target words (e.g., "snake") if they had previously named the corresponding picture in the L2 than if they had previously named it in the L1. If a few trials are sufficient to induce inhibition of the L1 in the laboratory, then actual language immersion might be expected to have even more dramatic effects on L1 access.

The present study compared the performance of two groups of native English-speaking university students at an intermediate level of acquiring Spanish as an L2. One group was immersed in a Spanish-speaking environment during a semester abroad in Spain, and the other was studying Spanish in the classroom at their home university. Learners in each group performed a comprehension task (*translation recognition*) designed to engage both languages and a production task (*verbal fluency*) which was conducted separately in English and Spanish.

In translation recognition (De Groot, 1992), a word in Spanish was followed by a word in English, and participants were asked to indicate whether the English word was the correct translation of the Spanish word. Among the English words that were not correct translations, there were distractors that were similar to the correct Spanish translations either in lexical form or in meaning. Past research has shown that with increasing L2 proficiency, learners become less sensitive to distractors that resemble the correct translation in form (e.g., Sunderman & Kroll, 2006; Talamas, Kroll, & Dufour, 1999). If immersion enhances L2 proficiency more than classroom learning alone, then the immersed learners in our study would be less likely than the classroom learners to be fooled by such translation-neighbor distractors. Past research has also suggested that learners in both groups would find it more difficult to reject word pairs that were not correct translations but were semantically related than to reject word pairs that were not semantically related (e.g., Sunderman & Kroll, 2006; Talamas et al., 1999).

In addition to the two conditions used by Talamas et al. (1999), we included a condition in which English distractors were directly related to the lexical form of the presented Spanish word (see also Sunderman & Kroll, 2006). This lexical-neighbor condition resembled conditions of bilingual word-recognition experiments that have shown that cross-language neighbors influence word recognition even among the most proficient bilinguals (e.g., Dijkstra, 2005; Sunderman & Kroll, 2006). We predicted that if immersed learners were able to modulate the activity of the native language, they would also be less sensitive to lexical-neighbor distractors than classroom learners.

The production task was a verbal-fluency measure in which we asked participants to generate as many exemplars as possible from a designated semantic category. Past studies have shown that bilinguals generate fewer exemplars than monolinguals even when speaking their dominant language (e.g., Gollan, Montoya, & Werner, 2002), suggesting that simply having knowledge of multiple languages impacts verbal fluency. If the immersed learners had greater skill in the L2 than the classroom learners, they would be expected to produce a larger number of exemplars in Spanish. At the same time, if access to the L1 was reduced or inhibited in the immersed learners (e.g., Green, 1998), they would produce fewer exemplars in English than the classroom learners.

METHOD

Participants

The *immersed group* included 25 students from an American university; they were tested 3 months into a semester abroad in Spain. The *classroom group* included 20 students from the same American university; they were enrolled in intermediate-level Spanish language courses, but had no immersion experience. All participants were native English speakers.

Table 1 provides the characteristics of the two groups. They demonstrated similar levels of L2 proficiency both on their self-report ratings and on two on-line measures of L2 processing (overall accuracy and latencies of correct "yes" responses in the translation-recognition task). Nonetheless, we included both of the objective measures of L2 proficiency as covariates in all analyses to explicitly account for L2 proficiency in the models. The two groups were also similar on measures of cognitive ability that have been shown to be related to language processing, including working memory (e.g., Miyake & Friedman, 1998) and inhibitory control (e.g., Linck, Hoshino, & Kroll, 2008). Because immersion might be expected to improve measures of L2 proficiency (e.g., Freed, 1995), we matched the groups carefully so that, if anything, there was a bias for the classroom group to have had slightly more L2 experience or more enhanced cognitive ability than the immersed group. Thus, group differences reported for the critical language-processing tasks can be more clearly attributed to the nature of the immersion experience rather than to a preexisting advantage for the immersed

TABLE 1

Characteristics of the Participant Groups

Characteristic	Immersed group	Classroom group
Number of participants	25	20
Age (years)	20.6	21.2**
University semesters of Spanish study	3.9	5.7**
Translation recognition		
Overall accuracy	87.9%	86.6%
Mean latency of correct "yes" judgments (ms)	771	827
Self-rated proficiency in English[a,b]		
Reading	9.3	9.8**
Writing	8.9	9.6*
Speaking	9.5	9.8
Listening	9.7	9.8
Self-rated proficiency in Spanish[a]		
Reading	6.3	6.7
Writing	6.1	6.8
Speaking	6.0	5.8
Listening	7.2	6.7
Working memory capacity (number recalled)[c]	51.5	51.8
Simon effect (ms)[d]	38	20**

