Research Report

Inhibiting Your Native Language

The Role of Retrieval-Induced Forgetting During Second-Language Acquisition

Benjamin J. Levy,[1] Nathan D. McVeigh,[1] Alejandra Marful,[2] and Michael C. Anderson[1]

[1]University of Oregon and [2]University of Salamanca, Salamanca, Spain

ABSTRACT—*After immersion in a foreign language, speakers often have difficulty retrieving native-language words—a phenomenon known as first-language attrition. We propose that first-language attrition arises in part from the suppression of native-language phonology during second-language use, and thus is a case of phonological retrieval-induced forgetting. In two experiments, we investigated this hypothesis by having native English speakers name visual objects in a language they were learning (Spanish). Repeatedly naming the objects in Spanish reduced the accessibility of the corresponding English words, as measured by an independent-probe test of inhibition. The results establish that the phonology of the words was inhibited, as access to the concepts underlying the presented objects was facilitated, not impaired. More asymmetry between English and Spanish fluency was associated with more inhibition for native-language words. This result supports the idea that inhibition plays a functional role in overcoming interference during the early stages of second-language acquisition.*

Travelers immersed in a new language often experience a surprising phenomenon: Words in their native tongue grow more difficult to recall over time. Even words for everyday objects grow elusive, as speakers grope for sounds they had previously uttered without struggle. How can one forget, even momentarily, words used fluently for most of one's life? Here we offer an account of this ubiquitous experience that focuses on the interaction of executive-control mechanisms with long-term memory. We suggest that these dumbfounding lapses for native-language words may reflect an adaptive role of inhibitory control in hastening second-language acquisition.

Address correspondence to Ben Levy, Department of Psychology, 1227 University of Oregon, Eugene, OR 97403-1227, e-mail: blevy@uoregon.edu.

Many studies have documented first-language attrition, the forgetting of one's native tongue during second-language acquisition (e.g., de Bot, 1999; Seliger & Vago, 1991). This phenomenon affects vocabulary most strongly and is especially potent during second-language immersion, in which the native language is practiced infrequently. For example, Isurin (2000) described a native Russian speaker who did not practice Russian after being adopted by English speakers at age 9. In just 1 year, her Russian vocabulary declined 20%. Children adopted before age 9 and forced to change languages often, as adults, report no explicit memory of their native language, nor do they show implicit benefits for processing it (e.g., Pallier et al., 2003). These findings suggest that first-language attrition is related to disuse of one's native language and whatever passive forgetting mechanisms accompany that state (e.g., Olshtain & Barzilay, 1991; for a related argument, see Gollan & Acenas, 2004).

Although disuse may contribute to first-language attrition, it may also partly arise from the opposite circumstance: consistently expressing concepts with new phonological labels. Learning a new language requires learning a new word for nearly every object—a massive learning task. Fluently producing these new words entails a struggle against interference from one's native tongue. Unsurprisingly, novice speakers often access native-language words for objects immediately, even when the foreign word is desired (Colomé, 2001; Kroll & Stewart, 1994; see Fig. 1). This analysis suggests that first-language attrition may be related to a phenomenon known as retrieval-induced forgetting (RIF; Anderson, Bjork, & Bjork, 1994). Research on RIF indicates that when one retrieves a memory, inhibitory mechanisms suppress interfering traces (for reviews, see Levy & Anderson, 2002, and Anderson, 2003). In a standard RIF experiment, subjects study category-exemplar pairs (e.g., *fruits-orange*, *fruits-banana*, *drinks-bourbon*). They then practice retrieving half of the items from half of the studied categories (e.g., *fruits-orange*, but not *fruits-banana* or *drinks-bourbon*), and finally take a test in which they recall all studied exemplars. Unsurprisingly, practiced items are recalled more easily than

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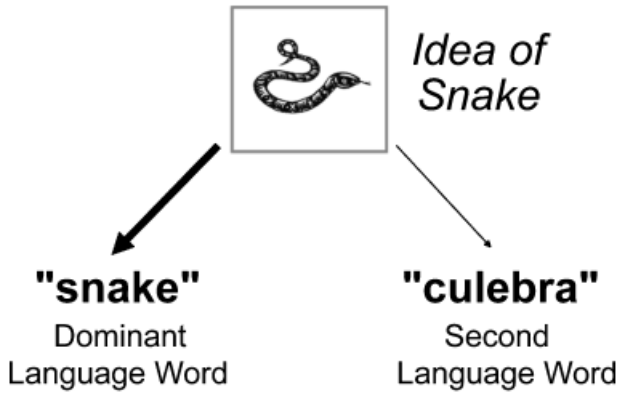

