Differential effects of language proficiency and use on L2 lexical prediction

Laura Fernández-Arroyo, Nuria Sagarra, and Kaylee Fernández
Rutgers University

Language experience is essential for SLA. Yet, studies comparing the role of L2 proficiency and L2 use on L2 processing are scant, and there are no studies examining how these variables modulate learners' ability to generalize grammatical associations to new instances. This study investigates whether L2 proficiency and L2 use affect L2 stress-tense suffix associations (a stressed syllable cuing a present suffix, and an unstressed syllable cuing a preterit suffix) using eye-tracking. Spanish monolinguals and English learners of Spanish varying in L2 proficiency and L2 use saw two verbs (e.g., *firma-firmó* '(s)he signs/signed'), heard a sentence containing one of the verbs, and chose the verb they had heard. Both groups looked at target verbs above chance before hearing the suffix, but the monolinguals did so more accurately and earlier than the learners. The learners recognized past verbs faster than present verbs, were faster with higher than lower L2 proficiency, and later with higher than lower L2 use. Finally, higher L2 proficiency yielded earlier morphological activation but higher L2 use produced later morphological activation, indicating that L2 proficiency and L2 use affect L2 word processing differently. We discuss the contribution of these findings to language acquisition and processing models, as well as models of general cognition.

Keywords: language experience, proficiency, use, lexical stress, morphology

Adults devote 70% of their waking hours communicating with others in some way. Of that time, 45% is spent listening (Adler et al. 2017). Extensive practice listening to massive amounts of information allows the brain to process an average of 800 words per minute. How is this possible? The answer partly lies in humans' exquisite ability to recognize language patterns and apply them to new instances after frequent exposure. This phenomenon is known as probabilistic associative learning and entails the unconscious gradual acquisition of cue-outcome associa-

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tions based on frequency (high number of examples) and consistency (few or no exceptions) (Cohen & Squire, 1980).

Probabilistic associations are essential to make language processing efficient (Romberg & Saffran, 2010), and are shaped through experience. In second language (L2) acquisition, the accumulation of L2 experiences modulates the processes and attentional biases underlying L2 processing. Most studies have examined L2 grammatical associations between written words (e.g., agreement), but little is known about the role of different L2 experiences on L2 learners' ability to form grammatical associations within words based on acoustic cues. Some studies show that higher L2 proficiency (how much L2 we know) facilitates tone-tense and tone-number associations in Swedish (Gosselke Berthelsen et al., 2018; Schremm et al., 2016) and stress-tense suffix associations in Spanish (Sagarra & Casillas, 2018). A few studies also suggest that greater L2 use (how often we comprehend, produce, and interact in the L2) promotes the discrimination of vowels (Flege & MacKay, 2004) and consonants (Black et al., 2020), but its effects on L2 phonomorphological associations is unknown. This study investigated the separate contributions of L2 proficiency and L2 use on the recognition of stress-tense suffix associations in Spanish regular verbs by English learners of Spanish, using eye-tracking methodology.

This question is relevant for three reasons, First, studies on the role of L2 proficiency and L2 use on learners' formation of phonomorphological associations is scarce (Sagarra & Casillas, 2018). Second, it is unclear whether adults' struggle acquiring new L2 inflectional morphology results from difficulties integrating morphological information during real-time lexical processing (e.g., Hopp, 2016),. Third, recent research indicates that language proficiency and use affect the brain differently (e.g., Del Maschio et al., 2020), and that language use, but not proficiency, promotes bilingualism-induced neuroplasticity (DeLuca et al., 2020).

Literature review

Effects of L2 proficiency and use on L2 phonological and morphological processing

Studies show that higher L2 proficiency facilitates L2 phonological and morphological processing. First, concerning L2 proficiency effects on L2 phonological processing, higher L2 proficiency decreases L1 lexical activation (Berghoff et al., 2021) reduces L1 influence on L2 intonation (Jun & Oh, 2000), L2 stress (Konishi et al., 2018), and L2 pronunciation and vowel duration (Maddah & Reiterer, 2018), and eases the distinction of L2 phonemic contrasts in implicit tasks (White et al., 2015). Regarding L2 proficiency effects on L2 processing of inflectional morphology, higher L2 proficiency promotes L2 morphosyntactic processing (see Alemán Bañón et al., 2018, for a review), as well as sensitivity to L2 verbal agreement violations (lower proficiency learners are insensitive, Sagarra, 2014) or show delayed sensitivity, Rossi et al., 2006, whereas higher proficiency learners are sensitive, Yao & Chen, 2017). Higher L2 proficiency also increased attention to morphological information (lower proficiency learners attend more to lexical than morphological information, Armstrong et al., 2018), and processing of L2 derived and inflected words, new valid derivations, and forms combining a real stem with a new suffix (Kimppa et al., 2020). Second, with respect to L2 use effects on L2 phonological processing, greater L2 use facilitates discrimination of consonants in early and late bilinguals (Black et al., 2020, respectively), vowels in early and late bilinguals (Flege & MacKay, 2004), pronunciation in early bilinguals (Lloyd-Smith et al., 2019), and reduction of foreign accent in early and late bilinguals (Guion et al., 2000; Abu-Rabia & Kehat, 2004, respectively). Finally, L2 use facilitates L2 morphosyntactic processing (e.g., Faretta-Stutenberg & Morgan-Short, 2018) and L2 grammar development (Isabelli-García & Lacorte, 2016), and it is a stronger predictor of L2 oral production than age of acquisition (Muñoz, 2014).

The studies listed investigate L2 proficiency or L2 use and cannot draw conclusions about differential effects on L2 processing. Studies comparing the two are scant and inconclusive, and do not examine effects on L2 phonological or morphological processing. Some studies indicate that both L2 proficiency and L2 use affect language code-switching and language mixing (Bonfieni et al., 2019), whereas others show that L2 proficiency and L2 use affect L2 processing differently. For example, Beatty-Martínez et al., (2020) found that higher L2 use increases sensitivity to gender code-switching rules in L2 learners of the same L2 proficiency level, and Del Maschio et al. (2020) reported that language use, rather than L2 proficiency or AoA, modulates white matter microstructure during language processing and especially during attentional control tasks (see DeLuca et al., 2020, for a review showing that diverse bilingual experiences affect the brain differently).

Effects of L2 proficiency and use on L2 phonomorphological associations

Recent studies with Spanish and Swedish show that monolinguals and high, but not low, proficiency L2 learners make morphophonological associations. Two ERP studies with German learners of Swedish (Swedish is tonal but German is not) show that higher L2 proficiency facilitates the recognition of tone-suffix lexical associations in Swedish verbs (low tone → present; high tone → past, Schremm et al., 2016) and nouns (low tone → singular high tone → plural, Gosselke Berthelsen et al., 2018). Notably, none of these studies included an objective L2 proficiency measure. Schremm et al. assessed L2 proficiency with university entry requirements and content of the syllabi used in the Swedish courses, and Gosselke Berthelsen et al. with self-ratings in spoken Swedish comprehension. Particularly relevant to our study, Sagarra and Casillas (2018) found that advanced, but not beginning, English-Spanish learners recognized stress-tense suffix associations (stressed initial syllable → present; unstressed initial syllable → past) in Spanish verbs in an eye-tracking task. The same results were obtained in a gating task containing verbs without suffixes (*la persona dice: firm* 'the person says: (s)he sign'), indicating that higher L2 proficiency also promotes L2 phonomorphological prediction.

There are no studies directly investigating L2 use effects on phonomorphological processing. However, studies show that L2 use promotes L2 sound discrimination (Black et al., 2020; Flege & MacKay, 2004), that higher prediction experience in interpreters yields faster recognition of stress-tense suffix associations than in non-interpreters of the same L2 proficiency (Lozano-Argüelles, Sagarra, & Casillas, 2020), and that higher phonotactic frequency increases recognition of such associations, independently of L2 proficiency level (Sagarra, 2021). However, the studies above failed to measure real-time processing or to assess L2 use. We employed objective measures of both L2 proficiency (a standardized Spanish proficiency test) and L2 use (% of time using Spanish weekly).

