Proficiency and transfer effects on anticipation of verb tense in Spanish by L1 Mandarin and L1 English speakers

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One way humans learn is through association. Associations are probabilistic connections between a cue and an outcome (Clark, 2013). Associations are essential for any kind of learning, including language. In language, associations allow speakers to anticipate incoming information based on the cues present, reducing the cognitive processing load and facilitating comprehension. For instance, phonological cues such as lexical stress can be associated with morphological outcomes such as verb tense suffixes. Inability to create this type of morphophonological association may be a source of L2 processing difficulty, as the outcome goes unnoticed since the L2 speaker cannot pay attention to all the incoming information.

While L2 speakers eventually acquire morphophonological associations (e.g., Sagarra & Casillas, 2018; Schremm, Söderström, Horne, & Roll, 2016), the factors contributing to their acquisition are unknown. Here we investigate L1 transfer, L2 proficiency and language use effects on the acquisition of L2 morphophonological associations. For that purpose, we examine verb tense suffix anticipation based on its association with lexical stress in adult English and Mandarin Chinese learners of Spanish at different stages of L2 development. We also compare their performance with a Spanish control group. The findings from this study can thus inform models of L2 acquisition about the different effects of L1 transfer, L2 proficiency and language use in the acquisition of morphophonological associations. Additionally, it can also provide insight into the learning mechanisms underlying L2 acquisition.

# 2. Background

## 2.1. L1 transfer

Cognitive models of L2 acquisition claim that a person’s native language influences L2 acquisition (e.g., Competition Model, P. Li & MacWhinney, 2012; MacWhinney & MacWhinney, 1987). This influence is called transfer or cross-linguistic influence (Lado, 1957). L1 transfer effects vary depending on the L1, the L2 and the information being processed. Sharing a structure (e.g., verbal morphology) in the L1 and the L2 accelerates the L2 acquisition process in comparison to differing structures across the L1 and the L2 (Luk & Shirai, 2009; Melby-Lervåg & Lervåg, 2011). L1 transfer has been found to affect processing of several L2 areas, including L2 syntax (see Lago, Mosca, & Stutter Garcia, 2020, for a review) and L2 morphosyntax (see Carrasco-Ortı́z et al., 2017, for a review). Relevant to our study, L1 transfer also modulates L2 phonology and morphology.

Regarding L1 transfer effects on L2 phonology, speakers transfer L1 processing skills and L1 knowledge. Transfer of L1 processing skills allows L2 speakers to segment, analyze, manipulate, and assemble L2 speech sounds (Yang, Cooc, & Sheng, 2017) and has been shown to play a major role in L2 phonological awareness (see Saiegh-Haddad, 2019, for a review). Apart from skills, L1 knowledge is crucial for L2 phonological processing at the segmental and suprasegmental level. At the segmental level, L1 Dutch speakers assimilate syllable- and word-final obstruents before voiced stops more often than before sonorant consonants in L2 English, following Dutch phonological rules instead of English rules (Simon, 2010). At the suprasegmental level, L1 French speakers have difficulties in perceiving lexical stress in L2 Spanish (Dupoux, Sebastián-Gallés, Navarrete, & Peperkamp, 2008). In contrast, L1 Cantonese and Mandarin speakers can learn to discriminate lexical stress in an L2 (Chen, 2013; X. Li, To, & Ng, 2017) and L1 Korean speakers also do so although with some difficulty (Hualde & Kim, 2015; Lee, Shin, & Garcia, 2019).

The findings above suggest that depending on the overlap between the L1 and the L2 the effects of L1 transfer will be different. Korean does not have lexical stress; there is no overlapping structure that therefore biases processing of L2 lexical stress. Cantonese and Mandarin arguably have lexical stress, but it is mixed with lexical tone realization, making it hard to determine what information is carried by tone and which one by stress. Lastly, French has lexical stress, like English or Spanish, but its nature is different. In French, lexical stress is fixed and marks mostly phrasal boundaries. The overlap in physical nature (i.e., the emphasis in a syllable) but the difference in function (i.e., word contrast) may be biasing French speakers in their processing of L2 lexical stress.

Concerning L1 transfer effects on L2 morphology, L1 transfer does not appear to impede L2 acquisition of inflectional morphology, but it makes its processing less efficient than in monolinguals (Hopp, 2010). Acquisition of L2 morphology is more continuous when L2 learners can transfer knowledge of morphology between two morphologically rich languages than between a morphologically poor and a morphologically rich language (De Clercq & Housen, 2019). L1 transfer of morphology is mediated by working memory, target language input and other languages known by the speaker, especially at the beginning of the L2 development, and by overlap between meaning of morphological structures. Higher working memory individuals are better able to overcome L1 transfer biases (Sagarra, 2008). With respect to target language input, speakers use probability to make generalizations and rely not only in their L1 but also in other languages spoken to process the L2 (Rast, 2010). These L1 transfer effects are stronger when the L2 structure to be acquired is infrequent in the L2 (Larrañaga & Ortega., 2012). The influence of other languages is also visible in L1 speakers of morphologically rich languages starting to rely on L2 morphology for L2 processing earlier than L1 speakers of morphologically poor languages (Sagarra & Ellis, 2013). Lastly, forms with a greater semantic overlap are easier to acquire than those whose meaning overlaps less (Nishi & Shirai, 2019).

