Phonologically Cued Lexical Anticipation in L2 English: A Visual World Eye-Tracking Study

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1. Introduction

Past studies have demonstrated that listeners are able to make use of a whole host of different cues for anticipatory processing of language, such as the context of the sentence, properties of the verb, grammatical structure and so on (Altmann & Kamide, 1999; DeLong, Urbach, & Kutas, 2005; Dussias, Valdés Kroff, Guzzardo Tamargo, & Gerfen, 2013; Kamide, Altmann, & Haywood, 2003; Kamide, Scheepers, & Altmann, 2003; Lew-Williams & Fernald, 2010). Most of this research has been conducted looking at morphosyntactic features of language. For example, we know that native speakers of Spanish use grammatical gender information encoded on prenominal modifiers to facilitate the processing of an upcoming word. Lew-Williams and Fernald (2010) presented L1-Spanish speaking children and adults with pairs of objects representing words with the same gender (e.g., *la pelota*, 'the^{fem} ball^{fem}' and *la galleta*, ' the^{fem} cookie^{fem}') or different genders (e.g., *la pelota*, 'the^{fem} ball^{fem}' and *el zapato*, 'the^{masc} shoe^{masc}'). Eye movements were recorded while participants heard spoken sentences asking them to locate a target object (e.g., *Encuentra la pelota*, 'Find the^{fem} ball^{fem}'). Results showed that participants were able to direct their gaze to the correct target faster when the two objects mismatched in gender than when they matched. This would indicate that when grammatical gender can be used informatively to identify the target noun (i.e. when there is a mismatch), participants were able to make use of the gender information to facilitate processing of an ensuing noun.

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 Proceedings of the 45th annual Boston University Conference on Language Development, ed. Danielle Dionne and Lee-Ann Vidal Covas, 171-183. Somerville, MA: Cascadilla Press.

If anticipating upcoming information is something that native speakers do and if it can contribute to efficient language processing (e.g., Federmeier, 2007), an important question is whether second language speakers can do the same.

The research on L2 anticipatory processing is mixed and has focused mainly on learners' ability to use offline grammatical knowledge and morphosyntactic cues such as case, gender or number agreement to anticipate upcoming information online. Even so, there is little agreement on whether learners are able to use these cues in online processing (Dussias et al., 2013; Grüter, Lew-Williams, & Fernald, 2012; Grüter & Rohde, 2013; Hopp, 2013, 2015; Kaan, 2014; Lew-Williams & Fernald, 2010). Additionally, several researchers have discussed how, among other factors, proficiency and language exposure play a crucial role in a learner's ability to anticipate, which may account for some of the discrepancies in the literature (Dussias et al., 2013; Hopp, 2013; Kaan, 2014). One account is that decreased exposure to the L2 may be generating incomplete or instable representations of the co-occurrence of words or morphemes, which in turn may lead to weaker anticipatory ability (Kaan, 2014). Therefore, it is perhaps not surprising that we see learners fail to engage in anticipatory processing online on the basis of morphosyntactic information alone, given that they are trying to use complicated representations that are weak and not easily accessible. It may be the case then, that what we are seeing is not a failure to use anticipatory processing per se, but rather a failure of the representations to provide stable enough information from which to generate predictions.

One way to clarify the situation could be to examine whether learners are able to engage in anticipatory processing in a different linguistic domain. While most past research examining anticipatory processing in L2 speakers has exploited the existence of allomorph choice that depends on morphosyntactic and lexical factors, one viable alternative is to investigate allomorph selection that can be predicted based on the phonological configuration of words. In this respect, the English indefinite article system is an ideal candidate. In English, the indefinite articles '*a'* and '*an'* alternate depending on a phonological rule triggered by the upcoming word form, with '*a'* before consonant-initial words and '*an'* before vowel-initial ones. One advantage of the *a-an* English alternation is its purported "simplicity." Unlike morpho-syntactic alternations, which are seldom exception-free, the *a-an* alternation has no exceptions. If this feature strengthens the memory representation of its co-occurrence statistics, and if information that has a strong memory representation is easy to retrieve (see Arnold, Kaiser, Kahn, & Kim, 2013 for related review), this should lead to stronger anticipatory abilities.