The study

This study investigates whether L2 proficiency and L2 use affect L2 stress-tense suffix associations in English learners of Spanish. Lexical stress consists of the auditory prominence of a syllable in relation to the other syllables in a word (Hualde, 2005). Spanish and English have contrastive lexical stress, but they differ in stress realization, functional load and stress frequency. First, Spanish is syllable timed, but English is stress timed. In Spanish, stress is realized mainly through pitch height, intensity and loudness (e.g., Hualde, 2005; Ortega-Llebaria, 2006). English lexical stress, on the other hand, is largely conveyed through pitch height and vowel duration and quality (Cooper et al., 2002; Cutler, 1986). Second, stress is contrastive in English and Spanish but it is more commonly used to distinguish words in Spanish than English (Cooper et al., 2002; Soto-Faraco et al., 2001). Third, most Spanish and English words are paroxytone (see Morales-Font, 2014, and Kelly & Bock, 1988, respectively), but in English, oxytones and paroxytones are equally frequent in disyllabic uninflected words (Clopper, 2002), and oxytones are more frequent than paroxytones in disyllabic verbs (Chomsky & Halle, 1968). Relevant to our study, in Spanish disyllabic transitive regular verbs, such as *comprar* 'to buy', a stressed initial syllable cues a present tense suffix (*SALta* '(s)he jumps'), whereas an unstressed initial syllable cues a preterit tense suffix (s*alTÓ* '(s)he jumped'), and present tense is more frequent than preterit tense for 3rd person singular (30,666.96 vs. 12,030.28 cases per million, respectively, CORPES, Real Academia Española). Finally, Spanish and English are inflectional languages but Spanish is a pro-drop language with a rich inflectional system, whereas English is a non-pro-drop language with a poor inflectional system.

We hypothesize that accurate activation of suffixes before hearing them will occur in all conditions in the monolinguals (Sagarra & Casillas, 2018, and Roll et al., 2011, found that natives use suprasegmental cues to make phonomorphological associations), and more often in preterite than present verbs in the learners (Lozano-Argüelles, Sagarra, & Casillas, 2020, reported that learners made more target-like fixations at preterite verbs because they have the least frequent L2 stress pattern). We expect higher proficiency (Sagarra & Casillas, 2018; Gosselke Berthelsen et al., 2018; Schremm et al., 2016) and higher use to yield more target-like fixations (L2 use promotes L2 sound discrimination, Black et al., 2020; Flege & MacKay, 2004). However, we think that higher L2 proficiency will yield earlier predictions whereas higher L2 use will produce later predictions. We base our prediction on studies showing differences between the two (e.g., Del Maschio et al., 2020), and considering that L2 proficiency tests only assess perception of written language, whereas L2 use involves written and spoken language perception, production and interaction.

Methods

Participants

The participants were 30 Spanish monolingual (20 females) and 65 English-speaking learners of Spanish (48 females). All participants were 18–45 years old, right-handed, and were born and raised in monolingual communities of their L1. All had normal hearing, corrected-to-normal vision, no motor disability, and at least high school education. The monolinguals lived in Madrid, a monolingual region of Spain, and had studied English as an L2 as part of their education, but none were proficient. None of them had lived abroad for more than two months and none spoke any other language. The learners were native speakers of American

English, learned Spanish after puberty (age of onset in years: $M = 16.3$, $SD = 5.55$), had had been living in Spain for a mean of 38.1 months ($SD = 33.5$), their proficiency ranged from intermediate to advanced ($M = 38.5$ out of 56 points in the proficiency test, $SD = 8.19$), and they used Spanish an average of 33.3% of the time on a weekly basis ($SD = 17.4$). A few had learned French in school, but none were fluent.

Materials and procedure

Participants completed four tasks individually in one session as follows: Spanish proficiency test (15–20 minutes, only the L2 speakers), language background questionnaire (5 minutes), language use questionnaire (5 minutes), and eye-tracking task (25 minutes).

First, learners completed a 56-item adapted version of the *Diploma de Español como Lengua Extranjera* (DELE) (Certificate of Spanish as a Foreign Language) assessing grammar and vocabulary (adapted versions of the DELE are widely used in L2 studies). Second, participants completed a language history questionnaire containing questions about age, handedness, onset age of L2 acquisition, time spent in Spanish-speaking countries, and other languages spoken fluently. Third, participants indicated languages used over the different levels of schooling, languages spoken in their household while growing up, and their weekly L2 use of each language spoken in all contexts.

Fourth, participants completed an oral eye-tracking task, using an EyeLink 1000 Plus eye-tracker (sampling rate: 1k Hz; spatial resolution of .32° horizontal and .25° vertical; averaged calibration error: .01°; velocity threshold to isolate fixations: 50°/second), a BenQ XL2420TE display monitor at a resolution of 1920 x 1080 pixels, and Sol Republic 1601–32 headphones. There were 100 grammatical sentences in Spanish between 5 and 14 words long (4 practice, 80 fillers, 16 experimental). Non-practice sentences were distributed into 8 blocks, each containing 2 experimental sentences, one for each of the two conditions (present, preterit), and 6 filler sentences. Sentences were randomized between blocks and pseudo-randomized within blocks to avoid two experimental sentences appearing consecutively. Filler sentences had anaphoras, gender agreement and figurative expressions, and the written words were nouns or adjectives. Experimental sentences followed a SVO word order and contained disyllabic regular transitive CVC-CV -ar verbs conjugated in third-person singular. Each experimental sentence had a version with a present verb and another with a preterit verb (e.g., *El ladrón salta/saltó la valla* 'the thief jumps/jumped over the fence').

Sentences were recorded with a Fostex DC-R302 digital recorder and a Shure SM10A head-mounted microphone in a Whisper room 6084 E sound booth at a sampling rate of 44.1 kHz and 16-bit quantization. A female native speaker of

Peninsular Spanish unaware of the experiment's goal recorded all the sentences three times in three different pseudo-randomized orders, at a mean speech rate of 4.37 syllables per second ($SD = 0.68$), and a mean sentence length of 4.17 seconds ($SD = 1.14$). For each sentence, the best pair of the three repetitions was chosen based on clarity. Intensity was normalized to ~75dB, and a 100 ms of silence was added before and after each sound file. No other modifications were made. The mean duration of verbs was 424 ms ($SD = 42.22$, CI [408.78, 439.22]) and of initial syllables was 308.38 ms ($SD = 52.03$, CI [284.74, 321, 20]). The mean F0 of first syllables was 283.11 Hz ($SD = 21.86$, range: 241.53–325.25), of first syllables in present verbs was 290.75 Hz ($SD = 18.26$, range: 254.59–323.46), and of first syllables in preterite verbs was 275.46 Hz ($SD = 23$, range: 241.53–325.25).

Before starting the eye-tracking task, participants were randomly assigned to one of two versions. Each version contained one of the two conditions of a given sentence. Subsequently, participants rested their head on a chin rest, completed a 9-point grid calibration task, and completed the practice trials followed by the non-practice trials. Each trial began with a drift correction sign, a 250-ms blank screen, and two verbs side by side (half with the present verb on the left). Images of words rather than objects were used because it is difficult to illustrate present and past actions graphically, it is uncertain which word(s) participants truly activate when they see an object, and phonological competitor effects are stronger with words than with pictures (e.g., Ito et al., 2017). After 1,000 ms, participants listened to a sentence containing one of the two verbs on the screen. Verbs remained on the screen until the participant selected one by pressing a left- or a right-shift key. Next, a rectangle appeared around the selected verb, but no feedback was provided. Response recording was set up to be registered only when the key press happened at or after the onset of the verb. Key presses before the onset of the verb did not stop the sound file and were not analyzed. At the end of each trial, there was a 500 ms blank screen, and the next trial began. Figure 1 illustrates a sample trial.

