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Real-time processing of gender-marked articles by native and non-native Spanish speakers

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Abstract

Three experiments using online processing measures explored whether native and non-native Spanish-speaking adults use gender-marked articles to identify referents of target nouns more rapidly, as shown previously with 3-year-old children learning Spanish as L1 (Lew-Williams & Fernald, 2007). In Experiment 1, participants viewed familiar objects with names of either the same or different grammatical gender while listening to Spanish sentences referring to one object. L1 adults, like L1 children, oriented to the target more rapidly on different-gender trials, when the article was informative about noun identity; however, L2 adults did not. Experiments 2 and 3 controlled for frequency of exposure to article-noun pairs by using novel nouns. L2 adults could not exploit gender information when different article-noun pairs were used in teaching and testing. Experience-related factors may influence how L1 adults and children and L2 adults—who learned Spanish at different ages and in different settings—use grammatical gender in realtime processing.

Keywords

language processing; grammatical gender; second language; eye movements; language development; statistical learning

Adults learning a second language typically lack the fluency in understanding and speaking that is characteristic of native speakers. One aspect of morphosyntax that can be especially complicated for learners to master is grammatical gender—a system found in many of the world's languages that assigns nouns to noun classes and marks syntactically related words for agreement. Writer David Sedaris, a native English speaker, describes his difficulty learning the French gender-marked articles *la* and *le* (‘the’), and his increasing reliance on the gender-neutral, plural article *les*: “My confidence hit a new low when my friend Adeline told me that French children often make mistakes, but never with the [gender] of their nouns. ‘It's just something we grow up with,’ she said. ‘We just hear the gender once and think of it as part of the word.’ Tired of embarrassing myself in front of two-year-olds, I've started referring to everything in the plural” (Sedaris, 2000, p. 190). Indeed young children learning a language with grammatical gender not only make far fewer gender agreement errors than do older language learners (Karmiloff-Smith, 1979; Slobin, 1985; Scherag, Demuth, Rösler, Neville, & Röder, 2004), but also take advantage of gender-marked words in real time to interpret spoken sentences more rapidly (Lew-Williams & Fernald, 2007).

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Here we explore how adults learning Spanish as a second language (L2 adults) process gender-marked articles, such as *la* and *el* ('the$_{[fem/masc]}$'), as compared to adults who learned Spanish as a first language (L1 adults). In Experiment 1, we asked whether native English- speaking adults learning Spanish as L2 were able to use potentially informative gender-marked articles to interpret familiar nouns more efficiently. These L2 adults were compared with adult native speakers of Spanish, and also with the 3-year-old children learning Spanish as L1 observed in our previous research (Lew-Williams & Fernald, 2007). Because native speakers have been exposed to the names of familiar objects and animals many more times than have non-native speakers, Experiments 2 and 3 equated frequency of exposure to the target nouns used in testing. L1 and L2 adults were trained and tested on newly learned Spanish nouns preceded by gender-marked articles. Thus we sought to determine whether adult L2 learners of Spanish differ from native Spanish speakers in the efficiency with which they process both familiar and novel article-noun sequences in real-time language comprehension.

Processing of grammatical gender by native speakers

While research on grammatical gender in linguistics has documented the complex noun categorization systems that exist in many languages throughout the world (Corbett, 1991), psycholinguistic researchers have focused on the learning and processing of gender systems. Such studies explore how learners use phonological, semantic, and morphological cues to assign nouns to gender classes (Karmiloff-Smith, 1979; Pérez-Pereira, 1991) and to track gender agreement across words in both speech production (e.g., Andersen, 1984) and sentence comprehension (e.g., Bates, Devescovi, Hernandez, & Pizzamiglio, 1996).

Experimental studies show that L1 speakers of languages with grammatical gender use morphosyntactic cues to gender in real time to identify words and build sentence meaning. In one study, native speakers of French responded more rapidly to nouns preceded by an article correctly marked for gender than to nouns that were not (Grosjean, Dommergues, Cornu, Guillelmon, & Besson, 1994). In the first experiment, French-speaking adults participated in a gating task in which they heard incrementally longer portions of noun phrases beginning either with a gender-marked article (e.g., *une jolie plage*, 'a$_{[f]}$ nice beach$_{[f]}$') or without a gender-marked article (e.g., *jolie plage*, 'nice beach$_{[f]}$'). Because the adjective *joli(e)* has the same pronunciation in both feminine and masculine forms, it served as an intervening word that was uninformative about gender in all article-noun pairs, allowing for more processing time. On trials with prenominal gender marking, participants needed to hear less of the target noun to determine its identity than on trials with no prenominal gender marking. In a second experiment, French-speaking adults listened to the same stimuli in a lexical decision task, indicating via a button-press whether nouns were real words or non-words. When prenominal gender marking was present, participants responded faster, showing that gender marking on articles affected speed of lexical access by native French speakers.

Gender information also facilitates interpretation for native speakers of Italian (Bates et al., 1996). In a series of studies using auditory naming and grammaticality judgments, adults were presented with adjective-noun pairs that were gender-congruent (e.g., *brutta casa*, 'ugly$_{[f]}$ house$_{[f]}$'), gender-incongruent (e.g., **brutto casa*, 'ugly$_{[m]}$ house$_{[f]}$'), or gender-ambiguous (e.g., *grande casa*, 'large[amb.] house$_{[f]}$'). Participants' latencies to repeat the noun or make a grammaticality decision were faster for gender-congruent pairs and slower for gender-incongruent pairs relative to the neutral baseline. Since processing was disrupted when Italian speakers encountered violations of gender agreement, these findings revealed inhibitory as well as facilitatory effects of gender priming. Differences in processing speed were also evident in research using event-related brain potentials, as native Spanish-speaking adults read complex sentences containing nouns that either agreed or disagreed in gender with the preceding article (Wicha, Moreno, & Kutas, 2004). These results revealed sensitivity at a neural

level to violations of gender agreement, providing further evidence that native speakers use gender information in real time to form expectations about possible subsequent words.

One previous study has used eye tracking to investigate whether prenominal gender marking affects how listeners recognize spoken words (Dahan, Swingley, Tanenhaus, & Magnuson, 2000). French-speaking adults viewed scenes containing objects with names that shared phonological onsets but differed in grammatical gender (e.g., *vase*, 'vase$_{[m]}$,' *vache*, 'cow$_{[f]}$'). Eye-tracking studies investigating the cohort effect show that when listeners hear the first few phonemes of a noun, they are equally likely to look at a target picture or a cohort competitor that share a phonological onset; only with more speech information do listeners increasingly shift to the target picture. Dahan et al. proposed that the presence of a prenominal gender marker might guide listeners to the target with fewer false alarms to competitor objects. Participants heard gender-informative commands (e.g., *Cliquez sur le*$_{[m/singular]}$ *vase*) as well as gender-uninformative commands (e.g., *Cliquez sur les*$_{[neutral/plural]}$ *vases*, 'Click on the vases'). Listeners responded more rapidly to nouns preceded by a gender-informative singular article (*la*$_{[f]}$, *le*$_{[m]}$) than to nouns preceded by a gender-ambiguous plural article (*les*$_{[neut.]}$). Moreover, the gender-marked article eliminated interference from the phonological competitor. These findings were interpreted as evidence that gender-marked articles affect lexical access directly, by constraining the set of candidates considered as possible referents. Using diverse methodologies—including those that require metalinguistic judgments, like lexical decision, and those that reflect more naturalistic processing, like eye tracking—these studies show that gender information can enable adult native speakers to recognize familiar words more rapidly.

Such impressive efficiency in processing is not restricted to adults. Lew-Williams and Fernald (2007) found that 3-year-olds learning Spanish as L1 can also use gender-marked articles to more rapidly identify visual referents. Children looked at paired pictures of objects with names of either the same (e.g., *la pelota*, 'ball', *la galleta*, 'cookie') or different grammatical gender (*la pelota*, *el zapato*, 'shoe'), as they heard a Spanish sentence referring to one of the objects (*Encuentra la pelota*, 'Find the ball'). Eye movements were used as an index of listeners' latency to identify the target referent: Children were faster to orient to the correct referent on different-gender trials, when the article was potentially informative, than on same-gender trials, when the article revealed nothing about the following noun. When the monolingual Spanish-speaking parents of these children were tested in the same procedure, they were faster than children overall on both trial types, but showed the same advantage on different-gender trials. This study provided the first evidence that young Spanish-learning children with only 500 words in their expressive vocabularies already demonstrated a processing advantage characteristic of adult native speakers. Similar findings have since emerged from studies with French- and Dutch-learning toddlers (van Heugten & Johnson, in press; van Heugten & Shi, 2009).