Taken together, research on L2 phonology and morphology shows that L1 transfer is an important factor of L2 processing. The characteristics of each language known by the speaker and how they overlap will determine the effects of L1 transfer and how difficult it is for the L2 speaker to overcome the effects. In addition, L1 transfer interacts with other factors, such as working memory, in magnifying or reducing the L1 transfer effects. Another such factor is L2 proficiency.

## 2.2. L2 proficiency

L2 proficiency has constantly been shown to be a major factor in L2 processing. Importantly, L2 proficiency modulates processing of L2 phonology and morphology. In terms of L2 phonology, lower proficiency L2 learners can only distinguish L2 phonemic contrasts when their attention is directed towards them; higher proficiency learners, in contrast, can distinguish L2 phonemic contrasts in broader contexts and show similar brain activity to L1 speakers (White, Titone, Genesee, & Steinhauer, 2015). L2 proficiency also affects processing of sounds for word activation. Lower proficiency L2 learners activate phonologically similar translations of words in their L1, but this cross-linguistic activation diminishes as proficiency increases (Berghoff, McLoughlin, & Bylund, 2021). In terms of prosody, complete mastering of L2 prosody is difficult, even when highly proficient (Schmidt, Pérez, Cilibrasi, & Tsimpli, 2020). The effects of L2 proficiency also cause L1 transfer effects in phonology to vary. As the L2 system develops, the L1 transfer effects decrease (Jun & Oh, 2000). Sometimes, however, the L1 transfer effects are only visible at advanced levels of proficiency, when there is an overlapping structure in both languages (e.g., lexical stress) that mixes up with another phonological structure only present in the L2 (e.g., lexical tones, Shih & Lu, 2010).

With regard to L2 morphology, lower proficiency L2 learners show brain activity responses to L2 morphology (derived and inflected words, novel derivations and pseudo-suffixed words) that deviate from L1 processing-style, and these brain activity responses change as a function of proficiency to resemble L1 processing responses (Kimppa et al., 2019). Behavioral studies with eye-tracking suggest that the processing similarity starts to be developed at intermediate stages of proficiency, when learners start to be sensitive to morphological processes and violations (Sagarra & Ellis, 2013). The behavioral responses may however still be different between the native and non-native populations, as L1 speakers appear to be more conditioned by the internal structure of words than L2 speakers in activating them (Song, Do, Thompson, Waegemaekers, & Lee, 2020).

Like for phonology, L2 proficiency also conditions L1 transfer effects on L2 morphological processing. Most research indicates that transfer at beginner stages is not strong (Rast, 2010) or even null (Sagarra, 2008). Speakers at beginner stages of L2 acquisition may nevertheless show evidence of easier processing of L2 morphological structures when the L1 also has that structure (e.g., Ellis, 2008; Ellis & Sagarra, 2010), and thus tend to rely on the morphological processing mechanisms of their L1 to process L2 morphology (Sagarra & Ellis, 2013). Transfer starts to affect L2 processing more stably at intermediate levels (see Sagarra, 2020, for a review) and continues to do so until the learner is very advanced or has reached a near-native level of proficiency (Hopp, 2010).

In summary, L2 proficiency modulates processing of phonological and morphological information. As proficiency increases, processing becomes more efficient. However, an increased L2 proficiency alone does not guarantee monolingual-like processing, as it interacts with the L1 knowledge of the L2 speaker, resulting in effects that are still measurable even at advanced levels of proficiency.

## 2.5. Language use

L2 proficiency is important in L2 processing, but different patterns of language use may facilitate or hinder L2 processing in speakers at an otherwise similar proficiency. Bilingual speakers are likely to be more dominant in one language or another and to use a specific language in given contexts or with certain people, which will affect their language use patterns. In turn, the variability in language use may cause differences in language processing.

Most research on language use has been conducted in the fields of code-switching and in cognitive control. The findings in the code-switching field are relevant to the present study as they refer to language processing in particular, rather than general executive functions. Research on language use and code-switching indicates that brain activity reflecting processing costs decrease with increased exposure to the phenomenon causing the cost. For instance, code-switching requires effortful processing for non-code-switchers, but its processing requires no extra effort in code-switchers compared to monolingual speech (Beatty-Martı́nez & Dussias, 2017), making code-switchers faster in adapting to code switches (Hartanto & Yang, 2016). This difference in language processing is observable across individuals with similar proficiency who have different patterns of language activation (Beatty-Martı́nez et al., 2020). The effect of language use is also evidenced in brain connectivity and proactive control in linguistic tasks (Gullifer et al., 2018).