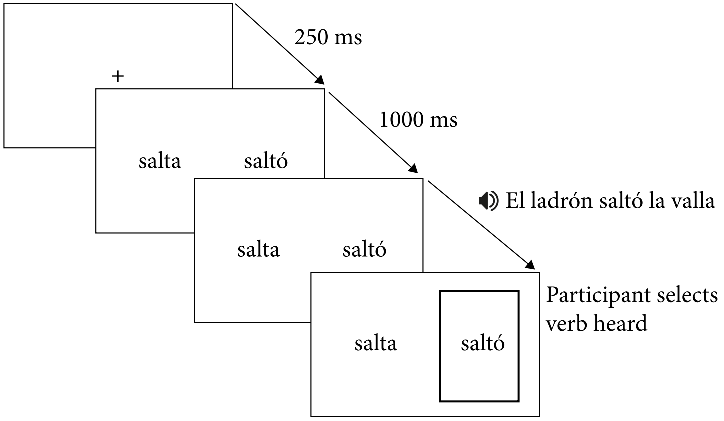

Figure 1. Sample trial of the eye-tracking task

Statistical analyses

All scripts and data are available online.[1] Data preprocessing and exploratory statistical analyses were conducted on R (R Core Team, 2019) using the packages *lme4* (Bates et al., 2014) and *performance* (Lüdecke et al., 2021). Only the fixation information of the eye tracking data was examined. It was downsampled to 50 ms bins using DataViewer (SR-Research) and we kept only accurate trials. This resulted in about 0.42% of data loss. Removing inaccurate trials resulted in 0.18% of monolingual data loss (0% in present and 0.36% in preterite) and 0.58% of learner data loss (0.76% in present and 0.77% in preterite).

Growth curve analyses (GCA, Mirman, 2016) were conducted to analyze the pattern of gaze fixations towards the target over time. We analyzed the time window of 200 ms before and 200 ms after the onset of the second syllable of target words (8 bins). Therefore, the onset of the last syllable was our center point. Probabilities of fixation were calculated for 200 ms after the onset of the last syllable of the target items to account for the time it takes to plan and launch a saccade (e.g., Fischer, 1992). We included linear and quadratic orthogonal polynomial time terms to model the time course. The polynomial terms help to capture the curve of the fit in non-linear regressions. Thus, while the linear term stands for a normal linear fit, the quadratic term allows to fit curves with one bow in the estimates. The empirical logit transformation was applied to binary responses (fixations on target or distractor, Barr, 2008), and the linking function used accordingly was the binomial distribution. Separate GCAs were conducted for the natives and the learners as L2 proficiency and L2 use data only applied

1. https://osf.io/va93f/?view_only=698f5a86209b4caf827e4623a1e65ac7

to the latter. The GCA for the monolinguals included lexical stress and the time terms as fixed effects, and participant and item as random intercept and lexical stress as random slopes. We initially included more complex random effects but the models were singular. In addition, the GCA for the learners included L2 proficiency and L2 use as fixed effects. Categorical variables were sum-coded and continuous variables were standardized. Factors and interactions not yielding significant effects were removed from posterior analyses. Alpha level was .05. To calculate fixation probabilities, the *plogis()* function was employed on the model estimates. Finally, we tested collinearity by running a correlation between L2 proficiency and L2 use, and then obtaining eigenvalues and the variance inflation factor (VIF) for both variables from the GCA.

Results

Appendices 2 (monolinguals) and 3 (learners) offer an overview of the GCA model. Figure 2 shows that the proportion of looks at targets departed from chance level before hearing the syllable containing the suffix for all participants, and continued increasing over time, and that monolinguals fixated on targets earlier than learners.

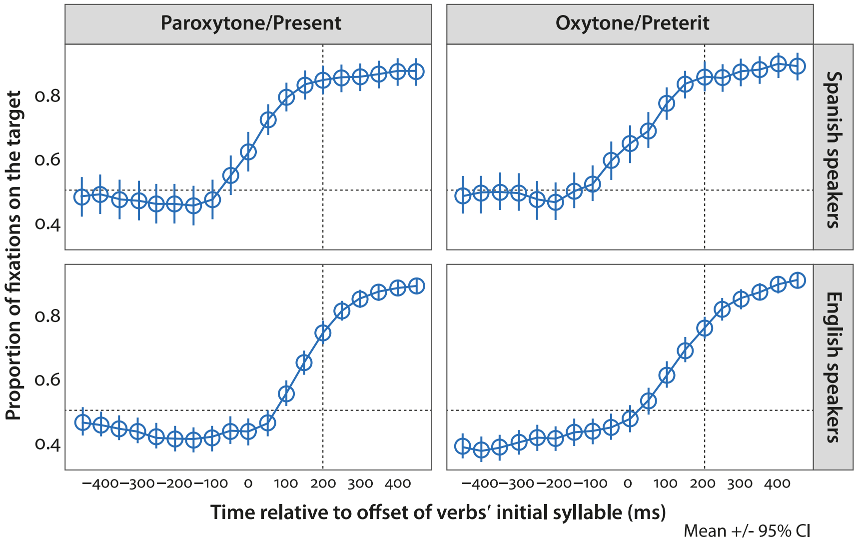

Figure 2. Time course of the gaze fixation patterns on targets from 500 ms before the offset of the first syllable to 500 ms after as a function of L1 and stress condition

The GCA for the monolinguals retained the linear ($\gamma_{10}=2.42$; $SE=0.14$; $t=17.60$; $p<.001$) and quadratic ($\gamma_{20}=0.51$; $SE=0.13$; $t=3.82$; $p<.001$) time terms, so main effects and interactions were tested against all three. The model's intercept at the offset of the first syllable is $\gamma_{00}=0.68$; $SE=0.12$; $t=5.48$; $p<.001$, and the estimated fixations on targets 200 ms after are 90%. Because there were no stress effects, stress was removed from the model.

The learners' GCA retained the linear ($\gamma_{10}=1.47$; $SE=0.10$; $t=15.61$; $p<.001$) and quadratic ($\gamma_{20}=0.67$; $SE=0.10$; $t=7.09$; $p<.001$) time terms. The model's intercept at the offset of the first syllable is $\gamma_{00}=0.07$; $SE=0.09$; $t=0.81$; $p=.416$ and the estimated fixations on targets 200 ms after are above 50% under all conditions. Table 1 illustrates these results and shows that learners were less accurate than monolinguals.

Table 1. Model estimates for probability of fixations on the target ±SE at 200 ms after offset of the first syllable in the verbs for L2 learners. Proficiency and Spanish use values represent the mean (0), one standard deviation below (−1), and one standard deviation above (1) for normalized scores

Lexical stress	Proficiency	Spanish use	Probability	Lower bound	Upper bound
Paroxytone (present: *CANta*)		−1	0.68	0.64	0.72
	−1	0	0.69	0.65	0.72
		1	0.69	0.65	0.73
		−1	0.72	0.68	0.75
	0	0	0.72	0.69	0.75
		1	0.73	0.69	0.76
		−1	0.76	0.72	0.79
	1	0	0.76	0.73	0.79
		1	0.76	0.73	0.79
Oxytone (preterit: *canTÓ*)		−1	0.77	0.74	0.80
	−1	0	0.77	0.74	0.80
		1	0.78	0.74	0.81
		−1	0.80	0.77	0.83
	0	0	0.80	0.78	0.83
		1	0.81	0.78	0.83
		−1	0.83	0.80	0.86
	1	0	0.83	0.81	0.85
		1	0.83	0.81	0.86

A main effect of stress on the linear term ($\chi^2(1)=9.160$, $p=.002$) with a positive increase in the coefficient ($\gamma_{11}=0.29$; $SE=0.09$; $t=3.10$; $p=.002$) shows that the curve for past verbs was steeper (see Figure 3). This indicates that target-like fixations departing from chance level in past verbs increased faster than in present verbs. A main effect of proficiency on the linear term ($\chi^2(1)=10.050$, $p=.002$) with a positive increase in the coefficient ($\gamma_{12}=0.31$; $SE=0.10$; $t=3.13$; $p=.002$) reveals a steeper slope (faster target-like fixations) in higher than lower proficiency learners (see Figure 3). There was also a main effect of L2 use on the quadratic time term ($\chi^2(1)=6.675$, $p=.010$); a positive coefficient ($\gamma_{23}=0.24$; $SE=0.09$; $t=2.59$; $p=.010$) reveals a more curved fit in higher than lower L2 use learners, indicating that greater L2 use yields later (target-like predictions increase at a later point in time) but faster (once the target has been selected, target-like fixations increase at a higher speed) activation of suffixes. There was no interaction among factors.

