The processing of Spanish article-noun gender agreement by monolingual and bilingual toddlers

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Abstract

We assessed monolingual Spanish and bilingual Spanish-Basque toddlers' sensitivity to gender agreement in correct vs. incorrect Spanish noun phrases (definite article + noun), using a spontaneous preference listening paradigm. Monolingual Spanish-learning toddlers exhibited a tendency to listen longer to the grammatically correct phrases (e.g., *la casa*; 'the house'), as opposed to the incorrect ones (e.g., **el casa*). This listening preference toward correct phrases is in line with earlier results obtained from French monolingual 18-month-olds (van Heugten & Christophe, 2015). Bilingual toddlers in the current study, however, tended to listen longer to the incorrect phrases. Basque was not a source of interference in the bilingual toddler's input as Basque does not instantiate grammatical gender agreement. Overall, our results suggest that both monolingual and bilingual toddlers can distinguish between the correct and incorrect phrases by 18 months of age, however monolinguals and bilinguals might rely on different cognitive mechanisms when processing grammatically incorrect forms.

1. Introduction

Infants learn a great deal about language during their first years of life through exposure to speech. Comparing the linguistic and cognitive abilities of infants and toddlers exposed to one (monolingual) or two (bilingual) spoken languages has been the focus of a growing number of recent studies (e.g., Bialystok & Werker, 2017). Several of these studies focused on *phonetic* and/or *lexical* development or the cognitive mechanisms enabling the acquisition of these linguistic elements. However, little is known about the earliest stages of *syntax or morphosyntax* acquisition in bilinguals, despite the fact that just like phonetic and lexical acquisition, (morpho)syntax acquisition begins as soon as infants are exposed to spoken language (e.g., Childs, 1998; Gervain & Werker, 2013; Morgan & Demuth, 2014).

Here, as part of (morpho)syntactic development, we focus on Spanish monolingual and Spanish-Basque bilingual toddlers' ability to recognize gender agreement between Spanish articles and nouns. Because bilingual infants likely receive less exposure to each of their languages compared to their monolingual peers, it is a possibility that they learn these (morpho)syntactic dependencies at a different pace than monolinguals. Spanish and Basque provide an ideal test bed for assessing bilingual toddlers' sensitivity to article-noun agreement. In Spanish, all nouns are assigned one of two genders, masculine or feminine, and definite articles agree in gender with the nouns they select (e.g., *el dedo* "the-MASC finger-MASC" vs. *la casa* "the-FEM house-FEM"). Basque, in contrast, does not instantiate grammatical gender agreement. Therefore, Spanish-Basque bilingual infants likely receive less exposure to (Spanish) gender dependencies than Spanish monolinguals. Moreover, Basque does not represent a potential

source of interference in acquiring grammatical gender dependencies, as Basque lacks such regularities [1].

Based on the production patterns of monolingual children, it seems as if they begin to learn articles later than nouns. Children up to two years of age mostly produce single word utterances, and they tend to omit function words (words that signal grammatical relationships), including articles. Around 2-3 years of age, definite articles appear in the production of children. Spanish-learning children are able to produce correct gender agreement between articles (e.g., '*la*' or '*el*') and nouns before 4 years of age (Perez-Pereira, 1991). However, several comprehension studies have reported that monolingual children process articles well before they start to produce them (e.g., Kedar, Casasola, & Lust, 2006; Petretic & Tweney, 1977). For instance, by 3 years of age, Spanish-learning monolingual toddlers use the gender of the article to predict the upcoming noun, when their task is to match noun phrases with one out of two pictures on a screen (Lew-Williams & Fernald, 2007).

