



# IMPLICIT AND EXPLICIT LANGUAGE LEARNING

Conditions, Processes, and Knowledge  
in SLA and Bilingualism

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## ■ Aging, Pedagogical Conditions, and Differential Success in SLA: An Empirical Study

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**LEARNING A SECOND LANGUAGE** is difficult but not impossible for older adults. There is evidence that intentional instructions to learn material such as word pairs or paragraphs often result in larger age-related memory deficits than do more incidental instructions, in part because the strategies that older adults adopt for memorizing are less effective than those adopted by younger adults. This suggests that older adults might benefit from language instruction that encourages more incidental, implicit learning. In our study twenty adults aged sixty-six through eighty-one and twenty college-aged participants were exposed to a lesson on semantic function assignment in Latin under two conditions that differed in degree of explicitness: the presence or absence of grammar rules provided as part of feedback. Our results revealed no significant age deficits in learning and showed that feedback without grammar rules was more effective than more explicit feedback for the older, but not for the younger, adults. The study also demonstrated retention of limited exposure to high school Latin lasting over five decades, consistent with Bahrick's (1984) *permastore*. Contrary to common belief, our evidence bodes well for older adults who are motivated to learn a second language, especially when conditions are similar to those in naturalistic rather than academic contexts.

### Introduction

Why second language acquisition becomes more difficult with aging is unclear. The *critical period hypothesis* (e.g., Penfield and Roberts 1959) was later replaced by the idea of a *sensitive period* (Hyltenstam and Abrahamsson 2000). However, these

notions have now been nearly dismissed in favor of the *linear decline hypothesis* that says the ability to learn a second language decreases steadily with age. For example, Hakuta, Bialystok, and Wiley (2003) used 1990 census data to show a negative linear relationship between age of arrival (AOA) in a new country and end-state L2 acquisition. Flege, Yeni-Komshian and Liu (1999) found that L1 Korean/L2 English bilingual speakers' foreign accent positively correlated with their AOA in the US, while accuracy in morphosyntax was negatively correlated. Similarly, Birdsong (2006) highlighted a negative correlation between AOA and ultimate attainment, and that a later AOA often led to more errors in grammatical judgment and a higher degree of nonnative accent.

#### **Sources of Age Effects: Biological**

Brain changes that occur with aging likely contribute to these linear age-related declines in grammar learning. For example, there is some evidence (e.g., reviewed by Ullman 2001) that syntax is processed mainly in the frontal cortex and basal ganglia, areas that show structural and functional declines beginning in young adulthood (e.g., Hedden and Gabrieli 2005; Raz et al. 2005). Birdsong (2006) noted the importance of dopamine in SLA, and several studies show a decrease in dopamine receptors beginning around age twenty (Li, Lindenberger, and Sikström 2001; Volkow et al. 1998). Further, while some forms of implicit learning are relatively spared with aging, others are not, particularly the learning of subtle, complex sequential structure that calls on frontostriatal systems (e.g., Bennett, Howard, and Howard 2007; Gagnon, Bedard, and Turcotte 2005; Howard et al. 2008).

#### **Sources of Age Effects: Cognitive and Social-Affective Factors**

Park (2000) suggested the main deficits that occur with cognitive aging are decreases in simultaneous processing and storage capacity (working memory capacity, WMC), processing speed, and inhibitory control. Inhibitory control may explain bilinguals' advantage in cognitive tasks (Bialystok, this volume) and L3 learning, as it helps suppress irrelevant input (Sanz 2000). WMC is important in SLA because it enables the short-term rehearsal of sequences and their consolidation into language (Ellis and Sinclair 1996). SLA studies examining the interaction between WMC and pedagogical treatments (e.g., Erlam 2005; Sanz et al., unpublished ms.)—including explicit feedback (Lado 2008; Lin 2009) and recasts (Mackey et al., in press; Sagarra 2007)—have also identified WMC as a predictor of success in language development.

Decreased speed and attention also contribute to uneven success in adult SLA (Kemper 1992). Whether attention (with awareness) is required for SLA is debated (Hama and Leow, in press; Williams 2005), but it is important for learning complex sequences hidden in grammar (Cohen, Ivry, and Keele 1990).

Social-affective factors that covary with age may also contribute to age effects. For example, younger learners are exposed to literacy, which increases their exposure to the input (Bialystok and Hakuta 1999). Motivation, self-esteem, attitude, and desire to assimilate (Long 1999; Singleton 2001) are factors internal to the learner that can further affect L2 success.