[a]Ratings were made on a 10-point scale ranging from 1 (*not proficient*) to 10 (*highly proficient*). [b]Two immersed students and 1 classroom student did not provide self-ratings for their English proficiency; thus, mean values for the immersed and classroom groups were based on sample sizes of 23 and 19, respectively. [c]Working memory was measured as the number of correctly recalled to-be-remembered words out of 80 possible. [d]The Simon effect indicates the amount of interference due to a mismatch between the stimulus and response locations.
*$p_{rep} > .95$. **$p_{rep} > .99$.

TABLE 2

Distractors Used for the Pair "Cara–Face" in the Translation-Recognition Task

Grammatical class	Lexical neighbors	Translation neighbors	Semantic neighbors
Same	card	fact	head
Different	care	fast	pretty

Note. Each participant saw only one of the six possible distractors for "cara" during the task. When a word fell into multiple grammatical classes, the most frequent grammatical class was used for purposes of classification (i.e., the frequency of *care* as a verb is greater than that of *care* as a noun).

learners and, in fact, may underestimate the true advantage for the immersed learners.

Materials and Procedure

Participants performed two linguistic tasks (translation-recognition and verbal-fluency tasks) and two cognitive tasks (reading-span and Simon tasks). The materials and procedure for the translation-recognition task were taken from Sunderman and Kroll (2006). Two words were presented one after the other, the first in Spanish and the second in English, and participants were instructed to indicate with a button press whether the two words were translation equivalents. The stimuli included correct translations (e.g., "cara–face") that required a "yes" response and distractors that required a "no" response.

Three critical-distractor conditions were included. In the *lexical-neighbor condition*, distractors were words that were similar in form to the Spanish word with which they were paired (e.g., "cara–card"). In the *translation-neighbor condition*, distractors were words that were similar in form to the English translation of the Spanish word (e.g., "cara–fact"). In the *semantic-neighbor condition*, distractors were words that were related in meaning to the Spanish word (e.g., "cara–head"). In all conditions, half of the word pairs came from the same grammatical class (e.g., noun–noun) and half came from different grammatical classes (e.g., noun–adjective). Each condition included its own unrelated control words, which were incorrect translations that were unrelated to the Spanish word in lexical form and meaning and unrelated to the correct English translation in lexical form. These control words were matched item by item to the related, critical distractors on word length and word frequency (for a detailed description of the task and the item-matching procedure, see Sunderman & Kroll, 2006). Table 2 provides examples of same- and different-grammatical-class stimuli in the three distractor conditions (lexical neighbor, translation neighbor, and semantic neighbor); six experimental word lists were created to counterbalance stimuli across distractor condition and grammatical class. If performance was significantly slower on *critical distractor trials* than on the matched, unrelated control word trials, we could conclude that the lexical form or semantic relatedness of the distractors impaired the participant's ability to make a "no" response.

To measure L1 and L2 production abilities, we asked participants to perform the verbal-fluency task (e.g., Gollan et al., 2002) in English and Spanish. In this task, a series of category names (i.e., *animals*, *clothing*, *fruits*) was presented one at a time, and the participants were instructed to produce as many category exemplars as possible in 30 s. Language of production was blocked such that participants completed the task for all categories in one language before switching to the other language: The immersed learners performed the verbal-fluency task in the L2 first and the L1 second, and the classroom learners did the task in the L1 first and the L2 second.

In addition, participants performed the Simon (e.g., Simon & Rudell, 1967) and reading-span (Waters & Caplan, 1996) tasks, our measures of individual differences in cognitive processing. In the Simon task, participants viewed a series of colored boxes presented left or right of fixation and had to make a left or right button press based on stimulus color (not location). In the critical incongruent trials (when the location of the stimulus and the location of the response do not match), responses are typically slower than on congruent trials (when stimulus and response locations match) because of the need to inhibit the prepotent tendency to respond based on stimulus location. The degree of interference on incongruent trials (termed the *Simon effect*) is taken as a measure of inhibitory control. In the reading-span task, participants read a series of sentences and made judgments about the plausibility of each sentence. Immediately following each plausibility judgment, a to-be-remembered word was briefly presented. After two to six sentence-word pairs were presented, participants had to recall the list of to-be-remembered words from that sequence. Working memory span was measured as the total number of successfully recalled to-be-remembered words across a series of sentence-word pairs.