Fig. 1. The basic situation in which interlingual retrieval-induced forgetting occurs. When confronted with a visual stimulus or an internally generated thought, bilingual speakers have two possible verbal labels that compete for access. In this article, we explore the situation in which native speakers of English are learning Spanish. We propose that when they see a picture of a snake and try to recall the nondominant Spanish label (*culebra*), they must inhibit the more accessible phonology of the English label (strength of association is indicated by the thickness of the lines).

items from unpracticed categories (baseline items; e.g., *drinks-bourbon*). More interestingly, unpracticed items from practiced categories (e.g., *fruits-banana*) are recalled less often than baseline items. Thus, retrieving practiced items impairs retrieval of related nonpracticed items. RIF has been observed with various stimuli, including visuospatial objects, photographs of crime scenes, and details about autobiographical events (see Anderson, 2003, for a review). It is critical to our current proposal that these inhibitory effects are not limited to episodic retrieval. Johnson and Anderson (2004) demonstrated that when items intrude from semantic memory, they are also vulnerable to inhibition. The generality of RIF suggests that it may be a factor in producing first-language attrition.

Despite our emphasis on inhibition, the basic RIF effect is compatible with noninhibitory explanations (see Anderson & Bjork, 1994, for a review). For example, the practiced items may be so accessible that when the category appears on the final test, they intrude and block access to the weaker, unpracticed items. If retrieval practice inhibits the competing item itself, though, the impairment should generalize to novel test cues (*independent probes*) that are unrelated to the practiced items (e.g., *monkey* for *banana*). The blocking theory, however, does not predict generalized impairment, because the independent probe (*monkey*) is not associated to the practiced item. Impaired performance for independent probes has now been observed many times (e.g., Anderson & Spellman, 1995; Camp, Pecher, & Schmidt, 2005; MacLeod & Saunders, 2005). Also supporting the inhibitory-control view is the finding that RIF depends on the need to resolve interference during retrieval. For example, weak competitors (e.g., *fruit-kiwi*) are unlikely to interfere during retrieval practice and, therefore, are inhibited less than strong competitors (e.g., Anderson et al., 1994). These findings, along with several others (see Anderson, 2003), are not well explained by noninhibitory accounts and indicate that competing items are inhibited in this paradigm.

THE CURRENT STUDY

In the present study, we examined whether inhibitory control mechanisms resolve interference from one's native language during foreign-language production. If so, retrieving the foreign-language word for an idea may induce forgetting of the phonology of the native-language term.[1] To evaluate this hypothesis, we asked native English speakers to repeatedly name objects in either English or a nondominant language they were learning (Spanish). Afterward, we measured the accessibility of the English labels for the objects using rhyming independent probes. We predicted that naming an item in Spanish would suppress the phonology of the corresponding English word, making people less likely to generate the English word on the final test.

In addition, in Experiment 2, we sought evidence that inhibition is specific to phonology and does not affect semantic representations. For one group of subjects, the final test used independent probes and test instructions designed to measure the accessibility of the underlying concepts. We predicted that on this semantic test, English words for pictures named in either language should be primed, though perhaps the effect would be smaller for words named in Spanish than for words named in English. Another group of subjects received independent probes and test instructions designed to measure the phonology of the English words. Both groups were given free-association instead of explicit-recall instructions so we could confirm that inhibition effects were not limited to explicit memory. A final goal of both experiments was to assess whether the engagement of inhibition differs across varying levels of fluency in the second language, given that inhibition should be needed most when a strong asymmetry exists between one's native and second languages.

METHOD FOR EXPERIMENTS 1 AND 2

Subjects, Design, and Materials

Participants were University of Oregon undergraduates who had recently completed at least 1 year of college-level Spanish (N = 32 in Experiment 1 and 64 in Experiment 2).

In both experiments, subjects named pictures in English or Spanish. Each picture was named 0, 1, 5, or 10 times (manipulated within subjects). Baseline items (0 repetitions) were seen in the initial refresher phase (see Procedure), but not during the picture-naming phase. In Experiment 2, the type of final test

[1]Isurin and McDonald (2001) suggested retroactive interference as a mechanism of language attrition and then tested this hypothesis. Although retroactive interference may reflect inhibition, other mechanisms might also underlie such effects (see Anderson, 2003). Therefore, it is unclear whether Isurin and McDonald's results were due to inhibition or other, noninhibitory mechanisms.