Differences between native and non-native speakers in processing grammatical gender

A substantial literature investigating differences in language processing between native and non-native speakers shows that L2 adults are generally slower in lexical access than L1 adults across a variety of tasks and language structures (Hahne, 2001; McDonald, 2000; Segalowitz, 2003). In research using ERP measures, L1 and L2 adults also show different responses to sentences containing syntactic violations, such as incorrect phrase structure or incorrect grammatical gender agreement (Hahne, 2001; Tokowicz & MacWhinney, 2005; Weber-Fox & Neville, 2001). While native speakers show a positivity in the centroparietal cortex after roughly 600 ms, L2 adults' responses are characterized by ERP distributions with slower latencies. In contrast, when listening to sentences with semantic rather than syntactic violations, L1 and L2 adults are more similar in their responses: both groups show a negativity in the

centroparietal cortex after roughly 400 ms—a similarity that can appear after only 14 hours of L2 instruction (McLaughlin, Osterhout, & Kim, 2004). However, L2 adults' ERP responses to semantic violations may be slightly delayed relative to L1 adults (Neville et al., 1997).

The research reviewed here shows that native speakers exploit gender information to interpret spoken language more efficiently. Can non-native speakers of a language with grammatical gender also take advantage of gender information to identify nouns more rapidly? Guillelmon and Grosjean (2001) studied monolingual French-speaking adults as well as highly proficient English-French bilinguals who had learned French either in childhood or in early adulthood. Bilingual participants were highly fluent speakers with at least 20 years of immersion in a French community. In an auditory naming task, participants repeated a noun within a short phrase that was either preceded by gender marking or not. Monolinguals and early bilinguals were significantly faster to repeat the noun when prenominal gender marking was present. However, the late bilinguals were slower overall and showed no processing advantage on gender-marked trials. Participants who had learned French as adults were less able to make efficient use of morphosyntactic cues in online processing, as compared to native French speakers and early L2 learners—a surprising finding given that they had been immersed in French for an average of 24 years.

In a related study comparing native German-speaking adults with L2 German speakers whose L1 was English, the L2 speakers showed a similar insensitivity to gender marking (Scherag et al., 2004). Both groups were highly proficient, with no differences in vocabulary level, grammatical knowledge, or productive language competence, based on language assessments for foreign students learning German. In a priming procedure, participants were presented with an adjective (e.g., *faltiges*, 'wrinkled$_{[neut.]}$') that either agreed or disagreed in gender with the noun that followed (*Gesicht*, 'face$_{[neut.]}$' vs. *Haut*, 'skin$_{[f]}$'). Some nouns were real German words while others were non-words, and participants were asked to distinguish between these in a lexical decision task. When the adjective and noun agreed in gender, L1 German speakers were faster to identify the targets as real German words. However, processing speed was slower for L2 learners overall, and they responded with the same RT regardless of whether or not the adjective and noun matched in grammatical gender. As in the Guillelmon and Grosjean (2001) study with French speakers, highly proficient speakers who learned their L2 after childhood were not able to use gender agreement to facilitate lexical access. L2 learners in both studies showed less efficient processing than L1 speakers, a disadvantage that may have resulted from several interconnected factors: less experience processing and speaking the gender-marking language, less cumulative frequency of hearing the phrases used in testing, and later age of exposure to the gender-marking language.

Comparing incremental processing by children and adults

While many studies have explored how adults process grammatical gender in L1 and L2, none have examined sentence processing by young children learning L1, adults learning L2, and adult L1 speakers in a comparable task. In the present study, one goal was to provide direct comparisons of performance by adult and child participants, to better understand how age- and experience-related differences influence gender processing. Such a comparison requires a procedure suitable for participants across a broad range of ages. Eye-tracking measures have been used effectively with children (Fernald, Pinto, Swingley, Weinberg, & McRoberts, 1998; Trueswell, Sekerina, Hill, & Logrip, 1999) as well as adults (Tanenhaus, Spivey-Knowlton, Eberhard, & Sedivy, 1995) to reveal how listeners interpret speech from moment to moment in relation to referential information in the visual field. Fernald et al. (1998) explored the time course of familiar word recognition in 15-, 18-, and 24-month-olds. In the looking-while-listening (LWL) procedure (Fernald, Zangl, Portillo, & Marchman, 2008), participants looked at two pictures (e.g., ball, shoe) and heard a simple sentence referring to the target

picture (e.g., *Where's the ball?*). The dependent measure was the speed with which children moved their eyes from the distracter to the target picture. English-learning children became faster with age at finding the referent, with RTs decreasing more than 300 ms between 15 and 24 months, a pattern of findings also observed in Spanish-learning infants (Hurtado, Marchman, & Fernald, 2007). A longitudinal study with English-learning infants across the same age range showed that measures of processing efficiency in the LWL procedure at 24 months predicted vocabulary growth over the second year (Fernald, Perfors, & Marchman, 2006) as well as cognitive and language outcomes several years later (Marchman & Fernald, 2008).

Like adults, children process speech incrementally, making use of what they have heard so far to interpret words and sentences that are not yet complete. They can use partial phonetic information to establish reference (Fernald, Swingley, & Pinto, 2001; Swingley, Pinto, & Fernald, 1999), and they use prenominal verbs (Fernald, 2004) and adjectives (Fernald, Thorpe, & Marchman, 2010) to identify target nouns that follow later in the sentence. Moreover, two-year-olds respond as if they expect an object name to follow an article (Zangl & Fernald, 2007). When an unstressed adjective occurs instead, they 'listen through' it and wait for the following noun before responding; but if the adjective is stressed and novel, children tend to misinterpret the word as a potential object name (Thorpe & Fernald, 2006). This tendency to 'false alarm' in response to stressed novel words preceded by the article *the* shows that these children are integrating prosodic information with knowledge of the distributional patterns of English determiners to predict what kind of word is coming next. Further evidence for early skill in incremental processing was found in the study showing that young Spanish-learning children can also take advantage of informative gender-marked articles to identify the appropriate referent before it has been named (Lew-Williams & Fernald, 2007).

Goals of the current experiments

The first goal of this research was to explore how adult L2 Spanish learners process gender information in online comprehension, comparing them with native Spanish-speaking adults and also with young children learning Spanish as L1. Is the ability to make use of *la* and *el* as predictive cues in incremental processing more difficult for adult L2 learners than for adults and children for whom Spanish is the native language? In Expt. 1, we used the same child-friendly experimental procedure and stimuli used previously with Spanish-learning children (Lew-Williams & Fernald, 2007), comparing L1 adults, L2 adults, and L1 children in the efficiency of their processing of gender-marked articles paired with familiar Spanish nouns.

The second goal of this research was to examine how native and non-native Spanish-speaking adults make use of gender-marked articles paired with newly-learned object names rather than well-known familiar words, thus controlling for participants' previous exposure to the target noun. Expts. 2 and 3 asked whether L1 and L2 adults show a processing advantage when trained and tested on novel nouns preceded by informative gender-marked articles. When listeners first learn a novel object name paired with a particular article, can they generalize to a different article they have never before heard paired with that noun? Or is experience with a specific article-noun sequence required before the listener is able to use the article as a predictive cue? In interpreting the results from these experiments, we consider the nature of L1 and L2 learning environments, as well as different characteristics of child and adult learners, as ways to understand how gaining proficiency in real-time processing of determiner-noun phrases varies for first and second language learners.

Experiment 1

Extending our earlier study with Spanish-learning children and their monolingual Spanish-speaking parents (Lew-Williams & Fernald, 2007), Expt. 1 explored how native and non-native

Spanish-speaking adults use gender-marked articles in fluent speech to identify the appropriate referent in the visual array. While the L1 adult participants in the earlier study were primarily from low-income families and had roughly nine years of education, the L1 and L2 participants in the present study were all university students matched for age and education level. These participants were tested in the same eye-tracking procedure used to monitor the time course of children's sentence interpretation in the earlier study. On each trial, L1 and L2 adults viewed pictures of two objects with names of either the same or different grammatical gender, as they heard a Spanish sentence referring to one of the objects. RTs to the target were calculated on those trials where participants were initially looking at the distracter at article onset and then shifted to the target picture by the end of the noun. If they could use information from the gender-marked article to identify the referent, they should shift to the target object more rapidly on different-gender than on same-gender trials. Comparable data from the 3-year-old participants in our previous research were included in the statistical analyses in Expt. 1 to enable direct comparison of L1 Spanish-learning children and L2 Spanish-learning adults.