#### **Adults Can Attain Native-Like Proficiency in a Foreign Language**

Despite the factors working against older learners, recent views (e.g., Birdsong 1992; Birdsong and Molis 2001) suggest SLA is possible across the lifespan, and is influenced by individual differences (IDs) and external conditions. Marinova-Todd (2003) showed that some adults who arrived in an English-speaking country after the age of sixteen were indistinguishable from native speakers on certain language measures. Birdsong (1992) examined English speakers (mean age of forty) who were first exposed to French after puberty and found that many with significant exposure to the language reached native-like abilities in grammaticality judgment tests. Bongaerts, Mennen, and van der Silk (2000) studied late learners of Dutch and found that adults (mean age of forty) could demonstrate native-like accent with enough practice. Finally, Birdsong and Molis's (2001) replication of Johnson and Newport (1989) demonstrated, unlike the original study, that a number of late learners showed native-like attainment.

#### **Age-Appropriate Pedagogical Conditions**

For decades SLA research has been examining the effects of pedagogical conditions and IDs in language development. Only recently, however, have studies explored how IDs mediate the effects of such pedagogical variables as type of practice and exposure to grammar lessons or feedback (e.g., work by Erlam 2005; Mackey et al., in press; Sagarra 2007; and Sanz et al. 2009).

There is evidence in cognitive psychology that intentional instructions to learn material, such as word pairs or paragraphs, often result in larger age-related memory deficits than do more incidental instructions (e.g., Old and Naveh-Benjamin 2008), in part because the strategies that older adults adopt for memorizing are not as effective as those adopted by younger adults. In contrast, automatic processing without the active use of strategies may be unaffected by age (Hasher and Zacks 1979). Further, there is evidence that trying to learn can even hurt implicit forms of learning under some conditions (e.g., Howard and Howard 2001; Song et al. 2009).

Midford and Kirsner (2005) offered evidence that the optimal method of L2 teaching might differ between younger and older adults. They used Reber's (1967) artificial grammar paradigm to examine the effects of explicit and implicit methods of L2 teaching in older (mean age 65.9) and young adults (mean age 20.6). They varied type of instruction (explicit or none), and grammar complexity. Explicit instruction told participants to look for the underlying pattern of the artificial grammar, which they were later asked to describe. Results indicated that the older group was least disadvantaged in the most implicit condition and most disadvantaged in the simple grammar, particularly with explicit instruction. The older group showed deficits in all conditions but were least disadvantaged in the most implicit condition.

The present experiment attempts to extend Midford and Kirsner's results, using a real language and operationalizing the degree of explicitness. The Explicit treatment combines feedback on accuracy with a grammar explanation, while the Less Explicit treatment provides only accuracy feedback. L2 development is measured by accuracy in assignment of semantic functions to noun phrases in L2 Latin. Interpretation,

production, and grammaticality judgment tests are given in pretests, and in posttests immediately following treatment, and one week after treatment to observe retention. Based on Midford and Kirsner's findings, we predicted that older adults would learn better in the Less Explicit than the Explicit condition.

## Methods

### Participants

Participants were twenty older adults (eleven female, nine male) who had previously participated in an experiment in the Georgetown University Cognitive Aging Lab and who expressed interest in returning. They ranged in age from sixty-six to eighty-one ( $m = 72.3$ ). These older adults were compared to twenty Georgetown students (thirteen female, seven male, age range eighteen to twenty-one,  $m = 18.7$ ) who were part of a dissertation study (Lado 2008). All participants were monolingual (English) and had no significant exposure to any case-marking language (e.g., German, Turkish). Participants were assigned to one of two treatment groups: Less Explicit or Explicit feedback. The treatment groups were matched for gender and background in Latin and other foreign languages. The older treatment groups did not differ significantly from each other on Mini-Mental State Examination Score ( $m = 29$ ,  $sd = 1$ ), WAIS-III Vocabulary ( $m = 66$ ,  $sd = 9.7$ ), WMS-III Digits Span Forward ( $m = 9$ ,  $sd = 2.3$ ), or WMS-III Digit Span Backwards ( $m = 6$ ,  $sd = 1.9$ ).

### Procedure

Procedures and materials followed the Latin Project's design. The experiment was administered in three sessions in the iMac language Lab or the Cognitive Aging Lab. Tests and treatments were delivered by a computer application that combines Flash and ColdFusion programming tools. Except for treatment assignment, all participants were treated identically, following the procedure detailed below. Further details on testing and treatment materials may be found in Lado's (2008) dissertation.