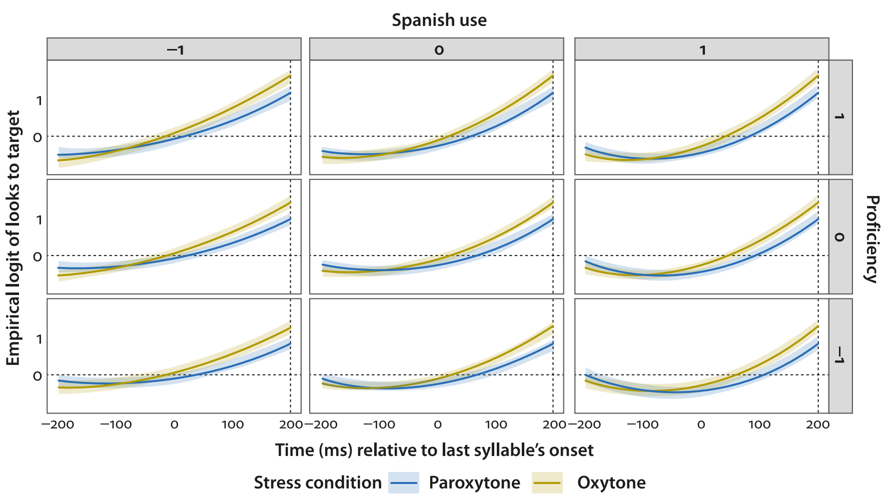

Figure 3. Growth curve analysis estimates of fixations on target during the analysis window for the sample's mean score in Spanish proficiency and use (0), one standard deviation above (1) and one standard deviation below (−1). Lines represent model estimates. Empirical logit values on the y-axis correspond to proportions of 0.50 and 0.73. The horizontal dotted line represents the 50% probability of fixating on the targets. The vertical dotted line indicates 200 ms after the offset of the first syllable

The expected correlation of the regression coefficients between L2 proficiency and L2 use in the GCA model was −0.306 on the intercept. The eigenvalues (variance in the direction indicated by the effect) were 0.008 for L2 proficiency and 0.07 for L2 use. The VIFs indicate a weak relation ($VIF=1.11$, Increased $SE=1.05$, *Tolerance* = 0.90 for both). The combination of these coefficients with the GCA effects and the Spearman correlation (*rho* = 0.38, *S* = .000, *p* < .001) show a positive but weak correlation (Figure 4).

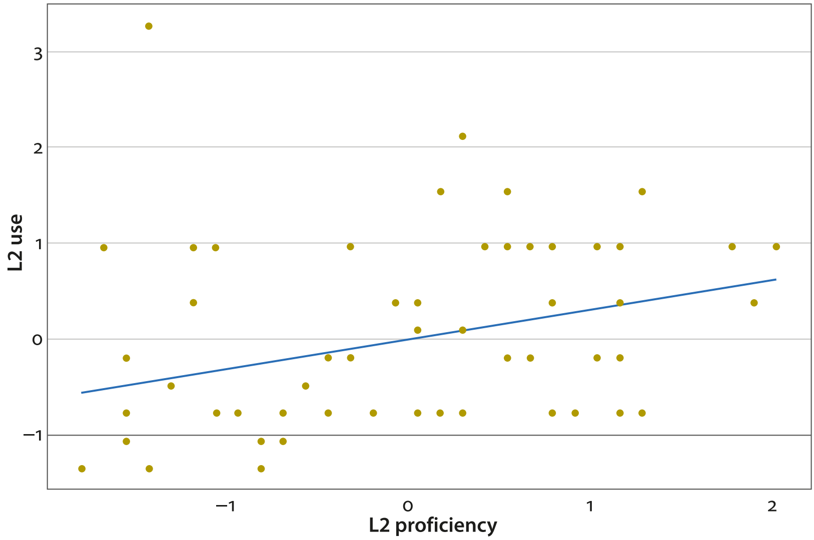

Figure 4. Correlation plot between L2 proficiency and L2 use

Discussion

This study investigates whether L2 proficiency and L2 use affect L2 stress-tense suffix associations (a stressed syllable cuing a present suffix, and an unstressed syllable cuing a preterit suffix) using eye-tracking. Monolinguals and L2 learners fixated on target verbs on the screen above chance before hearing the syllable containing the suffix, but monolinguals showed more and earlier target-like fixations than the learners (see Sagarra & Casillas, 2018, and Perdomo & Kaan, 2019, for similar monolingual-learner differences). Furthermore, the learners showed target-like fixations faster with past than present verbs, faster with higher than lower L2 proficiency, and later with higher than lower L2 use. Finally, higher L2 proficiency yielded faster target-like fixations but higher L2 use generated later target-like fixations, and both variables correlated positively but weakly. Taken together, these findings show that adults can acquire phonomorphological associations absent in their L1 after puberty, and that this acquisition is modulated by stress, L2 proficiency, and L2 use.

Lexical stress

All groups looked at target verbs above chance with present and past verbs (see also Sagarra & Casillas, 2018), supporting our hypothesis and studies showing that native speakers and non-beginning L2 learners employ suprasegmental cues to form phonomorphological associations (natives: Sagarra & Casillas, 2018; Roll et al., 2011; Roll et al., 2015; non-natives: Lozano-Argüelles, Sagarra, & Casillas, 2020; Schremm et al., 2016) and to predict verb endings (see gating task in Sagarra & Casillas, 2018). There were no stress effects in the monolinguals. However, the learners showed more target-like fixations with past than present verbs, in line with Lozano-Argüelles, Sagarra, & Casillas' (2020) results with CV verbs, but against Sagarra & Casillas' (2018) lack of stress effects (probably due to Sagarra & Casillas' 2018 inclusion of beginning learners in the statistics).

In addition, the learners produced more target-like fixations faster with past than present verbs. One explanation is that L2 learners form phonomorphological associations faster with fewer than more lexical competitors, that is, words sharing both an initial segment and suprasegmental information (most words in Spanish are paroxytone, Morales-Font, 2014). This finding mirrors studies linking fewer lexical competitors to increased lexical access (Cholin et al., 2006), recognition of phonomorphological associations (Roll et al., 2017), and brain activation (Roll et al., 2015). Another explanation is that English speakers are influenced by the higher frequency of stress patterns in disyllabic past verbs in their L1. Since we did not include two L2 populations to compare L1 transfer effects, we cannot draw any conclusion on that subject. Finally, another explanation is that stress-tense suffix associations in preterite verbs are less frequent because preterite verbs are less frequent than present verbs, resulting in less time needed to discard non-target items.

L2 proficiency

Higher L2 proficiency learners looked at targets faster than lower proficiency learners, in line with our hypothesis and with studies showing that higher proficiency facilitates L2 phonomorphological associations. For instance, intermediate and upper-intermediate, but not beginning or early intermediate, German-Swedish learners use tone to activate tense suffixes (Gosselke Berhelsen et al., 2018; Schremm et al., 2016), and advanced, but not beginning, English-Spanish learners use stress to activate tense suffixes (Author, 2018). These two studies show that low proficiency learners are unable to use suprasegmental cues to form phonomorphological associations. Our study also indicates that, at intermediate and advanced proficiency levels, higher proficiency affects how fast learners can form associations. Our proficiency findings parallel studies associating higher L2 proficiency to L2 phonological processing (e.g., Berghoff et al, 2021; White et al., 2015), L2 phonological perception and production less dependent on the L1 (e.g., Jun & Oh, 2000; Konishi et al., 2018; Maddah & Reiterer, 2018), L2 morphological processing (Kimppa et al., 2019), and L2 morphosyntactic verbal processing (see Alemán Bañón et al., 2018, for a review).

L2 use

Greater L2 use yielded later fixations on targets, against our hypothesis that greater L2 use would be beneficial. One can claim that greater L2 use may allow learners to consider more options, which may require additional time to consider more options and a delay fixating at targets. Importantly, greater L2 use did not produce less target-like fixations than low use, indicating that the delay is not detrimental to the recognition of phonomorphological associations. Greater L2 use yields later fixations at targets. This result is in line with previous L2 studies showing that greater L2 use facilitates discrimination of consonants (e.g., Black et al., 2020) and vowels (Flege & MacKay, 2004), reduction of foreign accent (Abu-Rabia & Kehat, 2004), L2 morphosyntactic processing (Faretta-Stutenberg & Morgan-Short, 2018), and L2 grammar development (Isabelli-García & Lacorte, 2016; Linck et al., 2009).

