Salvaging a childhood language

Terry Kit-fong Au [a,*], Janet S. Oh [b], Leah M. Knightly [c],
Sun-Ah Jun [d], Laura F. Romo [e]

[a] *Department of Psychology, University of Hong Kong, Pokfulam Road, Hong Kong*
[b] *Department of Psychology, California State University, Northridge, USA*
[c] *Department of Psychology, University of California, Los Angeles, USA*
[d] *Department of Linguistics, University of California, Los Angeles, USA*
[e] *Gevirtz Graduate School of Education, University of California, Santa Barbara, USA*

Abstract

Childhood experience with a language seems to help adult learners speak it with a more native-like accent. Can analogous benefits be found beyond phonology? This study focused on adult learners of Spanish who had spoken Spanish as their native language before age 7 and only minimally, if at all, thereafter until they began to re-learn Spanish around age 14 years. They were compared with native speakers, childhood overhearers, and typical late-second-language (L2)-learners of Spanish. Both childhood speakers and overhearers spoke Spanish with a more native-like accent than typical late-L2-learners. On grammar measures, childhood speakers—although far from native-like—reliably outperformed childhood overhearers as well as typical late-L2-learners. These results suggest that while simply overhearing a language during childhood could help adult learners speak it with a more native-like phonology, speaking a language regularly during childhood could help re-learners use it with more native-like grammar as well as phonology.
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Childhood language experience seems special. Without childhood exposure to a language, we generally cannot fully master it even if massive input is available later. Indeed, late language learners typically find phonology (e.g., Flege, 1987, 1991; Oyama, 1976) and morphosyntax difficult to master (e.g., Newport, 1990; but cf. Flege, Yeni-Komshian, & Liu, 1999). By contrast, if children's immersion in a language begins by age four or five years, they can often pass as native speakers, except perhaps

when scrutinized by experts (Flege & Eefting, 1988; Williams, 1977, 1980).

What would happen if a child started out speaking one language, then switched to speaking another language almost exclusively, using the first language only sparingly if at all thereafter? In one study, adults who had been adopted from Korea to France as monolingual Korean children between ages three and eight years seemed unable to access their childhood language memory. They could neither discriminate among certain Korean speech sounds (Ventureyra, Pallier, & Yoo, 2004) nor identify Korean sentences from a series of sentences in unfamiliar languages (Pallier et al., 2003), performing

* Corresponding author. Fax: +852 2858 3518.
  E-mail address: terryau@hku.hk (T.K. Au).

just like native French speakers never exposed to Korean. Moreover, adoptees' event-related fMRI brain activation patterns revealed no signs of recognition of Korean: their patterns did not differ while listening to Korean *vs.* a completely unfamiliar language, and their patterns for French *vs.* Korean looked just like those of native French speakers (Pallier et al., 2003). Dramatic and rapid first-language loss has also been documented in other studies of international adoption (e.g., Isurin, 2000; Nicoladis & Grabois, 2002).

Several case studies, however, suggest that childhood languages apparently can become accessible under age-regressed hypnosis (e.g., Ås, 1962; Au & Romo, 1997; Fromm, 1970). In each case, an adult or young adolescent managed to speak and answer simple questions in a childhood language, although in his normal alert state he understood little of the childhood language and perhaps was not even aware that he used to speak it. Such cases hint that early childhood language memory can last for many years, although retrieving it may require drastic means such as hypnosis. Research on aphasia in bilinguals has also uncovered tacit memory of childhood languages (e.g., Paradis, 2004).

Measurable benefits of childhood language memory have also been found in adults who, unlike participants of Pallier and colleagues' adoptee studies, grew up living with their biological families and had continued, albeit very minimal, exposure to their heritage language. For instance, English-speaking adults who had heard Hindi regularly only before age two could distinguish among difficult Hindi consonants much better than novice adults (Tees & Werker, 1984). Analogous benefits in speech sound perception were observed for Korean–American adults who had heard Korean regularly before age 6 (Oh, Jun, Knightly, & Au, 2003). Childhood language experience also seems to have lasting benefits for speech production. Adult learners of Spanish who had overheard Spanish regularly only before age 7 spoke it with a more native-like accent than those without such experience, and this advantage was evident by both acoustical analyses and native-speaker accent ratings (Au, Knightly, Jun, & Oh, 2002; Knightly, Jun, Oh, & Au, 2003). Adult re-learners of Korean who had spoken Korean regularly only as young children had an analogous advantage over adult novice learners for both production and perception of Korean speech sounds (Oh et al., 2003).

Beyond documenting lasting benefits of childhood language experience, these studies also highlight naturally occurring subtypes of such experience. For instance, some have spent enough time around native speakers to learn to speak a heritage language as their dominant or only language during their early years (i.e., childhood speakers); others have had too little exposure to native speakers to learn to speak the language (e.g., only a few hours each week), but the exposure they did have was quite regular (e.g., childhood hearers). Comparing such subtypes could enrich our understanding of the impact of childhood language experience (e.g., Kondo-Brown, 2005). That is exactly what we did in our study of adult re-learners of Korean (Oh et al., 2003), and both acoustical analyses and native-speaker accent ratings revealed that childhood speakers sounded more native-like than childhood hearers, who did not sound reliably better than the novice learners in their Korean class. The comparison between childhood speakers and childhood hearers helps us focus on probable benefits of speaking Korean during childhood (e.g., helping adult re-learners speak the language with a more native-like accent).

We further focused on a sub-sample of childhood speakers who spoke no Korean or virtually no Korean (i.e., no more than short Korean phrases or isolated words) beyond age 6 years, which is when childhood hearers' exposure ended in that study. Importantly, this sub-sample of childhood speakers still sounded reliably more native-like than the novice learners, whereas the childhood hearers did not. However, unlike the full sample, they no longer had a clear advantage over childhood hearers. It seems, then, that speaking a language during childhood helps adults learn to speak the language later with more native-like phonology, but how much it helps may depend on how long they spoke it as children.

Together, our studies of adult re-learners of Spanish and Korean have documented measurable benefits of childhood language experience for phonology (Au et al., 2002; Knightly et al., 2003; Oh et al., 2003). In our present study, we looked for analogous benefits for grammar. There is some evidence that such benefits, if any, are smaller (e.g., Flege et al., 1999). Still, like phonology, basic morphosyntax is readily acquired by children but seems difficult to master by adult learners (e.g., Newport, 1990; Snow & Hoefnagel-Hohle, 1978). It is therefore a good candidate for revealing any lasting benefits of childhood language experience. We did not assess morphosyntax in our earlier study of childhood hearers and speakers of Korean (Oh et al., 2003). We did assess the Spanish morphosyntax of childhood overhearers but did not find any measurable benefits (Au et al., 2002; Knightly et al., 2003). In this study, we will compare childhood speakers and childhood hearers to hunt for possible benefits of speaking a language during early childhood, especially in the domain of grammar.