**Vocabulary training.** After a questionnaire that assessed language experience, each subject received a Latin vocabulary lesson consisting of thirty-five nouns and eleven verbs. Each lexical item was presented with a picture, an English translation, and a sound file. The nouns were presented with gender- and case-appropriate endings (singular and plural nominative and accusative forms). Verbs were presented in third person singular and plural forms. Items were presented once for twelve to fifteen seconds each, and the lesson advanced automatically.

Table 7.1  
Experiment Procedures

Day 1	Day 2 (1–2 Days after Day 1)	Day 3 (1 week after Day 2)
• Vocabulary training	• Grammar training 2 rounds Explicit or Less Explicit	• No training
• Pretest	• Posttest	• Delayed test

Presentation was followed by a quiz. If participants did not reach a 60 percent accuracy level, they were automatically prompted to go through the vocabulary lesson again. If they reached the 60 percent threshold, they were quizzed again on those items they had failed. The procedure was repeated until 100 percent accuracy was reached, at which point participants completed a pretest.

**Grammar pretest.** This test, like the post- and delayed tests, was divided into four sections: aural interpretation, written interpretation, written grammaticality judgment, and written production. All items, as well as test ordering, were randomized, except for the production test, which was always administered last. All treatment and critical sentences consisted of two human nouns performing transitive actions. The Written Interpretation test required matching the correct sentence with the picture appearing on the screen with two people in costume, one of whom was performing an action on the other. The Aural Interpretation test was similar except that the input was oral. In the Grammaticality Judgment test, a sentence appeared on the screen and participants used the keyboard to indicate whether or not the sentence was grammatical. In all three tests participants could choose an "I don't know" option. In the Sentence Production test, participants created Latin sentences to depict a picture. The roots and Latin endings were provided in boxes, and participants were instructed to drag and drop so as to avoid typing errors.

**Treatments.** On their second test day, participants were assigned to either the Explicit or the Less Explicit group. Both treatments consisted of six untimed versions of a task that provided input-based practice and asked participants to read or listen to a Latin sentence and to pick a picture or English translation that represented what they saw or heard. After they entered their response, both feedback groups were told if they were correct or incorrect, as in *Oops! That's incorrect!* The Explicit group also received a grammatical explanation, as in *Oops! -us is a subject ending, and -um is an object ending.* Feedback in both groups was visible for six seconds. All subjects completed two lessons, each lasting approximately thirty minutes.

**Posttest.** Following the treatments on Day 2, the participants completed a posttest.

**One-week-delayed grammar test.** Identical to the others, this assessed retention.

## Results

### Performance in the Older Group

Figure 7.1a–d shows the mean number correct on each of the four grammar tests for the older adults broken down by Time (pre-, post-, delayed) and Treatment (Less Explicit and Explicit). Visual examination suggests the Less Explicit group is in the direction of performing better than the Explicit group for all four tests. However, when separate mixed design Treatment  $\times$  Time ANOVAs were conducted for each measure, only Grammaticality Judgment yielded a significant Treatment  $\times$  Time interaction,  $F(2,32) = 3.323$ ,  $p = .0488$ . For Grammaticality Judgment, the Less Explicit treatment yielded significantly higher scores during the posttest than the Explicit treatment,

