When actions and looks don't line up

The contribution of referential and prosodic information in the processing of PP ambiguities in child-L2 speakers of English

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In two eye tracking experiments, we investigate how adult child-L2 speakers of English resolve prepositional phrase (PP) attachment ambiguity in their dominant language (English), and whether they use prosodic information to aid in the process of garden-path recovery. The findings showed an increased processing cost associated with the revision of temporary ambiguous sentences for the child-L2 adults relative to the native English speakers. When prosody was informative, the child-L2 adults were able to use prosodic information to guide the interpretation of their later acquired, dominant language. However, they performed revision significantly less successfully than the native speakers. Although processing was similar for the native English speakers and the adult child-L2 speakers of English, when it comes to sensitivity to prosodic information and referential context, the two groups differed with regards to reanalysis both in the presence and absence of salient prosodic and referential information.

Keywords: prepositional phrase ambiguity resolution, adult child-L2 speakers of English, syntactic processing, bilingualism

1. Introduction

Many studies involving early bilinguals, including heritage speakers, have been concerned with the acquisition and processing of the heritage language, and in particular with areas of divergence in comparison to monolingual speakers. A heritage speaker typically refers to "an early bilingual who grew up hearing

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and speaking the heritage language (L1) and the majority language (L2) either simultaneously or sequentially in early childhood (that is, roughly up to age 5; see Schwartz, 2004; Unsworth, 2007), but whose L2 became their primary language at some point during childhood (typically after the onset of schooling)." (Benmamoun, Montrul & Polinsky, 2013, p. 133; for similar definitions see Pascual y Cabo & Rothman, 2012; Valdés, 2005). In comparison to the abundant linguistic and psycholinguistic research on the heritage language (e.g., Montrul, 2008b and references therein; Montrul, 2015; O'Grady, Lee, Choo, 2001; Polinsky, 2011; Polinsky & Kagan, 2007), fewer studies have examined how adult heritage speakers acquire and process the dominant L2 (some notable exceptions are Lein, Kupisch & van de Weijer, 2016; Kupisch, Lein, Barton, Schöder, Stangen & Stoehr, 2014). One reason for this is that because the L2 is the societal language and the language of instruction from early childhood, acquisition and processing of the L2 in heritage speakers is assumed to be similar to that of monolingual speakers. However, as Benmamoun et al., (2013) discuss, "the study of heritage speakers lies at the forefront of language development in migration contexts and is relevant given recent trends in globalization and population movements across linguistic borders" (p. 133). Hence, it is important to gain an understanding of the representational, cognitive and neural machinery supporting the acquisition and processing of a heritage speaker's dominant language. Furthermore, we know that speakers of two or more languages experience co-activation between their languages in production and comprehension, in both visual and spoken language modalities, and even when context strongly points towards staying in one language alone (e.g., Dijkstra & Van Heuven, 2002; Kroll, Dussias, Bogulski & Valdés Kroff, 2012; Marian & Spivey, 2003; but see Weber & Cutler, 2004). The parallel activation of the bilingual's two languages creates cross-language interactions that are bidirectional, with the L1 influencing the L2 in ways similar to how the L2 influences the L1 (Dussias, 2003; Kroll, et al., 2012). In other words, the availability of both languages affects not only the activation of the two languages, and the resulting mechanisms of cognitive control (Kroll & Bialystok, 2013), but also the way in which each of the two languages is processed. Given this, one empirical question is how heritage speakers process their dominant language. This is the goal of the experiments presented here. In this study, we focus on a group of adult early bilingual speakers who acquired Spanish first but whose L2 and dominant language is English by virtue of the fact that they grew up in an English-speaking environment from early childhood. We will refer to this group of speakers as 'adult child-L2 speakers of English' or simply 'child-L2 adults'. We ask whether syntactic processing in the dominant language resembles that of native English speakers or whether the dominant language is impacted by their bilingualism. We examine the processing of syntactic ambiguity resolution in English because it is a domain of

syntactic processing that has been widely studied in monolingual speakers and in other bilingual populations.