L2 proficiency vs. L2 use

Finally, our hypothesis that L2 proficiency and L2 use are different constructs was supported. On the one hand, higher L2 proficiency yielded faster target-like fixations at targets, but higher L2 use produced target-like fixations; on the other hand, there was a weak correlation between L2 proficiency and L2 use. Our data suggesting that language proficiency and language use are separate phenomena mirror recent research demonstrating that language use, but not language proficiency, promote sensitivity to code-switching rules (Beatty-Martinez et al., 2020), bilingualism-induced neuroplasticity (DeLuca et al., 2020), and white matter microstructure during language processing (Del Maschio et al., 2020).

Theoretical implications

Taken together, the findings of the present study inform linguistic models, language acquisition and processing models, and general cognition models. First, our findings agree with phonological models (e.g., L2L2, Van Leussen &

Escudero, 2015; SLMr, Flege & Bohn, 2021) proposing that adult L2 learners can acquire new suprasegmental information, and that input plays a fundamental role in how L2 suprasegmental information is processed and with models of word activation arguing that prosodic structure is essential in how a lexical item is stored and activated during processing (Roll et al., 2015).

Second, our finding that higher L2 proficiency yields earlier morphological activation support Single Mechanism Accounts (e.g., Bybee, 1985; Gonnerman et al., 2007), positing that treating irregular and regular forms as non-compositional or compositional during processing is a matter of degree, based on frequency of occurrence, rather on strictly decompositional or chunk processing. As L2 proficiency increases, stress-tense suffix associations may be automatized, allowing learners to move from decompositional to full-storage lexical access. Furthermore, our result that greater L2 use promotes later morphological activation aligns with: (a) Information Theoretic Approaches (e.g., Kostić et al., 2003; Shannon, 1948), which claim that uncertainty describes how likely a word is to appear as a candidate for activation, and (b) usage-based models traditionally anchored in an abstract notion of language use, often mixed with language proficiency.

Third, our outcomes are in line with L2 processing models linking adults' persistent struggle acquiring L2 inflectional morphology absent in the L1 to difficulties in integrating morphological information during real-time processing (e.g., Hopp, 2016). Finally, our conclusion that language proficiency and language use are separate constructs support neurocognitive models of neuroanatomy (Del Maschio et al., 2020) and bilingualism-induced neuroplasticity (DeLuca et al., 2020). We propose that bilingual studies include L2 proficiency, L2 use and other language experience measures to deepen our understanding of language experience effects on the bilingual brain.

Conclusion

This study investigated whether L2 proficiency and L2 use affect L2 stress-tense suffix associations (stressed initial syllable → present; unstressed initial syllable → past), in Spanish monolinguals and English learners of Spanish. These associations are highly frequent but are rarely taught and have rarely been investigated. Participants saw a present and a past verb on a screen, heard a sentence containing one of the two words, and chose the word they had heard. Eye-tracking data revealed that all natives and non-natives fixated on target verbs above chance before hearing the syllable containing the suffix, and that the monolinguals predicted more and earlier than the learners. Furthermore, the learners predicted faster with past than present verbs, faster with higher than lower proficiency, and later with greater than lower L2 use. Finally, higher L2 proficiency produced faster predictions but higher L2 use produced later predictions, and both variables correlated weakly with each other. We conclude that native and non-native speakers use suprasegmental information to make lexical predictions during spoken word processing, that adult L2 learners can form new L2 stress-tense suffix associations, and that L2 proficiency and L2 use have distinct effects on forming these associations.

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References

Abu-Rabia, S., & Kehat, S. (2004). The critical period for second language pronunciation: is there such a thing? *Educational Psychology*, *24*(1), 77–97. https://doi.org/10.1080/0144341032000146467

Adler, R. B., & Proctor II, R. F. (2017). *Looking out. Looking in.* Cengage Learning.

Alemán Bañón, J., Fiorentino, R., & Gabriele, A. (2018). Using event-related potentials to track morphosyntactic development in second language learners: The processing of number and gender agreement in Spanish. *PloS one*, *13*(7), e0200791. https://doi.org/10.1371/journal.pone.0200791

Armstrong, A., Bulkes, N., & Tanner, D. (2018). Quantificational cues modulate the processing of English subject-verb agreement by native Chinese speakers: an ERP study. *Studies in Second Language Acquisition*, *40*(4), 731–754. https://doi.org/10.1017/S0272263118000013

Barr, D. J. (2008). Analyzing 'visual world' eyetracking data using multilevel logistic regression. *Journal of Memory and Language*, *59*(4), 457–474. https://doi.org/10.1016/j.jml.2007.09.002

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2014). Fitting linear mixed-effects models using *lme4*. *arXiv Preprint arXiv:1406.5823*.

Beatty-Martínez, A. L., Navarro-Torres, C. A., Dussias, P. E., Bajo, M. T., Guzzardo Tamargo, R. E., & Kroll, J. F. (2020). Interactional context mediates the consequences of bilingualism for language and cognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *46*(6), 1022–1047. https://doi.org/10.1037/xlm0000770

Berghoff, R., McLoughlin, J., & Bylund, E. (2021). L1 activation during L2 processing is modulated by both age of acquisition and proficiency. *Journal of Neurolinguistics*, *58*, 100979. https://doi.org/10.1016/j.jneuroling.2020.100979

Black, M., Joanisse, M. F., & Rafat, Y. (2020). Language Dominance Modulates the Perception of Spanish Approximants in Late Bilinguals. *Languages*, *5*(1), 7. https://doi.org/10.3390/languages5010007

Bonfieni, M., Branigan, H. P., Pickering, M. J., & Sorace, A. (2019). Language experience modulates bilingual language control: The effect of proficiency, age of acquisition, and exposure on language switching. *Acta psychologica*, *193*, 160–170. https://doi.org/10.1016/j.actpsy.2018.11.004

Cohen, N. J. & Squire, L. R. (1980). Preserved learning and retention of pattern-analyzing skill in amnesia: Dissociation of knowin how and knowing that. *Science*, *210*(4466), 207–210. https://doi.org/10.1126/science.7414331

Bybee, J. L. (1985). *Morphology: A study of the relation between meaning and form*, vol. *9*. John Benjamins Publishing. https://doi.org/10.1075/tsl.9

Cholin, J., Levelt, W. J., & Schiller, N. O. (2006). Effects of syllable frequency in speech production. *Cognition*, *99*, 205–235. https://doi.org/10.1016/j.cognition.2005.01.009

Chomsky, N., & Halle, M. (1968). *The sound pattern of English*. New York: Harper and Row.

Clopper, C. G. (2002). Frequency of stress patterns in English: A computational analysis. *IULC Working Papers Online*, *2*(2), 1–9.

Cooper, N., Cutler, A., & Wales, R. (2002). Constraints of lexical stress on lexical access in English: Evidence from native and non-native listeners. *Language and Speech*, *45*(3), 207–228. https://doi.org/10.1177/00238309020450030101

Cutler, A., Mehler, J., Norris, D., & Segui, J. (1986). The syllable's differing role in the segmentation of French and English. *Journal of memory and language*, *25*(4), 385–400. https://doi.org/10.1016/0749-596X(86)90033-1

Del Maschio, N., Sulpizio, S., Toti, M., Caprioglio, C., Del Mauro, G., Fedeli, D., & Abutalebi, J. (2020). Second language use rather than second language knowledge relates to changes in white matter microstructure. *Journal of Cultural Cognitive Science*, *4*, 165–175. https://doi.org/10.1007/s41809-019-00039-z

DeLuca, V., Segaert, K., Mazaheri, A., & Krott, A. (2020). Understanding bilingual brain function and structure changes? U Bet! A Unified Bilingual Experience Trajectory model. *Journal of Neurolinguistics*, *56*, 100930. https://doi.org/10.1016/j.jneuroling.2020.100930

Faretta-Stutenberg, M., & Morgan-Short, K. (2018). The interplay of individual differences and context of learning in behavioral and neurocognitive second language development. *Second Language Research*, *34*(1), 67–101. https://doi.org/10.1177/0267658316684903

Fischer, B. (1992). Saccadic reaction time: Implications for reading, dyslexia, and visual cognition. In Rayner, K. (Ed.), *Eye Movements and Visual Cognition. Springer Series in Neuropsychology* (pp. 192–202). Springer, New York, NY. https://doi.org/10.1007/978-1-4612-2852-3_3

Flege, J. E., & Bohn, O. S. (2021). The revised speech learning model (SLM-r). *Second Language Speech Learning: Theoretical and Empirical Progress*, 3–83. https://doi.org/10.1017/9781108886901.002