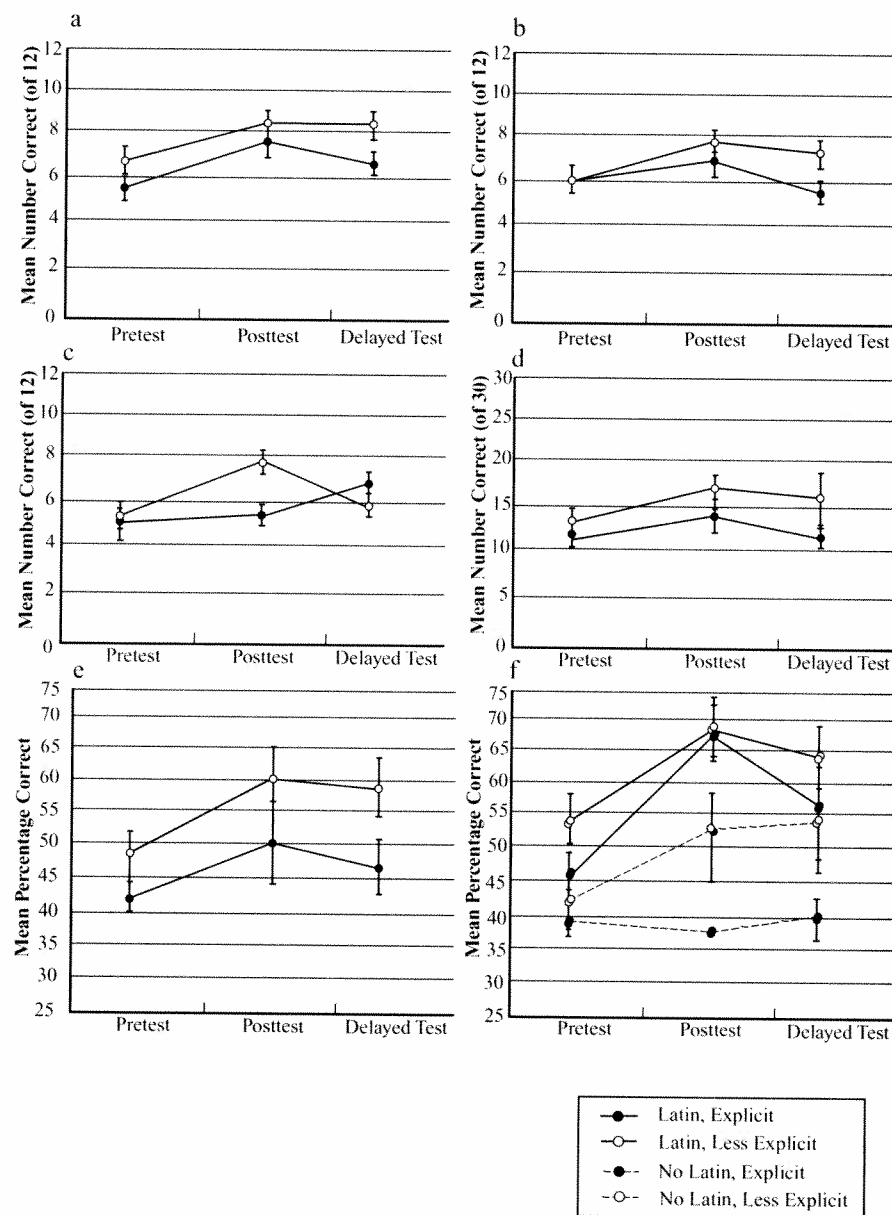


Figure 7.1 Mean Number of Correct Performances of the Older Adults on the Four Grammar Tests. (a) Mean number correct on the Written Interpretation test. (b) Mean number correct on the Aural Interpretation test. (c) Mean number correct on the Grammaticality Judgment test. (d) Mean number correct on the Sentence Production test. (e) Mean percent correct combined across the four tests. (f) The effect of Latin experience on combined test performance of the older participants.

$t(18) = 2.304, p = .0334$ . Grammaticality Judgment also yielded a main effect of Time  $F(2, 32) = 4.644, p = .0170$ , indicating there was learning over the three testing days. For Written Interpretation, there was a main effect of Time  $F(2, 32) = 4.045, p = .0271$ . For Aural Interpretation there were no significant effects. For Sentence Production there was a main effect of Time,  $F(2, 28) = 3.660, p = .0387$ ; this effect was carried by the Less Explicit group, which showed a significant effect of Time,  $F(2, 12) = 4.105, p < .0438$ , while the Explicit group did not,  $F(2, 16) = .945, ns$ .

#### Combining the Measures

To improve statistical power, scores from the four tests were combined into one composite measure by averaging percentage scores from all four tests for each participant (fig. 7.1e). Only the Less Explicit feedback group showed a main effect of Time  $F(2, 16) = 6.969, p = .0067$ , and was therefore the only older group to show significant learning.

#### Previous Latin Experience in the Older Group

Because some older participants ( $n = 5$  in the Less Explicit group,  $n = 4$  in the Explicit group) reported previous coursework in Latin, the effect of their Latin experience on their overall performance was assessed via the composite measure, as shown in figure 7.1f. There was a main effect of Latin experience,  $F(1, 14) = 12.337, p = .0034$ , suggesting previous Latin experience enhanced performance.