Speech perception studies have demonstrated that monolingual children recognize definite articles at an even earlier age. Shi, Werker, & Cutler (2006) tested at what age English-learning infants are sensitive to segmental detail in function words. In a listening preference paradigm, the infants heard nonsense noun phrases with real function words (e.g., 'the breek'), as opposed to prosodically analogous noun phrases with nonsense function words (e.g., 'kuh breek'). While 8-month-old English-learning infants spent the same amount of time listening to

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[1] Unlike Spanish, the vast majority of Basque nouns do not carry either grammatical or biological gender marking. Basque noun phrases headed by a common noun require a determiner, i.e. an article. The Basque definite article (*–a*) is a bound morpheme that attaches to the noun (e.g., *maha***i***a*, 'table-**the**'). Grammatical gender agreement is only present in Basque allocutive forms, which are at risk of loss as their frequency of usage is rapidly reducing, as it is limited only to some dialectal variants of Basque.

the two types of noun phrases, around one year of age, they preferred listening to the real

function words (Shi, Werker, & Cutler, 2006). When a similar testing paradigm was used with

real nouns and articles, monolingual French-learning 18-month-olds spent more time listening to

article-noun sequences (i.e., noun phrases) that agree in gender (e.g., *la poussette* 'the-FEM

stroller-FEM') as opposed to sequences with incorrect articles (e.g., *le poussette 'the-MASC

stroller-FEM'; van Heugten & Christophe, 2015). Monolingual French 18-month-olds' listening

preference to the noun phrases with correct gender agreement suggests that they are able to

distinguish between correct and incorrect syntax in article-noun sequences, hence they track the

co-occurrences between articles and nouns in their input.

Thus far, only a handful of experiments have assessed grammar learning in bilingual

infants or toddlers. Most of these studies focused on speech perception abilities related to word

order acquisition during the first years of life (e.g., Gervain & Werker, 2013). By 7 months of

age, both bilingual and monolingual infants are able to recognize language-specific

rhythm/prosody that can aid them with learning about the syntactic structures (i.e., word order)

of their native language(s) (Gervain & Werker, 2013; also see, Molnar, Gervain, Carreiras, 2014;

Molnar, Carreiras, Gervain, 2016). Studies with older children indicate that after 3 years of age,

the development of morphosyntax in bilinguals is greatly determined by the amount of exposure

they receive in each language. The more linguistic input bilingual children have in the language

that instantiates certain syntactic regularities (e.g., gender dependencies), the earlier they acquire

them (e.g., Gathercole, 2007; Nicoldais & Marchak, 2011; Thordardottir, 2014). Furthermore,

typically developing Spanish-English bilingual children, irrespective of their English proficiency

levels, produce more errors in articles than Spanish monolingual children (Castilla-Earls et al.,

2019). Meanwhile, little is known about bilingual children's processing of gender dependencies,

during the developmental stage when function words are mostly omitted in production (i.e.,

before 2 years of age).

The goal of the current study is to investigate (morpho)syntactic development in

monolingual and bilingual Spanish-learning 18-month-olds. We assessed whether Spanish

monolingual and Spanish-Basque bilingual toddlers are able to distinguish between correct and

incorrect Spanish article-noun sequences. Regarding the monolingual toddlers, we predicted that

they would be able to distinguish between noun phrases with correct vs. incorrect gender

agreement, given that their French-learning monolingual peers are able to do so by this age (van

Heugten & Christophe, 2015). To test this, we used the same preference listening paradigm as

van Heugten and Christophe (2015). In this paradigm, infants listen to trials consisting of

article-noun sequences that either agree (e.g., 'la casa') or disagree in gender (e.g., 'el casa'). If

the toddlers listen significantly longer to one type of trial over the other, it is considered as

evidence that they are able to distinguish between the two types of trials (e.g., Hunter & Ames,

1988).