(semantic or phonological) was varied between subjects. In both experiments, the dependent measure was the percentage of test trials completed with the English label for a previously viewed object. In Experiment 1, each test cue was a word that rhymed with the word to be recalled, whereas in Experiment 2, each test cue was either a semantically or a phonologically related word, presented with the first letter of the word to be recalled.

The pictorial stimuli were line drawings selected to unambiguously identify concrete nouns that had been chosen from Spanish textbooks (40 experimental items and 13 fillers). Experimental items were counterbalanced across subjects through each of the eight conditions (4 levels of repetition × 2 naming languages).

For each word (e.g., *snake*), a rhyming word was selected as a phonological independent probe to measure the accessibility of the English phonology (e.g., *break*). To measure accessibility of the concepts underlying the items (Experiment 2), we generated a semantically related independent probe for each item (e.g., *venom*).

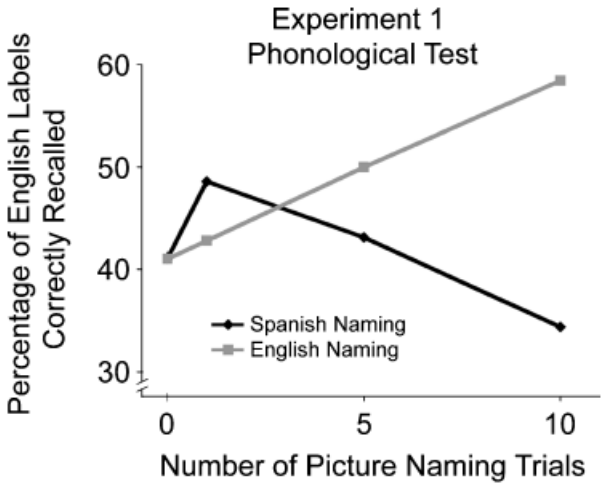

Fig. 2. Performance on the final rhyme-cued recall test in Experiment 1. The graph shows the percentage of English labels generated for previously viewed pictures, as a function of whether the picture had been named in English or Spanish and whether it had been named 0, 1, 5, or 10 times. Mean SE = 3.7%.

Procedure

Initial Refresher Phase

First, subjects were shown each line drawing (in black), along with its Spanish label, for 5 s. The purpose of this phase was to refresh their memory for the Spanish words.

Picture-Naming Phase

Next, colored line drawings appeared for up to 4 s each. Subjects were asked to produce the English label for each green picture and the Spanish label for each red picture. A microphone recorded response times, and the computer advanced upon detection of a response. If no response was made, the correct response was displayed by itself for 500 ms. The language in which each object was named remained the same throughout this phase.

Final Test Phase

Finally, the English name for each picture was tested. In Experiment 1, a phonological independent probe (e.g., *break*) was presented for up to 4 s on each trial, and subjects were asked to provide a rhyming English word that matched a previously viewed picture (*snake*). In Experiment 2, subjects were asked to generate the first word that came to mind that either rhymed with the cue (phonological test) or was semantically related to the cue (semantic test). Because subjects were not asked to recall studied items, the test displays in Experiment 2 included the initial letter of the target words along with the independent probes (e.g., *break-s*_____ or *venom-s*_____); this procedure ensured sufficiently high performance. To discourage episodic retrieval strategies and disguise the relation between the earlier phases and the test, in Experiment 2, we ensured that 50% of the test trials could not be completed with previously viewed items.[2]

RESULTS

Picture-Naming Performance

In both experiments, subjects were more accurate, $F(1, 24) = 44.62$, $p < .0001$, and $F(1, 45) = 80.37$, $p < .0001$, and faster, $F(1, 24) = 3.06$, $p = .09$, and $F(1, 45) = 14.98$, $p < .0005$, naming pictures in English than in Spanish. These results confirm that the subjects had greater fluency in English than in Spanish.

Final Test Performance

Experiment 1

Naming a picture in English increased recall of that English word on the phonological independent-probe test (see Fig. 2). Subjects generated the word more often after 10 naming trials (58%) than after 0 naming trials (41%), $F(1, 16) = 36.01$, $p < .0001$, $\eta_p^2 = .692$. Naming a picture in Spanish, however, had a very different effect: Whereas 1 naming trial facilitated later recall of the corresponding English item[3] (from 41% to 49%), $F(1, 16) = 8.22$, $p < .05$, $\eta_p^2 = .339$, 10 naming trials impaired later recall (34%). Recall was significantly worse after 10 re-

[2]In Experiment 2, 81% of subjects reported making no effort to think back to the earlier phases, which indicates that our rhyme task was effective as an implicit test. Furthermore, when subjects who did report thinking back to the earlier phases were excluded, the pattern of results remained unchanged.