TABLE 3

Mean Accuracy on the Translation-Recognition Task

Distractor condition	Immersed group	Classroom group
Lexical neighbors		
Distractor	92.5	91.8
Matched control	93.2	93.4
Semantic neighbors		
Distractor	86.2	90.3
Matched control	93.0	94.0
Translation neighbors		
Distractor	93.7	91.5
Matched control	93.0	92.5

Note. The table lists the percentage of trials with correct responses.

Analysis

In line with recent calls in the literature to account for subject and item effects in the same analysis (e.g., Brysbaert, 2007), we analyzed the data from the translation-recognition task using multilevel modeling (MLM), an advanced regression analysis. An alternative to traditional repeated measures analysis of variance (ANOVA), MLM allows subject and item effects to be included in the same regression model, thereby potentially solving the language-as-fixed-effect fallacy (for a detailed discussion of the benefits of employing MLM in psycholinguistic studies, see Locker, Hoffman, & Bovaird, 2007). Moreover, MLM does not require aggregation across trials. Because the translation-neighbor condition has demonstrated L2 proficiency effects more reliably than the other conditions in previous studies (e.g., Sunderman & Kroll, 2006), we first modeled participants' reaction times (RTs) in the translation-neighbor condition as a function of two within-subjects fixed factors (relatedness: related vs. unrelated; grammatical class: same vs. different) and one between-subjects fixed factor (group: immersed vs. classroom). In a second analysis, we modeled RTs in the lexical- and semantic-neighbor conditions as a function of relatedness, grammatical class, group, and the within-subjects fixed factor of distractor type (lexical neighbor vs. semantic neighbor). Preliminary models indicated that both subjects and items as random effects improved the fit of the models, and thus both were included in the error structure of the final models reported here.

Table 3 shows the mean accuracy for critical distractor and control items in all three distractor conditions. Trials with outlying RTs (i.e., below 300 ms or above 3,000 ms) or incorrect responses were excluded from the analyses. In the translation-neighbor condition, 6.8% and 7.7% of trials were excluded, and in the lexical-neighbor and semantic-neighbor conditions, 11.4% and 10.0% of trials were excluded (for the immersed and classroom learners, respectively). We report standard ANOVA results for the verbal-fluency task.[1]

[1]In the verbal-fluency task, each participant generates a unique pattern of items. Thus, item analyses of the sort typical in RT tasks are not suitable.

RESULTS

The results of the final MLM analyses for the translation-recognition task are presented in Table 4. In preliminary analyses, both L2 proficiency factors (overall accuracy and latencies of correct "yes" responses in the translation-recognition task) improved the fit of the models, significantly accounting for unique variance in RTs. Critically, the substantive predictors (relatedness, grammatical class, distractor type, and group) further improved the fit of the models; thus, these factors accounted for variance left unexplained by L2 proficiency. Therefore, group differences likely reflect differences in language-learning experience (i.e., immersion) and not simply differences in L2 proficiency.

In the analysis of the translation-neighbor condition, the factors of group, grammatical class, and their higher-order interactions did not improve the fit of the model, and so their main and interaction effects were removed from the model. Thus, the best-fitting model included only the effect of relatedness (see Table 4), which was marginally significant, $p_{rep} = .91$. That is, participants in both groups suffered translation distractor interference, which has been taken as evidence of the occurrence of primarily lexically mediated processing in a backward translation task (e.g., Sunderman & Kroll, 2006). Although the relatedness effect did not significantly interact with group in the analysis, a trend in the magnitude of translation neighbor interference suggested that the immersed learners ($M = 25$ ms) shifted away from lexically mediated processing relative to the classroom learners ($M = 65$ ms; see Fig. 1). This small but reliable translation-neighbor distractor effect for the immersed learners replicated previous findings with moderately proficient learners (Sunderman & Kroll, 2006; Talamas et al., 1999) and suggests that the immersed learners in our study were not as proficient as Sunderman and Kroll's higher-proficiency learners, who had previously lived abroad and had spent more time on L2 study.