Method

Participants—L1 adults were 26 undergraduate students (*M* = 20.1 years) who were exposed to Spanish from birth. L2 adults were 26 native English-speaking undergraduate students (*M* = 18.8 years) who had been exposed to Spanish in school. Participants completed a language questionnaire that addressed (1) age of first exposure to Spanish in a home, school, or community setting, (2) years of classroom exposure to Spanish during elementary school, middle school, high school, and college, and (3) self-rated proficiency in understanding Spanish using a 5-point scale: 1 (not proficient), 3 (moderately proficient), 5 (very proficient). Table 1 provides language background information for L1 and L2 adults.

The child participants from Lew-Williams and Fernald (2007), whose data are also included in the analyses in Expt. 1, were 26 monolingual Spanish-learning toddlers (*M* = 37.7 months, range = 34-42 months) from families recently immigrated from Mexico. All toddlers had more than 85% exposure to Spanish in their daily interactions at home.

Stimuli—A list of speech stimuli from all experiments is provided in the Appendix. The stimuli in Expt. 1 were identical to those used by Lew-Williams and Fernald (2007). In a soundproof booth, a female native Spanish speaker recorded sentences consisting of a simple frame (*Encuentra*, 'Find' or *¿Dónde está*, 'Where is') followed by one of 8 article-noun pairs, half feminine and half masculine (*la pelota*, 'ball,' *la galleta*, 'cookie,' *la vaca*, 'cow,' *la rana*, 'frog,' *el zapato*, 'shoe,' *el carro*, 'car,' *el pájaro*, 'bird,' or *el caballo*, 'horse'). Articles were unstressed, as is typical in Spanish conversation. Since these stimuli were originally designed for use with 3-year-olds, nouns were selected based on their high familiarity to Spanish-learning children, according to the Inventario del Desarrollo de Habilidades Comunicativas (the Spanish-language version of the MacArthur-Bates Communicative Development Inventory; Jackson-Maldonado et al., 2003). Each sentence was followed by a short attention-getting phrase (e.g., *¿Te gusta?*, 'Do you like it?). Three tokens of each sentence were recorded using intonation characteristic of child-directed speech. The best token was selected for the final stimulus set based on a prosodic and temporal match to other selected tokens. Minor editing of the waveform of each sentence was conducted to control for the duration of the sentence frame (*M* = 914 ms, range = 900-931 ms), gender-marked article (*M* = 280, range = 268-299), and noun (*M* = 720, range = 670-770). Visual stimuli were colorful digital pictures of the named objects on grey backgrounds. Each picture served as target on four trials and as distracter on four trials, with side of target picture presentation counterbalanced. Two tokens of each object/animal were used in testing to enhance the variety of visual stimuli.

Procedure—Participants were briefly introduced to the object names to be used as target words prior to the eye-tracking procedure. A Spanish-speaking experimenter asked participants to indicate their familiarity with the eight target nouns, using a five-point scale, to ensure that all participants were familiar with the appropriate label for a particular picture. For example, one of the pictures used in testing depicted a frog, and we wanted participants to access the feminine noun *rana*, 'frog,' (the label used during the test session), as opposed to the masculine noun *sapo*, 'toad.' Thus the experimenter asked participants to indicate familiarity with the noun *rana* and never said the word *sapo*. Similarly, we wanted to increase the likelihood that participants would access the feminine noun *vaca*, 'cow,' during the test session, as opposed to the masculine noun *toro*, 'bull.' Consistent with the familiarization procedure used in our previous study with L1 toddlers, each object was named using only the indefinite article (*una* or *un*) with the target noun, in order to avoid priming the particular article-noun sequences that would be used later in the test session. Thus, during the test session participants heard each target noun paired with an article that was different from the one heard during familiarization.

Following familiarization, L1 and L2 adults were tested in the looking-while-listening (LWL) procedure, a child-friendly technique that yields online measurements of the time course of spoken language processing (see Fernald et al., 2008). Adult participants were told that the experiment was designed for young children, and they were asked to look at a series of pictures as they listened to Spanish sentences. Participants were seated 150 cm from a rear-projection screen on which they viewed two pictures side-by-side on each trial. Pictures were ca. 36 × 50 cm, with 60 cm between pictures. On each trial, one of the pictures was named in a pre-recorded sentence. The target noun was always preceded by a definite article. Following a protocol similar to that used with children (Lew-Williams and Fernald, 2007), adults were presented with 16 *same-gender trials*, where pictures depicted objects with names of the same grammatical gender, and 16 *different-gender trials*, where pictures depicted objects with names of different grammatical gender, interspersed in two counterbalanced, quasi-random orders. Test trials were interspersed with 24 filler trials. Across Expts. 1, 2, and 3, filler trials consisted of a variety of Spanish sentence structures with copulas, articles, verbs, adjectives, and nouns.

On each trial, pictures were visible for 2 s prior to the speech signal, for the duration of the 3-s speech signal, and for 1 s following the speech signal. The participant's face was recorded from a centrally located camera. Using custom software, eye movements were coded offline, frame-by-frame, with 33-ms resolution. A digital time-code was time-locked to the acoustic onset of the article on each trial, and coders blind to trial type indicated at each frame whether the participant was looking left, right, between the pictures, or away from both.

To assess the reliability of eye-movement coding, two independent observers coded 25% of the trials from 25% of the participants in each group, yielding a total of 6.25% of trials coded by two observers. Trials were selected for reliability coding only if they contained two or more shifts between the pictures. Because participants spend far more time maintaining fixation on pictures than they do shifting between pictures, including stationary fixations in reliability comparisons can result in overrepresentation of consistency between observers. Thus the calculation of inter-observer agreement was based only on those 33-ms frames surrounding shifts. Using this conservative, shift-specific method of assessing reliability, the two observers agreed within a single frame on 98.8% of the frames for L1 adults and on 95.6% for L2 adults.

Measures of speech-processing efficiency—In eye-tracking studies with adults, it is possible to direct attention to a central fixation point prior to the onset of speech, which permits an analysis of the direction and latency of a shift in gaze on every trial (e.g., Allopenna, Magnuson, & Tanenhaus, 1998). Child participants, however, will not comply with a request to maintain fixation on a central point. Because the LWL procedure was designed to accommodate child participants, and because a goal of Expt. 1 was to replicate the Lew-

Williams and Fernald (2007) results with adult L2 learners, adult participants were given no instructions about initial fixation. Since participants could not know in advance which picture would be named, they were by chance equally likely to be looking at the target or distracter picture at the onset of the article. Thus there were two ways of responding correctly, contingent on which picture they happened to be fixating initially. If they were already looking at the correct picture (target-initial trials), they should maintain fixation; but if they were looking at the distracter picture (distracter-initial trials), they should shift their eyes to the named picture as the article-noun sequence unfolded. We expected that such distracter-to-target shifts would begin more rapidly on different-gender trials, where the article provides a prenominal cue to the identity of the target referent.

Distracter-initial trials were used to calculate reaction time (RT), the latency to initiate a shift toward the target picture. RT was calculated from article onset—the first moment in the unfolding sentence where participants received relevant acoustic information. For L1 adults, 52% (235) of the same-gender trials and 54% (248) of the different-gender trials were distracter-initial. For L2 adults, 54% (251) of the same-gender trials and 54% (244) of the different-gender trials were distracter-initial. Shifts initiated in the first 300 ms were not included in the analyses, because they were likely to represent random shifting initiated prior to the possible influence of the article (Haith, Wentworth, & Canfield, 1993). RTs were included in analyses if they occurred between 300 and 1300 ms from article onset. The 1300-ms cutoff , which corresponded to the total duration of the article and noun, was selected because, across experiments and participant groups, roughly 90% of shifts from distracter to target occurred within this window.

Results

The main question addressed in Expt. 1 was how adult L2 Spanish-learners would compare to adults and young children who were native Spanish speakers in their ability to take advantage of the articles *la* and *el* to identify the correct referent on each trial. The plot in Figure 1a depicts the time course of speech processing on same-gender and different-gender trials for L1 and L2 adults. Only those trials where participants were looking at the distracter picture at article onset are included in this plot; thus the curve begins at zero and rises over time as participants shift their eyes to the target picture (see Fernald et al., 2008). Time from article onset is shown on the x-axis. The y-axis shows the proportion of trials on which participants were looking at the correct picture at each 33-ms frame after shifting from distracter to target, averaged across participants. Because the plot is not a direct reflection of RT data, Figure 1b shows mean RTs on each trial type for each group. Data from the Lew-Williams and Fernald (2007) study with Spanish-learning 3-year-olds are also included in these figures, as well as in the statistical analyses below, to enable comparison with the two groups of adult participants.