[3]Similar nonmonotonic patterns have been observed in other inhibitory paradigms. For another example and further discussion, see Johnson and Anderson (2004).

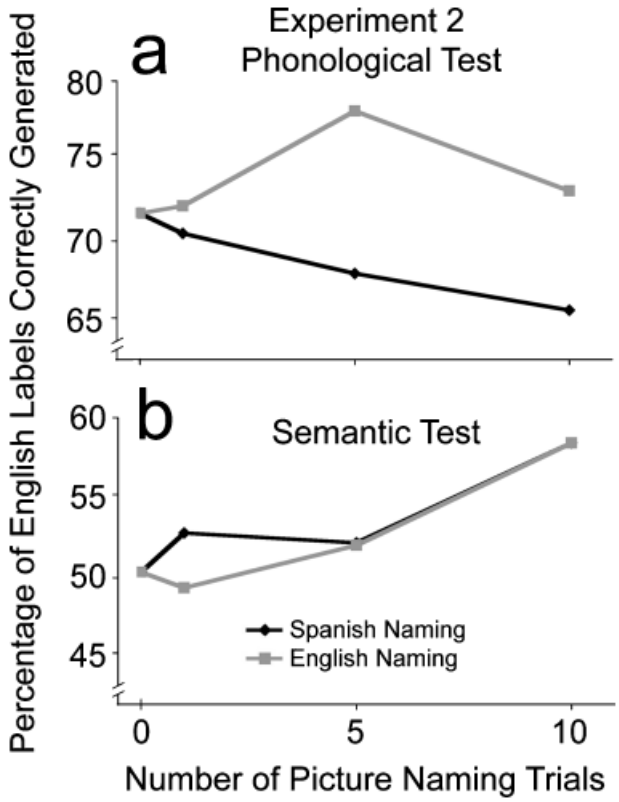

Fig. 3. Percentage of English labels generated for previously viewed pictures in Experiment 2. In the phonological condition (a), the final test was an implicit rhyme-generation task (e.g., *break-s___* for *snake*). In the semantic condition (b), the final test was an implicit semantic generation task (e.g., *venom-s__*). For each test, results are shown as a function of whether the picture had been named in English or Spanish and whether it had been named 0, 1, 5, or 10 times. Mean *SE* = 3.3% on the phonological test and 4.5% on the semantic test.

trievals of the Spanish label than after none, $F(1, 16) = 6.25$, $p < .05$, $\eta_p^2 = .281$, and was much worse after 10 retrievals than after 1, $F(1, 16) = 13.60$, $p < .005$, $\eta_p^2 = .459$.

Experiment 2: Suppression in the Phonological Condition

Compared with baseline, retrieving the Spanish name for a picture 10 times decreased generation of the English word on the final implicit-memory test (72% vs. 66%), $F(1, 24) = 4.79$, $p < .05$, $\eta_p^2 = .166$ (Fig. 3a). In contrast, producing the English name for a picture 10 times nonsignificantly increased generation of the word (73%) compared with baseline (72%), $F < 1$, and producing the English name 5 times significantly facilitated performance (78%), $F(1, 24) = 5.65$, $p < .05$, $\eta_p^2 = .190$. Thus, naming a picture in Spanish impaired access to the English word, whereas naming a picture in English did not, and in some cases led to facilitation.

Experiment 2: Priming in the Semantic Condition

Naming pictures in either language marginally facilitated performance on the semantic test, $F(1, 24) = 3.69$, $p = .07$, $\eta_p^2 = .131$. This facilitation did not depend on the naming language,[4] $F < 1$ (see Fig. 3b).