Flege, J. E., & MacKay, I. R. (2004). Perceiving vowels in a second language. *Studies in Second Language Acquisition*, *26*(1), 1–34. https://doi.org/10.1017/S0272263104261010

Gonnerman, L. M., Seidenberg, M. S., & Andersen, E. S. (2007). Graded semantic and phonological similarity effects in priming: evidence for a distributed connectionist approach to morphology. *Journal of Experimental Psychology: General*, *136*(2), 323. https://doi.org/10.1037/0096-3445.136.2.323

Gosselke Berthelsen, S., Horne, M., Brännström, K. J., Shtyrov, Y., & Roll, M. (2018). Neural processing of morphosyntactic tonal cues in second-language learners. *Journal of Neurolinguistics*, *45*, 60–78. https://doi.org/10.1016/j.jneuroling.2017.09.001

Guion, S., Flege, J., Liu, S., & Yeni-Komshian, G. (2000). Age of learning effects on the duration of sentences produced in a second language. *Applied Psycholinguistics*, *21*(2), 205–228. https://doi.org/10.1017/S0142716400002034

Hopp, H. (2016). Learning (not) to predict: Grammatical gender processing in second language acquisition. *Second Language Research*, *32*(2), 277–307. https://doi.org/10.1177/0267658315624960

Hualde, J.I. (2005). *The sounds of Spanish with audio CD*. Cambridge University Press.

Isabelli-García, C., & Lacorte, M. (2016). Language learners' characteristics, target language use, and linguistic development in a domestic immersion context. *Foreign Language Annals*, *49*(3), 544–556. https://doi.org/10.1111/flan.12215

Ito, A., Dunn, M.S., & Pickering, M. (2017). Effects of language production on prediction: Word vs. picture visual world study. (Poster) *Architectures and mechanisms of language processing*.

Jun, S.A., & Oh, M. (2000). Acquisition of second language intonation. In *Sixth International Conference on Spoken Language Processing*. https://doi.org/10.21437/ICSLP.2000-754

Kelly, M.H., & Bock, J.K. (1988). Stress in time. *Journal of Experimental Psychology: Human Perception and Performance*, *14*(3), 389. https://doi.org/10.1037/0096-1523.14.3.389

Kimppa, L., Shtyrov, Y., Hut, S.C., Hedlund, L., Leminen, M., & Leminen, A. (2019). Acquisition of L2 morphology by adult language learners. *Cortex*, *116*, 74–90. https://doi.org/10.1016/j.cortex.2019.01.012

Konishi, T., Yun, J., & Kondo, M. (2018). Acoustic correlates of L2 English stress – Comparison of Japanese English and Korean English. *Phonetics Speech Sci.*, *10*(1), 9–14. https://doi.org/10.13064/KSSS.2018.10.1.009

Kostić, A., Markovic, T., & Baucal, A. (2003). Inflectional morphology and word meaning: Orthogonal or co-implicative cognitive domains? *Trends in Linguistics Studies and Monographs*, *151*, 1–44. https://doi.org/10.1515/9783110910186.1

Lloyd-Smith, A., Einfeldt, M., & Kupisch, T. (2020). Italian-German bilinguals: The effects of heritage language use on accent in early-acquired languages. *International Journal of Bilingualism*, *24*(2), 289–304. https://doi.org/10.1177/1367006919826867

Lozano-Argüelles, C., Sagarra, N., & Casillas, J. V. (2020). Slowly but surely: Interpreting facilitates L2 morphological anticipation based on suprasegmental and segmental information. Special issue "Interpreting: A Window to Bilingual Processing" (Eds. Yanping Dong and Ping Li). Bilingualism: Language and Cognition, *23*, 752–762. https://doi.org/10.1017/S1366728919000634

Lüdecke, D., Ben-Shachar, M.S., Patil, I., Waggoner, P., & Makowski, D. (2021). *performance*: An R package for assessment, comparison and testing of statistical models. *Journal of Open Source Software*, *6*(60). https://doi.org/10.21105/joss.03139

Maddah, Z.G., Reiterer, S.M. (2018). Language Transfer vs. Language Talent? Individual Differences and Aptitude in L2 Phonology of Persian-Speaking Learners of English. In: Reiterer, S. (Eds.), *Exploring Language Aptitude: Views from Psychology, the Language Sciences, and Cognitive Neuroscience. English Language Education*, vol. *16* (pp. 363–388). Springer, Cham. https://doi.org/10.1007/978-3-319-91917-1_19

Mirman, D. (2016). *Growth curve analysis and visualization using R*. CRC press.

Morales-Font, A. (2014). El acento [The accent]. In R.A. Núñez., S. Colina., & T.G. Bradley (Eds.). *Fonología generativa contemporánea de la lengua española* [Contemporary generative phonology of the Spanish language] (2nd Edition) (pp. 235–265). Washington, DC: Georgetown University Press.

Muñoz, C. (2014). Contrasting effects of starting age and input on the oral performance of foreign language learners. *Applied Linguistics*, *35*(4), 463–482. https://doi.org/10.1093/applin/amu024

Ortega-Llebaria, M. (2006). Phonetic cues to stress and accent in Spanish. In *Selected proceedings of the 2nd conference on laboratory approaches to spanish phonetics and phonology* (pp. 104–118). Somerville, MA: Cascadilla Proceedings Project.

Perdomo, M., & Kaan, E. (2019). Prosodic cues in second-language speech processing: A visual world eye-tracking study. *Second Language Research*, *37*(2), 349–375. https://doi.org/10.1177/0267658319879196

R Core Team. (2019). *R: A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing. Retrieved from https://www.R-project.org/

Ranta, L., & Meckelborg, A. (2013). How much exposure to English do international graduate students really get? Measuring language use in a naturalistic setting. *Canadian Modern Language Review*, *69*(1), 1–33. https://doi.org/10.3138/cmlr.987

Real Academia Española. Banco de datos (CORPES XXI) [online]. *Corpus del Español del Siglo XXI (CORPES).* <http://www.rae.es> [February 11, 2022]

Roll, M., Horne, M., & Lindgren, M. (2011). Activating without inhibiting: Left-edge boundary tones and syntactic processing. *Journal of Cognitive Neuroscience*, *23*(5), 1170–1179. https://doi.org/10.1162/jocn.2010.21430

Roll, M., Söderström, P., Frid, J., Mannfolk, P. & Horne, M. (2017). Forehearing words: Pre-activation of word endings at word onset. *Neuroscience Letters*, *658*, 57–61. https://doi.org/10.1016/j.neulet.2017.08.030

Roll, M., Söderström, P., Mannfolk, P., Shtyrov, Y., Johansson, M., Westen, D.V., & Horne, M. (2015). Word tones cueing morphosyntactic structure: Neuroanatomical substrates and activation time-course assessed by EEG and fMRI. *Brain and Language*, *150*, 14–21. https://doi.org/10.1016/j.bandl.2015.07.009

Romberg, A.R., & Saffran, J.R. (2010). Statistical learning and language acquisition. *Wiley Interdisciplinary Reviews: Cognitive Science*, *1*(6), 906–914. https://doi.org/10.1002/wcs.78

Rossi, S., Gugler, M.F., Friederici, A.D., & Hahne, A. (2006). The impact of proficiency on syntactic second-language processing of German and Italian: Evidence from event-related potentials. *Journal of Cognitive Neuroscience*, *18*(12), 2030–2048. https://doi.org/10.1162/jocn.2006.18.12.2030

Sagarra, N. (2014). Absence of morphological transfer in beginners. In Z. Han and R. Rast (Eds), *First exposure to a second language. Learners' initial input processing* (pp. 139–170). Oxford University Press. https://doi.org/10.1017/CBO9781139084390.006

Sagarra, N. (2021). When more is better: Higher L1-L2 similarity, L2 proficiency, and working memory facilitate L2 morphosyntactic processing. In M. Leeser, G. Keating, & W. Wong (Eds.), *Research on Second Language Processing and Processing Instruction* (pp. 125–150) (Studies in Bilingualism; Vol. 62). Amsterdam: John Benjamins. https://doi.org/10.1075/sibil.62.04sag