A prior study has investigated this alternation in L2 learners' anticipatory processing, while recording event related potentials (or ERPs). Martin et al. (2013) presented L2 English learners with written sentences such as *He was very tired, so he sat on a chair/an armchair* and compared the ERP responses at the indefinite article and noun for each continuation. Both continuations of the sentence are grammatical and plausible; however, *chair* is much more expected than *armchair*. The authors reason that if speakers were engaging in anticipatory

processing, when reading the phrase *he sat on*, they would be expecting 'chair' as the continuation, and so would show an N400 effect when they encountered the unexpected 'an' (**an chair* is not possible) compared to the expected 'a' (*a chair*). The results showed no N400 effect at the article, but rather at the actual noun. These findings were interpreted as evidence that L2 learners are not able to use anticipatory processing based on the phonological alternation.

As mentioned previously, a growing body of research has shown that proficiency plays a role in a learner's ability to engage in anticipatory processing; however, proficiency was not included as a predictor in the analysis of Martin et al. (2013). The present study aimed to add to this literature by re-investigating L2 learners' ability to use the phonological alternation of the English indefinite article during anticipatory processing to better understand the cues L2 learners utilize when processing language. We conducted a visual world eye-tracking study with L1 Spanish-L2 English speakers, and we measured L2 proficiency in order to investigate whether it is a modulating factor.

2. Methods

2.1. Participants

Forty-seven adult second language speakers of English were recruited from the University of Granada (Spain). All participants gave informed consent and received monetary compensation for their participation. Nine participants were excluded because they reported speaking a first language other than Spanish, four participants were excluded due to incomplete language history questionnaire responses, and four participants were excluded due to technical issues. An additional two participants were excluded for lack of fixations in the eye-tracking task (this can happen if participants use their peripheral vison to complete the task and thus do not launch any fixations to the visual stimuli). This left a total of twenty-eight participants (mean age 25; 21 females) for analysis. Three behavioral tasks that were used as proxy for language proficiency were administered: a language history questionnaire, a verbal fluency task, and a picture naming task. Each is described below. Participant characteristics are shown in Table 1.

2.1.1. Language history questionnaire

To assess language experience, participants completed a modified version of the LEAP-Q language questionnaire (Marian, Blumenfeld, & Kaushanskaya, 2007) administered through Qualtrics. The questionnaire collected information about aspects of participants' acquisition of their L1 (Spanish) and L2 (English) by self-report. For example, the questionnaire asked about place of birth, how long participants had been speaking and writing their two languages, and languages spoken in the home during early childhood. Responses to the questionnaire showed that participants began their formal study of English in elementary school but acquired functional use of English in adulthood. They reported using English in varied contexts, including at home, at work and with

friends. The questionnaire also asked participants to self-rate their linguistic ability in speaking, listening, reading, and writing in both languages. Overall, participants self-rated their proficiency in Spanish (the L1) higher than in English (their L2); see Table 1 below[1]; scale for self-ratings is out of 10.

2.1.2. Category verbal fluency task

Participants completed a category verbal fluency task in Spanish and English. In this task participants are asked to generate out loud within a 30-second time limit as many exemplars as possible that belong to a given semantic category. We chose this task because there is some evidence suggesting a strong correlation between verbal fluency scores and objective measures of language proficiency (Beatty-Martínez et al., 2020). The version of the verbal fluency task employed in this experiment included two sets of four categories, taken from Baus, Costa, and Carreiras (2013) and Linck, Kroll, and Sunderman (2009) (i.e., animals, clothing, musical instruments, and vegetables or body parts, colors, fruits, and furniture). The presentation of the categories was counterbalanced by language, such that one participant named clothing in Spanish, and the next participant named the same category in English. Participants were asked to avoid producing repetitions and names of people or places. Participants were given 1 point per word named; lexical alternatives across varieties of Spanish were accepted as correct responses (e.g., *elote* for corn as opposed to the more general *maíz*). Paired-samples t-tests of participants' total number of exemplars in each language revealed that the L2 learners produced significantly more items in Spanish (M=45, SD= 7.5) than in English (M=35 SD= 7.5) $t(27)$ -5.6181, $p < 0.01$. This indicates that the L2 learners were more dominant in their L1.