#### Learning in the Young Group

Figure 7.2a–d show the performances of the younger group on the four tests. Neither treatment was significantly better on any of the four tests, that is, there were no main effects nor interactions for Treatment. Participants in the Explicit group showed a main effect of Time on the Written Interpretation test ( $F[2, 18] = 5.004, p = .0187$ ), and on the Grammaticality Judgment test ( $F[2, 16] = 6.695, p = .0077$ ) and this effect was marginally significant for the Sentence Production test ( $F[2, 18] = 3.143, p = .0675$ ). Participants in the Less Explicit group showed a significant Time effect only on the Grammaticality Judgment test,  $F[2, 18] = 5.812, p = .0113$ . The composite measure of the younger groups (fig. 7.2e) suggests that for the young adults, in contrast to the older, Explicit feedback was superior to Less Explicit. Separate ANOVAs revealed significant learning in the Explicit group  $F(2, 18) = 11.583, p = .0006$ , but only marginally significant learning in the Less Explicit group  $F(2, 18) = 3.268, p = .0616$ .

#### Age and Learning

Because prior Latin exposure influenced performance, and younger participants did not have previous exposure, older adults with this exposure were excluded from the age comparison. Figure 7.3 shows the composite measure of participants without previous Latin experience for both age and treatment groups. There was no main effect of Age, showing that there were no significant age deficits in this experiment. There was a main effect of Time,  $F(2, 52) = 8.468, p = .0007$ , indicating overall learning among participants without previous Latin exposure.

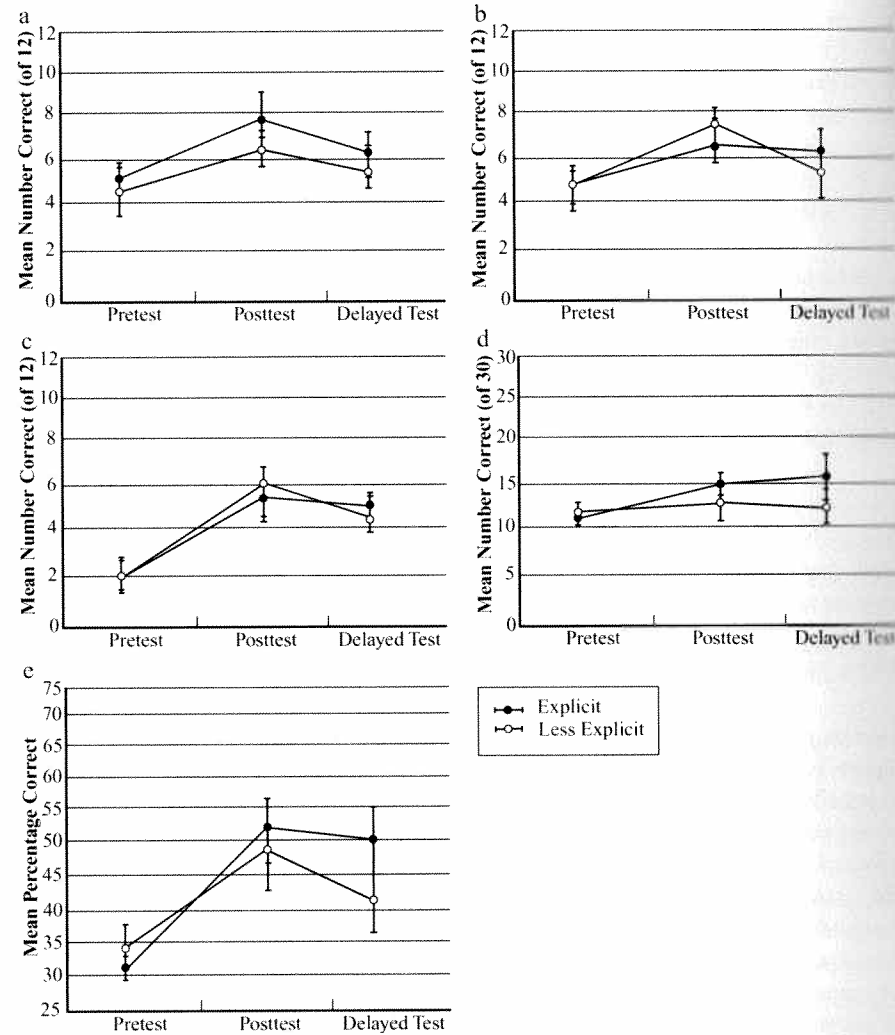


Figure 7.2 Mean Number of Correct Performances of the Younger Group on the Four Grammar Tests. (a) Mean number correct on the Written Interpretation test. (b) Mean number correct on the Aural Interpretation test. (c) Mean number correct on the Grammaticality Judgment test. (d) Mean number correct on the Sentence Production test. (e) Mean percent correct combined across the four tests.