Sagarra, N. & Casillas, J. V. (2018). The use of stress in L1 and L2 lexical access. Special issue on Second Language Processing (Ed. Jiang). *Journal of Second Language Studies*, *1*(1), 31–60. https://doi.org/10.1075/jsls.17026.sag

Schremm, A., Söderström, P., Horne, M., & Roll, M. (2016). Implicit acquisition of tone-suffix connections in L2 learners of Swedish. *The Mental Lexicon*, *11*(1), 55–75. https://doi.org/10.1075/ml.11.1.03sch

Shannon, C.E. (1948). A mathematical theory of communication. *The Bell system technical journal*, *27*(3), 379–423. https://doi.org/10.1002/j.1538-7305.1948.tb01338.x
Soto-Faraco, S., Sebastián-Gallés, N., & Cutler, A. (2001). Segmental and suprasegmental mismatch in lexical access. *Journal of Memory and Language*, *45*, 412–432. https://doi.org/10.1006/jmla.2000.2783
Van Leussen, J.-W., & Escudero, P. (2015). Learning to perceive and recognize a second language: the L2LP model revised. *Frontiers in Psychology*. *6*. https://doi.org/10.3389/fpsyg.2015.01000
White, E.J., Titone, D., Genesee, F., & Steinhauer, K. (2015). Phonological processing in late second language learners: The effects of proficiency and task. *Bilingualism*, *20*(1), 162. https://doi.org/10.1017/S1366728915000620
Yao, P., & Chen, B. (2017). Cross-linguistic differences affect late Chinese-English learners' on-line processing of English tense and aspect. *International Journal of Bilingualism*, *21*(3), 268–290. https://doi.org/10.1177/1367006915624248

Appendix 1a. Experimental sentence stimuli used in the visual world paradigm

1. El agente corta/cortó los materiales.
2. El alumno pinta/pintó su cuaderno.
3. El científico firma/firmó la patente.
4. La esposa plancha/planchó las camisas.
5. La amiga canta/cantó la ópera.
6. La maestra busca/buscó la información.
7. La inversora compra/compró el local.
8. La economista gasta/gastó los fondos.
9. La madre junta/juntó los sofás.
10. El tío salva/salvó su vehículo.
11. El tenista lanza/lanzó la pelota.
12. El pescador pesca/pescó los salmones.
13. El general monta/montó su caballo.
14. La fotógrafa manda/mandó las fotos.
15. El ladrón salta/saltó la valla.
16. La prima carga/cargó la batería.

Appendix 1b. Filler stimuli used in the visual world paradigm

1. Mientras el mensajero abandona al boxeador, (él) está tirando un sobre a la basura.
2. Mientras el mensajero abandona al boxeador, (él) está tirando un guante a la basura.
3. Mientras el señor aguanta al niño, (él) está leyendo un poema en el jardín.
4. Mientras el señor aguanta al niño, (él) está leyendo un cómic en el jardín.
5. Mientras el pastelero asusta al cocinero, (él) está preparando un postre en la casa.
6. Mientras el pastelero asusta al cocinero, (él) está preparando un arroz en la casa.
7. Mientras el cantante desmiente al escritor, (él) está presentando un disco en el centro.
8. Mientras el cantante desmiente al escritor, (él) está presentando un libro en el centro.

9. Mientras el médico entretiene al artista, (él) está haciendo un informe en el tren.
10. Mientras el médico entretiene al artista, (él) está haciendo un dibujo en el tren.
11. Mientras el militar espera al agricultor, (él) está reparando un tanque en el camino.
12. Mientras el militar espera al agricultor, (él) está reparando un tractor en el camino.
13. Mientras el carnicero evita al jardinero, (él) está vendiendo un pollo en la plaza.
14. Mientras el carnicero evita al jardinero, (él) está vendiendo un árbol en la plaza.
15. Mientras el bailarín habla al jugador, (él) está mirando un festival en la tele.
16. Mientras el bailarín habla al jugador, (él) está mirando un torneo en la tele.
17. Mientras el secretario interrumpe al arquitecto, (él) está guardando un papel en el armario.
18. Mientras el secretario interrumpe al arquitecto, (él) está guardando un plano en el armario.
19. Mientras el policía investiga al geólogo, (él) está cogiendo un visado en la frontera.
20. Mientras el policía investiga al geólogo, (él) está cogiendo un mineral en la frontera.
21. Mientras el cartero recoge al frutero, (él) está dejando un paquete a la vecina.
22. Mientras el cartero recoge al frutero, (él) está dejando un plátano a la vecina.
23. Mientras el pintor saluda al actor, (él) está abriendo un museo en el pueblo.
24. Mientras el pintor saluda al actor, (él) está abriendo un teatro en el pueblo.
25. Mientras el detective sigue al explorador, (él) está descubriendo un crimen en la playa.
26. Mientras el detective sigue al explorador, (él) está descubriendo un templo en la playa.
27. Mientras el camarero sirve al peluquero, (él) está quitando un plato de la mesa.
28. Mientras el camarero sirve al peluquero, (él) está quitando un champú de la mesa.
29. Mientras el músico sorprende al atleta, (él) está trayendo un violín a la oficina.
30. Mientras el músico sorprende al atleta, (él) está trayendo un trofeo a la oficina.
31. Mientras el turista ve al poeta, (él) está usando un mapa de la ciudad.
32. Mientras el turista ve al poeta, (él) está usando un texto de la ciudad.
33. Mientras el motorista abandona al futbolista, (él) está reservando un casco en la tienda.
34. Mientras el motorista abandona al futbolista, (él) está reservando un balón en la tienda.
35. Mientras el reportero aguanta al humorista, (él) está revisando un artículo en la estación.
36. Mientras el reportero aguanta al humorista, (él) está revisando un monólogo en la estación.
37. Mientras el padre asusta al hijo, (él) está bebiendo un vino en el bar.
38. Mientras el padre asusta al hijo, (él) está bebiendo un jugo en el bar.
39. Mientras el mecánico espera al compositor, (él) está probando un motor en el garaje.
40. Mientras el mecánico espera al compositor, (él) está probando un piano en el garaje.
41. Mientras el bombero desmiente al fumador, (él) está pidiendo un extintor en el salón.
42. Mientras el bombero desmiente al fumador, (él) está pidiendo un cigarro en el salón.
43. Mientras el presentador entretiene al astronauta, (él) está estudiando un programa en el sofá.
44. Mientras el presentador entretiene al astronauta, (él) está estudiando un planeta en el sofá.
45. Mientras el periodista sigue al guionista, (él) está filmando un reportaje en el bosque.
46. Mientras el periodista sigue al guionista, (él) está filmando un episodio en el bosque.
47. Mientras el ingeniero habla al diseñador, (él) está dibujando un robot en el estudio.
48. Mientras el ingeniero habla al diseñador, (él) está dibujando un jersey en el estudio.
49. Mientras el inspector interrumpe al famoso, (él) está escribiendo un documento en el hotel.
50. Mientras el inspector interrumpe al famoso, (él) está escribiendo un autógrafo en el hotel.
51. Mientras el director investiga al dentista, (él) está arreglando un contrato en la clínica.
52. Mientras el director investiga al dentista, él está arreglando un contrato en la clínica.