Considering that L2 speakers vary in their L2 use, the findings on the relationship between code-switching and language use to L2 acquisition are easily extrapolated to L2 processing. For L2 speakers, an increased L2 use is likely to produce a less cognitively taxing L2 processing. It is even possible that the effects of language use in L2 speakers are more remarkable than in code-switchers, as their proficiencies in the L1 and the L2 are more likely to be more different than in code-switcher. The combination of language use and L2 proficiency will thus condition how the L2 is processed, and the L2 speakers create and use associations to predict what they are going to hear and alleviate the L2 processing.

## 2.4. L2 proficiency and L2 prediction

Linguistic prediction is a crucial aspect of language processing. Linguistic prediction consists of the anticipation of incoming linguistic information based on information already available. The cue and outcome may belong to the same linguistic component (e.g., semantic cue-semantic outcome, Altmann & Kamide, 1999) or to different ones (e.g., phonological cue-morphological outcome, Sagarra & Casillas, 2018). Because of their probabilistic nature, associations are acquired gradually according to their frequency and consistency. An association will be stronger the more examples in the input (high availability) and the more regular it is (high reliability, Bates& MacWhinney, 1987). These associations are crucial for language acquisition (Bates & MacWhinney, 1982; MacWhinney, 1997; Romberg & Saffran, 2010) and prediction (Kuperberg & Jaeger, 2016).

Monolinguals use semantic-semantic (Altmann & Kamide, 1999), semantic-morphosyntactic (Altmann & Kamide, 2007), morphosyntactic (Grüter, Takeda, Rohde, & Schafer, 2016; Huettig & Mani, 2016; Lew-Williams & Fernald, 2010), and morphophonological (Roll, Horne, & Lindgren, 2010; Roll, Söderström, & Horne, 2013) predictive associations. Relevantly for the study, morphophonological associations are typical across languages. Among others, pitch accent can be used to predict noun and verb suffixes in Swedish (Roll, Horne, & Lindgren, 2011; Schremm, Novén, Horne, & Roll, 2017), lexical stress predicts verb noun suffixes in Spanish (Lozano-Argüelles, Sagarra, & Casillas, 2020; Sagarra & Casillas, 2018), and vowel duration predicts active and passive voice in English (Rehrig, 2017).

Unlike monolinguals, adult L2 learners show variability in making L2 predictions. L2 prediction studies have primarily focused on morphosyntactic associations (e.g., Dussias, Kroff, Tamargo, & Gerfen, 2013; Grüter & Rohde, 2013; Grüter, Rohde, & Schafer, 2014; Lew-Williams & Fernald, 2010). The findings of these studies show that, while accurate, L2 learners are not able to make associations with native-like efficiency, and that such inability is due to L2 proficiency—the higher the proficiency, the likelier the prediction. Other factors such as variability in informativeness of the cue (e.g., gendered article), differences in L1 and L2 acquisition format (e.g., influence of top-down knowledge in L2 speakers), recency of cues, fewer opportunities to hear the associations, different processing strategies, cognitive maturity, or L1 transfer have been suggested as factors impeding monolingual-like efficiency but have not been properly researched. Of these factors, L1 transfer may prove to be crucial for acquisition of not only morphosyntactic, but also morphophonological associations.

## 2.5. L1 transfer and L2 phonological and morphological prediction

Research on the implicit acquisition of the within-word association between phonological cues and morphological outcomes has focused on pitch accent and lexical stress as cues, corresponding to Central and South Swedish and to Spanish. In Central Swedish, Accent 1 cues present tense (*skrämme* ‘I scare’), and Accent 2 cues past tense (*skrämde* ‘I scared’). Schremm, Söderström, Horne, and Roll (2016) explored L2 acquisition of pitch accent-suffix associations in verbs in Central Swedish. L1 speakers of non-tonal languages learning L2 Central Swedish were faster at identifying words containing congruent accent-suffix associations than a L1 Swedish control group, but the difference in response time against incongruent words was larger in the L1 speakers. Since the participants in that study were intermediate to upper-intermediate, Gosselke Berthelsen, Horne, Brännström, Shtyrov, and Roll (2018) tested whether L2 beginners could also learn and use pitch accent to predict morphological outcomes, noun number in this case, when their L1 does not have pitch accent. The brain activity of the participants, L1 German-L2 Central Swedish speakers, revealed that they could not pre-activate noun number suffixes based on pitch accent yet. These results suggest that L2 learners, similar to natives, were unconciously using pitch accents to predict grammatical suffixes already at intermediate levels of proficiency but not beginning stages. However, given that each study used different types of morphological outcomes, we cannot know if the inability to predict in the beginner groups is due to lacking the association or to the suffixes.