### Discussion

Overall, our results are consistent with Midford and Kirsner's (2005) findings that the older group did better in the Less Explicit form of the task, whereas the young did not. However, the age deficits seen by Midford and Kirsner are not as pronounced in the current study.

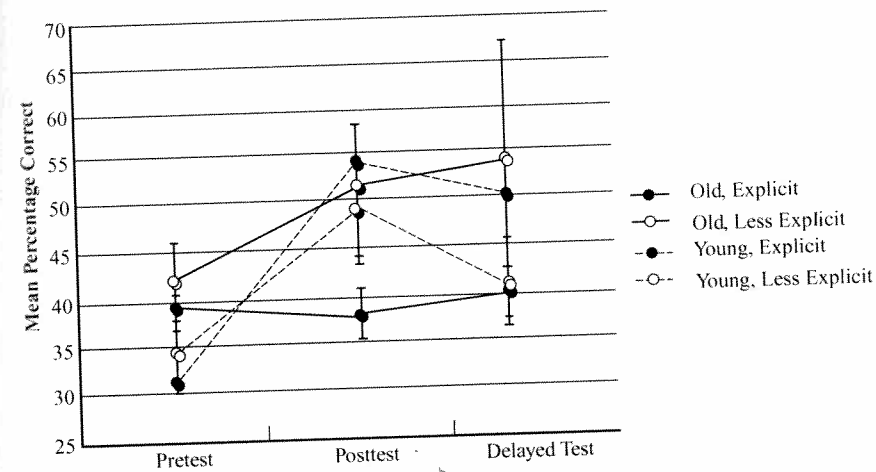


Figure 7.3 Composite Measure of Participants without Previous Latin Experience for Both Age and Treatment Groups.

We have identified evidence of overall learning in the older group that was not significantly less than in the young group, even when those with previous Latin experience were removed (fig. 7.3). This supports the notion that older adults are still capable of learning complex morphosyntax (Birdsong 1992; Marinova-Todd et al. 2003). It is possible the older adults were very motivated, as they were recruited from past experiments in the lab and had expressed interest in coming back, and they asked about their progress frequently. While this experiment did not provide prolonged exposure to a second language, the ability of these older adults to learn a complex structure that required realignment of cue preference (from word order to subject-verb agreement and case morphology) in Latin in a short time is noteworthy.

The hypothesis that Less Explicit feedback would be more effective than Explicit for older participants received support. While only one measure (Grammaticality Judgment) yielded the predicted Treatment  $\times$  Time interaction, it is evident from the individual and composite graphs that the Less Explicit feedback was more helpful to the older adults than the Explicit. This holds true especially when the adults with previous Latin experience ( $n = 9$ ) are removed (fig. 7.3). In the young group the opposite pattern is occurring, favoring the Explicit feedback. The small sample size may explain the lack of significant Treatment effects in the young group.

A common complaint from older adults in the Explicit training group was that the feedback was not presented for enough time. While our purpose was to match the timing between the groups, this may account for the relative success of the older Less Explicit group. Future studies could be self-paced. Another possibility is that the Explicit feedback was distracting and encouraged older adults to try to memorize the rules contained in the feedback, and their strategies were unsuccessful, actually hurting the learning of the syntax. Further research could ask participants to find patterns

in the grammar during the training phase to see if effortful processing would diminish the advantage of the Less Explicit group. This could even take the form of verbalization of thoughts during the grammar tests, which shows the potential to aid younger adult learners of a second language (Sanz et al. 2009).

The analyses also yielded evidence of retention despite a five-decade lag between exposure to Latin in high school and current testing (fig. 7.1f). Bahrck (1984) used regression analysis to examine the recall and recognition of adults who were one to fifty years beyond the end of their high school and/or college Spanish instruction. Reading comprehension, recall, and vocabulary and grammar recognition were related to the level of initial instruction and the grades received in the Spanish course. Bahrck concluded there existed a fifty-year *permastore* for adults who studied Spanish in school, despite having engaged in little to no rehearsal in the interim. In the present experiment older participants who claimed to have limited recollection of Latin exposure had higher baseline performances than participants with no previous Latin (young and old).

### Conclusion

Our results suggest that older adults are as capable as college-aged learners of developing new L2 knowledge after limited exposure, especially under the right conditions. This is encouraging for adults motivated to become bilingual and carries implications for the field of aging and SLA. It is sobering that, contrary to general beliefs in the teaching profession, more grammar does not always mean faster rates of acquisition. Clearly, a one-size-fits-all approach to language teaching is not the best solution, and the field needs to continue investigating the interaction between individual differences, including adult age, and pedagogical variables.