Methods

Participants

Using a detailed language-background questionnaire and follow-up interview, we screened about 200 undergraduate students enrolled in second-year college-level

Spanish language classes at the University of California, Los Angeles (UCLA). These language-background self-reports have been found to correspond well with independent reports from informants who knew the participants during childhood (Au et al., 2002; Knightly et al., 2003). From these participants, who had all taken about 3–5 years of Spanish classes beginning in high school, we identified 10 childhood speakers (mean age = 22.2; all female) who reported speaking Spanish regularly for at least three years in early childhood ($M = 30.8$ h/wk, $SE = 2.2$). Their Spanish utterances were usually whole sentences, rather than isolated words or phrases, and had little or no English mixed in. These childhood speakers all reported a massive drop in using Spanish by age 7 (mean age of drop = 5.6 years, $SE = .3$), spending at most a few hours per week afterwards around Spanish-speaking relatives ($M = 1.2$ h/wk, $SE = .5$) and speaking Spanish at most in short phrases, if at all, between age 7 and 12. Ethnographies of immigrant families in the U.S. suggest that once children start favoring English, they rarely talk to their relatives who speak little or no English even when they are together (e.g., Fillmore, 1991; Kouritzin, 1999).

We also identified two comparison samples among the Spanish learners: 20 childhood overhearers (mean age = 19.7; 75% female) who had regularly overheard Spanish for several hours a week until about age 6 (up to age 6: $M = 6.2$ h/wk around Spanish-speaking relatives, $SE = 1.7$; age 7–12: $M = 2.3$ h/wk, $SE = .7$), and 39 typical late-L2-learners (mean age = 19.2; 77% female) who had minimal exposure (i.e., around someone who uttered at most isolated Spanish words or short phrases for less than an hour each week; $n = 9$) or had no regular exposure to Spanish until they started taking Spanish classes around age 14 in high school ($n = 30$). We also recruited 25 native Spanish speakers (mean age = 20.9; 72% female) at UCLA for comparison. A portion of the data from about half of the participants in the comparison groups has been reported earlier (Au et al., 2002; Knightly et al., 2003), specifically, 13 out of 25 native speakers, 13 out of 20 childhood overhearers, and 14 out of 39 typical late-L2-learners.

To corroborate self-reports of childhood language experience, we assessed participants' knowledge of Spanish childhood slang—terms typically used by native speakers around children but seldom heard in formal Spanish-language classes. Participants were asked to translate orally 20 English expressions (e.g., *cry baby, pacifier, dry crust in the eyes*) into Spanish slang (Slang Production), and to translate orally 40 childhood Spanish slang terms (e.g., *coco* for "a boo boo, hurt/cut/bruise" or "head;" *las escondidas* for "hide-and-seek") into English (Slang Comprehension). The test was self-paced, and responses were audiotaped, transcribed, and compared against a list of acceptable responses compiled by a team of native Spanish speakers who spoke a variety of dialects commonly found in southern California.

For both Slang Production and Comprehension, typical late-L2-learners did the worst (about 3% correct responses; see Table 1). They were reliably outperformed by childhood overhearers (about 20%), who in turn were reliably outperformed by childhood speakers (close to 40%), with native speakers doing the best (about 80%). One-way ANCOVAs with language background group as the independent variable and gender as a covariate revealed reliable differences among the four language background groups for both production and comprehension of Spanish childhood slang ($Fs(3, 88) > 200$, $ps < .001$); there were no reliable gender effects. Table 2 presents the 95% confidence intervals and effect sizes of the pairwise contrasts. Confidence intervals were calculated from the mean square error for the relevant main effect in the omnibus analysis of variance (e.g., Masson & Loftus, 2003). In all analyses, we interpret an effect as statistically significant at $p < .05$ if the 95% confidence interval around the difference between the group means does not include zero, and we consider an effect size large if $d > .8$ (Cohen, 1977).

Note that the standard errors for the average percent correct in both the production and comprehension task are relatively small for the native speakers (3% and 2% respectively; Table 1), suggesting that this assessment of childhood slang knowledge worked quite well despite

Table 1
Characteristics of the four language-background groups

	Native speakers	Childhood speakers	Childhood overhearers	Typical late-L2-learners
Childhood slang knowledge				
Production	75$_a$ (3)	35$_b$ (5)	21$_c$ (3)	3$_d$ (1)
Comprehension	83$_a$ (2)	40$_b$ (8)	19$_c$ (2)	3$_d$ (1)
Current use of Spanish				
Speaking (h/wk)	14.2$_a$ (2.5)	4.0$_b$ (1.6)	3.3$_b$ (1.1)	1.6$_b$ (.9)

Note. The numbers indicate the mean percentage correct unless specified otherwise. For this and other tables of means, standard errors are given in parentheses. Within a row, means with different subscripts were reliably different from each other (by HSD post-hoc test, $p < .05$).

Table 2
Pairwise contrasts on childhood slang knowledge and current use of Spanish

	Native *vs.* Child Sp	Child Sp *vs.* Child OH	Child Sp *vs.* Late	Child OH *vs.* Late
Childhood slang				
Production				
95% c.i. of mean difference	40 ± 8.09	13.8 ± 8.37	32.1 ± 7.68	18.4 ± 5.97
Effect size	2.61	.93	2.63	2.01
Comprehension				
95% c.i. of mean difference	43.6 ± 8.35	21.1 ± 8.60	36.9 ± 7.90	15.7 ± 6.15
Effect size	2.29	1.14	2.12	2.12
Current use (*speaking*)				
95% c.i. of mean difference	8.35 ± 5.85	0.74 ± 6.04	2.46 ± 5.53	1.72 ± 4.29
Effect size	0.88	0.15	0.47	0.34

For this and other tables of pairwise contrasts: Native, native speakers; Child Sp, childhood speakers; Child OH, childhood overhearers; Late, typical late-L2-learners. Mean difference for "Native *vs.* Child Sp" = "Native" minus "Child Sp" and so forth.

dialect differences among the native-speaker participants. Importantly, these findings suggest that the childhood speakers had substantially more childhood experience with Spanish than the childhood overhearers and typical late-L2-learners, but they were very far from native-like.

Materials and procedure

Participants were tested individually, and the Spanish assessment focused primarily on basic phonology and morphosyntax that are typically acquired in early childhood. Instructions and stimuli were presented on a computer using PsyScope (Cohen, MacWhinney, Flatt, & Provost, 1993) in a soundproof room, with auditory stimuli presented via a headset. Participants responded via a button box or by speaking into professional-grade recording equipment.

Phonology production assessment

Sentence accent ratings. Participants were asked to say 36 target words containing one of the target Spanish phonemes /p, t, k, b, d, g/ in initial or medial position (e.g., /b/ in *base* 'base' and *cabeza* 'head'; see Knightly et al., 2003 for a complete list) embedded in the sentence frame "*Diga* (target word) *por favor*," meaning "Say (target word) please." All of the sentences produced by each participant were rated by 16 native speakers of Spanish using a 5-point scale (1 = very strong foreign accent, definitely non-native; 5 = no foreign accent, definitely native; adopted from Bongaerts, Van Summeren, Planken, & Schils, 1997). Inter-rater reliability was excellent (intraclass *R*s > .95).