We predicted that monolingual Spanish 18-month-olds would listen longer in response to

either trial type; we also predicted that the Spanish monolingual toddlers would spend more time

listening to the correct phrases over the incorrect ones, like the French-learning monolingual 18-

month-olds (van Heugten & Christophe, 2015). Taking under account the optimal-level

processing theories developed to explain infant (listening) preferences in similar testing

paradigms (e.g., Multifactor Model: Hunter & Ames, 1988; Goldilocks Effect: Kidd, Piantadosi,

& Aslin, 2014), this preference signals that the infants increase their attention[2] when hearing the

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[2] Attention consists of different sub-components, including attention arousal and/or sustaining attention. These attentional states are common during infancy and are optimal for information processing (e.g., Richards, 2001). The preference listening paradigm utilized in the current study

correct noun phrases. Moreover, this spontaneous preference pattern could be labeled as familiarity preference, because the correct noun phrases should be familiar to the infants due to exposure to their native language (e.g., Hunter & Ames, 1988; Houston-Price & Nakai, 2004; Colombo & Bundy, 2004). In the case of the van Heugten & Christophe (2015) paradigm, familiarity preference reflects the monolingual toddlers' ability to distinguish between the two types of events and their ability to recognize the correct forms. However, it should also be noted that preference studies do not always produce a familiarity preference when providing evidence for infants' ability to distinguish between two events. Novelty preference can also signal this ability (Hunter & Ames, 1988; Houston-Price & Nakai, 2004; Colombo & Bundy, 2004).

Regarding the bilingual infants, we predicted that if they keep up with their monolingual peers in terms of (morpho)syntax development, then they as well should be able to distinguish between the correct and incorrect noun phrases by 18 months of age. Considering infants' preference patterns when processing auditory information, it appears that stimuli that are generally more known to the infant (i.e., more familiar) more likely elicit a familiarity preference, although age and (re-)familiarization before preference testing could also interact with preference patterns (Hunter & Ames, 1988; Houston-Price & Nakai, 2004; Colombo & Bundy, 2004). We assume that bilingual toddlers are less familiar with Spanish article-noun sequences than their monolingual peers, given that their linguistic input contains less of these regularities. Whether such difference in exposure would affect bilinguals' spontaneous familiarity preference is unclear.

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does not allow to identify which attentional component(s) might interact with the infant's behavior during the task.

Methods

1.1. Participants

Data from 40 full-term 18-month-old toddlers were included in the final analysis. An additional seven toddlers were tested but excluded from the analysis due to fussiness or crying (6) or equipment failure (1). Toddlers were recruited from the Basque-Spanish bilingual city of San Sebastian, Spain. The amount of exposure to each language in the toddlers' environment was estimated using a detailed language background questionnaire adapted to the Spanish-Basque bilingual population (e.g., Molnar, Gervain, & Carreiras, 2014). The questionnaire was completed through an interview with one of the primary caregivers. The questions focused on the different sources of language(s) in the toddlers' environment (e.g., family members, friends, daycare, TV, etc.) and the amount of time the toddler is exposed to these sources (e.g., approximate hours per weekday or weekend). We estimated the amount of exposure to each language the toddlers received by calculating the proportion of time they heard the languages (i.e., dividing the amount of time exposed to one language by the total amount of time exposed to all languages). Toddlers in the current study were only exposed to Spanish and/or Basque. No third language was present in their environment.

Nineteen toddlers who received less than 10% exposure to Basque (mean age = 562 days; range: 532 days to 579 days; females = 9) were assigned to the *monolingual Spanish group* (average Spanish exposure = 95%; range of Spanish exposure = 91-99%). All toddlers categorized as monolinguals came from Spanish-speaking families, the source of their Basque exposure was limited to infrequent interactions with family friends and/or TV/Radio/Podcasts. Twenty-one toddlers were exposed to both languages regularly since birth and constituted the simultaneous *bilingual Basque-Spanish group* (mean age = 574 days, range 543 to 585 days; females = 11; average Spanish exposure = 63%; Spanish exposure 11-19%: n=2; Spanish

exposure 20-29%: n=7; Spanish exposure 30-39%: n=5; Spanish exposure 40-49%: n=1; Spanish exposure 50-59%: n=3; Spanish exposure 60-69%: n=1; Spanish exposure 70-79%: n=1; Spanish exposure 80-89%: n=1). All toddlers who were categorized as bilingual had family members interacting with them in Spanish and Basque regularly.