2.1.3. Picture naming task

The picture naming task was adapted from a version used by Beatty-Martinez (2020). In this task, participants are shown pictures one by one on a computer screen and are instructed to name them out loud as quickly and accurately as possible. In the version used in this experiment, participants named 140 black-and-white line drawings that were matched in frequency (log count words/million) across languages (English, SubTLEX-us, Brysbaert & New, 2009; Spanish, Espal, Duchon, Perea, Sebastián-Gallés, Martí, & Carreiras, 2013). Participants completed this task in both of their languages. The 140 pictures were divided into 2 lists so that participants named all 140 pictures, 70 in English and 70 in Spanish counterbalanced across participants by language. Participants completed the English version before the Spanish version of the task. Participants were assigned a 1 if they correctly identified the picture and a 0 if they did not correctly identify

[1] Four participants did not report their self-ratings in the questionnaire. Their scores were removed for these averages; however, their scores are included in the reports for verbal category fluency and picture naming.

the picture. As with the verbal fluency task, lexical alternatives across varieties that correctly identified the picture were counted as correct. Both accuracy and onset latencies were analyzed. Paired-samples t-tests revealed that the L2 participants were significantly more accurate in Spanish (M = 96%) than in English (M = 88%; $t(27) = -3.769$, $p < .01$), and significantly faster to respond in Spanish (M = 1291ms) than in English (M = 1486ms; $t(27) = 2.223$, $p < .05$).

Table 1. Summary of L2 proficiency variables

	Speaking	Listening	Verbal Category Fluency	Picture Naming	
				Accuracy	Onset Latency
English	7.04 (1.68)	7.76 (1.74)	34.72 (7.61)	88% (12%)	1486ms (450ms)
Spanish	9.64 (0.60)	9.76 (0.44)	45.49 (7.65)	96% (5%)	1291ms (260ms)

Note: mean (SD)

2.2. Materials

For critical trials in the visual world task, a total of 64 common imageable nouns were selected: half consonant initial and half vowel initial. All words were represented in color images used to create the visual displays. Each visual display included four pictures: one target (singular-object picture), one competitor (singular-object picture) and two distractors (plural-object pictures). The target picture represented the word that participants heard in a spoken instruction. The competitor picture in the display corresponded to one of two conditions: same article or different article (Figure 1 and Figure 2). In the same-article condition, each target (e.g., compass) was paired with a frequency-matched same-article word (e.g., tomato) and in the different-article condition with a frequency-matched different-article word (e.g., umbrella) from the same list of 64 words. In this way, every word had a same-article competitor and a different-article competitor (see Table 2).

Table 2. Example item set

	Same-article	**Different-article**
A	a compass – a tomato	a compass – an umbrella
An	an umbrella – an acrobat	an umbrella – a compass

Finally, the two plural-object pictures served as distractor images. By being plural, these images are excluded as possible referents for *a/an*. This design created 32 critical trials. Eight practice trials were also included to familiarize participants with the experimental task.