This accent measure has been corroborated by acoustical analyses of the target phonemes. Specifically, Knightly and colleagues (2003) found that the voice-onset-time (VOT) for /p, t, k/ in the "*Diga* (target word) *por favor*" sentences correlated reliably with accent ratings of those sentences ($r = -.53$, $p < .001$; i.e., shorter VOT is associated with higher accent ratings). At the phonological rule level, the percentage of lenited intervocalic /b, d, g/ correlated strongly with accent ratings of those sentences ($r = .78$, $p < .001$; for more on these acoustical analyses, see Knightly et al., 2003).

Narrative accent ratings. We also elicited more natural speech using an abridged version of a wordless picture book from Mercer Mayer's "Frog, Where are you?" series. Participants were given two minutes to scroll through a 10-page version of the storybook on a computer before telling the story. They then saw each page for 12 s, with enough time to say one or two sentences in Spanish per page. Audio-recordings were rated independently by two native Spanish speakers, using the same scale adopted for sentence accent ratings. Inter-rater agreement was excellent (intraclass *R*s > .95).

Morphosyntax assessment

Noun-phrase production. Participants were asked to complete orally five 4-piece jigsaw puzzles, each presented for 18 s on a computer screen. For example, a correct response might be "Pon los pianos blancos en cuatro. Pon la vaca negra en tres..." (meaning "Put the white pianos in four. Put the black cow in three..."). The noun phrases specifying the puzzle pieces required marking both number (singular or plural) and gender (feminine or masculine) on the determiner, noun, and adjective. Audiotaped responses were independently transcribed and coded for grammatical agreement by two native Spanish speakers; a third native speaker resolved any discrepancies. Disagreement occurred in less than 5% of the words and codes between transcribers/coders.

Verb-phrase production. Participants heard 20 sentence fragments, one at a time, illustrated with pictures presented on a computer. For instance, they might hear "Ayer fuí a la tienda, y yo..." (meaning "Yesterday I

went to the store, and I...") and see a picture of someone in a store and then a picture of the same person buying milk. Participants were then given 6 s to complete the sentence orally. Morphosyntactic markers for the verb in each completion were coded for agreement with the lead-in clause (e.g., first person singular preterite form in this example). If a verb was repaired spontaneously, the final attempt was coded. Two native speakers coded all audiotaped verb phrases on number, person, and verb tense. Inter-coder agreement was excellent (Cohen's *kappa*s = .88 to .90); discrepancies were resolved by a third native Spanish speaker.

Grammaticality judgment. Participants listened to 33 grammatical–ungrammatical sentence pairs spoken by a native Spanish speaker. Each sentence was presented twice consecutively, and the 66 sentences were presented in random order. The 33 ungrammatical sentences each contained an error in one of the following six categories: negative marking (e.g., *Él conoce a nadie*; 3 items), tense agreement (e.g. *Dentro de cuatro años, soy un abogado*; *Ellos cenan y después se fueron*; 3 items each on future and preterite tense), person agreement (e.g., *nosotros comienzan*, *A qué hora llegué usted*; 3 items each on 1st and 2nd person marker), gender agreement (*La libro*, *El carro blanca*; 3 items each on determiner and adjective), number agreement (e.g., *la flores*, *Las fresas...están bien roja*, *Marta corren*; 3 items each on determiner, adjective, and verb), or indirect object marking (e.g., *Él enseña a nosotros*; 3 items). Participants were asked to indicate after each sentence whether it was grammatical or ungrammatical by pressing a button. Both decision and response time were recorded.

Grammatical well-formedness of narrative production

Each frog story produced for narrative accent rating was rated by two other native speakers of Spanish on a 5-point grammatical well-formedness scale analogous to that used for accent ratings (1 = definitely non-native; 5 = definitely native; intraclass R = .95). Although the same frog stories were rated for both accent and grammatical well-formedness, note that Knightly et al. (2003) found measurable benefits of childhood overhearing of Spanish for accent ratings but not grammatical well-formedness on the same frog-story task. Agreement among independent native-speaker raters was excellent for both kinds of ratings (intraclass Rs > .94). The different patterns of results for accent ratings versus grammatical well-formedness ratings are likely to reflect genuine differences, suggesting that these two kinds of ratings were reasonably independent.

Perception of sentences-in-noise assessment

Perceiving sentences in noise is a challenge for typical late-L2-learners even if they speak the language fluently

(e.g., Mayo, Florentine, & Buss, 1997). Mastery of phonological and higher level contextual information (e.g., semantic, grammatical) may help decipher a sentence presented in noise. We presented participants with 12 simple Spanish sentences, first mixed digitally with noise (+5 dB S/N level) and then without noise. The sentences were four or five words long (e.g., *A los chicos les gusta jugar*.) After each sentence, participants had 4 s to say aloud exactly what they heard. Their audiotaped responses were transcribed and scored for percentages of words correctly repeated.

Errors were further categorized into "lexical" versus "inflectional." Lexical errors consisted of substituting one word for another (often similar in sound or meaning), or adding or omitting a word. Inflectional errors consisted of incorrect morphosyntactic inflections (e.g., incorrect gender, number, person, tense/aspect, case marking). Two native speakers coded all the transcribed responses independently. Inter-coder reliability was excellent (intraclass Rs > .96 for each type of error in each condition, namely, with noise *vs.* without); discrepancies were resolved by discussion.

Results

A one-way ANCOVA with language background group as the independent variable and gender as a covariate was conducted on each outcome measure. No gender effects were uncovered. By contrast, these ANCOVAs revealed reliable differences among the language background groups in all but one case (Fs > 8; ps < .01). The exception involved number marking in the noun-phrase production task. We will first take a look at the pattern of results for phonology.

Phonology

The patterns of accent ratings were identical for the frog stories and the "Diga... por favor" sentences. Specifically, both childhood speakers and childhood overhearers spoke with a more native-like accent than the typical late-L2-learners. All three groups received reliably lower accent ratings than native speakers (Table 3; for all reliable pairwise differences reported, p < .05 by HSD post-hoc tests). Ninety-five percent confidence intervals and effect sizes of pertinent pairwise contrasts revealed a similar story. Furthermore, there is a hint that childhood speakers outperformed childhood overhearers, as assessed by the sentence accent ratings (means = 3.8 *vs.* 3.4, respectively, d = 1.02; 95% CI for this difference of .4 was +/−.37, see Table 4).

Earlier, we reported an interim finding that overhearing a language during childhood could help adult learners speak the language with a more native-like phonology (Au et al., 2002; Knightly et al., 2003). This

Table 3
Spanish phonology assessment outcomes

	Native speakers	Childhood speakers	Childhood overhearers	Typical late-L2-learners
Sentence accent rating	4.4_a (.05)	3.8_b (.11)	3.4_b (.11)	3.0_c (.09)
Narrative accent rating	5.0_a (0)	3.4_b (.34)	3.1_b (.22)	2.4_c (.12)

Note. Accent ratings were on a 5-point scale, with higher ratings indicating more native-like performance.