Gosselke Berthelsen, Horne, Shtyrov, and Roll (2020) explored the effects of L1 transfer on the acquisition of morphophonological associations between pitch accent and suffixes. They compared anticipation of number and gender suffixes in pseudo-nouns cued through pitch accent in a group of South Swedish speakers and in a group of German speakers as reflected by ERPs. Participants’ brain activity suggests that while Swedish speakers used knowledge of pitch accent in Swedish to process pitch accent in the pseudowords, the German speakers were not accessing pitch meaning to preactivate the suffixes. Their accuracy at the end of the experiment was, however, similar. The findings from this study demonstrate that transferring acoustic processing abilities as well as the function associated to the acoustics from the L1 to the L2 can facilitate L2 acquisition of morphophonological associations.

Regarding lexical stress-tense associations, Sagarra and Casillas (2018) investigated the role of proficiency and verbal working memory in the integration of lexical stress in the stem of verbs as a cue to present and past tense suffixes in Spanish. In Spanish, paroxytone stress in bisyllable verbs in Spanish cues present tense (*FIRma* ‘s/he signs’), while oxytone stress cues past tense (*firMÓ* ‘s/he signed’). They recruited Spanish monolinguals and English-Spanish late bilinguals whose proficiency was either beginner or advanced. Eye-tracking data revealed that advanced L2 speakers of Spanish and monolinguals could predict tense based on lexically stressed and unstressed syllables, but beginner speakers could not. In addition, the advanced L2 speakers only made predictions when the stem syllabic structure was CVC. Working memory did not affect integration of lexical stress and prediction of verb tense suffixes, suggesting that working memory does not affect processing of morphophonological associations when the speaker has already had some experience with the language.

In the search for other factors constraining morphophonological prediction, Lozano-Argüelles, Sagarra, and Casillas (2020) investigated whether anticipatory experience could affect anticipation abilities for the same type of association, for which they added a group of English-Spanish interpreters. Anticipatory experience did have a positive effect in some conditions (CVC stem + past tense), allowing interpreters to predict faster, although not earlier, than monolinguals did. The findings from the two studies on stress-suffix associations indicate that morphophonological associations are not only restricted to pitch accent. Importantly, they also indicate that anticipation abilities for morphophonological associations are constrained by each speaker’s background.

In sum, the studies on lexical stress extend previous findings on pitch accent to other phonological structures. By studying L2 populations at different levels of L2 development, these studies point towards the fundamental effects of L2 proficiency in L2 prediction. However, by leaving L1 transfer out, it is impossible to ascertain so far how morphophonological prediction abilities are conditioned by the previous linguistic knowledge of the speakers.

## 2.6. Linguistic phenomena

Morphophonological associations are crucial for the efficient processing of morphology. This study focuses on a morphophonological association of lexical stress as the cue and verb tense suffix as the outcome. In order to study different possible degrees of transfer of association, English and Mandarin Chinese were selected as the L1s and Spanish as the L2.

### 2.4.1. Lexical stress (the cue).

Lexical stress is the emphasis of a syllable relative to the rest of the syllables in a word (Hualde, 2005). Spanish and English have lexical stress, and Mandarin Chinese arguably so. Different acoustic correlates, their importance or weight, and how they combine cause the acoustic realization of lexical stress in each language to vary. In Spanish, pitch (F0) is higher for stressed syllables and lower for unstressed syllables, and stressed syllables sound louder and are usually slightly longer (Hualde, 2005; Ortega-Llebaria, 2006; Ortega-Llebaria & Prieto, 2007, 2009). In English, the main correlates are vowel duration and quality (Cooper, Cutler, & Wales, 2002; Cutler, 1986), but other correlates such as pitch are also involved in stressed syllables (Fry, 1955, 1958). Lexical stress in Mandarin Chinese is harder to classify. Some scholars have in fact described Mandarin Chinese as a language without stress (Hyman, 1977), while others propose that Mandarin Chinese may have some realization of lexical stress (e.g., Duanmu, 2007). However, it is unclear how stress is represented in speakers’ minds. Shanghai Chinese speakers, for example, may have no judgment on stress (Selkirk & Shen, 1990). Research on the phonetic realization of Mandarin Chinese lexical stress has revealed that it may rely duration, vowel quality, and pitch height (Lin & Yan, 1980).

In English and Spanish, lexical stress has no fixed position, playing a phonologically contrastive function at the lexical level depending on its location. This contrastive function is more typical in Spanish than in English. In English, lexical stress is used predominantly to distinguish heteronyms or pairs of verb-noun that have no segmental differences (to “proDUCE,” verb vs “PROduce,” noun). In Spanish, lexical stress differentiates all kinds of word categories and information, such as verbal tense and person (*CANto* “I sing” vs *canTÓ* “s/he sang”), or nouns (*PApa* “potato” vs *paPÁ* “dad”), or nouns from verbs (*TÉRmino* “term” vs. *terMIno* “I finish” vs *termiNÓ* “s/he finished”).