### NOTE

This study is part of The Latin Project<sup>©</sup>, developed to investigate the relationship among bilingualism, cognition, and language development. All materials, including the treatment and test components, were developed by Cristina Sanz, Harriet Bowden, and Catherine Stafford, with support from Spencer Foundation and Georgetown's GSAS grants to Sanz and assistance from Bill Garr from Georgetown University Information Systems. The older participants were tested as part of Alison E. Lenet's senior honors thesis and the younger participants were part of Beatriz Lado's dissertation (2008). The study was supported by NIH/NIA Grant R37AG1545.

### REFERENCES

- Bahrck, Harry P. 1984. Semantic memory content in permastore: Fifty years of memory for Spanish learned in school. *Journal of Experimental Psychology: General* 113:1–29.
- Bennett, Ilana J., James H. Howard Jr., and Darlene V. Howard. 2007. Age-related differences in implicit learning of subtle third-order sequential structure. *Journals of Gerontology: Series B, Psychological Sciences and Social Sciences* 62:98–103.
- Bialystok, Ellen, and Kenji Hakuta. 1999. Confounded age: Linguistic and cognitive factors in age differences for second language acquisition. In *Second language acquisition and the critical period hypothesis*, ed. David Birdsong, 161–81. Mahwah, NJ: Lawrence Erlbaum Associates.
- Birdsong, David. 1992. Ultimate attainment in second language acquisition. *Language* 68:706–55.
- . 2006. Age and second language acquisition and processing: A selective overview. *Language Learning* 56:9–49.

- Birdsong, David, and Michelle Molis. 2001. On the evidence for maturational constraints in second-language acquisition. *Journal of Memory and Language* 44:235–49.
- Boutangs, Theo, Susan Mennen, and Frans van der Silk. 2000. Authenticity of pronunciation in naturalistic second language acquisition: The case of very advanced late learners of Dutch as a second language. *Studia Linguistica* 54:298–308.
- Bussey, Asher, Richard Ivry, and Steven Keele. 1990. Attention and structure in sequence learning. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 16:17–30.
- Hills, Nick, and Susan Sinclair. 1996. Working memory in the acquisition of vocabulary and syntax: Putting language in good order. *Quarterly Journal of Experimental Psychology: Section A* 49:234–50.
- Irwin, Rosemary. 2005. Language aptitude and its relationship to instructional effectiveness in second language acquisition. *Language Teaching Research* 9:147–71.
- Jiang, James, Grace Yeni-Komshian, and Serena Liu. 1999. Age constraints on second language acquisition. *Journal of Memory & Language* 41:78–104.
- Jiang, Sylvain, Marie-Josée Bedard, and Josee Turcotte. 2005. The effect of old age on supra span learning of visuo-spatial sequences under incidental and intentional encoding instructions. *Brain Cognition* 59:225–35.
- Kikusa, Kenji, Ellen Bialystok, and Edward Wiley. 2003. Critical evidence: A test of the Critical-Period Hypothesis for second-language acquisition. *Psychological Science* 14:31–38.
- Liava, Mika, and Ronald P. Leow. In press. Learning without awareness revisited: Extending Williams (2005). *Studies in Second Language Acquisition* 32.
- Neisser, Lynn, and Rose T. Zacks. 1979. Automatic and effortful processes in memory. *Journal of Experimental Psychology: General* 108:356–88.
- Shulman, Trey, and John D. E. Gabrieli. 2005. Healthy and pathological processes in adult development: New evidence from neuroimaging of the aging brain. *Current Opinion in Neurology* 18:740–47.
- Howard, Darlene V., and James H. Howard Jr. 2001. When it does hurt to try: Adult age differences in the effects of instructions on implicit pattern learning. *Psychonomic Bulletin & Review* 8:798–805.
- Howard James H., Jr., Darlene V. Howard, Nancy A. Dennis, and Andrew J. Kelly. 2008. Implicit learning of predictive relationships in three-element visual sequences by young and old adults. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 34:1139–57.
- Hyman, Kenneth, and Niclas Abrahamsson. 2000. Who can become native-like in a second language? All, some, or none? On the maturational constraints controversy in second language acquisition. *Studia Linguistica* 54:150–66.
- Johnson, Jacqueline, and Elissa Newport. 1989. Critical period effects in second language learning: The influence of maturational state on the acquisition of ESL. *Cognitive Psychology* 21:60–99.
- Kemper, Susan. 1992. Language and aging. In *Handbook of aging and cognition*, ed. Fergus I. M. Craik and Timothy Salthouse, 213–70. Mahwah, NJ: Lawrence Erlbaum Associates.
- Lado, Beatriz. 2008. *The role of bilingualism, type of feedback, and cognitive capacity in the acquisition of non-primary languages: A computer-based study*. PhD diss., Georgetown University, Washington, DC.
- Li, Shu-Chen, Ulman Lindenberger, and Sverker Sikström. 2001. Aging cognition: From neuromodulation to representation. *Trends in Cognitive Sciences* 5:479–86.
- Liu, Hui-Ju. 2009. *Bilingualism, feedback, cognitive capacity, and learning strategies in L3 development*. PhD. diss., Georgetown University, Washington, DC.
- Long, Michael. 1999. Maturational constraints on language development. *Studies in Second Language Acquisition* 12:251–85.
- Mackey, Alison, Rebecca Adams, Catherine Stafford, and Paula Winke. In press. Exploring the relationship between modified output and working memory capacity. *Language Learning* 60.
- Marinova-Todd, Stefka H. 2003. Know your grammar: What the knowledge of syntax and morphology in an L2 reveals about the critical period for second/foreign language acquisition. In *Age and the acquisition of English as a foreign language: Theoretical issues and field work*, ed. Maria del Pilar Garcia-Mayo and Maria Luisa Garcia Lecumberri, 59–73. Clevedon, UK: Multilingual Matters.
- Midford, Richard, and Kim Kirsner. 2005. Implicit and explicit learning in aged and young adults. *Neuropsychology & Cognition* 12:359–87.