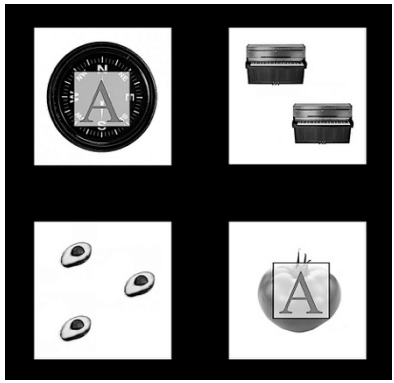

Figure 1. Same-article condition

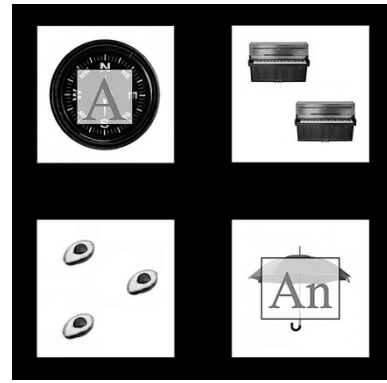

Figure 2. Different-article condition

A context-neutral preamble was created for each item set/display to license the use of the indefinite article (e.g., *The boy found*…). The preambles ended with the target noun phrase. An additional 64 words were selected to create 32 filler trials. The displays in filler trials were identical to the critical trials (i.e., they included two single-object pictures and two plural-object pictures). In these trials, however, the plural object pictures served as the target and competitor pictures, with an equal number of two-object and three-object targets. The experimental and filler items in each set were separated out into 4 lists in a pseudo-Latin square design to ensure no target or picture was ever repeated on a list.

A female native speaker of English recorded the auditory stimuli in a sound-attenuated booth using a USBPre2 connected to a MacBook Pro in Praat, and with an Audix HT-5 head-worn microphone. To normalize the duration between the article and the critical noun, two procedures were followed. First, the spoken sentences were separated into two segments: the first included the beginning of the sentence up to the end of the indefinite article; the second one included the single critical word. The segments were subsequently concatenated together with a 500ms pause between them. Finally, the intensity of the recordings was normalized to 65db.

2.3. Procedures

After participants provided informed consent, they were directed to an eye-tracking chamber. To ensure that participants were familiar with the names for the objects in the eye-tracking experiment, a word-picture familiarity task preceded the eye-tracking experiment proper. In this task, participants were presented with pictures one at a time and were asked to name them out loud. The experimenter coded (in-situ) the response provided by the participants as correct or incorrect. Pictures that were incorrectly named were randomly repeated through the task until all pictures were named correctly. After this task was complete, participants began the eye-tracking experiment.

The eye-tracking experiment was compiled using Experiment Builder software (SR Research). Participants' eye-movements were recorded with a desktop EyeLink 1000 eye tracker recording at 1000 Hz (1 gaze position sample recorded every millisecond). The experiment began with a calibration of the participants' right pupil and corneal reflection using a 9-point calibration procedure. Following the calibration, participants completed a practice session. Upon completing the practice, participants were encouraged to ask questions. After questions were answered, the experiment began.

A trial began with the images appearing on the screen in a non-displayed 2x2 grid that equally spaced the images from each other in vertical and horizontal directions centered around the midpoint of the screen. The images remained on the screen for 4000 ms (preview time). This time allowed participants to pre-activate the names for each of the pictures and to familiarize themselves with their locations. No auditory stimulus was heard during the preview. After the 4000 ms preview, the display disappeared, and a fixation cross appeared in the middle of the screen for 500 ms to return the participants' gaze to a neutral starting point. When the fixation cross disappeared, the images reappeared on the screen in the same locations as during the preview. A sentence was played auditorily through the computer's speakers; participants were instructed to click on the picture that was mentioned in the sentence as quickly as possible. Once the participant clicked, a blank screen appeared for 700 ms, after which the next trial began. Eye movements and click accuracy were recorded.

The experiment was broken into four blocks to offer breaks for the participants, and also to allow for recalibration of the eye tracker as necessary. Each block included 16 items and contained an equal number of each type of trial. Pre-defined interest areas were built into the experiment for subsequent analysis. The pictures were 350 x 350 pixels each on the screen and the interest areas were 450 x 450 pixels centered over each picture.

After the main eye-tracking experiment, participants completed the English category fluency and picture-naming tasks and finished with the Spanish category fluency and Spanish picture-naming tasks.