In Mandarin, pitch in lexical stress interacts with lexical tones. Tones are the pitch contour modulations in each syllable (Chao, 1968). Many languages use tones, or changes in pitch-contour, at a phrasal level for pragmatic purposes. However, only a few use tones contrastively at a lexical level. The acoustic correlate for tones in most Mandarin dialects (e.g., from Beijing and Tianjin) is pitch contour (Gandour & Fromkin, 1978; Zhu & Wang, 2015), accompanied by other correlates like creakiness for some of the tones [e.g., tone 3; Chao (1968)]. The interaction of pitch in stress with pitch in tones may prevent speakers from distinguishing between stress or tones.

### 2.4.2. Verbal inflectional morphology (the outcome).

The outcome in the morphophonological association with lexical stress tested in this study is verbal tense suffix. Spanish is a morphologically rich language, using suffixes to indicate tense along with other information such as aspect, person and number (*lavó* ‘s/he wash-ed~3 SG Past Perfect~’). All tenses and all persons require their own suffix, usually different from each other, and each verb needs to be conjugated even if the time frame and person have already been established.

English is a morphologically poorer language than Spanish. English indicates some information with bound morphemes, such as past tense (-ed) or 3rd person singular in the present tense (-s). English indicates some tenses with independent morphemes, like future (will) or conditional (would), but these morphemes do not vary according to person or number.

Finally, Mandarin Chinese does not use inflectional morphology to indicate tense. The same word is used for all tenses (e.g., 吃 /chī/ ‘eat’) and tense is indicated lexically, via temporal adverbs (e.g., “yesterday”) or unbound particles (e.g.,了 /le/ indicates completeness or near future). These particles do not change depending on the person the verb refers to and, similarly to temporal adverbs, can oftentimes be omitted once the time frame has been established.

# 3. This study

Mandarin Chinese and English differ from Spanish to different degrees in the way they associate lexical stress with morphology. The different similarity makes them a perfect pair to compare L1 transfer effects on L2 word prediction. By adding L2 proficiency, we can also discern what effects are due to L1 transfer or to the development of the L2 system. Examining that distinction will clarify whether the results from previous studies with morphophonological associations are due to varying effects of L1 transfer over L2 proficiency or to L2 acquisition stages general to all L2 Spanish speakers, regardless of their L1. In addition to L1 transfer and L2 proficiency, language use may contribute to morphophonological association acquisition too, since an increased use of the language will expose the speaker to more instances of the association. So far, we know that L2 speakers can acquire morphophonological associations (e.g., Schremm, Söderström, Horne, & Roll, 2016), but it requires time (Gosselke Berthelsen, Horne, Brännström, Shtyrov, & Roll, 2018; Sagarra & Casillas, 2018).

Following the previous research on acquisition of morphophonological association, it is difficult to ascertain the role of L1 transfer (Gosselke Berthelsen et al., 2020) and language use (e.g., Beatty-Martı́nez & Dussias, 2017) as factors contributing to language processing and prediction for several reasons. First, there has only been one study exploring the role of L1 transfer (Gosselke Berthelsen, Horne, Shtyrov, & Roll, 2020) and none testing language use effects on prediction. The study on L1 transfer is problematic because the stimuli were pseudo-words and because transfer was considered as a categorical event, rather than an overlap between languages that can range from total, to partial, to none. Second, some studies have mixed L2 speakers of several L1s (Schremm, Söderström, Horne, & Roll, 2016), because, the authors argued, the L1s do not have pitch accents, or the L2 speakers spoke a third or even a fourth language, which were not stated. However, with so much variability the languages may have differed in similarity to the L2, therefore making possible L1 transfer effects. Third, while studies on pitch accent as a cue covered L2 learners at all levels of proficiency, studies on lexical stress as a cue have examined only beginners and advanced speakers. Fourth, the two lines of research in the topic, one with pitch accents and the other with lexical stress, are not easily comparable for three reasons: L2 proficiency was sometimes self-reported, sometimes assigned according the level of the language course the learners were enrolled in, and sometimes measured with a standardized test; speakers in the pitch accent studies lived immersed in the L2 but speakers in the lexical stress studies lived in an L1 context; and fifth, the behavioral research on pitch accent associations consist of reaction times, while the behavioral research on lexical stress consists of eye-tracking.

The present study addresses the issue of the interaction between L1 transfer, L2 proficiency, and language use effects on the acquisition of morphophonologial associations. To that end, we investigate L2 use of lexical stress to predict verbal tense suffixes. To tease the effects of L1 transfer, L2 proficiency, and language use apart, we compare two populations from different L1s (English and Mandarin Chinese) at different stages of proficiency (intermediate-near native), and we also compare their weekly language use. The specific research questions are:

*1. Does L1 transfer affect L1 Mandarin and L1 English learners of L2 Spanish’s abilities to use lexical stress to anticipate verbal suffixes in Spanish?* We predict that L1 transfer effects will manifest differently in English and Mandarin speakers’ ability to anticipate, given the different phonological characteristics of each language and their similarity to Spanish phonology (Gosselke Berthelsen, Horne, Shtyrov, & Roll, 2020). English speakers will anticipate (Lozano-Argüelles, Sagarra, & Casillas, 2020; Sagarra & Casillas, 2018) with more ease than Mandarin speakers because their knowledge of lexical stress in English will aid them in creating morphophonological associations for prediction. The mixing of lexical stress with tones in Mandarin will prevent the L1 Mandarin speakrs from transfering lexical stress knowledge, therefore delying the creation of morphophonological associations. This delay will translate into later abilities to predict.