53. Mientras el director investiga al dentista, (él) está arreglando un implante en la clínica.
54. Mientras el astrónomo recoge al biólogo, (él) está llevando un telescopio a la facultad.
55. Mientras el astrónomo recoge al biólogo, (él) está llevando un microscopio a la facultad.
56. Mientras el banquero saluda al técnico, (él) está cambiando un cheque en el banco.
57. Mientras el banquero saluda al técnico, (él) está cambiando un cable en el banco.
58. Mientras el extranjero sigue al enfermero, (él) está poniendo un pasaporte en la bolsa.
59. Mientras el extranjero sigue al enfermero, (él) está poniendo un termómetro en la bolsa.
60. Mientras el cajero sirve al nadador, (él) está metiendo un billete en la caja.
61. Mientras el cajero sirve al nadador, (él) está metiendo un bañador en la caja.
62. Mientras el piloto sorprende al capitán, (él) está mostrando un avión en el móvil.
63. Mientras el piloto sorprende al capitán, (él) está mostrando un barco en el móvil.
64. Mientras el político ve al estudiante, (él) está repasando un discurso en el bus.
65. Mientras el político ve al estudiante, (él) está repasando un examen en el bus.
66. Dice que el/su colegio nuevo cuesta mucho dinero.
67. Dice que el/su proyector nuevo cuesta mucho dinero.
68. Avisa de que la/su máquina moderna repara el sistema.
69. Avisa de que la/su conexión moderna repara el sistema.
70. Cree que el/su plato típico lleva demasiados ingredientes.
71. Cree que el/su pastel típico lleva demasiados ingredientes.
72. Comenta que la/su silla rosada mejora la sala.
73. Comenta que la/su pared rosada mejora la sala.
74. Anuncia que el/su palo roto crea más basura.
75. Anuncia que el/su cristal roto crea más basura.
76. Piensa que la/su charla larga produce insomnio.
77. Piensa que la/su crisis larga produce insomnio.
78. Descubre que el/su teclado bueno vale menos dinero.
79. Descubre que el/su borrador bueno vale menos dinero.
80. Cuenta que la/su planta bonita gana el concurso.
81. Cuenta que la/su canción bonita gana el concurso.
82. Declara que el/su carro antiguo contamina el ambiente.
83. Declara que el/su camión antiguo contamina el ambiente.
84. Menciona que la/su falda dorada causa sorpresa.
85. Menciona que la/su nariz dorada causa sorpresa.
86. Indica que el/su mercado pequeño contrata a estudiantes.
87. Indica que el/su hospital pequeño contrata a estudiantes.
88. Aclara que la/su palabra secreta resuelve el misterio.
89. Aclara que la/su imagen secreta resuelve el misterio.
90. Opina que el/su cuero negro cautiva al cliente.
91. Opina que el/su collar negro cautiva al cliente.
92. Señala que la/su fiesta perfecta requiere preparación.
93. Señala que la/su lección perfecta requiere preparación.
94. Señala que su lección perfecta requiere preparación.
95. Explica que el/su tamaño mediano resulta más práctico.
96. Explica que el/su cinturón mediano resulta más práctico.
97. Aclara que la/su escuela pública trae problemas.
98. Aclara que la/su opinión pública trae problemas.
99. Sugiere que el/su anillo rojo llama la atención.

100. Sugiere que el/su pantalón rojo llama la atención.
101. Manifiesta que la/su piedra preciosa sorprende al hombre.
102. Manifiesta que la/su mansión preciosa sorprende al hombre.
103. Descubre que el/su sombrero barato soporta la lluvia.
104. Descubre que el/su paraguas barato soporta la lluvia.
105. Sostiene que la/su taberna oscura necesita más luz.
106. Sostiene que la/su estación oscura necesita más luz.
107. Demuestra que el/su zapato caro resiste la lluvia.
108. Demuestra que el/su maletín caro resiste la lluvia.
109. Dice que la/su sala limpia recibe más turistas.
110. Dice que la/su nación limpia recibe más turistas.
111. Avisa de que el/su templo sagrado tiene poderes mágicos.
112. Avisa de que el/su metal sagrado tiene poderes mágicos.
113. Cree que la/su cena mala decepciona al padre.
114. Cree que la/su acción mala decepciona al padre.
115. Comenta que el/su suelo blanco demanda mucho cuidado.
116. Comenta que el/su sillón blanco demanda mucho cuidado.
117. Piensa que la/su iglesia estricta molesta al joven.
118. Piensa que la/su religión estricta molesta al joven.
119. Anuncia que el/su vaso sucio disgusta al invitado.
120. Anuncia que el/su jardín sucio disgusta al invitado.
121. Opina que la/su novela trágica divide al pueblo.
122. Opina que la/su situación trágica divide al pueblo.
123. Cuenta que el/su cuadro famoso representa su vida.
124. Cuenta que el/su lugar famoso representa su vida.
125. Declara que la/su lámpara rara confunde al rey.
126. Declara que la/su tradición rara confunde al rey.
127. Menciona que el/su bolso morado lidera las ventas.
128. Menciona que el/su maíz morado lidera las ventas.
129. Indica que la/su revista cómica divierte a todos.
130. Indica que la/su reunión cómica divierte a todos.
131. El abogado se dedicó en cuerpo y alma/mente al último caso.
132. El soldado apareció en carne y hueso/sangre en la televisión.
133. El vecino obtiene a la vuelta de la esquina/carrera la comida.
134. La enferma tenía lágrimas de cocodrilo/sufrimiento en la cara.
135. La estudiante encontró a su príncipe azul/real en un bar.
136. El sobrino es la oveja negra/joven de la familia.
137. El jugador quería ganar a toda costa/hora el partido.
138. La niña no cambia por nada del mundo/cuarto la muñeca.
139. La cocinera preparó la receta al pie de la letra/hoja para cenar.
140. El hombre peleó con uñas y dientes/puños por el dinero.
141. El deportista ganó con el sudor de su frente/cuerpo el campeonato.
142. La profesora tiene todo al alcance de la mano/vista donde vive.
143. El empleado desea a fin de cuentas/año tener trabajo.
144. El candidato no aceptó después de todo/comer la oferta.
145. La presidenta es el talón de Aquiles/apoyo de la compañía.
146. La entrenadora es como un libro abierto/viejo para la gimnasta.

Appendix 2. Final growth curve analysis formula for monolingual speakers

eLog ~ ot1 + ot2 + (1 + condition_sum | participant) + (1 | target)

Fixed effects of the final model for monolingual speakers

Parameter	Estimate	SE	*t*	*p*	CI	Conditional R^2	Marginal R^2
Intercept (γ_{00})	0.680	0.124	5.480	< .001	[0.679, 0.693]	0.107	0.066
Time[1] (γ_{10})	2.418	0.137	17.597	< .001	[2.417, 2.433]		
Time[2] (γ_{20})	0.509	0.133	3.822	<.001	[0.510, 0.524]		

Random effects of the final model for monolingual speakers

Group	Parameter	Variance	SD	Correlations	
Participant	Intercept	0.103	0.321	1.00	
	Lexical stress	0.053	0.230	1.15	1.00
Item	Intercept	0.322	0.568	1.00	
Residual		9.198	3.033		

Appendix 3. Final growth curve analysis formula for L2 learners

eLog ~ ot1 + ot2 + condition_sum + DELE_z + use_z + ot1:condition_sum + ot1:DELE_z + ot1:use_z + ot2:use_z +

(1 + condition_sum | participant) + (1 | target)

Fixed effects of the final model for L2 speakers

Parameter	Estimate	SE	*t*	*p*	CI	Conditional R^2	Marginal R^2
Intercept (γ_{00})	0.070	0.086	0.813	.416	[0.070, 0.080]	0.071	0.031
Time[1] (γ_{10})	1.469	0.094	15.612	< .001	[1.468, 1.483]		
Time[2] (γ_{20})	0.668	0.094	7.092	< .001	[0.668, 0.680]		

Appendix 3. *(continued)*

Parameter	Estimate	SE	*t*	*p*	CI	Conditional R^2	Marginal R^2
Lexical stress (γ_{01})	0.074	0.083	0.897	.370	[0.074, 0.084]		
DELE_z (γ_{02})	0.022	0.058	0.377	.706	[0.022, 0.029]		
use_z (γ_{03})	−0.077	0.058	−1.323	.186	[−0.078, −0.071]		
$Time^1$ × Lexical stress (γ_{11})	0.291	0.094	3.096	.002	[0.290, 0.301]		
$Time^1$ × DELE_z (γ_{12})	0.311	0.100	3.127	.002	[0.311, 0.322]		
$Time^1$ × use_z (γ_{13})	−0.072	0.096	−0.750	.453	[−0.073, −0.061]		
$Time^2$ × use_z (γ_{23})	0.239	0.093	2.585	.010	[0.239, 0.250]		

Random effects of the final model for L2 speakers

Group	Parameter	Variance	SD	Correlations	
Participant	Intercept	0.139	0.373	1.00	
	Lexical stress	0.149	0.386	−.02	1.00
Item	Intercept	0.140	0.374	1.00	
Residual		9.862	3.140		

Address for correspondence

Laura Fernández-Arroyo
Rutgers University
Academic Building-CAC
15 Seminary Place
New Brunswick, NJ 08901
Canada

lf402@spanport.rutgers.edu

Co-author information

Nuria Sagarra
Rutgers University
nuria.sagarra@rutgers.edu

Kaylee Fernández
Rutgers University
knf43@scarletmail.rutgers.edu

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