Table 4
Pairwise contrasts on spanish accenting ratings

	Native *vs.* Child Sp	Child Sp *vs.* Child OH	Child Sp *vs.* Late	Child OH *vs.* Late
Sentences				
95% c.i. of mean difference	0.61 ± 0.36	0.39 ± 0.37	0.77 ± 0.34	0.38 ± 0.24
Effect size	2.36	1.02	1.90	0.81
Narratives				
95% c.i. of mean difference	1.60 ± 0.54	0.29 ± 0.57	0.97 ± 0.51	0.68 ± 0.41
Effect size	2.11	0.29	1.06	0.80

finding also holds in our full sample reported here. In addition, this study reveals a similar and possibly somewhat stronger (according to the sentence accent ratings) advantage for childhood speakers.

Morphosyntax

Noun-phrase production

The four groups did not differ reliably on how well number agreement was marked in the noun-phrases produced in the jigsaw-puzzle task. For gender agreement, the native speakers reliably outperformed the other three groups, while the latter three groups did not differ reliably among themselves. Therefore, no lasting benefits of childhood language experience were found for basic morphosyntax in this task (see Table 5).

Verb-phrase production

For person and tense markings on verbs in the sentence-completion task, native speakers outperformed the three groups of non-native speakers, who did not differ among themselves. For number marking, native speakers reliably outperformed both childhood overhearers and typical late-L2-learners but not childhood speakers. The childhood speakers did not reliably outperform their peers without regular childhood speaking experience (Table 5).

Simple sentence repetition

In the perception of sentence-in-noise task, participants repeated aloud simple 4- or 5-word sentences heard under two conditions: with and then without white noise. The latter condition allows us to examine the participants' ability to repeat simple sentences in Spanish in a quiet context. Their repetition errors were categorized into inflectional errors (i.e., morphosyntactic

errors in number, gender, person, or tense inflection) and lexical errors (i.e., addition, omission, or substitution of words). For both kinds of errors, native speakers made reliably fewer errors than childhood overhearers and typical late-L2-learners.

Childhood speakers, according HSD post-hoc tests, did not differ statistically from any other group (Table 5). Nonetheless, they did make noticeably fewer inflectional errors than typical late-L2-learners (mean difference = .41 error/sentence); the lexical error rates for these two groups were comparable (mean difference = .07). The effect size for the inflectional error rates is rather large ($d = 1.24$; 95% CI for this difference of .41 was $+/-.32$, see Table 6). Overhearers were similar to typical late-L2-learners for both kinds of errors (mean difference = .13 and.04, respectively). Together, these results hint at a possible morphosyntax advantage favoring the childhood speakers (but not childhood overhearers) over typical late-L2-learners.

Grammaticality judgment

As reported earlier, a one-way ANCOVA (with gender as a covariate) revealed reliable differences in grammaticality judgment accuracy among the 4 participant groups (Table 5). This main effect of Group holds even when generalizability across the 66 items (clustered in 6 sub-categories; see Methods section on grammaticality judgment) is taken into account ($F_1(3, 90) = 126$, $F_2(3, 240) = 32.3$, *min* $F'(3, 322) = 25.7$, $p < .05$).

Childhood speakers did reliably worse than native speakers but reliably better than childhood overhearers and typical late-L2-learners on grammaticality judgment. Importantly, the reaction-time data suggested no speed–accuracy trade-off (Table 5). The effect sizes are quite large for childhood speakers over childhood overhearers ($d = .98$; 95% CI for this difference of .9 was

Table 5
Spanish grammar-related assessment outcomes

	Native speakers	Childhood speakers	Childhood overhearers	Typical late-L2-learners
Morphosyntax				
Production				
Noun phrase				
Number	96$_a$ (2)	86$_a$ (5)	86$_a$ (4)	88$_a$ (3)
Gender	96$_a$ (2)	72$_b$ (6)	70$_b$ (5)	74$_b$ (3)
Verb phrase				
Number	99$_a$ (1)	83$_{a,b}$ (6)	76$_b$ (4)	76$_b$ (3)
Person	98$_a$ (1)	77$_b$ (6)	73$_b$ (4)	71$_b$ (3)
Verb Tense	94$_a$ (1)	53$_b$ (7)	51$_b$ (4)	47$_b$ (3)
Sentence repetition (Number of errors per sentence)				
Inflectional errors	.07$_a$ (.03)	.21$_{ab}$(.12)	.49$_b$ (.13)	.62$_b$ (.12)
Lexical errors	.02$_a$ (.01)	.15$_{ab}$ (.09)	.26$_b$ (.08)	.22$_b$ (.08)
Grammaticality Judgment				
Accuracy	0.91$_a$ (0.01)	0.71$_b$ (0.03)	0.62$_c$ (0.02)	0.61$_c$ (0.01)
Reaction time (msec)	1171$_a$ (82)	2173$_b$ (397)	2352$_b$ (228)	2014$_b$ (152)
Grammatical well-formedness				
Narrative Grammar Rating	4.9$_a$ (.04)	3.3$_b$ (.26)	2.6$_c$ (.16)	2.6$_c$ (.09)
Perception of sentences in noise				
No noise	98$_a$ (1)	95$_{a,b}$ (3)	88$_b$ (3)	89$_b$ (2)
Decrement due to noise	13$_a$ (2)	30$_b$ (5)	41$_{b,c}$ (5)	52$_c$ (3)

Note. Grammatical well-formedness ratings were on a 5-point scale, with higher ratings indicating more native-like performance. Mean number of error per sentence is reported for lexical *vs.* inflectional error analysis. For all other measures, the table indicates the mean percentage correct.

Table 6
Pairwise contrasts on Spanish grammar-related assessment

	Child Sp *vs.* Native	Child Sp *vs.* Child OH	Child Sp *vs.* Late	Child OH *vs.* Late
Morphosyntax				
Production (Inflectional errors in sentence repetition)				
95% c.i. of mean difference	-0.14 ± 0.30	-0.28 ± 0.35	-0.41 ± 0.32	-0.13 ± 0.27
Effect size	0.70	0.93	1.24	0.35
Grammaticality judgment accuracy				
95% c.i. of mean difference	0.20 ± 0.05	0.09 ± 0.05	0.10 ± 0.05	0.01 ± 0.04
Effect size	2.42	0.98	1.04	0.13
Narrative grammatical well-formedness				
95% c.i. of mean difference	1.64 ± 0.42	0.67 ± 0.44	0.72 ± 0.40	0.05 ± 0.32
Effect size	2.73	0.89	1.01	0.08
Perception of sentences (decrement due to noise)				
95% c.i. of mean difference	0.17 ± 0.10	0.11 ± 0.12	0.22 ± 0.11	0.11 ± 0.09
Effect size	1.88	1.00	2.20	1.00

+/−.5) and over typical late-L2-learners ($d = 1.04$; 95% CI for this difference of 1.0 was +/−.5; Table 6). These findings reveal measurable morphosyntax benefits of early childhood speaking experience.