- Old, Susan R., and Moshe Naveh-Benjamin. 2008. Differential effects of age on item and associative measures of memory: A meta-analysis. *Psychology and Aging* 23:104–18.
- Park, Denise C. 2000. The basic mechanisms accounting for age-related decline in cognitive function. In *Cognitive aging: A primer*, ed. Denise C. Park and Norbert Schwarz, 3–21. Philadelphia: Psychology Press.
- Penfield, Wilder, and Lamar Roberts. 1959. *Speech and brain mechanisms*. Princeton, NJ: Princeton University Press.
- Raz, Naftali, Ulman Lindenberger, Karen M. Rodrigue, Kristin M. Kennedy, Denise Head, Adrienne Williamson, et al. 2005. Regional brain changes in aging healthy adults: General trends, individual differences and modifiers. *Cerebral Cortex* 15:1676–89.
- Reber, Arthur S. 1967. Implicit learning of artificial grammars. *Journal of Verbal Learning and Verbal Behavior* 6:855–63.
- Sagarra, Nuria. 2007. From CALL to face-to-face interaction: The effect of computer-delivered recasts and working memory on L2 development. In *Conversational interaction in second language acquisition: A series of empirical studies*, ed. Alison Mackey, 229–76. Oxford: Oxford University Press.
- Sanz, Cristina. 2000. Bilingual education enhances third language acquisition: Evidence from Catalonia. *Applied Psycholinguistics* 21:23–44.
- Sanz, Cristina, Hui-Ju Lin, Beatriz Lado, Harriet W. Bowden, and Catherine A. Stafford. 2009. Concurrent verbalizations, pedagogical conditions, and reactivity: Two CALL studies. *Language Learning* 59:3–71.
- . Unpublished ms. Pedagogical conditions and working memory capacity in early language development: Two CALL studies.
- Singleton, David. 2001. Age and second language acquisition. *Annual Review of Applied Linguistics* 21:77–89.
- Song, Sunbin, Brynn Marks, James H. Howard Jr., and Darlene V. Howard. 2009. Evidence for parallel explicit and implicit sequence learning systems in older adults. *Behavioural Brain Research* 196:328–32.
- Ullman, Michael. 2001. A neurocognitive perspective on language: The declarative/procedural model. *Nature Reviews Neuroscience* 2:717–26.
- Volkow, Nora, Gene-Jack Wang, Joanna Fowler, Yu-Shin Ding, Ruben Gur, et al. 1998. Parallel loss of pre- and postsynaptic dopamine markers in normal aging. *Annals of Neurology* 44:143–47.
- Williams, John N. 2005. Learning without awareness. *Studies in Second Language Acquisition* 27:269–304.