The first analysis compared mean RTs for L1 adults, L2 adults, and L1 children on same- and different-gender trials, showing that native Spanish speakers at both ages, but not L2 adults, used informative gender-marked articles to facilitate word recognition. Mean RTs were analyzed in a 3 × 2 mixed ANOVA, with group (L1 adults, L2 adults, L1 children) as a between-subjects factor and trial type (same-gender, different-gender) as a within-subjects factor. The three groups differed in overall processing speed, as shown by a significant main effect of group, $F(2, 74) = 26.2$, $p < .001$, $\eta_p^2 = .42$. Bonferroni-corrected comparisons revealed that L1 adults ($M = 642$, $SD = 119$) responded significantly faster than L2 adults ($M = 781$, $SD = 148$), $t(50) = 4.2$, $p < .001$, $d = 1.16$, and that L2 adults, in turn, were faster than L1 toddlers ($M =$ 887 ms, $SD = 141$ ms), $t(50) = 2.8$, $p < .01$, $d = .78$. The group x trial type interaction was also significant, $F(2, 74) = 4.2$, $p < .02$, $\eta_p^2 = .10$, indicating that RT differences between the two trial types were not consistent across groups. Bonferroni-corrected post-hoc comparisons ($p < .01$) revealed that L1 adults were significantly faster to initiate eye movements to the target

picture on different-gender trials (M = 608, SD = 125) than on same-gender trials (M = 674, SD = 103), $t(25) = 3.0$, $p < .005$, $d = .59$, as were L1 toddlers (different-gender: M = 843, SD = 148; same-gender: M = 935, SD = 130), $t(24) = 2.9$, $p < .005$, $d = .62$. However, L2 adults did not respond differentially to the two trial types (different-gender: M = 788, SD = 151; same-gender: M = 775, SD = 144), $t(25) = .5$, $p = .30$, $d = .09$. Despite the fact that L2 adults reported high familiarity with the target nouns used in testing, they nevertheless were less efficient in using their knowledge of gender information in real-time processing. Note that block was initially included as a factor in the mixed ANOVA, to determine whether participants were faster to process article-noun pairs in the second half of the test trials. In all three experiments, participants showed no significant improvement in performance between the first 16 and second 16 test trials, and this was the case for both L1 and L2 adults on both same- and different-gender trials.

Also of interest was whether those L2 adults who reported greater Spanish proficiency, more years of classroom exposure to Spanish, or a younger age of exposure to Spanish would show faster absolute processing speed and/or greater efficiency in exploiting gender-marked articles. As a measure of overall processing speed, mean RT was calculated across both trial types combined for each participant. Overall RT was significantly correlated with self-reported Spanish proficiency, $r(25) = -.51$, $p < .01$, and with years of classroom exposure to Spanish, $r(25) = -.46$, $p < .025$, but not with age of exposure, $r(25) = .20$, $p = .33$. Self-reported Spanish proficiency and years of classroom exposure to Spanish were not significantly intercorrelated, $r(25) = .17$, $p = .3$, and multiple regression analyses indicated that self-reported proficiency accounted for a marginally significant proportion of unique variance in overall RT, $F(1, 23) = 4.2$, $p < .055$. To quantify efficiency of processing, a difference score was calculated between the mean RTs on same- and different-gender trials for each participant. A positive difference score indicated a faster response on different-gender than on same-gender trials, when the articles were informative about the subsequent noun. Difference scores did not correlate significantly with self-reported proficiency, years of classroom exposure, or age of exposure to Spanish. Thus L2 adults who were more proficient in Spanish were slightly faster overall in orienting to the named target picture, although greater proficiency in Spanish was not associated with greater efficiency in making use of the gender-marked article in online processing.

Discussion

Three main findings emerged from Expt. 1. First, adult native Spanish speakers took advantage of the gender-marked articles *la* and *el* to rapidly identify the referent of a familiar noun, when the two candidate referents had names belonging to different noun classes, consistent with our earlier results (Lew-Williams & Fernald, 2007). Second, adults learning Spanish as L2 were *not* able to use a gender-marked article to identify the referent more quickly, although they had on average five years of L2 instruction and reported high familiarity with the nouns used in testing. Third, the L1 and L2 adults in Expt. 1 were faster in absolute processing speed than the Spanish-learning 3-year-olds tested in our previous study; however, children were more similar to L1 adults in their ability to use gender-marked articles to establish reference more quickly in online comprehension. Thus, from an early age, native Spanish speakers had an advantage in processing determiners marked with gender information, an advantage that was not shared by late L2 learners.

The mean RT of L1 adults in this experiment was identical to that of adult participants in the study by Lew-Williams and Fernald (2007). Adult participants in the earlier study were low-income, monolingual Spanish-speakers, while adult participants in the present experiment were university students, highly proficient in English, with greater knowledge of how research is conducted. Although these groups of participants differed demographically in several respects,

they shared an important life experience: they had all been immersed in Spanish from early in life. Their comparable efficiency in online processing suggests that the LWL procedure is resistant to strategizing by test-savvy adults, and that the online-processing measures used here are sensitive to small effects in participants at different ages from diverse populations.

One factor that could account for the striking differences between L1 and L2 adults is that they differed substantially in their previous experience with the article-noun combinations used in Expt. 1. L1 adults have typically heard article-noun sequences such as *la pelota* and *el zapato* many thousands of times, and even Spanish-learning toddlers have received extensive exposure to these particular article-noun sequences by the age of three years. By comparison, it is safe to assume that L2 adults who have learned Spanish in a classroom setting have typically had much less exposure to the article-noun pairs used here. Given that the cumulative frequency of exposure to nouns is known to affect speed of access (Dahan, Magnuson, & Tanenhaus, 2001; Gollan, Montoya, Cera, & Sandoval, 2008; Oldfield & Wingfield, 1965; Zevin & Seidenberg, 2004), differences in amount of exposure to article-noun pairs could account for the differential efficiency of native speakers and L2 adults in using gender information in Expt. 1. If L1 and L2 adults experienced particular article-noun sequences the same number of times, would these two groups be more similar in how quickly and efficiently they recognized spoken words? To address this question, Expt. 2 controlled for overall frequency of exposure to novel nouns combined with gender-marked articles.

Experiment 2

In Expt. 2 we asked how L1 and L2 adults make use of articles preceding newly learned object names. During the training phase, L1 and L2 adults were exposed the same number of times to four unfamiliar objects, each named with a novel noun preceded by a definite article. Two of these novel words ended in the vowel *-a*, the most common ending for feminine nouns in Spanish, and these target words were preceded by the feminine singular article *la*. The other two novel words ended in the vowel *-o*, the most common ending for masculine nouns, and were preceded by the masculine singular article *el*. During the testing phase, participants heard sentences with the same definite articles and saw pairs of novel objects on same- and different-gender trials, as in Expt. 1. Given equal exposure to these four novel article-noun pairs in a simplified word-learning environment, we predicted that L2 adults as well as L1 adults would be able to use gender-marked articles to more rapidly interpret newly learned object names.

Method

Participants—L1 adults were 12 Spanish-English bilinguals (M = 20.1 years). L2 adults were 12 native English speakers (M = 19.7 years). Table 1 provides information about age of first exposure to Spanish, years of classroom exposure to Spanish, and self-rated proficiency in understanding Spanish for participants in Expt. 2.

Stimuli—On teaching trials, the speech stimuli consisted of a simple sentence frame (*¡Mira, es*, 'Look, it's') followed by one of the four novel Spanish nouns preceded by a definite article, half feminine and half masculine (*la catela*$_{[f]}$, *la pifa*$_{[f]}$, *el durino*$_{[m]}$, or *el tebo*$_{[m]}$). On test trials, the four nouns were paired with the same definite articles used in teaching, preceded by a different frame (*¿Dónde está*, 'Where is'). Duration of sentence frames, articles, and nouns used on test trials were edited to closely parallel those of Expt. 1. The visual stimuli were digital pictures of four novel objects, which were constructed of plastic and differed from each other in color and shape. Pictures of 12 familiar objects were also used on filler trials.