In the analysis of the lexical-neighbor and semantic-neighbor conditions, the best-fitting model included all four factors and their interactions (see Table 4). A reliable simple effect of relatedness was qualified by the Relatedness × Distractor Type

TABLE 4

Estimated Coefficients From the Multilevel Model Analyses of Translation-Recognition Reaction Times

	Analysis	
Parameter	Translation-neighbor condition	Lexical- and semantic-neighbor conditions
Fixed effects		
Intercept	966.8 (22.2)**	1,003.1 (38.9)**
Accuracy	−21.4 (4.8)**	−18.2 (4.3)**
Mean "yes" RT	0.7 (0.1)**	0.8 (0.1)**
Relatedness	−42.4 (22.1)†	−86.2 (43.8)*
Class	—	18.7 (44.6)
Distractor	—	−84.4 (44.0)†
Group	—	−74.9 (51.5)
Relatedness × Class	—	−70.1 (59.6)
Relatedness × Distractor	—	142.8 (59.2)*
Relatedness × Group	—	53.2 (54.7)
Class × Distractor	—	63.6 (60.0)
Class × Group	—	24.3 (55.7)
Distractor × Group	—	97.3 (55.5)†
Relatedness × Class × Distractor	—	−54.0 (82.0)
Relatedness × Class × Group	—	43.0 (74.7)
Relatedness × Distractor × Group	—	−155.4 (74.7)*
Class × Distractor × Group	—	−122.7 (75.6)
Relatedness × Class × Distractor × Group	—	83.6 (103.3)
Random effects		
Subjects	11,197.9 (3,190.5)**	9,696.4 (2,475.9)**
Items	7,826.9 (2,551.0)**	10,830.3 (2,042.4)**
Residual	107,095.7 (4,572.9)	101,947.4 (3,146.4)

Note. The table lists maximum likelihood estimates. Standard errors are in parentheses. "Relatedness" refers to the form or semantic relatedness of the word pair (critical distractor vs. control), "class" refers to grammatical class (same vs. different), "distractor" refers to distractor type in the analysis of the lexical- and semantic-neighbor conditions (lexical neighbor vs. semantic neighbor), and "group" refers to language group (immersed vs. classroom learners). Accuracy was calculated as the overall proportion correct. "Yes" RT was the reaction time on correct "yes" trials.
†$p_{rep} > .87$. *$p_{rep} > .95$. **$p_{rep} > .99$.

interaction, which confirmed that the magnitude of distractor interference differed for lexical-neighbor and semantic-neighbor distractors. Critically, these effects were qualified by the significant three-way interaction of relatedness, distractor type, and group, which suggests that the immersed and classroom learners showed different patterns of lexical-neighbor and semantic-neighbor distractor interference. Indeed, an examination of the magnitude of distractor interference (see Fig. 2) suggests that the immersed and classroom learners performed this task in two distinct ways. The immersed learners appeared to process the L2 more deeply, showing greater sensitivity to semantic-neighbor distractors, but suffered no lexical neighbor interference, a result that has not been found in past studies using this task. Given the relatively automatic nature of L1 activation in L2 word recognition (e.g., Dijkstra & Van Heuven, 2002), the finding that the immersed learners were unaffected by the high perceptual overlap of the lexical-neighbor distractors suggests that they inhibited their L1. This is clearly not an effect of L2 proficiency alone, but rather reflects a change in L1 processing during L2 immersion.

To analyze verbal fluency, we performed a 2 × 2 analysis of covariance (ANCOVA) on the total number of exemplars produced by the participants across categories (see Fig. 3). The ANCOVA involved the between-subjects factor of group, the within-subjects factor of language (English vs. Spanish), and the overall proportion correct in translation recognition as a covariate to control for differences in L2 proficiency. After factoring out the significant amount of variance accounted for by the covariate, $F(1, 42) = 8.04$, $p_{rep} = .97$, $\eta_p^2 = .16$, there was a main effect of language: Participants produced more exemplars in English than in Spanish, $F(1, 42) = 5.36$, $p_{rep} = .94$, $\eta_p^2 = .11$. The interaction between language and group was significant, $F(1, 42) = 42.19$, $p_{rep} > .99$, $\eta_p^2 = .50$. Follow-up ANCOVAs confirmed that the immersed learners produced significantly more Spanish (L2) exemplars than the classroom students, $F(1, 44) = 14.68$, $p_{rep} > .99$, $\eta_p^2 = .26$, but significantly fewer English (L1) exemplars, $F(1, 44) = 18.46$, $p_{rep} > .99$, $\eta_p^2 = .31$. These results provide further evidence of impairments to L1 processing as a consequence of L2 immersion.