1.1 Syntactic processing in adult child-L2 speakers and other bilingual populations

Studies on bilingual language processing have mostly examined L1 and L2 processing in child (e.g., Chondrogianni & Marinis, 2012) and adult learners (e.g., Pan, Schimke & Felser, 2015; Pozzan & Trueswell, 2016), as well as in the heritage language of early bilinguals who grow up speaking a heritage language, and for whom the L2 becomes the primary, and dominant language during early childhood (e.g., Montrul, 2008a; Polinsky, 2011; Rothman, 2009; Schwartz, 2004). To our knowledge, no study to date has investigated the processing of the dominant language in adult child-L2 speakers. There are, however, reasons to believe that these bilinguals may not be completely monolingual-like in their dominant language. First, we know that there is parallel activation of the two languages in bilingual linguistic systems, which creates competition for selection (Kroll, et al., 2012 for a review). This configuration requires higher demands for a bilingual to control the language not in use, with less cognitive resources being available to perform concurrent tasks that also rely on cognitive control mechanisms – for example, performing syntactic processing of structures that require abandoning a preferred interpretation in favor of a less preferred one (Novick, Trueswell & Thompson-Schill, 2005). An increasing number of studies has shown bidirectional cross-language interactions, indicating, for example, that the second language of an adult learner can come to affect the first language, both at the level of lexical processing and of syntactic processing (e.g., Bice & Kroll, 2015; Dussias & Sagarra, 2007; Linck, Kroll & Sunderman, 2009). In a study showing bidirectional cross-language interactions at the sentence level, Dussias and Sagarra (2007) investigated the processing of syntactically ambiguous sentences such as "The police arrested the brother of the baby-sitter who was ill." Here, the relative clause *who was ill* can refer to the noun phrase *the brother* or to *the baby-sitter*. While English speakers are known to interpret the relative clause as referring to 'baby-sitter' (*low attachment*), Spanish speakers favor the *high attachment* interpretation, where 'brother' is modified by the relative clause (e.g., Cuetos & Mitchell, 1988). Dussias and Sagarra found that Spanish-English bilinguals with limited exposure to English preferred the high attachment interpretation in Spanish, while a group of bilinguals immersed in English preferred the low attachment interpretation. This suggests that exposure to the non-dominant L2 can change processing strategies in the native language. Findings from Dussias and Sagarra (2007) indicate that not only the L2 but also the L1 can be affected by language contact.

Overall, previous studies reveal that the two languages of a bilingual interact and can be different from the linguistic system of monolingual speakers (Grosjean, 1998; Kroll & Dussias, 2017). A question that remains is whether the dominant language of a child-L2 speaker (i.e., English in the case studied here) may be affected by the presence of the non-dominant language (i.e., Spanish); adult child-L2 speakers of English whose first language is Spanish may show some differences in the processing of English compared to native English speakers. In the present study, we examine this by comparing adult child-L2 speakers of English to native English speakers on their ability to process syntactic ambiguities in English.

1.2 The structure under investigation

One finding from the literature on syntactic ambiguity resolution is that monolingual speakers sometimes use top-down information available to the processor to commit to an analysis when processing syntactically ambiguous sentences (e.g., Trueswell, Sekerina, Hill & Logrip, 1999). Here, we investigate the role of two types of top-down information: referential context and prosodic cues. In particular, we examine syntactic ambiguity resolution in an act-out task in which participants listen to sentences with prepositional phrase (PP) ambiguities ((1) below) and to unambiguous controls ((2) below), while their eye movements are monitored:

(1) Put the frog on the napkin onto the box.

(2) Put the frog that's on the napkin onto the box

In (1), the prepositional phrase 'on the napkin' is temporarily ambiguous because it can either be interpreted as a verb-phrase (VP) modifier (*where* the frog should be moved) or as a noun-phrase (NP) modifier (*which* frog should be moved). In (2), the NP modifier interpretation is the only available interpretation due to the presence of the relative pronoun 'that', which makes the sentence syntactically unambiguous. In Spanish, the heritage language of the speakers recruited in this study, the equivalent structure is not syntactically ambiguous when the preposition 'de' (English 'of') is used. To illustrate, in 'Pon la rana de la servilla en la caja' ('Put the frog of the napkin in the box') 'de la servilleta' unambiguously functions as the modifier of the NP 'la rana' ('the frog'). Although 'de' is the highly preferred preposition in Spanish when prepositional phrases function as an NP modifiers (Rigau, 1999, p. 344), the use of 'en' (English 'in') is also possible (Brito & Raposo, 2013: 1045). For example, 'Follow the instructions on the screen' is preferably expressed in Spanish as 'Siga las instrucciones de la pantalla,' although the use of 'en' is beginning to percolate in the language (e.g., 'Siga las instrucciones en la pantalla;' 'Presionar el botón en la pantalla). If 'en' is used in place of 'de', then "en la