1.2. Stimuli

Spanish nouns show two main types of regularities based on their gender-to-ending consistency. In about 70% of Spanish singular nouns, the noun ending provides a transparent phonological cue to the gender of the noun (i.e., transparent nouns): most nouns ending in –*o* are masculine and most nouns ending in –*a* are feminine (e.g., *el dedo* "the-MASC finger-MASC"; *la casa* "the-FEM house-FEM"). In the current experiment, we included only transparent nouns, as they represent the most frequent article-noun gender relationship in Spanish. The testing material was prepared in the same way as described in van Heugten & Christophe (2015). Twelve Spanish nouns most toddlers know by 18 months of age were selected. Half of the nouns were feminine (*camiseta* "t-shirt", *casa* "house/home", *cuna* "crib", *mesa* "table", *oreja* "ear", *pierna* "leg") and half of them were masculine (*barco* "boat", *caballito* "little horse", *camino* "way/path/road", *cepillo* "brush", *culo* "bum", *dedo* "finger").

The stimuli were produced by a Spanish-Basque bilingual female speaker from San Sebastian, who learnt both of her languages from birth. The sound files were edited with PRAAT (Boersma & Paul, 2001). First, the target nouns were recorded with the correct articles, and the nouns were spliced from these recordings. Then, the articles ('la' and 'el') followed by other correct nouns that had the same sound onset as the target nouns were recorded. The articles with the first sound of the noun were spliced from these recordings (to control for co-

articulation). Finally, the spliced nouns and articles were cross-spliced, resulting in correct (e.g., 'el barco') and incorrect (e.g., 'la barco') article-noun sequences.

The NPs were presented during 38-second long audio files (or trials) with 750 ms interstimulus intervals. The stimuli were distributed across 8 trials: 4 correct trials (contained correct NPs only) and 4 incorrect trials (contained incorrect NPs only). Within each condition, the feminine nouns were presented across two trials (each trial contained 3 feminine nouns that were repeated in a random order; 6 feminine nouns total across the two trials) and the masculine nouns were presented across the other two trials (each trial contained 3 masculine nouns that were repeated in a random order; 6 masculine nouns total across the two trials). Each infant listened to all the 8 trials in a randomized order across and within infants. The sound intensity level of the audio files was normalized at 70 dB. The stimuli are available upon request.