*2. Does L2 proficiency affect L1 Mandarin and L1 English learners of L2 Spanish’s abilities to use lexical stress to anticipate verbal suffixes in Spanish?* Based on previous studies with L2 Swedish speakers (Gosselke Berthelsen, Horne, Brännström, Shtyrov, & Roll, 2018; Schremm, Söderström, Horne, & Roll, 2016) and L2 Spanish speakers (Sagarra & Casillas, 2018), we expect advanced speakers to predict more frequently than intermediate speakers. They will not develop monolingual-like abilities, however. Advanced L2 speakers are expected to anticipate more because of their longer exposure to and interaction with the L2. Previous studies on the relationship between L2 proficiency and morphophonological prediction were carried out with populations immersed in an L2 context (Gosselke Berthelsen, Horne, Brännström, Shtyrov, & Roll, 2018; Schremm, Söderström, Horne, & Roll, 2016) and not immersed (Sagarra & Casillas, 2018), yielding different results. Speakers immersed were able to start anticipating earlier in the L2 development process. Given that none of those studies included a group to test different effects of L1 transfer, we do not have a prediction about intermediate L2 speakers’ abilities to anticipate.

*3. Does language use affect L1 Mandarin and L1 English learners of L2 Spanish’s abilities to use lexical stress to anticipate verbal suffixes in Spanish?* Following previous results on the facilitatory role of bilingual processing (e.g., Beatty-Martı́nez & Dussias, 2017), we hypothesize language use to be positively correlated with anticipatory abilities. In other words, individuals who use their L2 more frequently will anticipate more in comparison to individuals who use their L2 less often. Language use will thus contribute to the creation of morphophonological associations and their activation, determining language processing costs.

# 4. Methods

## 4.1. Participants

The sample pool consisted of 30 Spanish monolinguals (20 females), 65 English learners of Spanish (48 females), and 64 Mandarin learners of Spanish (52 females). The age range for all groups was 18-45 (Spanish: *M* = 26.2, *SD* = 8.82, English: *M* = 26.8, *SD* = 4.54; Mandarin: *M* = 24.7, *SD* = 4.13). All participants were raised in monolingual families in monolingual communities of their L1, but were living in Spain at the time of data collection. All participants had completed at least high school. Their cognitive capacity was compared as measured by verbal working memory. The monolingual group obtained a mean working memory score of 6.20 (*SD* = 2.72), the English group got a mean score of 8.89 (*SD* = 2.11), and the Mandarin group of 7.78 (*SD* = 2.14). All participants were right-handed, had normal to corrected-to-normal hearing and vision, and no motor disability.

The monolingual Spanish speakers were local to the Madrid area. They had studied English in school but did not speak it fluently or had lived abroad. They did not speak any other language.

English L1 speakers had been in a Spanish-speaking country for a mean of 38.1 months (*SD* = 33.5) and the L1 Mandarin speakers for a mean of 40.8 months (*SD* = 45.5). All L2 speakers were late learners of Spanish. At the time of data collection, the L1 English speakers a mean of 33.3% (*SD* = 17.4) and the L1 Mandarin speakers used Spanish a mean of 41.6% of the week (*SD* = 21.7). The values used to calculate language use were self-reported. Most English speakers were working as English instructors. Most Mandarin speakers were enrolled in the university. Some English speakers had studied other languages, but none said to speak them fluently. Mandarin speakers had also taken English classes while growing up. Their self-reported proficiency in English varied from participant to participant.

## 4.2. Procedure

Data collection was conducted in a single session with each participant individually. Each session lasted around 1 hour and 15 minutes and participants could take breaks between tasks anytime they wanted. All interactions happened in Spanish. The room was isolated from external noise and light. Participants first participants listened to an overview of the tasks and signed the consent form. They then completed the following tasks: Spanish proficiency test (only L2 learners; 15-20 minutes), language background questionnaire (10 minutes), eye-tracking task (25 minutes), and working memory (15 minutes).

For the experimental task, a visual-world paradigm, participants rested their head on a chin rest, completed an 11-point grid calibration task, and received task instructions both orally and in writing. Then, they completed the practice trials and were given the opportunity to ask questions. Afterwards, they performed the task. For each trial, participants saw three screens: one for drift correction for 250 ms before the stimuli were presented, a second one with the target and distractor words alone for 1000 ms, and a third one with those same words at the same time the sentence played. The sentence was played entirely and did not stop when participants selected the word they heard. When they pressed the key to record their choice, a green rectangle appeared around the selected verb. Response recording was set up to be registered only when the press happened after the start of the verb in the sentence. No feedback was provided.