Procedure—L1 and L2 adults were exposed to the unfamiliar objects labeled by four novel nouns, two masculine and two feminine. Participants were presented with 24 teaching trials, 32 test trials, and 24 filler trials in one of two counterbalanced orders. On teaching and testing

trials, each of novel object was labeled consistently with one of the four novel words, with assignment of novel word to novel object counterbalanced across participants. On each teaching trial, a picture of one of the novel objects was presented centrally on the screen, accompanied by a simple sentence naming the object (*¡Mira, esla catela!*, 'Look, it's the [novel noun]!'). The four novel object/word pairings were presented six times each in alternating order. On test trials, participants viewed pairs of the novel objects side by side and heard sentences containing the same sequences of definite articles and newly learned nouns (e.g., *¿Dónde está la catela?*, 'Where's the catela?'). Each novel object served as target and as distracter on eight test trials. As in Expt. 1, half the test trials were *same-gender trials*, on which the two pictures had names of the same grammatical gender (e.g., *catela, pifa*), and half were *different-gender trials*, on which the two pictures had names that differed in grammatical gender (e.g., *catela, durino*). Timing of stimulus presentation and coding were comparable to Expt. 1. For L1 adults, 51% (114) of the same-gender trials and 48% (104) of the different-gender trials were distracter-initial. For L2 adults, 57% (118) of the same-gender trials and 59% (122) of the different-gender trials were distracter-initial. Reliability coding was conducted on 6.25% of trials. Inter-coder agreement within a single frame was 99.8% for L1 adults and 99.1% for L2 adults.

Results

To succeed in Expt. 2, participants had to associate a definite article and a novel noun, and then, on different-gender trials, to use the article as a prenominal cue to the referent named by the subsequent target noun. Under these conditions, both L1 and L2 adults took advantage of gender-marked articles to identify the correct referent more quickly on different-gender trials than on same-gender trials. Figure 2a depicts the time course of language interpretation by L1 and L2 adults. Figure 2b shows mean RTs on each trial type for each group.

Mean RTs were analyzed in a 2 (group) × 2 (trial type) mixed ANOVA. As in Expt. 1, L1 adults (M = 670 ms, SD = 91 ms) responded faster overall than L2 adults (M = 776, SD = 147), as shown by a significant main effect of group, $F(1,22) = 4.5$, $p < .05$, $\eta_p^2 = .17$. The main effect of trial type was also reliable: Participants responded faster on different-gender than on same- gender trials, $F(1,22) = 10.9$, $p < .005$, $\eta_p^2 = .33$. However, unlike in Expt. 1, the group x trial type interaction was not significant, $F(1,22) = .1$, $p = .72$, $\eta_p^2 = .01$, indicating that the difference in speed across trial types was similar in L1 and L2 adults. As shown in Figure 2b, L1 adults responded faster on different-gender trials (M = 620, SD = 105) than on same-gender trials (M = 719, SD = 121). The RT difference between trial types was slightly smaller in L2 adults (different-gender: M = 737, SD = 183; same-gender: M = 816, SD = 135). Bonferroni-corrected post-hoc comparisons ($p < .025$) showed that the main effect of trial type was significant for L1 adults, $t(11) = 2.5$, $p < .015$, $d = .74$. For L2 adults, the effect was marginally significant, since it did not meet the more conservative alpha criterion of .025, $t(11) = 2.1$, $p < .03$, $d = .49$. These results show that when we controlled for exposure to article-noun sequences in Expt. 2, L2 adults were able to take advantage of gender-marked articles in ways that resembled L1 adults. Among L2 adults, the self-report measures of Spanish experience, proficiency, and age of exposure were not significantly correlated with overall RT or efficiency in processing.

Discussion

The main finding in Expt. 2 was that on different-gender trials, when the article was potentially informative, L2 as well as L1 Spanish-speaking adults were able to use the gender-marked article preceding a newly-learned nonce word to identify the correct referent more quickly. When exposed to the novel word/object pairings the same number of times, non-native as well as native speakers were successful in this task, and the difference between these groups observed in Expt. 1 was not as evident.

Both in training and in testing, participants in Expt. 2 heard the same nonce words paired consistently with either *la* or *el*, which raises further questions: Does performance in Expt. 2 reflect the same processes underlying interpretation of familiar article-nouns pairs in Expt. 1? What does Expt. 2 reveal about processing grammatical gender? The verbal stimuli were in Spanish and listeners clearly took advantage of information in the carrier phrase preceding the newly learned noun to identify the referent more quickly on different- than on same-gender-trials. However, this study failed to capture an essential property of grammatical gender in natural speech: that no noun is uniquely associated with a single determiner. Parental utterances recorded in the Child Language Data Exchange System (MacWhinney, 2000) reveal that young Spanish-learning children hear the noun *pelota* preceded by a variety of determiners: the definite article *la*, the indefinite article *una*, the demonstrative *esta* ('this'), the comparative *otra* ('other'), the negative adjective *ninguna* ('no'), and the plural forms of these, along with other determiners. However, in Expt. 2, *catela* and *pifa* were always preceded by *la*, and *durino* and *tebo* by *el*. So the article might in effect be perceived as the initial syllable of the novel word. If novel objects had been paired with unfamiliar names such as *doohickey* and *doodad* on same-gender trials, and *doohickey* and *gizmo* on different-gender trials, the results would presumably have been comparable. On same-gender trials, participants would have to wait for the second syllable to identify the target, while on different-gender trials, they would be able to use the first syllable to establish reference. In this case, Expt. 2 could be testing something comparable to a cohort effect in word recognition—as in previous eye-tracking studies showing that adults take longer to identify a target if its name shares a phonological onset with a distracter, such as 'candy' and 'candle' (Tanenhaus, Spivey-Knowlton, Eberhard, & Sedivy, 1996). The results of Expt. 2 could also be explained in terms of simple paired-associate learning. Even a listener with no knowledge of Spanish could potentially have succeeded in this experiment by simply linking adjacent syllables. In fact, if the feminine and masculine articles used here had been replaced with tones differing in frequency, these tones might also have served as predictive cues in some contexts (see Saffran, Johnson, Aslin, & Newport, 1999).

The finding that L1 adults were faster than L2 adults to respond to articles paired with novel nouns indicates that Expt. 2 tested linguistic processing on some level. However, the use of *la* and *el* as predictive cues in this context does not necessarily provide evidence for 'nativelike' processing of gender agreement by L2 adults. To address these concerns, the design of Expt. 2 was modified in Expt. 3. Rather than pairing the same articles with particular novel nouns during both training and testing, participants were trained on novel nouns preceded by *indefinite* articles, and were later tested on these nouns preceded by *definite* articles. Thus in Expt. 3, successful performance required *generalization* between different article forms.

Experiment 3

As language learners become familiar with new nouns, they typically hear them in combination with several different determiners. Spanish determiners mark definiteness, gender, and number, with many possible forms. Can listeners generalize between different articles, e.g. *una* and *la*, for a feminine noun, to more rapidly identify a noun as belonging to a particular noun class? Or must they actually hear a particular article in conjunction with a new noun before the article can become useful as a prenominal cue? The L1 and L2 adults in Expt. 3 were exposed to the same four novel objects paired with the same nouns used in Expt. 2, half feminine and half masculine. However, while the participants in Expt. 2 had heard definite articles on both training and test trials (e.g., Training: *¡Mira, es la catela!* Test: *¿Dónde está la catela?*), in Expt. 3 they heard *indefinite* articles on training trials followed by the same test trials as in Expt. 2 (e.g., Training: *¡Mira, es una catela!* Test: *¿Dónde está la catela?*). Since these test trials contained only definite articles, the participants in Expt. 3 had not previously heard these particular article-noun combinations during training. To succeed in this task, they

had to learn an association between a gender-marked article and novel noun, and then use a different article form as a predictive cue when asked to identify the referent of the newly learned object name.

Method

Participants—L1 adults were 18 Spanish-English bilinguals (*M* = 19.9 years). L2 adults were 18 native English speakers (*M* = 20.2 years). Table 1 provides information about age of first exposure to Spanish, years of classroom exposure to Spanish, and self-rated proficiency in understanding Spanish. Note that we tested more participants in Expt. 1 in order to match the sample sizes used in Lew-Williams and Fernald (2007). However, since previous eye-tracking studies with adult bilinguals have found effects by testing groups of 12 participants (e.g., Dahan et al., 2000), fewer participants were tested in Expts. 2 and 3.

Stimuli and procedure—The procedures in Expt. 3 were identical to those in Expt. 2, except that the sentences used on teaching trials contained indefinite articles, while those used on test trials contained definite articles. Waveforms were edited to control for the duration of sentence frames, definite articles, and novel nouns. For L1 adults, 60% (187) of the same-gender trials and 58% (181) of the different-gender trials were distracter-initial. For L2 adults, 57% (176) of the same-gender trials and 55% (172) of the different-gender trials were distracter-initial. Reliability coding was conducted on 6.25% of trials: coders agreed within a single frame on 96.6% of the frames for L1 adults and on 97.9% for L2 adults.