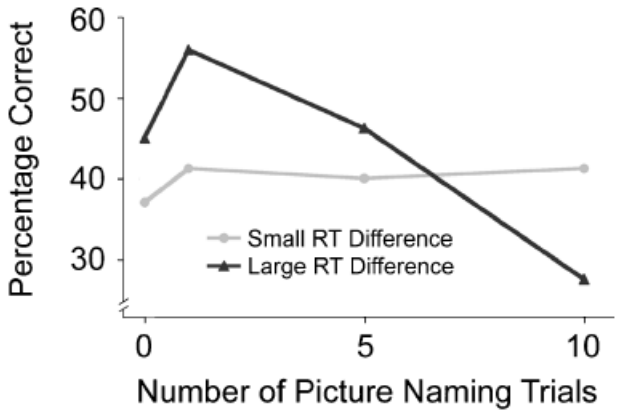

Fig. 4. Influence of native-language dominance on the inhibition of English labels after Spanish naming (data collapsed across Experiments 1 and 2). Subjects were divided into two groups on the basis of the difference between their average reaction times (RTs) for Spanish and English trials during the picture-naming phase. Subjects with a large RT difference are presumably less fluent in Spanish than English and would therefore be expected to show the largest phonological suppression. Mean *SE*s = 4.1% for the small-difference group and 4.3% for the large-difference group.

Phonological Suppression as a Function of Language Dominance

To operationally define each subject's language asymmetry (i.e., superiority of English over Spanish), we computed the reaction time difference between naming pictures in Spanish and in English and performed a median split of our subjects. The group with the larger language asymmetry was much slower to name the pictures in Spanish (1,214 ms) than in English (1,008 ms), whereas the more fluent group was actually slightly faster to name the pictures in Spanish (1,039 ms) than in English (1,062 ms). Across the two experiments, the less-fluent Spanish speakers showed substantial phonological inhibition (see Fig. 4): They were 13% less likely to produce the English word if they had named the picture in Spanish 10 times than if they had never named the picture in Spanish (i.e., baseline items), and this below-baseline impairment was significant in both experiments, $F(1, 32) = 18.6$, $p < .0001$, $\eta_p^2 = .367$, and $F(1, 32) = 4.2$, $p < .05$, $\eta_p^2 = .116$. Higher-fluency Spanish speakers, however, showed no inhibition, Fs <1. The interaction between language dominance and inhibition was highly significant, $F(1, 32) = 10.2$, $p < .001$, $\eta_p^2 = .242$.

[4]Apparently, conceptual priming combined with letter cues was enough to undo phonological suppression in the Spanish condition. This suggests that lapses for native-language words may resolve more quickly with access to some of their phonology.

DISCUSSION

The present experiments support the inhibitory-control account of first-language attrition. Three findings support this view. First, the more often novice Spanish speakers produced Spanish names for objects, the worse their later production of the corresponding English names became. Second, subjects who were least fluent with the Spanish vocabulary we tested showed the largest phonological inhibition of the English words, which suggests that native-language words are most vulnerable to forgetting when people struggle to produce foreign vocabulary, as might occur to novices during immersion. Third, Experiment 2 isolated the inhibition effect to phonology. Access to the semantics underlying the previously seen pictures was facilitated by picture naming, regardless of the naming language. Thus, although generating Spanish words suppressed the phonology of their English equivalents, the underlying concepts grew more accessible. These findings isolate the role of inhibition to resolving competition between phonological labels during production, as our hypothesis suggests.

The phonological-inhibition effect observed in this study provides specific evidence for a role of inhibition in first-language attrition because it was obtained with the independent-probe test method (Anderson & Spellman, 1995). If the final test had instead measured subjects' ability to name the same objects in English after naming them in Spanish, and subjects had been worse at retrieving the English words than the names of unpracticed objects, we would not have known whether the impairment reflected inhibition. Impairment might have arisen instead from associative blocking from the freshly practiced foreign-language label, because the final test would have used the same cue used to perform retrieval practice (the object). Because we tested subjects with rhyming cues—cues that were unrelated to the phonology of the foreign-language items and that minimized the influence of the semantics of the English words—we can be confident that the impaired generation of the English words reflected inhibition.

Our account of first-language attrition bears resemblance to Green's (1998) inhibitory-control model of bilingual lexical activation. Green claimed that bilinguals experience interlingual lexical competition and use inhibition to allow selection of the desired lexical item. Furthermore, a study by Costa and Santesteban (2004) showed that inhibition in language switching is required only by lower-fluency speakers, mirroring our findings. However, this literature has focused entirely on transitory suppression effects, typically in task-switching situations, and thus does not make obvious predictions about longer-term suppression effects, as would be necessary to explain first-language attrition. To our knowledge, the current study is the first demonstration of long-term inhibition of lexical items due to resolving interlingual competition.