To see if the childhood speakers' advantage would hold across all six sub-categories of grammaticality judgment, we compared the three groups of learners' accuracy rates for each category separately (Fig. 1). Pairwise contrasts suggest that childhood speakers outperformed the childhood overhearers on negative marking ($d = 1.24$; 95% CI for this difference of .23 was +/−.15), tense agreement ($d = .81$; 95% CI for this difference of .13 was +/−.11), and gender agreement ($d = 1.00$; 95% CI for this difference of .15 was +/−.9). The childhood speakers also outperformed the typical-late-L2-learners on negative marking ($d = 1.20$; 95% CI for this difference of .23 was +/−.13), tense agreement ($d = .96$; 95% CI for this difference of .14 was +/−.10), person agreement ($d = .63$; 95% CI for this difference of .1 was +/−.09), and gender agreement ($d = 1.37$;
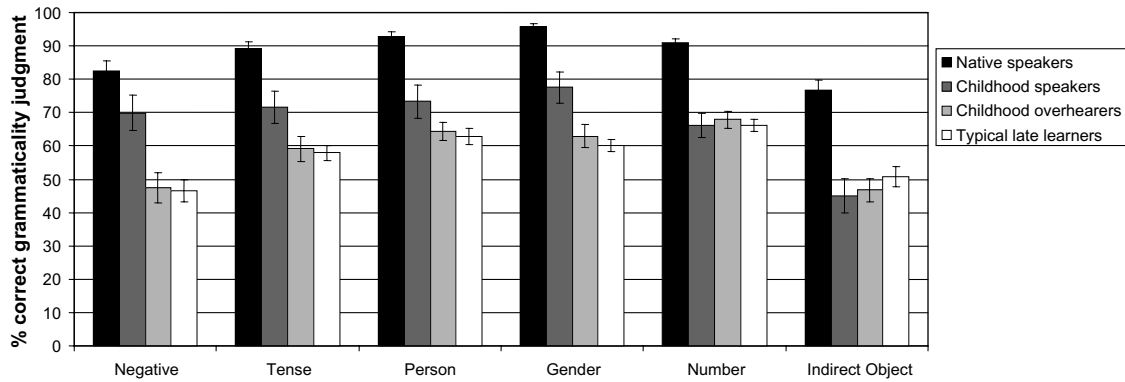
Fig. 1. Grammaticality judgment on different kinds of morphosyntactic markers.

95% CI for this difference of .18 was +/−.08). In six of these seven pairwise contrasts, the effect size is quite large (*d*s range from .81 to 1.73). Childhood speaking experience does not seem to benefit adult re-learners in making grammaticality judgments on number agreement and indirect object marking (Table 7).

In short, this full sample of childhood overhearers confirms our earlier interim report that merely overhearing a language for several hours a week during childhood does not seem to have measurable benefits in grammaticality judgment for adult learners of Spanish (Au et al., 2002; Knightly et al., 2003). By contrast, adult learners who have spoken a language regularly during early childhood (on average 30 h/wk) seem better able to judge whether morphosyntactic markers (e.g., nega-

tive, tense, person, and gender markers) in that language are used correctly, compared to those with no such childhood speaking experience.

Prior research has found early Spanish–English bilinguals outperforming typical late-L2-learners of Spanish on grammaticality judgments, in the case of adult learners with low proficiency of Spanish; no analogous difference was observed for learners at the higher end of the proficiency continuum (e.g., Montrul, 2006). However, because it is not clear whether those early bilinguals with low Spanish proficiency also experienced a sharp drop in Spanish input by age 7 years, as did the childhood speakers in our study, we need to interpret this potential convergence of findings with caution.

Table 7
Pairwise contrasts on sub-categories of grammaticality judgment

	Child Sp *vs.* Child OH	Child Sp *vs.* Late	Child OH *vs.* Late
Negative marking			
95% c.i. of mean difference	0.23 ± 0.15	0.23 ± 0.13	0 ± 0.10
Effect size	1.24	1.20	0
Tense agreement			
95% c.i. of mean difference	0.13 ± 0.11	0.14 ± 0.10	0.01 ± 0.08
Effect size	0.81	0.96	0.06
Person agreement			
95% c.i. of mean difference	0.09 ± 0.10	0.10 ± 0.09	0.01 ± 0.07
Effect size	0.64	0.63	0.07
Gender agreement			
95% c.i. of mean difference	0.15 ± 0.09	0.18 ± 0.08	0.03 ± 0.06
Effect size	1.00	1.37	0.23
Number agreement			
95% c.i. of mean difference	0.02 ± 0.08	0 ± 0.07	0.02 ± 0.05
Effect size	0.18	0	0.18
Indirect object marking			
95% c.i. of mean difference	−0.02 ± 0.13	−0.06 ± 0.12	−0.04 ± 0.09
Effect size	0.13	0.34	0.23

We should also note that grammaticality judgment is by nature an off-line task. We did not find any benefits of childhood speaking experience in our on-line noun-phrase and verb-phrase production tasks. While childhood speakers were rated higher than childhood overhearers and typical late-L2-learners on the grammatical well-formedness of their on-line narrative production, the ratings did not focus on morphosyntax. Nonetheless, early Spanish–English bilinguals with low-to-intermediate Spanish proficiency as adults have been found to outperform typical late-L2-learners in an oral picture naming task for gender agreement among nouns, determiners, and adjectives (Montrul, Thornhill, Foote, Perpiñán, & Vidal, 2006). Given the importance of on-line language use, it will be helpful to consider this promising task and other on-line tasks (e.g., assessing decreases in reading speed due to morphosyntactic errors in the text; Jiang, 2004).

Grammatical well-formedness of narrative production

The pattern of results for grammatical well-formedness ratings on the narrative production was identical to that for the grammaticality judgment task. In the frog-story task, childhood speakers were considered by native-speaker raters to produce reliably better formed sentences than both childhood overhearers ($d = .89$; 95% CI for this difference of .67 was $+/-.44$) and typical late-L2-learners ($d = 1.01$; 95% CI for this difference of .72 was $+/-.40$), whereas the latter two groups did not seem to differ. Native speakers reliably outperformed the three other groups (Tables 5 and 6). Recall that the pattern of results was quite different for accent ratings on these frog stories. Namely, childhood speakers' and childhood overhearers' accent ratings did not differ reliably, and both groups outperformed typical late-L2-learners (Tables 3 and 4). Given the excellent inter-rater reliability for both kinds of ratings, the contrasting patterns of results for grammatical well-formedness ratings *vs.* accent ratings suggest that the two kinds of ratings are quite reliable and independent.

We recognize that the grammatical well-formedness ratings of narrative production offer a somewhat "brute-force" measure, assessing "global" well-formedness rather than focusing on morphosyntax, which was what we set out to examine. These ratings may have been contaminated by other characteristics of the narrative production (e.g., fluency, accent), even though we explicitly instructed our raters to focus only on grammatical well-formedness. Yet, despite these potential shortcomings, the pattern of results for grammatical well-formedness ratings on frog-story production coincides perfectly with the pattern of results for the grammaticality judgment task, which focused on detection of morphosyntactic errors. These converging findings help strengthen the case for lasting and measurable benefits of childhood speaking experience in the domain of grammar.