2.4. Data Analysis

The eye-tracking data was exported using SR Research Data Viewer software. An interest period was set from the onset of the article until the participant clicked on an item. A Time Course (Binning) report was used to export the data. This report was set to bin time into 10ms bins; it excluded samples that fell outside of pre-defined interest areas and samples during blinks or saccades. Trials for which the target object had not been correctly identified or trials which generated no response from the participants were excluded from the eye-movement analyses (1.6%). All further analyses were conducted in *R* (R Core Team, 2013).

The fixations were time locked to the onset of the article preceding the target noun, and included a 200-ms baseline (for the time it takes to plan and launch a saccade; (Hallett, 1986). Differential proportions of fixations to target (DPFT) were then

calculated for use in the analysis by subtracting the proportions of competitor fixations from the proportions of target fixations.

The analysis was conducted over a pre-determined time window from 200 to 1,000 ms and included the article (average duration 300ms) and the 500ms pause after the article. This window represents the period of time where participants were hearing/had heard the article, but had not yet heard the critical noun, and is the window necessary to look for effects of lexical anticipation. The productions of the article differed in the initial vowel ('a'- /ə/ , 'an'-/æn/); hence, the onset of the article could be informative.

The DPFT were analyzed with Linear Mixed Effects model (LME) using the Buildmer (Voeten, 2020) and lme4 (Bates, Mächler, Bolker, & Walker, 2015) packages in *R*. The model included fixed effects of article (a vs an), match (same vs different), and median split proficiency (high vs low, coded as 0.5 and -0.5, respectively). The proficiency variable was contrast coded so that the effects of match and article could be interpreted on both levels of the proficiency variable. The same-article 'an' condition served as the baseline to which all comparisons were made. The model also included random effects of participant and item on the intercept. This model performs a backwards stepwise elimination based on the significance of the change in log-likelihood. This procedure identifies a 'maximal model', which is the model containing all effects specified by the user that still allow the model to converge.

3. Result

Figure 3 shows the Differential Proportion of Fixations to Target (DPFT) split by proficiency and by the article of the target word. Time in milliseconds is presented on the x-axis, and the DPFT on the y-axis. In this figure, data points at 0 reflect equal proportion fixations to target and competitor, and points above 0 reflect that participants were looking more at the target than the competitor.

The regions of interest are the article itself and the pause between the article and the noun. It is in these regions that we would look for an effect of anticipation when the listeners have heard the article, but have not yet heard the critical noun. An effect of anticipation would manifest in a higher DPFT in the different-article condition (when anticipation is possible) and DPFT around 0 for the same-article condition (when learners cannot anticipate, as the article is not informative).

The top two graphs of Figure 3 present the 'a' target trials for low- and high-proficiency learners. In the article and pause regions, we see no effect of prediction in either group. The DPFT hover at 0 for both the same- (dashed line) and different-article (solid line) conditions for both groups, indicating that participants were looking equally at the target and competitor in both conditions.