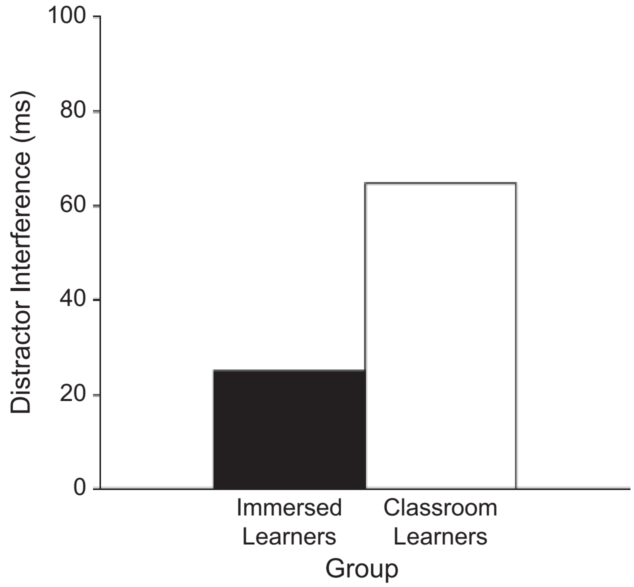

Fig. 1. Degree of translation interference for immersed and classroom learners. Translation interference was calculated as the difference in mean reaction time between translation-neighbor distractors and matched control words.

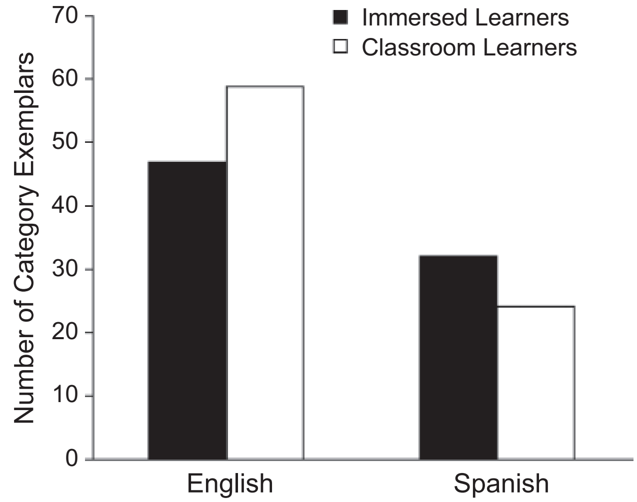

Fig. 3. Average number of exemplars produced by the immersed and classroom learners in the English and Spanish verbal-fluency tasks.

DISCUSSION

The results of the current study suggest that access to the L1 is attenuated during language immersion. In both comprehension and production, the L1 was less accessible for the immersed learners than for the classroom learners: In translation recognition, the immersed learners showed no sensitivity to lexical-neighbor distractors, and in the verbal-fluency task, they produced significantly fewer category exemplars in L1 than the classroom learners. Group differences in both tasks remained even after controlling for differences in objective measures of L2 proficiency. Because previous studies of translation recognition have reported lexical neighbor interference regardless of proficiency level (e.g., Sunderman & Kroll, 2006), the observed insensitivity to lexical-form overlap is a novel result that may be uniquely associated with decreased L1 activation in the immersion context.

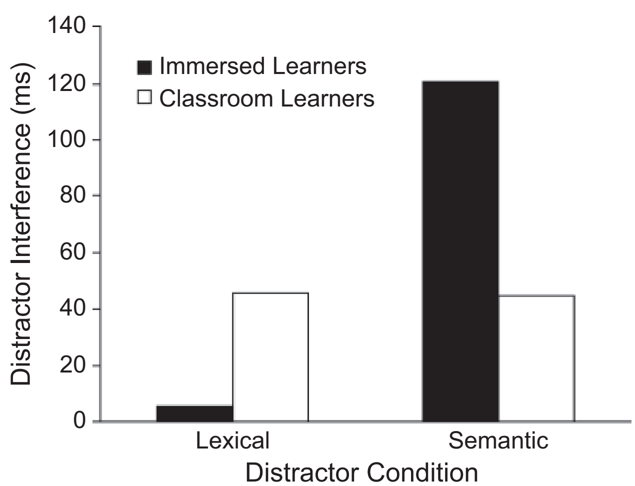

Fig. 2. Lexical and semantic interference for immersed and classroom learners. Lexical interference was calculated as the difference in mean reaction time between lexical-neighbor distractors and matched control words, and semantic interference was calculated as the difference in mean reaction time between semantic-neighbor distractors and matched control words.