Perception of sentences in noise

When simple Spanish sentences were presented without noise, all four groups repeated the sentences with little difficulty. The detrimental effect of noise on sentence perception was smallest for native speakers. It was reliably smaller than that for childhood speakers ($d = 1.88$; 95% CI for this difference of $-.17$ was $+/-.1$), which in turn was marginally smaller than that for childhood overhearers ($d = 1.00$; 95% CI for this difference of $-.11$ was $+/-.12$), which in turn was reliably smaller than that for typical late-L2-learners ($d = 1.00$; 95% CI for this difference of $-.11$ was $+/-.09$). Importantly, childhood speakers seemed far less vulnerable than typical late-L2-learners to such detrimental effect of noise ($d = 2.20$; 95% CI for this difference of $-.22$ was $+/-.11$).

Note that phonological and higher level contextual information (e.g., semantic, grammatical) may help listeners decipher a sentence presented in noise (e.g., Mayo et al., 1997). Like native speakers, childhood speakers seem less vulnerable than typical late-L2-learners to the detrimental effect of noise on sentence perception. Childhood speakers also seem to fare marginally better than childhood overhearers. Future research is needed to sort out how much the observed advantage of childhood speaking experience reflects an advantage in grammar *vs.* phonology and semantics. Nonetheless, these results are a promising start.

Benefits of childhood speaking experience: Summary

Our findings suggest that speaking a language regularly during early childhood has lasting benefits beyond the domain of phonology. Specifically, childhood speakers outperformed both childhood overhearers and typical late-L2-learners in producing grammatically well-formed narratives and making grammaticality judgment in detecting morphosyntactic errors. Childhood speakers also outperformed typical late-L2-learners in sentence perception in noisy contexts and made fewer morphosyntactic errors in repeating simple sentences presented without noise (according to the confidence interval and effect size analyses on the inflectional errors). By contrast, childhood overhearers outperformed the typical late-L2-learners on only one of these four measures (i.e., sentence perception in noise).

Amount of input during early childhood

To what extent can the pattern of results just summarized be explained by differences in the sheer amount of input versus speaking experience *per se* during early

childhood? To address this question, we estimated the amount of input during early childhood by computing the average number of hours each participant spent around native speakers of Spanish each week prior to age 7 years. The amount of input turned out to correlate reliably with narrative grammatical well-formedness and grammaticality judgment accuracy (rs = .38 and .44, respectively, ps < .05), but not with detriment due to noise in the sentence perception task.

We also examined whether the correlation between the amount of input and the two outcome measures holds within each learner subtype. As it turns out, the amount of input was not reliably correlated with grammaticality judgment for either the 10 childhood speakers (r = .24, p > .5) or the 20 childhood overhearers (r = .02, p > .9). The amount of input was marginally correlated with narrative grammatical well-formedness for the childhood speakers (r = .60, p < .07), but not for the childhood overhearers (r = −.23, p > .3). These correlation coefficients suggest that there is more to the story than sheer amount of input.

We then explored how well learner subtype (childhood speakers *vs.* overhearers) and amount of input in early childhood might predict narrative grammatical well-formedness ratings and grammaticality judgment accuracy, using stepwise multiple regression analysis. For each outcome measure, we entered the two predictors in two different orders. In all four analyses, the first predictor entered into the regression model explained a significant amount of variance (R^2s > .14, Fs > 4.6, ps < .05), but not the second predictor (R^2s-change <.03, Fs < 1.1, n.s.). These results suggest considerable collinearity; indeed, the two predictors were highly correlated (r = .78, p < .001). This collinearity therefore reflects natural profiles of heritage language learners, with childhood speakers having spent considerably more time around native speakers during early childhood than childhood overhearers—presumably because learning to speak a language requires substantial exposure to the language.

Current use of Spanish

Could our findings be explained by some other factors, such as current use of Spanish? There is some evidence that mastery of L2 morphosyntax could depend on how much learners use that language (e.g., Flege et al., 1999). To explore this possibility, we examined current use of Spanish that participants—all enrolled in second-year Spanish classes at UCLA at the time— reported in the language-background questionnaire.

Amount of current use of Spanish

We first examined how many hours outside of Spanish classes our participants reported spending each week around people they spoke Spanish with. As expected, the native speakers used Spanish reliably more often than the three groups of non-native speakers. A one-way ANCOVA on the latter three groups (with gender as a covariate) revealed that the weekly averages did not differ reliably among the childhood speakers, childhood overhearers, and typical late-L2-learners (respectively, 4.0, 3.3, and 1.6 h/wk; $F(2, 65) = 1.1$, $p = .34$; see Tables 1 and 2).

Participants also reported on how often they did the following in Spanish: spoke to their family, friends, people at work (i.e., co-workers or customers), or others (e.g., bus-drivers, cashiers); read magazines, literature, letters, email; wrote letters, email; listened to radio; watched television; sang. We coded their responses as follows: 0 = not at all; 1 = 1–3 days/month; 2 = 1–3 days/wk; 3 = 4–6 days/wk; 4 = everyday. Two-independent-sample *t*-tests revealed no reliable differences between childhood speakers and childhood overhearers on all but one of these 13 measures (ts(27) < 1.4, ps > .19; for these 12 pairwise comparisons, all 95% confidence intervals covered zero, and effect sizes are small with ds < .5). The exception was "speaking to co-workers or customers" ($t(27) = 2.09$, $p = .046$; $d = .74$; the 95% CI for this difference of .86 was +/−.84), but even this difference became statistically non-significant when the p-level was corrected for multiple comparisons.

Quality of current use of Spanish

We also looked at self-reports on the quality of current use. For the times when they spoke, were addressed in, or heard Spanish, we asked participants whether it was mostly Spanish, about half-Spanish–half-English, or mostly English mixed with some Spanish words or phrases. We also asked whether they generally spoke in whole sentences, phrases, or isolated words. All six chi-square tests revealed no reliable differences between childhood speakers and childhood overhearers on any of these outcome variables (all ps > .2).

As far as we could tell from the participants' detailed self-reports, then, the childhood speakers and overhearers did not differ reliably on the quantity and quality of their use of Spanish around the time they participated in our study.

Learning motivation

A third concern is that the childhood speakers, having spoken Spanish as young children, may have been more motivated to regain their use of Spanish than the childhood overhearers and typical late-L2-learners learning to speak Spanish in high school and college. Can it be that learning motivation, rather than childhood speaking experience per se, accounts for the childhood speakers' advantage in grammar? To explore this possibility, we focused on the three groups of learners

to see if their motivation to learn Spanish correlated with their Spanish language abilities. In the language background questionnaire, there were two items most relevant to learning motivation. In one we asked, "AFTER you finish this Spanish course, what is the percentage of time you will speak Spanish and the percentage of time you will speak English on a typical week?" A higher estimate for speaking Spanish in the future could reflect stronger learning motivation. The other item asked participants to rate on a 5-point scale (from not at all to extremely well) how well the statement "It is important for me to speak Spanish well" described the participants' motivation for taking a Spanish class at that time.

Correlations between all 13 measures of Spanish abilities used in this study (listed in Tables 3 and 5) and these two learning motivation items were computed for childhood speakers, childhood overhearers, and typical late-L2-learners combined. The percentage of time they expected to speak Spanish in the future was reliably correlated with narrative accent ratings and person agreement in the verb-phrase production task ($rs > .29$, $ps < .05$). However, neither of these Spanish ability measures revealed reliable differences between childhood speakers on the one hand and childhood overhearers and typical late-L2-learners on the other. The ratings of how important participants felt it was to speak Spanish well turned out not to correlate reliably with any of the Spanish language ability measures.