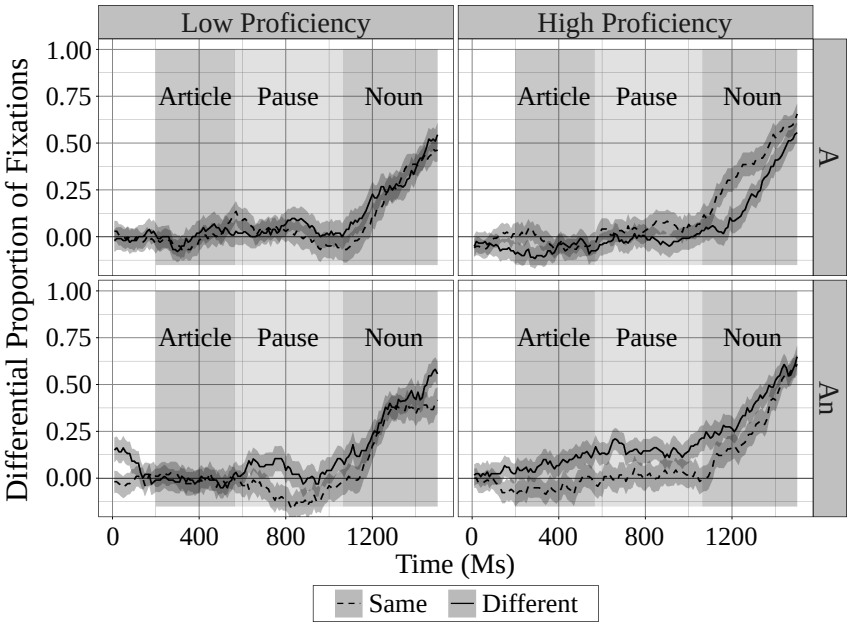

Figure 3. Native Spanish listeners' differential proportion fixations to target. The shaded regions along the solid and dashed lines represent ±1 standard error of the mean.

The bottom two graphs present the 'an' target items in both the high-and low proficiency learners. Both groups display a difference in the DFPT between the conditions, with the DPFT being higher in the different-article condition compared to the same-article condition. For the high proficiency learners, this is a clear anticipatory effect in that the DPFT are higher in the different-article condition and hover at 0 for the same-article condition. This indicates that before the participants heard the target word, they were looking at the correct target more than the competitor item in the different-article condition, but looked at them both equally in the same-article condition.

The story is slightly more complicated for the low proficiency learners. While it is true that the DPFT is higher for the different-article condition compared to the same-article condition, this appears to have less to do with increased looks to the target in the different-article condition, but rather increased looks to the competitor in the same-article condition (the same-article DPFT dropping negative in this region). The DPFT in the same-article condition drops drastically, indicating more looks to the competitor than to the target. The DPFT in the different-article condition rises slightly immediately after the offset of the article, but then drops to 0 only to rise again later. While it seems that there is an effect, it is not the clear and strong anticipatory effect seen in the high proficiency learners.

Additionally, the point at which the listeners begin to make anticipatory looks differs for high- and low-proficiency participants, with low-proficiency participants beginning to make anticipatory looks at the end of the article and high-proficiency learners beginning during the article. These results suggest that L2 learners are able to anticipate upcoming information based on the alternation of the indefinite article, but that proficiency modulates the strength and the timing of the anticipation.

Table 3 presents the results of the Linear Mixed Effects model (LME) with the best fit on the differential proportion fixations to target.

Table 3. Results of LME on second language English listeners

	Estimate	Std. Error	t value	Pr(>|t|)
Intercept	-0.02	0.02	-1.22	0.224
Condition	0.09	0.01	14.00	<0.001
Article	0.02	0.01	3.81	<0.001
Proficiency	0.05	0.02	2.20	0.028
Condition: Article	-0.10	0.01	-10.38	<0.001
Article : Proficiency	-0.06	0.01	-4.29	0.000
Condition: Proficiency	0.02	0.01	1.72	0.086
Condition : Article : Proficiency	-0.06	0.02	-3.22	0.001

The results in Table 3 give three main conclusions. First, across proficiency levels the DPFT were higher for the different-article condition compared to same article condition for 'an' target items which indicates anticipation of the upcoming word when hearing 'an'.

Second, the interaction of condition and article indicates that across groups the difference in looks to target between the same- and different-article conditions was larger for the 'an' items than for the 'a' items. This indicates that listeners were anticipating when the article was 'an', but not when it was 'a'.

Third, the three-way interaction between condition, article, and proficiency indicates that the effect of anticipating in the 'an' items was larger for the high-proficiency learners than for low-proficiency learners. In other words, the high proficiency learners showed a greater effect of anticipation than the low-proficiency leaners for the 'an' items.

4. Discussion

The study presented here investigated whether L2-English learners were able to utilize the phonological alternation of the indefinite article in English to engage in anticipatory processing of an upcoming noun. Visual world eye-tracking was used to measure anticipatory processing by testing whether participants made anticipatory fixations to the correct target after hearing an article but before hearing the noun, when two of the objects presented on the screen differed in their article. The results showed three primary effects of interest.