Might these effects have been caused by a reduction in L1 use in the immersion context—and not by inhibition of the L1? Such an account would be congruent with recent claims that, because bilinguals are likely to use either of their languages less often than monolinguals use their one language, lexical representations in each language have a reduced functional frequency and therefore are less easily accessed (i.e., the "weaker links" hypothesis; Gollan, Montoya, Fennema-Notestine, & Morris, 2005). The L2 immersion experience, in which learners reported using the L2 daily (although not exclusively), may have reduced the functional frequency of the immersed learners' L1, thereby making the L1 appear to be inhibited when in fact it was not.

A related alternative account is that increased L2 use during immersion may have shifted the learners into an L2 mental set. Indeed, studies of language switching have found that simply naming a few pictures in the L2 induces an L2 mental set that renders the L1 less accessible, to the point that it becomes more difficult to switch into the more dominant L1 than into the less dominant L2 (e.g., Meuter & Allport, 1999; but see Kroll, Bobb, Misra, & Guo, 2008, for a discussion of the challenges to that interpretation). By both the weaker links and the L2 mental set accounts, the difficulty in accessing the L1 should be reduced after immersed learners return home to an L1-dominant context. If instead the changes in L1 accessibility reflect a shift toward an inhibitory processing strategy, then these effects may persist even outside of the immersion context.

To address this question, we retested a subset of the immersed learners ($n = 14$) on the same language-processing tasks 6

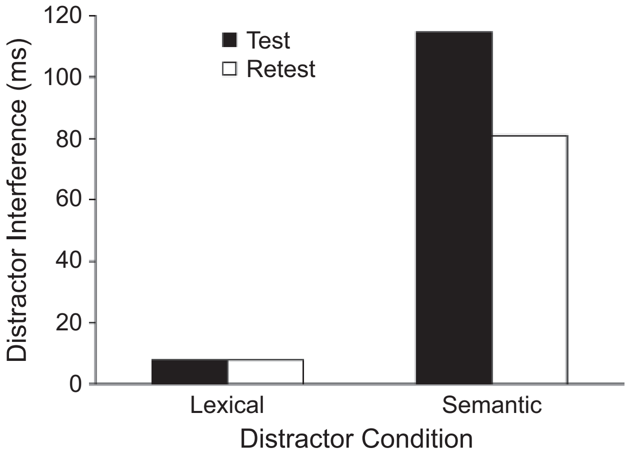

Fig. 4. Lexical and semantic interference, at both test and retest, for the 14 immersed learners retested 6 months after returning home. Lexical interference was calculated as the difference in mean reaction time between lexical-neighbor distractors and matched control words, and semantic interference was calculated as the difference in mean reaction time between semantic-neighbor distractors and matched control words.

months after they returned to the L1 environment (see Figs. 4 and 5 for this subset's test-retest data). In translation recognition, participants remained insensitive to the lexical-neighbor distractors. In verbal fluency, they maintained their production skills in the L2, whereas their L1 performance rebounded at retest, such that the number of exemplars was similar to that originally produced by the classroom learners who had no immersion experience. Although the weaker-links hypothesis and the L2-mental-set hypothesis can readily explain the rebound in L1 verbal fluency, neither account can satisfactorily explain the persistent insensitivity to lexical interference in translation recognition. Sensitivity to lexical neighbors has been found in many past L2 word-recognition studies with highly proficient bilinguals, so our immersed learners' insensitivity at both test and retest is particularly striking.

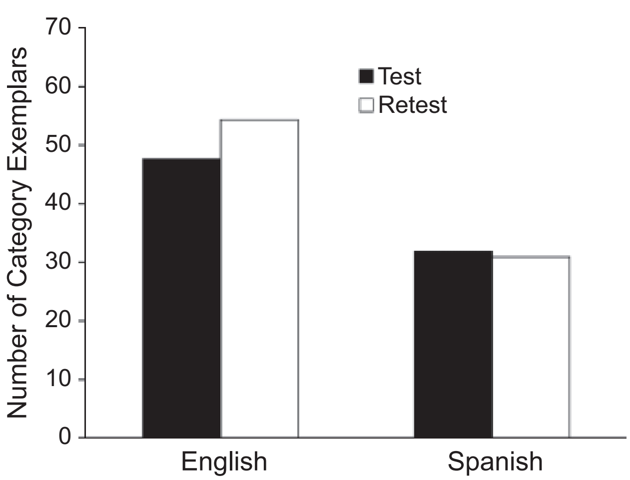

Fig. 5. Average number of exemplars produced in the verbal-fluency task by the 14 immersed learners when originally tested and when retested 6 months after returning home.