Taken together, these analyses suggest that learning motivation, at least as far as we were able to measure it in this study, does not seem to account for the observed advantage of childhood speakers in the domain of grammar.

Discussion

The impact of input timing on language acquisition was explored in prior research primarily in linguistic deprivation studies, focusing on what we cannot learn if input comes too late. This study focuses instead on how very early learning may make a difference in language acquisition even in adulthood. As it turns out, speaking a language regularly for several years during early childhood seems to have lasting and measurable benefits for both grammar and phonology.

Why might early language experience have a special status? One account has to do with the loss of neural plasticity due to massive pruning of synapses and brain cells during childhood (e.g., Rakic, Bourgeois, Zecevic, Eckenhoff, & Goldman-Rakic, 1986), rendering language learners less able to make use of relevant input later in life. Another account has to do with early language experience setting fundamental parameters in

the Universal Grammar, thereby heavily influencing subsequent language acquisition (e.g., Chomsky, 1981; see also Pinker, 1994, on both accounts).

A third and increasingly compelling account has emerged from connectionist modeling of age-of-acquisition effects (e.g., Juhasz, 2005). Its logic is as follows: A memory network organizes itself, through larger weight changes, into a certain efficient configuration early on to represent what it knows about (e.g., a childhood language); it cannot nimbly reorganize itself even if the nature of the input changes (e.g., a second language). Thus early-learned materials will have an advantage and lasting impact on the memory network (e.g., Ellis & Lambon-Ralph, 2000; Zevin & Seidenberg, 2004). While our study was not set up to evaluate this account, our findings nonetheless need to be reckoned with. A case in point: How might a connectionist network use the timing of input frequency to model childhood speakers' hold on their childhood language memory despite almost a decade of disuse and minimal input (if any) during their elementary and middle school years, and despite becoming practically monolingual in a second language?

Our research speaks to the nature, as well as the timing, of input. In our prior study of adults re-learning Korean (Oh et al., 2003), we found that childhood hearers outperformed novice adult learners in phoneme perception, whereas childhood speakers outperformed childhood hearers and novice learners in both phoneme production and perception. In short, regular childhood speaking experience seems crucial to speaking with a better accent later in life. By contrast, the present study revealed little difference between childhood overhearers and childhood speakers in productive phonology, with both groups showing a clear advantage over the typical late-L2 learners. This finding is especially remarkable given the substantial difference in their input amounts during early childhood: on average 30 h/wk for childhood speakers and 6 h/wk for childhood overhearers. One caveat: the "childhood overhearers" in this study actually continued to hear some Spanish beyond childhood (spending about 2 h/wk around relatives who spoke Spanish). Future research will need to sort out the relative importance of early childhood hearing experience versus such minimal hearing experience beyond early childhood. For ease of exposition, though, we have been referring to these re-learners as childhood overhearers, but only advisedly.

Why, in any case, does regular childhood speaking experience seem crucial to a better accent for adult re-learners of Korean but not Spanish? One possibility is that, for late learners who are native speakers of English, the 3-way contrast of the target phonemes we examined in Korean (aspirated *vs.* plain *vs.* tense consonants; Oh et al., 2003) is more challenging than the 2-way contrasts we examined in Spanish (voiced *vs.* voiceless stops; stop

vs. lenited consonants; Au et al., 2002; Knightly et al., 2003). If so, speaking the language regularly during childhood could be more crucial to mastering productive phonology in Korean than in Spanish.

Another possibility is that childhood hearing experience can actually benefit adult learners' accent in Korean as well as Spanish, but it takes times for the re-learning process to reveal such benefits. Hearing a language—spoken by native speakers—regularly during childhood probably suffices for developing an accurate mental model of its phonology, as evident in childhood hearers' advantage over novice adult learners for phoneme perception in Korean (Oh et al., 2003). When childhood hearers try to learn to speak the language later in life, they can probably compare their own utterances to their mental model of the target phonology and modify their speech in order to emulate native speakers (e.g., Best, 1994; Kuhl & Meltzoff, 1982). But this learning process may take a substantial amount of time. Note that the childhood hearers in Oh and colleagues' (2003) study had just started their first-year Korean classes at UCLA a few months earlier, and had not taken any prior Korean classes. By contrast, the childhood overhearers in this study were enrolled in the second-year Spanish classes at UCLA and had taken three to five years of Spanish classes since around age 14 years. It remains to be seen whether childhood hearers of Korean can, after several years of re-learning, speak with a more native-like accent than adult learners who had no childhood hearing experience. If they can, then childhood hearing experience together with a substantial amount of re-learning may suffice to yield measurable benefits in productive phonology.

Our findings also speak to the nature of childhood language experience (i.e., speaking versus hearing) in another way. Merely overhearing a language with little comprehension, as in the case of pre-verbal infants exposed to their first language (e.g., Jusczyk, 1997), may suffice for tuning childhood overhearers' perceptual-motor system for speech—thereby inoculating them against having a heavy foreign accent when learning that language in high school or college. However, acquiring its grammar probably requires using the language to communicate with competent speakers regularly, as in the case of the childhood speakers in this study (i.e., spending on average 30 h/wk around native speakers during early childhood). Merely overhearing it during childhood will not do, as anecdotal reports of children failing to learn a language from television also suggest (e.g., Rice, 1983). In this study, the childhood overhearers did not differ reliably from the typical late-L2-learners on any of the grammar-related measures but one (i.e., sentence perception in noise). By contrast, the childhood speakers outperformed both childhood overhearers and typical late-L2-learners in producing grammatically well-formed narratives and making

grammaticality judgments. They also outperformed typical late-L2-learners in sentence perception in noisy contexts and made fewer morphosyntactic errors in repeating simple sentences presented without noise.

The childhood speakers' advantage over the childhood overhearers, however, needs to be interpreted with caution. Note that the childhood speakers in this study had richer early experience with Spanish than childhood overhearers both in quantity and quality. The childhood speakers used Spanish for more hours each week as young children, and they spoke Spanish regularly instead of merely overhearing it. It remains to be seen to what extent the differences observed between these two groups of re-learners can be attributed to differences in quantity *vs.* quality of their early experience with the childhood language.

We are mindful that the sample size is modest, especially for childhood speakers ($N = 10$). This is a direct consequence of our adopting rather stringent inclusion criteria in order to get a "clean" sample for each group of participants. While this study can make a credible contribution as an initial demonstration of potential benefits of childhood speaking experience, further empirical confirmation is necessary. We are also mindful that the observed differences between childhood speakers and overhearers on the one hand and typical late-L2-learners on the other could be due to differences in the amount as well as timing of input. But importantly, the typical late-L2-learners did not perform across the board worse than the childhood speakers and overhearers. The areas where they did fall short, namely phonology and grammar, are good candidates for revealing benefits of early language experience.