## 4.3. Materials

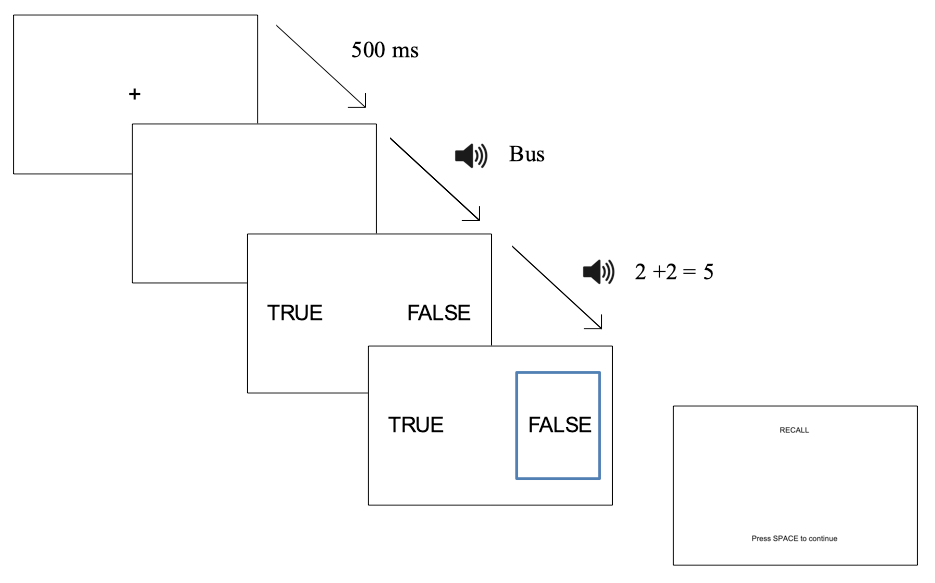
### 4.3.1. Screening tasks.

*Spanish proficiency test* (only L2 learners). The L2 learners completed an adapted version of the *Diploma de Español como Lengua Extranjera* [Certificate of Spanish as a Foreign Language’; Sagarra and Herschensohn (2010)] to assess their Spanish proficiency. The test comprised 56 questions on grammar and vocabulary. Each question was worth one point. Participants who scored below 25 were disqualified for the study. This test was computerized using Qualtrics.

*Language background questionnaire.* This questionnaire contained questions related to their age, handedness, languages spoken in their household while growing up, age of onset of the L2, time spent in Spanish-speaking countries, weekly percentage of use for each language at the time of data collection, and other languages spoken fluently.  
The questionnaire was completed orally.

*Working memory test.* An aural version of Unsworth, Heitz, Schrock, and Engle (2005)’s Operation Span task (OSpan) was used to measure verbal working memory. The aural version was selected because it aligns with the format of the linguistic task. Participants heard a word and then heard a simple mathematical problem that could be either true (2 + 2 = 4) or false (2 + 2 = 5). At the same time they heard the problem, participants saw the words TRUE or FALSE on each side of the screen. They had to select the correct option through a key-press. The word-mathematical problem pairs were grouped in set. At the end of each set, participants had to write down the words they had heard in the set in the same order they had appeared (see Figure 1 for a sample trial). The task was coded and administered via PsychoPy.

There were two practice sets of two trials each, and three experimental sets of 3, 4, 5 and 6 word-mathematical problem pairs each, totaling 12 experimental sets. The words and mathematical problems in each set appeared in a fixed order across participants. The words TRUE and FALSE on the scree accompanying the oral mathematical problems appeared counterbalanced on each side across participants. No feedback was provided. The task was delivered inthe participant’s L1.



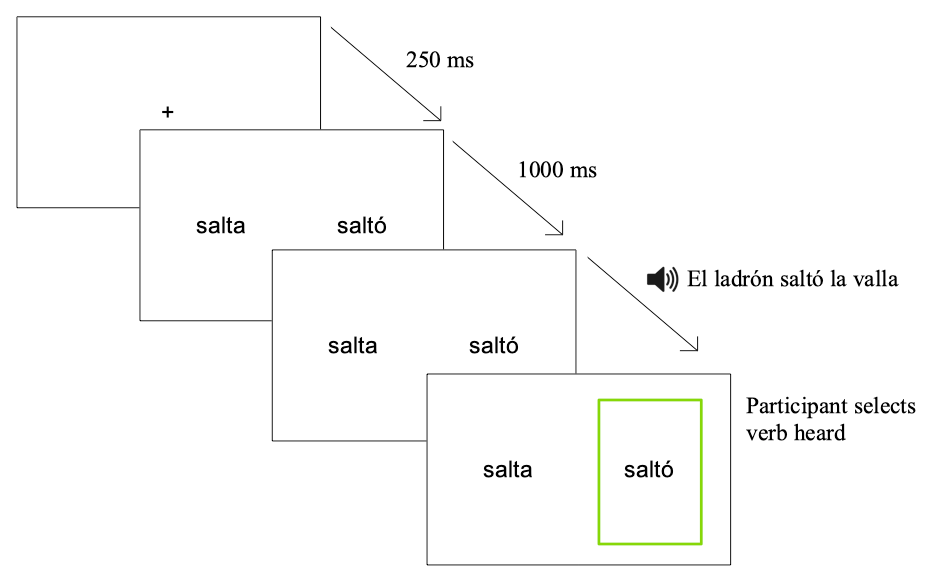
*Figure* *1:*. Sample trial of the OSpan