Results

The main finding in Expt. 3 was that L1 adults took advantage of gender-marked articles in online processing when generalization was required, but L2 adults did not. That is, on different-gender trials, L1 adults made use of an article they had not yet heard paired with the novel noun to identify the referent more quickly, while L2 adults failed to take advantage of the article as a predictive cue. Figure 3a shows the time course of looking on same- and different-gender trials. Figure 3b shows RTs for each participant group.

Mean RTs were analyzed in a 2 (group) × 2 (trial type) mixed ANOVA. The main effect of group was significant, $F(1, 34) = 5.5$, $p < .03$, $\eta_p^2 = .14$, indicating that L1 adults ($M = 662$, $SD = 124$) were faster in absolute processing speed than L2 adults ($M = 781$, $SD = 153$), consistent with results in the first two experiments. The main effect of trial type was also significant: Participants responded faster overall on different-gender trials than on same-gender trials, $F(1, 34) = 16.1$, $p < .001$, $\eta_p^2 = .32$. Moreover, the group x trial type interaction was also reliable, as in Expt. 1, $F(1, 34) = 7.8$, $p < .01$, $\eta_p^2 = .19$. Bonferroni-corrected post-hoc comparisons ($p < .025$) indicated that the effect of trial type was significant for L1 adults (different-gender: $M = 605$, $SD = 122$; same-gender: $M = 714$, $SD = 112$), $t(17) = 4.6$, $p < .0005$, $d = .69$, but *not* for L2 adults (different-gender: $M = 776$, $SD = 119$; same-gender: $M = 795$, $SD = 107$), $t(17) = .9$, $p = .29$, $d = .11$. Mean RTs for both trial types were similar in Expts. 1 and 3, showing that L1 and L2 adults identified newly learned nouns as quickly as familiar nouns.

Among L2 adults, overall RT was not significantly correlated with self-reported Spanish proficiency, years of Spanish classes, or age of exposure to Spanish. Efficiency of processing (RT on same-gender minus RT on different-gender trials) was not correlated with classroom exposure or age of exposure, but it was marginally correlated with self-reported Spanish proficiency, $r(17) = .40$, $p < .10$, suggesting that those participants with better Spanish skills were slightly faster in taking advantage of informative articles with newly learned words. In Exp. 3, the more challenging task of generalizing between article forms in rapid language

processing may have differentiated more practiced L2 Spanish learners from those who had less experience with the Spanish language.

Discussion

The adult L1 and L2 participants in these experiments all had explicit knowledge of relations among different forms of articles, and if asked, they could explain that the articles *una* and *la* are both used only with feminine nouns, while *un* and *el* are both used only with masculine nouns. But how efficiently was this knowledge actually put to use in real-time processing? Although the L1 and L2 adults in Expt. 3 had all heard the novel nouns the same number of times, thus equating for frequency of exposure, only L1 adults were able to generalize from the indefinite to the definite article. That is, on different-gender trials, L1 adults could make use of the gender-marked definite article to identify the correct referent of a newly learned object name, just as they did with familiar object names in Expt. 1, even though they had never heard the new word paired with a definite article. In contrast, when tested with different articles from those used in training, L2 adults waited to hear the noun before initiating a gaze shift, as they also did with familiar nouns in Expt. 1.

A possible limitation of the word-learning experiments reported in Expts. 2 and 3 is that participants were trained and tested on fewer items than is typical in most studies of adult language processing. This decision was a consequence of our desire to use experimental designs with adults that were comparable to those used with young children, where the number of items is necessarily limited. While the experiments did detect processing differences between L1 and L2 adults, the findings would be more convincingly generalizable if participants were tested across a wider range of stimulus materials. A second possible limitation is that L1 adults may in some sense have ‘learned’ the novel nouns better than L2 adults, a perspective suggested by research showing that proficient bilinguals have an advantage over less proficient bilinguals in vocabulary learning (Kaushanskaya & Marian, 2009). But given that there were only four novel noun-object pairings to learn during the experimental session, this interpretation may not be applicable. Although L1 and L2 adults showed equal accuracy in finding the target referents, evident in the near-perfect asymptotes of the curves in Figure 3a, L1 adults showed greater speed and efficiency than L2 adults in online interpretation of the article-noun phrase.

General Discussion

This research explored differences in the speed and efficiency with which native and non-native Spanish-speaking adults process article-noun pairs in relation to familiar and novel referents, extending previous research with Spanish-learning 3-year-olds tested in the same speech-processing task (Lew-Williams & Fernald, 2007). In three experiments, L1 Spanish-speaking adults took advantage of informative gender-marked articles to establish reference more rapidly, even when they had never heard these articles co-occurring with novel nouns. In contrast, L2 Spanish-learning adults exploited articles as predictive cues only under more limited circumstances. When listening to sentences with familiar nouns, L2 speakers were no quicker to orient to the target referent when the article was potentially informative than when it was uninformative. After learning novel nouns, they did not make use of gender-marked articles unless those articles had co-occurred with the novel target nouns throughout the experiment. Thus L2 adults did not take advantage of informative gender-marked articles to establish reference, confirming previous research on L2 learners' difficulty with grammatical gender.

Although speed in processing familiar article-noun pairs by L2 adults varied somewhat as a function of Spanish proficiency, L2 adults were 120 ms slower in mean RT as compared to L1 adults. This is consistent with previous studies of language processing by L2 adults, which interpreted slower RT as an indication of processing difficulty (Hahne, 2001; Segalowitz,

2003). In the present study, difficulty in processing gender was also evident in the fact that L2 adults did not identify targets with greater efficiency when gender-marked articles were informative about noun identity, i.e., on different-gender trials. How do these two measures of gender interpretation—overall RT and efficiency of processing—relate to each other? Collapsing across the three experiments, there was a marginally significant negative correlation between overall RT and efficiency of processing, $r(55) = -.28$, $p < .07$, showing that L2 adults with slower speed in lexical access were also those who did not initiate eye movements faster on different-gender trials than on same-gender trials. While each measure is individually informative about gender processing, this correlation shows that they are not entirely independent.

Could slower processing of Spanish sentences by L2 adults be a source of difficulty in processing gender-marked articles? Even if they did attend to the gender-marked article, the influence of the article might not have been observable until the noun itself had influenced their gaze, potentially masking sensitivity to prenominal gender marking. However, our earlier findings with young children argue against this explanation. Although most 3-year-olds responded only after hearing part of the noun and their mean RT was much slower overall than that of the L2 adults, they still showed a significant processing advantage on different-gender trials. Our methods cannot reveal whether L2 adults took advantage of gender-marked articles at a level that could not be detected, but it is clear that the behavioral manifestation of efficiency in using informative gender-marked articles was only apparent among L1 toddlers and adults.

Studies of incremental language processing in adults have explored how listeners use contextual information from words early in a sentence to estimate the relative likelihood of later words. DeLong, Urbach, & Kutas (2005) conducted a noteworthy investigation of listeners' ability to anticipate upcoming words. They tested the processing of functionally identical articles that convey no semantic information, yet differ in phonological form: *a* and *an*, which precede words beginning with consonants and vowels, respectively. Using ERP measures, DeLong et al. found that adults used the article form to make probabilistic predictions about sentence completions. The three Spanish experiments reported here provide convergent evidence for incremental processing: native Spanish speakers reliably took advantage of the articles *la* and *el*, which indicate whether a subsequent noun is feminine or masculine.

Differences between L1 and L2 learners related to age and experience

Why were English-speaking adults who had studied Spanish for several years unable to use gender-marked articles to guide their looking, while Spanish-learning 3-year-olds with a mean vocabulary of only 500 words used the same articles in the same referential context so much more efficiently? Why did Spanish-speaking adults generalize automatically from one article form to another when identifying newly learned words, while English-speaking adults learning Spanish as L2 did not—even though both groups had learned the new word under identical conditions? The observation that learning L1 early in life leads to greater fluency than learning L2 later in life is uncontroversial. Theorists with strong nativist views (e.g., Ullman, 2004; Pinker, 1984) as well as those who emphasize more gradual learning in language development (Tomasello, 2000; Pine & Lieven, 1997; Abu-Akel, Bailey, & Thum, 2004) all agree that early experience is crucial, although their explanations as to why children tend to learn language so readily and successfully vary considerably. Some researchers who describe language from a nativist perspective would argue that L2 adults' reduced mastery of language structure resulted from learning Spanish beyond a biologically determined period of maximal sensitivity to input (e.g., Johnson & Newport, 1989). There are also enormous differences in the amount and nature of language experienced by L1 and L2 learners. For example, L1 participants in these experiments presumably learned Spanish in socially rich environments with individual attention from caregivers, while L2 adults learned Spanish through formal classroom

instruction. Clark (2003) estimated that there is a striking 20:1 ratio in the amount of language experienced by L1 toddlers and L2 adults. Thus one reason why L2 adults in our experiments were at a disadvantage relative to L1 participants could be that as older learners, they had had far fewer opportunities to hear common article-noun sequences in Spanish.