Caveats aside, this study speaks to the accessibility of tacit childhood memory. It offers some evidence that childhood language experience can remain accessible after years of disuse. Re-learning a language, even in adulthood, could salvage bits of childhood—or at least bits of a childhood language.

Acknowledgments

References

Ås, A. (1962). The recovery of forgotten language knowledge through hypnotic age regression: A case report. *American Journal of Clinical Hypnosis, 5*, 24–29.

Au, T. K., Knightly, L. M., Jun, S.-A., & Oh, J. S. (2002). Overhearing a language during childhood. *Psychological Science, 13*, 238–243.

Au, T. K., & Romo, L. F. (1997). Does childhood language experience help adult learners? In H.-C. Chen (Ed.), *The cognitive processing of Chinese and related Asian languages* (pp. 417–441). Hong Kong: Chinese University Press.

Best, C. T. (1994). The emergence of native-language phonological influences in infants: A perceptual assimilation model. In J. C. Goodman & H. C. Nusbaum (Eds.), *The development of speech perception: The transition from speech sounds to spoken words* (pp. 167–224). Cambridge, MA: MIT Press.

Bongaerts, T., Van Summeren, C., Planken, B., & Schils, E. (1997). Age and ultimate attainment in the pronunciation of a foreign language. *Studies in Second Language Acquisition, 19*, 447–465.

Chomsky, N. (1981). *Lectures on government and binding.* Dordrecht, Holland: Foris.

Cohen, J. (1977). *Statistical power analysis for the behavioral sciences* (Rev. ed.). New York: Academic Press.

Cohen, J. D., MacWhinney, B., Flatt, M., & Provost, J. (1993). PsyScope: A new graphic interactive environment for designing psychology experiments. *Behavioral Research Methods, Instruments, and Computers, 25*, 257–271.

Ellis, A. W., & Lambon-Ralph, M. A. (2000). Age of acquisition effects in adult lexical processing reflect loss of plasticity in maturing systems: Insights from connectionist networks. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 26*, 1103–1123.

Fillmore, L. W. (1991). When learning a second language means losing the first. *Early Childhood Research Quarterly, 6*, 323–346.

Flege, J. (1987). A critical period for learning to pronounce foreign languages? *Applied Linguistics, 8*, 162–177.

Flege, J. (1991). Age of learning affects the authenticity of voice-onset time (VOT) in stop consonants produced in a second language. *Journal of the Acoustical Society of America, 89*, 395–411.

Flege, J. E., & Eefting, W. (1988). Imitation of a VOT continuum by native speakers of English and Spanish: Evidence for phonetic category formation. *Journal of the Acoustical Society of America, 83*, 729–740.

Flege, J. E., Yeni-Komshian, G. H., & Liu, S. (1999). Age constraints on second-language acquisition. *Journal of Memory & Language, 41*, 78–104.

Fromm, E. (1970). Age regression with unexpected reappearance of a repressed childhood language. *International Journal of Clinical and Experimental Hypnosis, 18*, 79–88.

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

Jiang, N. (2004). Morphological insensitivity in second language processing. *Applied Psycholinguistics, 25*, 603–634.

Juhasz, B. J. (2005). Age-of-acquisition effects in word and picture identification. *Psychological Bulletin, 131*, 684–712.

Jusczyk, P. W. (1997). *The discovery of spoken language.* Cambridge, MA: MIT Press.

Knightly, L. M., Jun, S.-A., Oh, J. S., & Au, T. K. (2003). Production benefits of childhood overhearing. *Journal of the Acoustical Society of America, 114*, 465–474.

Kondo-Brown, K. (2005). Differences in language skills: Heritage language learner subgroups and foreign language learners. *Modern Language Journal, 89*, 563–581.

Kouritzin, S. G. (1999). *Face(t)s of first language loss.* Mahwah, NJ: Erlbaum.

Kuhl, P. K., & Meltzoff, A. N. (1982). The bimodal perception of speech in infancy. *Science, 218*, 1138–1141.

Masson, M. E. J., & Loftus, G. R. (2003). Using confidence intervals for graphically based data interpretation. *Canadian Journal of Experimental Psychology, 57*, 203–220.

Mayo, L. H., Florentine, M., & Buss, S. (1997). Age of second-language acquisition and perception of speech in noise. *Journal of Speech and Hearing Research, 40*, 686–693.

Montrul, S. (2006). Incomplete acquisition as a feature of L2 and bilingual grammars. In R. Slabakova, S. Montrul, & P. Prévost (Eds.), *Inquiries in language development: Studies in honor of Lydia White* (pp. 335–359). Amsterdam: John Benjamins.

Montrul, S., Thornhill, D., Foote, R., Perpiñán, S., & Vidal, S., (2006). Gender agreement in Spanish heritage and L2 Grammars: When age meets task and context of acquisition. Seminar in the Department of Linguistics, University of Illinois, Urbana-Champaign, USA.

Newport, E. L. (1990). Maturational constraints on language learning. *Cognitive Science, 14*, 11–28.

Nicoladis, E., & Grabois, H. (2002). Learning English and losing Chinese: A case study of a child adopted from China. *The International Journal of Bilingualism, 6*, 441–454.

Oh, J. S., Jun, S.-A., Knightly, L. M., & Au, T. K. (2003). Holding on to childhood language memory. *Cognition, 86*, B53–B64.

Oyama, S. (1976). A sensitive period for the acquisition of a nonnative phonological system. *Journal of Psycholinguistic Research, 5*, 261–283.

Pinker, S. (1994). *The language instinct.* New York: Morrow.

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

Paradis, M. (2004). *A neurolinguistic theory of bilingualism.* Amsterdam: John Benjamins.

Rakic, P., Bourgeois, J-P., Zecevic, N., Eckenhoff, M. F., & Goldman-Rakic, P. S. (1986). Isochronic overproduction of synapses in diverse regions of the primate cerebral cortex. *Science, 232*, 232–235.

Rice, M. (1983). The role of television in language acquisition. *Developmental Review, 3*, 211–224.

Snow, C., & Hoefnagel-Hohle, M. (1978). The critical period for language acquisition: Evidence from second language learning. *Child Development, 49*, 1114–1128.

Tees, R. C., & Werker, J. F. (1984). Perceptual flexibility: Maintenance or recovery of the ability to discriminate non-native speech sounds. *Canadian Journal of Psychology, 38*, 579–590.

Ventureyra, V. A. G., Pallier, C., & Yoo, H.-Y. (2004). The loss of first language phonetic perception in adopted Koreans. *Journal of Neurolinguistics, 17*, 79–91.

Williams, L. (1977). The perception of stop consonant voicing by Spanish–English bilinguals. *Perception & Psychophysics, 21*, 289–297.

Williams, L. (1980). Phonetic variation as a function of second-language learning. In G. H. Yeni-Komshian, J. F. Kavanagh, & C. A. Ferguson (Eds.). *Child phonology: Perception* (Vol. 2, pp. 185–215). New York: Academic Press.

Zevin, J. D., & Seidenberg, M. S. (2004). Age-of-acquisition effects in reading aloud: Tests of cumulative frequency and frequency trajectory. *Memory & Cognition, 32*, 31–38.