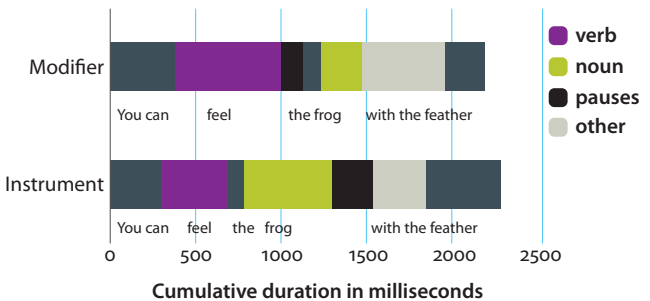
servilleta' in 'Pon la rana en la servilla en la caja' becomes syntactically ambiguous in Spanish as well. To our knowledge, there are no studies currently available that examine how the structure is processed in monolingual Spanish speakers; for the purposes of the present study, however, the answer to this question is not central.

We note also that cross-linguistic studies examining other types of syntactically-ambiguous constructions – most notably temporarily ambiguous relative clauses such as '*who was on the balcony*' in *Someone shot the son of the actress who was on the balcony* – have demonstrated a low attachment preference in English (e.g., Frazier & Clifton, 1996) and a high attachment preference in Spanish (e.g., Cuetos & Mitchell, 1988). In the present study, we examine a different type of syntactic ambiguity resolution, namely, one in which a highly-biased locative verb such as 'put' is immediately followed by a noun phrase and a prepositional phrase introduced by a locative preposition. Previous studies have shown that English speakers have a strong preference to pursue a verb-phrase interpretation, presumably because of the strong locative bias of the verb (e.g., Snedeker & Trueswell, 2004). Consequently, in the absence of disambiguating referential information, English speakers show a strong tendency to attach the prepositional phrase 'on the napkin' in (1) above to a high position (i.e., the verb 'put') in the syntactic tree (e.g., Trueswell et al. 1999). In this respect, the preference for low attachment reported in past studies investigating the resolution of ambiguous relative clauses in English (e.g., Frazier & Clifton, 1996) does not hold for the type of temporarily ambiguous construction tested here. With respect to the way in which the temporary ambiguity is resolved in Spanish, a similarly strong locative bias for the verb *poner* (to put) exists in Spanish, but the question remains as to whether the bias of the verb, in addition to the high attachment preference typically observed in other Spanish constructions, may results in a stronger verb-phrase attachment preference in Spanish compared to English. We address the potential differences between Spanish and English and the consequences for bilinguals in the discussion section.

In studies examining how PP ambiguities are resolved during spoken language processing, participants hear the syntactically ambiguous sentence in the presence of a *one-referent scene* (e.g., a frog on a napkin, a pig, an empty napkin, a box) that supports the VP-modifier interpretation of the ambiguous PP, or a *two-referent scene* (e.g., a frog on a napkin, a frog on a book, an empty napkin, a box), that supports the NP-modifier interpretation. Previous research using this paradigm has demonstrated that initial parsing commitments in adult monolingual English speakers are affected by the contextual information presented in the visual scene (e.g., Altmann & Steedman, 1988). Adult native English speakers typically look more at the "incorrect goal" (i.e., the empty napkin) in the one-referent condition in comparison to the two-referents condition, suggesting that 'on the napkin' is interpreted as the goal of the action (i.e., VP-modifier interpretation) more often

when only one frog is present in the visual scene. In addition, adult native English speakers who do not recover from this garden path also act out the action of moving the frog to the empty napkin (e.g., Trueswell, et al., 1999). The amount of actions to the incorrect goal has been interpreted as a failure to recover from the first VP-modifier interpretation. Because adult native English speakers can integrate the referential information provided by the contextual visual scene, usually fewer looks and also fewer actions to the incorrect goal are observed in the two-referent condition in comparison to the one-referent condition. Thus, the presence of the additional 'frog' in the visual context prevents participants from entertaining the VP- modifier interpretation.