Our findings support a new view on the causes of first-language attrition: First-language attrition is not produced by merely failing to use certain ideas during immersion. Although disuse may also be a contributing cause, it is worth emphasizing that the very English words not used in our picture-naming phase (baseline items) were recalled better than concepts used often in the foreign language. Thus, these data point to the opposite, paradoxical dynamic: Native-language words for ideas used most often in the foreign language are most vulnerable to inhibition. This phonological RIF arises precisely because frequent use engages inhibitory control to achieve the fluency desired by foreign-language speakers. Thus, bewildering lapses for words used throughout one's life may be an especially vivid example of forgetting as an adaptive response to the need to regulate interference (Anderson, 2003; Bjork, 1989).

REFERENCES

Anderson, M.C. (2003). Rethinking interference theory: Executive control and the mechanisms of forgetting. *Journal of Memory and Language*, *49*, 415–445.

Anderson, M.C., & Bjork, R.A. (1994). Mechanisms of inhibition in long-term memory: A new taxonomy. In D. Dagenbach & T. Carr (Eds.), *Inhibitory processes in attention, memory and language* (pp. 265–326). San Diego, CA: Academic Press.

Anderson, M.C., Bjork, R.A., & Bjork, E.L. (1994). Remembering can cause forgetting: Retrieval dynamics in long-term memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *20*, 1063–1087.

Anderson, M.C., & Spellman, B.A. (1995). On the status of inhibitory mechanisms in cognition: Memory retrieval as a model case. *Psychological Review*, *102*, 68–100.

Bjork, R.A. (1989). Retrieval inhibition as an adaptive mechanism in human memory. In H.L. Roediger, III, & F.I.M. Craik (Eds.), *Varieties of memory and consciousness: Essays in honor of Endel Tulving* (pp. 309–330). Hillsdale, NJ: Erlbaum.

Camp, G., Pecher, D., & Schmidt, H.G. (2005). Retrieval-induced forgetting in implicit memory tests: The role of test awareness. *Psychonomic Bulletin & Review*, *12*, 490–494.

Colomé, A. (2001). Lexical activation in bilinguals' speech production: Language-specific or language-independent? *Journal of Memory and Language*, *45*, 721–736.

Costa, A., & Santesteban, M. (2004). Lexical access in bilingual speech production: Evidence from language switching in highly proficient bilinguals and L2 learners. *Journal of Memory and Language*, *50*, 491–511.

de Bot, K. (1999). The psycholinguistics of language loss. In G. Extra & L. Verhoeven (Eds.), *Studies on language acquisition* (pp. 345–361). Berlin, Germany: Walter de Gruyter.

Gollan, T.H., & Acenas, L.R. (2004). What is a TOT? Cognate and translation effects on tip-of-the-tongue states in Spanish-English and Tagalog-English bilinguals. *Journal of Experimental Psychology*, *30*, 246–269.

Green, D.W. (1998). Mental control of the bilingual lexico-semantic system. *Bilingualism: Language and Cognition*, *1*, 67–81.

Isurin, L. (2000). "Deserted island" or a child's first language loss. *Bilingualism: Language and Cognition*, *3*, 151–166.

Isurin, L., & McDonald, J.L. (2001). Retroactive interference from translation equivalents: Implications for first language forgetting. *Memory & Cognition*, *29*, 312–319.

Johnson, S.K., & Anderson, M.C. (2004). The role of inhibitory control in forgetting semantic knowledge. *Psychological Science*, *15*, 448–453.

Kroll, J.F., & Stewart, E. (1994). Category interference in translation and picture naming: Evidence for asymmetric connections between bilingual memory representations. *Journal of Memory and Language*, *33*, 149–174.

Levy, B.J., & Anderson, M.C. (2002). Inhibitory processes and the control of memory retrieval. *Trends in Cognitive Sciences*, *6*, 299–305.

MacLeod, M.D., & Saunders, J. (2005). The role of inhibitory control in the production of misinformation effects. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *31*, 964–979.

Olshtain, E., & Barzilay, M. (1991). Lexical retrieval difficulties in adult language attrition. In H.W. Seliger & R.M. Vago (Eds.), *First language attrition* (pp. 139–151). Cambridge, England: Cambridge University Press.

Pallier, C., Dehaene, S., Poline, J.-B., LeBihan, D., Argenti, A.-M., Dupoux, E., & Mehler, J. (2003). Brain imaging of language plasticity in adopted adults: Can a second language replace the first? *Cerebral Cortex*, *13*, 155–161.

Seliger, H.W., & Vago, R.M. (Eds.). (1991). *First language attrition*. Cambridge, England: Cambridge University Press.

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