2.3. Procedure

The testing procedure followed the same steps as described in van Heugten & Christophe (2015). Toddlers' preferences in response to correct and incorrect NPs were measured using a listening preference paradigm, implemented using the Habit 2000 software (Cohen, Atkinson, & Chaput, 2000). The toddlers sat on the caregivers' lap facing a television screen (distance = 1.2 meters) in a sound-attenuated room. A video camera was located below the screen, and an experimenter in a control room observed the toddler on a monitor connected to this camera. Speakers located below the screen delivered the auditory stimuli with the sound level between 68 and 75 dB. During the experiment, the caregivers wore noise-cancelling headphones and listened to distracter music, to prevent them from influencing the infant's behavior. Each trial started by displaying an attention getter (a flashing red light). The experimenter in the control room coded the toddler's visual fixation patterns during the presentation of the auditory material.
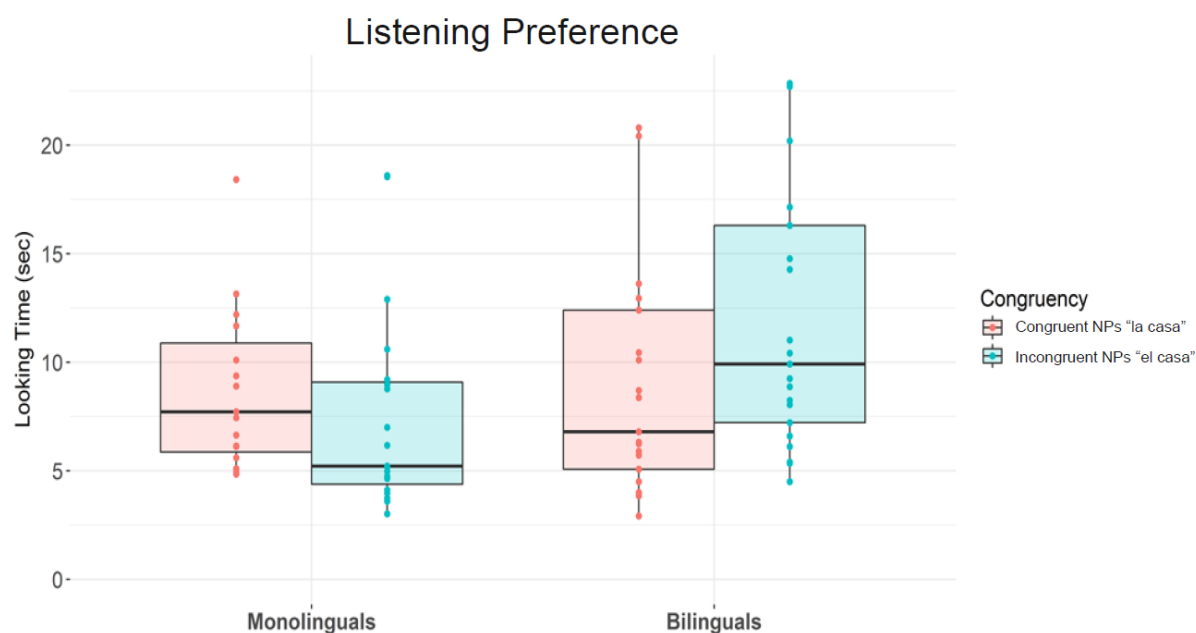
Once the toddler fixated on the attention getter, a black-and-white checkerboard appeared on the screen accompanied by the auditory stimulus (i.e., one of the trials played). If the toddler looked away for more than two seconds, the trial terminated and the attention getter appeared on the screen again. Each toddler listened to eight audio files (four with correct NPs and four with incorrect NPs) in a randomized order.

We modified the procedure described in van Heugten and Christophe (2015) in two ways. First, in addition to the eight test trials, we also included a pretest and a post-test trial, to evaluate the attention level of the infants before and after the experiment. These trials contained a video of a moving colored wheel accompanied by an infant-friendly song, which is a combination that infants typically find appealing. If infants exhibit low listening times during the pre- or post-test trials (e.g., equal to or shorter than their shortest listening time in response to a test trial), then it is assumed that the infant is not engaged in the task, and their data are discarded (n=1, in the current experiment). As a second modification, we opted for displaying a black-and-white checkerboard during the presentation of the auditory test trials, instead of a video of colorful swirls, to have a visually less interesting point where the infants fixate during the test trials. In this way, we assumed that infants' looking behavior would primarily reflect their interest in the auditory stimuli, and less their interest in the video. This methodological difference likely explains that the average orientation times reported in van Heugten & Christophe (2015) were higher than the ones reported in the current study.

2. Results

Looking times were averaged separately for the correct (congruent) and incorrect (incongruent) trials for each participant across the two language groups (Figure 1; the raw data

points are included in Appendix I). Monolingual Spanish 18-month-olds oriented toward the screen for an average of 9.33 seconds (*SD*=5.15) per trial when the correct NPs were played, and oriented for an average of 7.58 seconds (*SD*=4.7) during the incorrect NPs. Similarly to the findings of van Heugten and Christophe (2015), monolingual infants spent more time listening to the correct NPs, as opposed to the incorrect ones. Fourteen out of the 19 monolingual toddlers exhibited a correct NP preference. However, the bilingual 18-month-olds spent more time listening to the incorrect NPs (11.9 seconds; *SD*=6.15), as opposed to the correct ones (9.63 seconds; *SD*=6.75). Sixteen out of the 21 bilingual toddlers exhibited an incorrect NP preference.