First, across proficiency levels participants made more anticipatory looks to the correct target for the different-article condition compared to same-article condition. This effect suggests that the L1-Spanish L2-English learners are able to use the phonological alternation of the English indefinite article to engage in anticipatory processing. When the article is different between the objects on the screen, they are able to make looks to the correct target before the target word has been spoken. Conversely, when the article of the two objects is the same, listeners are not able to anticipate the upcoming noun and wait for the onset of the noun to begin fixating on the correct target.

The second finding is that the effect of anticipation is stronger for the 'an' target items than for the 'a' items. Judging by the results shown in Figure 3, it actually appears that there is no anticipatory processing in the 'a' items and that the effect is being driven solely by the 'an' target items. This asymmetry in the use of the different forms of the article may at first seem unexpected. However, findings reported in other linguistic domains have shown similarly asymmetric results. For example, Italian-Spanish learners as well as more balanced Spanish-English bilinguals have shown an asymmetry in their use of the masculine and feminine gendered articles, with the feminine-marked articles producing more facilitation compared to the masculine-marked articles (Dussias et al., 2013; Valdés Kroff, Dussias, Gerfen, Perrotti, & Bajo, 2017).

Valdés Kroff et al. (2017) has argued that this asymmetry in the use of the masculine and feminine articles in Spanish is at least in part due to markedness differences between the two forms of the article, with the masculine serving as the unmarked/default form and the feminine as the marked form of the determiner (Corbett, 1991; Eddington, 2002; Harris, 1991; Natalicio, 1983). Due to its default status, the masculine gendered article may not be informative enough to induce facilitative processing and so facilitative/anticipatory processing is simply not advantageous or worth the effort in a sense. The marked feminine form on the other hand, is much more salient and potentially informative enough to encourage facilitative/anticipatory processing.

The English indefinite article has a similar marked and unmarked relationship between its forms, with the unmarked form 'a' surfacing before consonant-initial words and the marked form 'an' before vowel-initial words. A search of all words in the English Lexicon Project excluding proper names reveals that vowel initial words make up only 22% of the English lexicon, leaving the remaining 78% consonant initial (Balota et al., 2007). While the markedness difference for Spanish gender is not founded on frequency differences alone, we argue that for our purposes here, the 'a' form resembles the unmarked form simply due to the overwhelming frequency advantage of consonant initial words in the language. Our results are therefore in line with the argument in Valdés Kroff et al. (2017), where the unmarked 'an' form is salient enough to spark anticipatory processing in these bilingual learners of English, but the unmarked 'a' form is not informative enough to spark this processing.

The third finding is that our results are not congenial with those reported in Martin et al. (2013), who found that learners were not able to use the a/an

alternation in reading to anticipate an upcoming word. As discussed earlier, this discrepancy may be due to L2 learner proficiency, which plays a significant role in L2 learners' ability to engage in anticipatory processing. Participant proficiency was established with self-report only in Martin et al. (2013), and was not included in the analysis. This is a limitation acknowledged by the authors and is the likely source of the null result for learners. This account of the difference between our results and those of Martin et al. (2013) is supported by the fact that proficiency modulated our findings. The high-proficiency learners engaged in stronger anticipatory processing for the 'an' targets than the low-proficiency learners. High-proficiency learners also appeared to begin launching anticipatory looks to the target during the article itself, while the low-proficiency learners waited for the end of the article to begin making these looks.

In sum, this study shows that L2 learners are able to use the phonological alternation of the English indefinite article to anticipate upcoming words in spoken speech comprehension. This effect was driven by the use of the 'an' article, and no anticipatory processing was found for 'a' targets. This asymmetry is in line with recent work on Spanish bilinguals use of gender in facilitative processing (Dussias et al., 2013; Valdés Kroff et al., 2017). The findings also showed that this anticipatory processing is modulated by proficiency, with stronger and earlier anticipatory processing found for those with high proficiency.

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Proceedings of the 45th annual Boston University Conference on Language Development

edited by Danielle Dionne
and Lee-Ann Vidal Covas

Cascadilla Press Somerville, MA 2021

ISSN 1080-692X
ISBN 978-1-57473-067-8 (2 volume set, paperback)

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