L2 adults' attention to relations between articles and nouns may also have been hindered by another factor known to affect L2 learning. While L1 adults began learning Spanish as infants, without influence from another language, the native English-speaking L2 adults had first learned a language with no grammatical gender system. MacWhinney (2001) described how cross-language transfer from a highly entrenched L1 to a less practiced L2 contributes to L2 processing differences, positing that a syntactic ‘accent’ carries over to the processing of L2 structures. Several studies have explored the transfer of processing strategies associated with grammatical gender (Sabourin, Stowe, & de Haan, 2006; Lemhöfer, Spalek, & Schriefers, 2008; Costa, Kovacic, Franck, & Caramazza, 2003). Sabourin et al. (2006) found that L1 Dutch speakers were highly accurate in judging the grammaticality of Dutch sentences with correct or incorrect gender agreement, while accuracy was lower among L2 learners who grew up learning other languages with gender systems, such as German or French. However, these L2 learners then outperformed L2 learners who were native speakers of English, whose accuracy in identifying gender violations in Dutch sentences was at chance. These findings suggest that having no grammatical gender system in L1 makes it especially difficult for learners to master the complexities of gender marking in L2. In the present experiments, L2 adults' default strategy for processing article-noun sequences may have been based on their experience in English, where they would have to wait for the noun before identifying the referent in this particular referential context. Other evidence suggests that L2 adults automatically access English labels for the objects presented in the referential scene, and thus may have defaulted to an English processing strategy (Kroll & Sholl, 1992). However, the fact that the L2 adults in Expt. 2 did successfully use informative articles shows that native English speakers do not adhere unconditionally to a processing strategy based on L1. When a familiar article was a reliable cue to the noun that followed, L2 adults were able to override their dominant processing strategy in favor of a strategy used by L1 adults that permits faster sentence interpretation.

An additional influence on the initial learning trajectories of child and adult language learners is that adults have more mature perceptual and memory capabilities. Newport's (1990) “less is more” hypothesis argues that young children's cognitive limitations actually help them filter the complexities of language structure. These internal constraints narrow their learning to simpler patterns in speech, facilitating greater eventual success in language learning relative to older learners. A complementary approach, the “starting small” hypothesis (Elman, 1993), emphasizes an external locus of differences between child and adult learners: because children have reduced information processing capabilities, they elicit simpler speech from caregivers that makes the basics of language structure more accessible (Fernald, 1992; Fernald & Mazzie, 1991; Snow, 1972). There are both computational (Elman, 1993) and human experimental data (Kersten & Earles, 2001) showing that grammar learning is more successful when learners first process simpler relations among sounds and words, and are then gradually introduced to more complex segments of speech, characteristic of parental use of child-directed speech. Thus, age-related changes in processing capacities, as well as environmental accommodations to the limitations of young children, could converge to benefit younger language learners, providing insight into how L1 Spanish-speaking toddlers and adults achieved such fluency in processing article-noun sequences.

These age- and experience-related differences suggest that L1 and L2 learners follow different trajectories in learning about grammatical gender, resulting in differences between L1 and L2 adults' knowledge and processing of Spanish gender agreement. Research on L2 learning in the Chomskian tradition often explains poorer performance by non-native speakers on language

tasks in terms of grammatical deficiencies (Bley-Vroman, 1990; Clahsen & Muysken, 1986; Hawkins & Chan, 1997). Another proposal is that L2 learners' difficulties arise from problems accessing and retrieving grammatical knowledge in situations that demand rapid language processing (Sharwood Smith, 1986; see also Jiang, 2004; Bialystok, 1978). Deficiencies in these domains may be jointly relevant in explaining why L2 adults did not exhibit native-like skill in using articles to guide search behavior. Our experiments cannot determine whether the differences observed between L1 and L2 adults are more attributable to grammatical representations or processing abilities, but by testing L1 children, L1 adults, and L2 adults, our experiments do speak to the divergent paths that children and adults take in learning about articles and nouns.

Learning associations between articles and nouns

The experience of hearing simple sentence structures in child-directed speech exposes young native speakers to tight links between gender-marked articles and nouns, almost as if they comprise a single unit, as in *lapelota*. For decades, language researchers have observed that young children often treat common multiword phrases as single lexical items, such as [e•d•no•], 'I dunno' (Peters, 1983). Is it possible that child learners also initially treat articles and nouns as unanalyzed sound sequences, and only later extract articles as distinct morphological units? J. B. Carroll (1939), an early contributor to research on language learning, proposed that the article was likely to be bound to the following noun in children's early language representations. MacWhinney (1978) also characterized the early association between articles and nouns as an "amalgamation" of sound sequences that are learned as rote items. From a very different theoretical perspective, Pinker (1984) described a comparable linkage between articles and nouns, proposing that children progress from memorizing affixes and stems as unanalyzed forms (e.g., *adog*) to understanding that the article encodes a distinct grammatical unit. Susanne Carroll (1989) also discussed how young French-learning children encode articles as unstressed prefixes of nouns, or as "arbitrary segments of their hosts" (pp. 569). If young children go through a period of binding articles and nouns in unanalyzed sequences, then there should be a very gradual diversification in the contexts of early article use. Research on item-based learning suggests that children do indeed learn to produce certain structures like article-noun pairs in just such a piecemeal fashion (Mariscal, 2009; Bassano, Maillochon, & Mottet, 2008; Abu-Akel et al., 2004; Pine & Lieven, 1997; Tomasello, 2000).

The article-as-prefix perspective must be reconciled with a robust body of research showing that learners can use statistical properties of language to segment words (Saffran, Aslin, & Newport, 1996). In the case of an article-noun sequence such as *la pelota*, transitional probabilities between those syllables that occur within the noun (*pe-lo-ta*) are higher than those between the article and the noun (*la-pe*), since nouns can co-occur with several determiners. A small corpus analysis of Spanish child-directed speech on CHILDES (MacWhinney, 2000) revealed that the probability of hearing *pelota* after the article *la* is just 0.002, showing that the article-noun boundary should be a straightforward segmentation site. But critically, the backward transitional probability between these words—i.e., the probability of *la* preceding *pelota*—is .624, suggesting that familiar nouns and definite articles co-occur at a striking rate. While most research on early statistical learning has focused on forward transitional probabilities, recent research shows that infants readily track backward transitional probabilities as well (Pelucchi, Hay, & Saffran, 2009). The L1 participants in our experiments may have begun the language learning process treating *lapelota* as an unanalyzed unit, such that the ability to use the gender-marked article to find a ball in the visual field relied on simple lexical recognition. Expt. 2 supports this possibility: only when L2 adults could treat the article and noun as a single unit did they respond in ways that resembled native Spanish speakers. Native speakers, however, reliably took advantage of whatever linguistic information was useful in each context.

Generalizing from item-specific associations to gender categories

Both L1 and L2 adults presumably had top-down knowledge about structural relations between articles and nouns, but L1 adults may have benefited from a gradual process of generalizing beyond memorized sequences of words and arriving at the correct parsing of article-noun sequences. This trajectory of learning about grammatical gender may set the stage for efficiency in generalization that enables fluent listeners to use many forms of gender marking to keep track of multiple referents in rapid, complex discourse.

How do children ultimately arrive at the correct parsing of determiners and nouns and generalize beyond memorized sequences of words? One possibility is that consistent phonological similarities between words—such as the suffixes *-a* on most feminine nouns and *-o* on most masculine nouns in Spanish—facilitate the formation of gender classes in Spanish (Braine, 1987). A robust finding from previous research is that assignment of new lexical items into existing noun classes is easier in languages that mark nouns with systematic, gender-specific indicators (Bordag, Opitz, & Pechmann, 2006; Brooks, Braine, Catalano, Brody, & Sudhalter, 1993; Frigo & McDonald, 1998; Karmiloff-Smith, 1979; MacWhinney, Leinbach, Taraban, & McDonald, 1989; Pérez-Pereira, 1991). Determiners may also facilitate the discovery of gender categories, since *la* and *el* have perfect informative value as the defining feature of feminine and masculine noun classes (Boloh & Ibernon, 2009). While learning Spanish as children, our L1 participants may have noticed that articles like *la* and *el* reliably preceded nouns, and only then extracted them as functionally distinct units. Many studies have shown that children compare information across utterances to learn grammatical patterns (Childers & Tomasello, 2001; Fisher, 1996; Pine & Lieven, 1997). It seems likely that distributional regularities between determiners and phonological endings facilitate the formation of noun classes. For example, Mintz (2003) has shown that words surrounding a given target word are potentially useful as indicators of the target word's grammatical category. Applied to Spanish, learners could infer that words occurring between the article (*la*) and noun ending (*-a*) belong to a particular category (see MacWhinney et al., 1989; Taraban, 2004; Taraban & Kempe, 1999). Nevertheless, although L2 participants in the present studies were surely able to assign lexical items to the appropriate gender classes, they did not show native-like fluency in interpreting article-noun sequences. Given that most Spanish nouns belong to such phonologically transparent categories, it is all the more surprising that L2 adults did not consistently take advantage of informative gender-marked articles in identifying referents.