Listening Preference

Looking Time (sec)

Congruency
- Congruent NPs "la casa"
- Incongruent NPs "el casa"

Monolinguals   Bilinguals

Figure 1. Looking times (in seconds) averaged in response to the congruent Spanish noun phrases (e.g., 'la casa') and incongruent noun phrases (e.g., *'el casa'), across monolingual Spanish and bilingual Spanish 18-month-old toddlers. The box plots, displayed together with individual data points, are showing first, second and third quartile of looking time for each experimental condition.

To contrast the performance of the two language groups, the average looking times were analyzed in an ANOVA that included Language Group (monolingual vs. bilingual) and Congruency (correct vs. incorrect agreement) as factors. All statistical tests were carried out using the R package emmeans (Lenth, Singmann, Love, Buerkner and Herve, 2020). The analysis yielded a significant interaction between Language Group and Congruency ($F_{1(1,38)}$=7.83, *p*=.008, ŋp^2= 0.17); no other effects reached significance (all *ps*>.17; see Appendix II for full results). A follow-up post-hoc analysis (FDR-corrected for all six possible comparisons) revealed a strong trend for the bilingual toddlers' preference toward the incorrect noun phrases over the correct ones (two-tailed t(20)=2.33; *p*=.076, *d*=0.35), and a strong trend for bilingual toddlers' spending more time orienting toward the incorrect NPs, as opposed to the time monolingual toddlers spent on orienting toward the incorrect NPs (two-tailed t(38)=2.41; *p*=.076, *d*= 0.78)[3].

To understand whether there is a relationship between the preference pattern (familiarity vs. novelty) and bilingual toddlers' language experience, we correlated the amount of exposure to Spanish each infant received with their preference pattern. First, we calculated the preference pattern (or congruency effect) for each infant by subtracting their listening time to congruent from incongruent trials. As shown in Figure 2, more negative values for the congruency effect signal a preference toward the correct/congruent (familiar) trials, and more positive values signal a preference toward the incongruent/incorrect (novel) trials. A two-tailed Pearson's correlation revealed a significant negative relationship between the amount of Spanish exposure and the

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[3] In the original analyses of van Heugten & Christophe (2015), a two-tailed t-test was used to contrast the congruent and incongruent trials directly. If we follow the same analyses, we again find evidence for a trend in the monolingual group (t_{18}=1.58; *p*=.131, *d*=0.35) and a significant difference in the bilingual group (t_{20}=-2.42; *p*=.025, *d*=0.35).