The retest patterns in both translation recognition and verbal fluency are compatible with the inhibitory account. In translation recognition, learners skillfully engaged an inhibitory control mechanism to reactively suppress the visually presented distractors from intruding on their judgments in both the immersion and L1-dominant testing contexts. In verbal fluency, the L1 was inhibited frequently during immersion to facilitate L2 use, making L1 lexical items more difficult to retrieve; after returning to the L1-dominant context, the need to frequently inhibit the L1 was gone and thus category exemplars were more readily retrieved.

The insensitivity to lexical-neighbor distractors found at test and retest is potentially congruent with the revised hierarchical model (RHM), according to which the connections between concepts and their L2 lexical representations are strengthened with increasing L2 proficiency (Kroll & Stewart, 1994). Although the RHM focuses on the links between translation equivalents, one can speculate that L1 inhibition within the immersion environment may have the consequence of allowing stronger lexical-conceptual links to develop, making learners more resistant to L1 lexical competition at multiple levels during translation recognition upon returning home to the L1-dominant environment.

Such an account is not incompatible with the inhibitory account. In fact, L1 inhibition during immersion learning may facilitate the strengthening of these lexical-conceptual links by inhibiting the direct L2-L1 lexical links. The current translation-recognition data do not support either of these two complementary hypotheses more than the other. However, the decrease in L1 verbal-fluency performance found during L2 immersion is not accounted for by the link-strengthening account. Taken together, the current comprehension and production results are most parsimoniously explained by an inhibitory account.

Evidence on linguistic convergence in highly proficient bilinguals has been reported at the level of phonology (e.g., Bullock & Gerfen, 2004), syntax (e.g., Dussias, 2003), and the lexicon (e.g., Ameel, Storms, Malt, & Sloman, 2005). Like the present study, these previous studies showed that not only the L2 but also the L1 is affected by language contact. They suggest a high degree of cross-language interaction and modulation even after proficiency in the L2 has been achieved. The results of the present study provide further evidence that the process of L2 learning affects the processing of the L1. Only a few past studies have examined the consequences of L2 learning for the L1, and the results of those studies, primarily with classroom learners, indicate that L2 learning imposes a processing cost for the L1 (e.g., Kroll, Michael, Tokowicz, & Dufour, 2002). The apparent inhibition of L1 during language immersion may represent an extreme version of these processing costs. This will clearly be an important focus in future research.

The present results also converge with an emerging body of evidence from both behavioral and neuroimaging studies implicating inhibitory mechanisms in proficient bilingual language processing (e.g., Abutalebi & Green, 2007; Kroll et al., 2008).

Recent developments in the cognitive literature highlight the need for a more highly differentiated view of executive functioning (e.g., Fournier-Vicente, Larigauderie, & Gaonac'h, 2008; Friedman & Miyake, 2004). In this spirit, recent studies have attempted to more precisely characterize the consequences of bilingualism for inhibitory control (e.g., Bialystok et al., 2006; Colzato et al., 2008; Levy et al., 2007). It is clear that further work is needed to advance a more nuanced account of the role of inhibitory mechanisms in bilingual language processing. Such theoretical developments will advance understanding of the cognitive mechanisms supporting L2 acquisition and use while also informing and constraining current theories of executive functioning more broadly.

CONCLUSIONS

We used on-line measures of language processing to examine the specific benefits to L2 learning that are acquired during language immersion. The results suggest that the process of acquiring an L2 has consequences for the learner's native language. In particular, data from comprehension and production tasks suggest that immersed learners inhibit the L1 while in the L2 context. It will be important for future research to further specify the means by which inhibition supports the acquisition of L2 skill and the precise locus of these effects. It will also be important to relate the present findings, based on a relatively brief immersion experience, to the reports of language attrition among immigrant populations who are more permanently placed in an L2 environment (e.g., Jia et al., 2002).

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