In Expt. 3, L1 adults not only categorized novel nouns into appropriate gender categories, but they were also able to access this category knowledge at an abstract level in real-time processing, when they heard a *different* article preceding the newly learned noun. This is a dimension of fluency that has not been addressed in previous studies, which have explored how speakers generalize across nouns but not determiners (e.g., Brooks et al., 1993). L2 adults were unable to generalize across articles in Expt. 3, failing to transfer the functionality of *una* (the familiar predictor of the novel feminine nouns) to *la* (the untested predictor of the novel feminine nouns). For L2 Spanish-speakers, why was *la* not interchangeable with *una* as a cue to noun identity in incremental language processing? Goldberg (2006) has argued that accruing routinized item-specific knowledge is an essential first step toward making successful generalizations, a step that L2 learners may have bypassed altogether.

Learning L1 and L2 in very different learning environments

In addition to characteristics of the learner that make it easier to master a language starting early in life, the environments in which L1 and L2 learners typically experience language vary in critically relevant ways. Preverbal infants hear their language spoken for months before they begin to talk, giving them extensive exposure to article-noun sequences before they have to produce them, and their first productions consist of one-word utterances, with a gradual

emergence of multi-word utterances. In contrast, adult L2 learners are expected to understand and produce complex messages within the first weeks of instruction. This focus on larger communicative goals in the classroom could hinder attention to local relations among words, such as links between specific articles and nouns. Moreover, adult L2 learners frequently see articles and nouns as separate items in written text, which could also interfere with the process of establishing strong links between particular determiners and nouns. Although top-down instruction from a Spanish instructor about definite and indefinite articles can help students form meta-level knowledge about grammatical relations, this type of learning may not facilitate the development of automaticity in *using* this knowledge in online interpretation of spoken language. Moreover, because non-native speakers learn Spanish in classrooms with many other novices, they frequently overhear classmates making gender agreement errors, which could also have negative consequences for the language representations they are in the process of forming. All of these factors indicate that infants and adults encounter a new language in quite different ways. One consequence is that adults learning L2 in a classroom do not go through the period of very gradual item-based learning of language-specific collocations, such as gender-marked determiners and nouns, which Goldberg (2006) and others have argued provides an essential foundation for L1 language learning.

Conclusion

In previous studies of gender processing, non-native speakers did not take advantage of gender information as skillfully as native speakers, even after many years of immersion in their L2 (Guillelmon & Grosjean, 2001). The experiments reported here confirmed these findings using eye-tracking measures of real-time language processing. Native Spanish-speaking children and adults showed impressive efficiency in using grammatical gender to establish reference. However, non-native Spanish speakers were less successful, exploiting prenominal gender marking only when nouns were preceded by a single article form with such regularity that the sequence could be memorized as a single lexical item. In addition to the biological factors that have been the focus of most debate on difficulties in late language learning, fundamentally different language learning environments may guide child and adult learners along two quite different paths. One path facilitates the formation of strong associations between gender-marked articles and nouns, while the other fosters attention to rules that denote noun class assignment. Native speakers are exposed to article-noun sequences through consistent caregiver input during the first years of life, establishing links strong enough for articles to serve as useful, prefix-like cues that facilitate efficiency in rapid language processing. Adult L2 learners, in contrast, typically learn *about* gender agreement from an instructor who calls attention to rules that denote noun class assignment, an approach that is less likely to support formation of the robust associations between articles and nouns essential for maximizing efficiency in incremental processing of spoken language.

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Appendix

Speech stimuli with English translations

Expt. 1	
Encuentra la pelota. ¿La ves?	(‘Find the ball. Do you see it?’)
Encuentra la galleta. ¿Te gusta?	(‘Find the cookie. Do you like it?’)
Encuentra el zapato. ¿Lo ves?	(‘Find the shoe. Do you see it?’)
Encuentra el carro. ¿Te gusta?	(‘Find the car. Do you like it?’)
¿Dónde está la vaca? ¿La ves?	(‘Where's the cow? Do you see it?’)
¿Dónde está la rana? ¿Te gusta?	(‘Where's the frog? Do you like it?’)
¿Dónde está el pájaro? ¿Lo ves?	(‘Where's the bird? Do you see it?’)
¿Dónde está el caballo? ¿Te gusta?	(‘Where's the horse? Do you like it?’)
Expt. 2	
Teaching Trials	
Mira, es la catela.	(‘Look, it's the [novel noun].’)
Mira, es la pifa.	(‘Look, it's the [novel noun].’)
Mira, es el durino.	(‘Look, it's the [novel noun].’)
Mira, es el tebo.	(‘Look, it's the [novel noun].’)
Test Trials	
¿Dónde está la catela?	(‘Where's the [novel noun]?’)
¿Dónde está la pifa?	(‘Where's the [novel noun]?’)
¿Dónde está el durino?	(‘Where's the [novel noun]?’)
¿Dónde está el tebo?	(‘Where's the [novel noun]?’)
Expt. 3	
Teaching Trials	
Mira, es una catela.	(‘Look, it's a [novel noun].’)
Mira, es una pifa.	(‘Look, it's a [novel noun].’)
Mira, es un durino.	(‘Look, it's a [novel noun].’)
Mira, es un tebo.	(‘Look, it's a [novel noun].’)
Test Trials	
¿Dónde está la catela?	(‘Where's the [novel noun]?’)
¿Dónde está la pifa?	(‘Where's the [novel noun]?’)
¿Dónde está el durino?	(‘Where's the [novel noun]?’)
¿Dónde está el tebo?	(‘Where's the [novel noun]?’)

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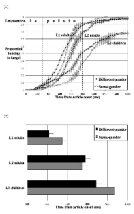

Figure 1.
(a) Time course of L1 and L2 adults' looking to the target on same- and different-gender trials in Expt. 1. Data from child participants are adapted from Lew-Williams and Fernald (2007). Vertical dashed lines indicate acoustic offsets of the article and noun. (b) Mean RTs in shifting from the distracter to the target picture. Error bars indicate $S.E._{mean}$.

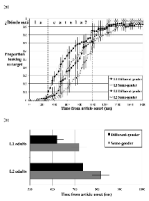

Figure 2.
(a) Time course of L1 and L2 adults' looking to the target picture on same- and different-gender trials in Expt. 2. (b) Mean RTs in shifting from distracter to target.

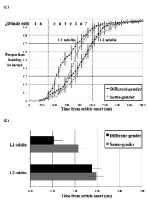

Figure 3.
(a) Time course of L1 and L2 adults' looking to the target picture on same- and different-gender trials in Expt. 3. (b) Mean RTs in shifting from distracter to target.

Table 1

Measures of L1 and L2 adults' language backgrounds and proficiency

	Age of exposure to Spanish[a]		Age of exposure to English[b]		Years of classroom exposure to Spanish[c]		Self-rated proficiency in understanding Spanish[d]	
	L1	L2	L1	L2	L1	L2	L1	L2
Expt. 1	0	12.8 (7-19)	4.3 (0-13)	0	5.0 (0-11)	5.5 (1-10)	4.8 (4-5)	3.6 (2-5)
Expt. 2	0	12.2 (7-18)	5.3 (0-15)	0	4.6 (0-8)	5.2 (1-9)	4.8 (4-5)	3.2 (2-5)
Expt. 3	0	12.1 (6-19)	4.4 (0-13)	0	5.1 (0-10)	5.6 (2-10)	4.9 (4-5)	3.6 (2-5)

[a] Mean age, in years, of participants' first exposure to Spanish in a home, school, or community setting. Ranges for these and other measures appear in parentheses below the means.

[b] Mean age, in years, of participants' first exposure to English in a home, school, or community setting.

[c] Mean number of years of classroom exposure to Spanish in elementary school, middle school, high school, and college. Participants were not given specific directions about what constitutes a year of Spanish instruction.

[d] Mean self-rated proficiency in understanding Spanish on a 5-point scale ranging from 1 (not proficient) to 5 (very proficient).