congruency effect, $r(38) = -.32$; $p = .04$, such that infants with less exposure to Spanish were more likely to show a preference to the incorrect noun phrases. However, this correlation was not significant ($r=0.06$, $p=0.78$) when only the bilingual toddlers were included, suggesting that in the current cohort it was the monolingual vs. bilingual status that determined the behavioral output. It should be noted that a reduced smaple size could also account for the lack of an effect in the bilingual group.
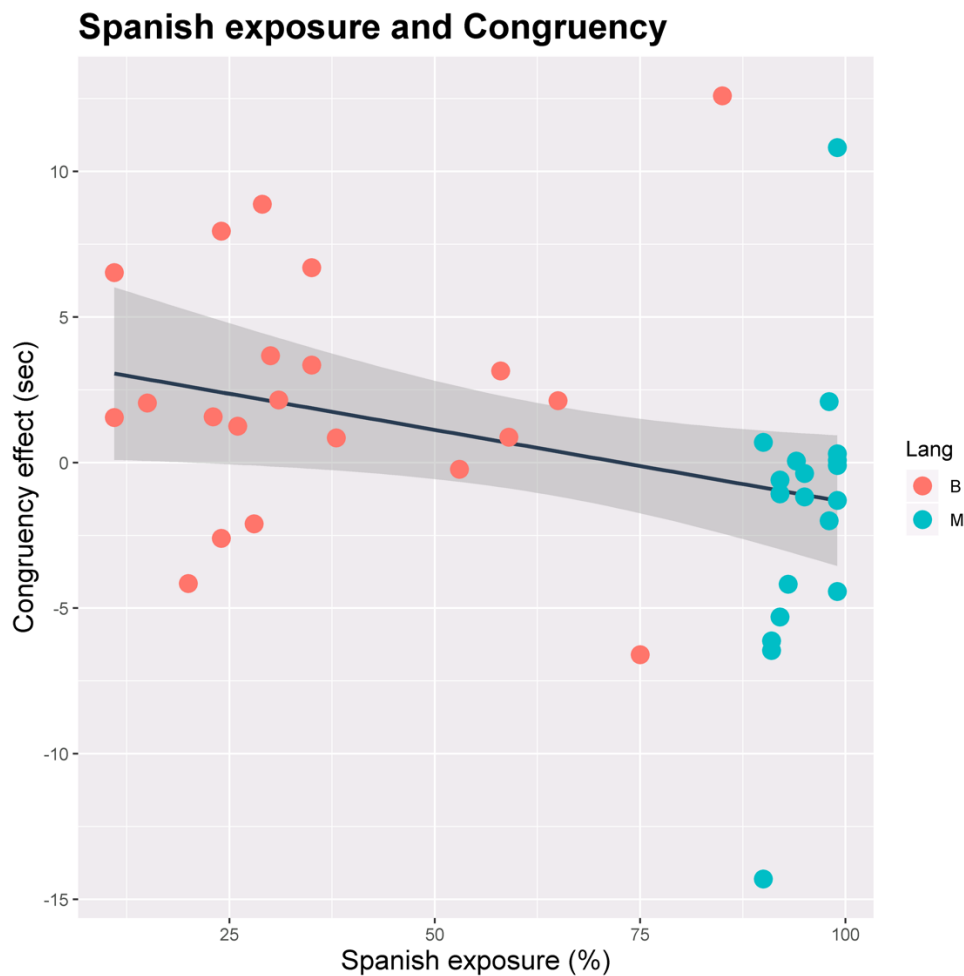
Figure 2. The plot demonstrates data for each infant (monolinguals=green dots; bilinguals=orange dots) considering the Congruency effect on the y-axis (in seconds; listening

time to incongruent minus listening time to congruent trials), and the estimated amount of Spanish exposure they received since from birth (on the x-axis).

Discussion

In summary, by 18 months of age both monolingual and bilingual Spanish-learning toddlers seem to distinguish between article-noun sequences with correct vs. incorrect gender agreement. Their ability to distinguish between the correct and incorrect phrases was signalled by their preference toward one type of trial (i.e., correct or incorrect). The performance of the Spanish monolingual group generally aligned with our predictions. Just like their French monolingual peers (van Heugten & Christophe, 2015), Spanish monolingual toddlers in the current study seemed to exhibit a spontaneous preference toward the correct phrases. The bilingual toddlers in the current study, however, exhibited the opposite pattern, as they listened longer to the incorrect phrases.

This finding suggests that 18-month-old Spanish monolingual and bilingual toddlers are able to track the co-occurrences between articles and nouns in their inputs (e.g., the article and noun in "la casa" often co-occur in speech, but the same is not true of "el casa"). Because our stimuli consisted of nouns that are part of the toddlers' real linguistic input (in the same way as in van Heugten & Christophe, 2015), we are unable to disassociate between whether the toddlers perceived these noun phrases as familiar speech chunks/co-occurrences only, or whether they are sensitive to the phonological/grammatical regularities between the articles and the noun-endings (e.g., 'la' is likely to be followed with a noun ending in 'a').