### 4.3.2. Linguistic prediction task.

A visual-world paradigm that recorded eye-movements was used to assess participants’ abilities to predict verbal suffixes based onthe associated stressed or unstressed syllables. The eye-movements were recorded with an EyeLink 1000 Plus desktop mount eye-tracker from SR Research (sampling rate: 1k Hz; spatial resolution of .32o horizontal and .25o vertical; averaged calibration error: .01o). The monitor was a BenQ XL2420TE display monitor at a resolution of 1920 x 1080 pixels. Tracking was binocular and the data were averaged across the right and left eyes. *THAT IS NOT TRUE. TRACKING WAS MONOCULAR* The task was programmed and delivered with SR Research’s Experiment Builder software, and the data were extracted with SR Research’s Data Viewer software. We followed Data Viewer’s cognitive parser settings (9-sample model) to isolate fixations (pauses over regions of interest). Smaller eye movements that take place during fixations (e.g., tremors, drifts, and micro saccades) were considered to form part of fixation if they did not surpass the aforementioned threshold, and were included because numerous studies show that they often mean little in higher-level analyses (e.g., Ditchburn, 1980). All equipment was identical for all participants.

In the visual-world paradigm, participants read two verbs on a computer screen side by side (*salta* ‘s/he jumps,’ *saltó* ‘s/he jumped’) and heard a sentence containing one of the two verbs (*El ladrón saltó la valla* ‘the thief jumped over the fence’) and selected the verb they heard as possible with a key press (see Figure 2 for a sample trial). The verbs shown on the screen were conjugated in the present tense and preterit tense 3rd person singular forms of regular -ar verbs. There were 4 practice sentences, 16 experimental sentences, and 80 fillers. The sentences were 5 words long with a neutral structure NPSUBJ-V-NPOBJ. The subject and object noun phrases in each sentence for each condition within a pair were the same (*El ladrón salta/saltó la valla* ‘the thief jumps/jumped over the fence’). The sentences were distributed into blocks by means of a Latin square design. That is, there were 8 blocks; each block contained 2 experimental sentences, one of each type, and 6 filler sentences. The blocks appeared in a randomized order. Within and across blocks, the sentences were pseudo-randomized to avoid two experimental sentences of the same condition appearing consecutively. The practice sentences were the same for all participants and appeared in a fixed order. The sentences were played at an intensity of ~75dB.

Bisyllable Spanish regular verbs have 2 cues to tense: initial syllable stress and word ending morphology. Stressed initial syllables indicate that the tense is present (*salta* ‘s/he jumps’), and unstressed initial syllables indicate that the tense is past (preterit, *saltó* ‘s/he jumped’). Regarding morphology, the verb suffix indicates tense, person and aspect. In total there were 16 verbs, which renders 16 pairs of present and preterit forms. The number of verbs in each tense on each side of the screen was counterbalanced across trials and across participants.



*Figure* *2:*. Sample trial of the visual-world paradigm

## 4.4. Statistical analysis

Statistical analyses were conducted on R (R Core Team, 2019) using the packages lme4 (D. Bates, Mächler, Bolker, & Walker, 2014) and multcomp (Hothorn et al., 2016). The gaze-fixation data was downsampled to 50 ms bins. We analyzed the data at 200 ms after the time stamp of interest to account for the time it takes to plan and launch a saccade (e.g., Fischer, 1992; Saslow, 1967), and centered at the onset of the last syllable of target items. The empirical logit transformation was applied to binary responses (fixations on target or distractor, Barr, 2008). The bins were used to model a growth curve analysis (GCA, Mirman, 2016) to observe how the pattern of gaze fixations changed over time. Data were modeled using linear, quadratic, and cubic orthogonal polynomials. We first ran a model for the monolingual speakers with lexical stress as fixed effect. For the L2 speakers, we ran two models. The first one included L1, lexical stress, and proficiency as fixed effects. The second one included L1, lexical stress, and language use as fixed effects. L1 was categorical and stood for transfer. Lexical stress was categorical and had been sum-coded. Proficiency and language use were continuous. By-subject and by-item random effects were also tested. In all models, subject and item were tested for random effects. Nested model comparisons were implemented to assess main effects and interactions.

# 5. Results

* Monolingual speakers
* Bilinguals
  + L1 transfer
  + L2 proficiency
  + Interaction L1 transfer ~ L2 proficiency
  + Language use
  + Interaction L1 transfer ~ Language use

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