Whether Spanish-learning toddlers develop sensitivity to the phonological regularity between articles and noun endings, as opposed to a more abstract agreement relation between

articles and nouns, could be tested by utilizing an artificial language that includes unknown article-noun sequences with or without the Spanish phonological regularity. In addition, toddlers' sensitivity to Spanish article-noun gender agreement could be tested with real nouns that do not show rhyming with the articles (e.g., *la leche* "the-FEM milk-FEM" vs. **el leche*), just like the stimuli set used by van Heugten and Christophe (2015). In the study conducted by van Heugten and Christophe (2015), French-learning toddlers were able to recognize correct noun phrases even when there was no rhyming between the article and the noun ending. However, the majority of the nouns in the Spanish-learning toddlers' environment contains a phonological regularity ('*la*' is typically followed by a noun ending in '*a*'; and '*el*' is typically followed by a noun ending in '*o*'). Whether Spanish-learning toddlers are also able to recognize correct noun phrases that lack of the typical phonological regularity (e.g., '*la leche*' vs. **'el leche'*) is currently unclear.

While the monolingual toddlers exhibited a familiarity preference, the bilingual toddlers as a group demonstrated a novelty preference - surprisingly. Because such difference in looking behavior was not predicted, one can only speculate about the reason behind the different preference patterns. The *cognitive adaptation theory* (e.g., Kovacs, 2015) proposes that bilingual infants, as part of their cognitive adaptation to a bilingual environment, allocate greater attentional resources toward novel linguistic information, to maximize their opportunity to learn new information. This is because a bilingual environment contains more novel linguistic information (e.g., more linguistic regularities) than a monolingual environment. In the current study, the incorrect noun phrases could be interpreted as novel linguistic information from the infants' perspective, hence they exhibited a novelty preference in the current task.

The findings are also relevant to the *optimal-level processing theories* (e.g., Multifactor Model: Hunter & Ames, 1988; Goldilocks Effect: Kidd, Piantadosi, & Aslin, 2014). According to the Goldilocks Effect framework, infants are motivated to find an optimal level of stimulation and are most interested in information (i.e., they show spontaneous preference) that is not too simple (i.e., too familiar or predictable) or not too complicated (i.e., too novel or unpredictable). Considering the infants' looking behavior in the current study, Spanish monolinguals found the correct noun phrases optimal, while the Spanish bilingual group found the incorrect noun phrases optimal. Therefore, the monolingual and bilingual infants perceived the complexity of the correct and incorrect noun phrases differently, hence they allocated their attentional resources differently. This interpretation complements the proposal of Kovacs (2015), that is, novel vs. familiar linguistic information is processed differently by monolingual and bilingual infants.

While a correlation analysis including all monolingual and bilingual toddlers revealed that a novelty preference was more evident in infants who received less exposure to Spanish, a correlation analysis within the bilingual group alone yielded no such findings. It is important to note however that the bilingual toddlers were not evenly distributed on the language exposure continuum: most bilingual toddlers in the current cohort received less than 50% exposure to Spanish (n=15). Whether the amount of exposure determines the bilingual toddlers' looking preference should be tested with a much larger sample of toddlers more evenly distributed on the exposure continuum.

In summary, the current experiment demonstrated that both monolingual and bilingual Spanish 18-month-olds seem to keep track of the co-occurrences between article and noun gender values (feminine or masculine) present in Spanish well before they begin to produce articles with nouns (e.g., 3-4 years of age). The differences between the preference patterns of

18-month-old monolingual and bilingual toddlers suggest that the two language groups possibly

rely on different cognitive mechanisms (as reflected by attention allocation to familiar vs.

novel/unknown regularity) when processing correct and incorrect Spanish noun phrases.

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