Past studies have shown that just as the visual scene can modulate the resolution of PP-ambiguous sentences, so can the presence of prosodic information, demonstrating that listeners are sensitive to prosodic information during syntactic processing (e.g., Snedeker & Trueswell, 2004; Snedeker & Yuan, 2008). For example, Snedeker and Yuan (2008) showed that the VP- and the NP-modifier interpretations of the syntactically ambiguous PP "feel the frog with the feather" are associated with different prosodic contours (i.e., with different combination of phrase length and pauses). This is illustrated in the caption from Snedeker and Yuan (2008, p. 582):



Caption from Snedeker & Yuan, 2008. Different prosodic contours (pauses and phrases' length) for the globally ambiguous sentence "feel the frog with the feather"

In the VP interpretation, which in this specific case amounts to an 'instrument' reading, there is a prosodic break (i.e., a pause) before the 'with-phrase,' indicating that there is a syntactic break between the noun phrase ('the frog') and the prepositional phrase ('with the feather'). When the interpretation is consistent with an NP modifier, there is no pause between the noun phrase and the prepositional phrase; instead, the prosodic break occurs before the noun phrase ('the frog'). Snedeker and Yuan (2008) showed that when adults heard utterances with instrument-consistent prosody, they performed actions with the target instrument ('the feather') 62% of the time; conversely, when hearing utterances with prosody

consistent with the modifier interpretation, they performed actions with the target instrument only 27% of the time. Analyses of the looks matched the results of the off-line actions, indicating that speakers use prosody to disambiguate sentences that have more than one possible meaning (see also Henry, DiMidio & Jackson, 2017; Snedeker & Trueswell, 2004). One aim of the present study is to investigate how adult child-L2 speakers integrate referential context as they interpret temporarily ambiguous English sentences similar to (1). A second aim is to investigate the integration of prosodic information present in the auditory signal.

L2 processing research has shown that beginning and intermediate L2 learners can use auditory prosody to interpret globally ambiguous sentences (Dekydtspotter, Donaldson, Edmonds, Fultz & Petrush, 2008). There is also evidence suggesting that (young) L2 speakers may rely more heavily on prosodic rather than on syntactic information, particularly when interpreting ambiguous sentences with conflicting prosodic and syntactic cues to structure (e.g., Harley, Howard & Hart, 1995). It is still unclear, however, how bilinguals' sensitivity to prosody can guide the interpretation of temporarily ambiguous sentences in their dominant language, such as in the case of adult child-L2 speakers of English. One prediction is that when these speakers listen to the temporarily ambiguous instructions in English, they will use the referential information in the visual scene to disambiguate the sentences, much like has been shown in past studies with monolingual English speakers. However, even if they are successful at integrating the referential context during the processing of the temporarily ambiguous sentences, they may not revise their initial interpretation as effectively as native English speakers. Despite having native-like proficiency, the bilingual speakers may experience a higher processing cost for revision in the dominant language in comparison to native English speakers, by virtue of the fact that they must manage two linguistic systems.

2. Experiment 1

2.1 Participants

Twenty-five native English speakers (mean age: 20 years; SD: 2) and 20 adult child-L2 speakers of English (mean age: 24 years; SD: 5) participated in the study. The native English speakers were undergraduate students at a large US university and received course credits for their participation. A Language History Questionnaire (LHQ, Marian, Blumenfeld & Kaushanskaya, 2007) revealed that English was the only language spoken proficiently by the native English speakers. The adult child-L2 speakers were students at the same institution and received monetary

compensation for their participation. Participants were exposed to the heritage language from birth, learning Spanish naturalistically in the home. We do not have information on whether these speakers had any school instruction in Spanish. They were living in the US at the time of testing and were first exposed to English before age 12 (3–10 years; mean age: 6 years; SD: 3). The community in which these bilinguals live is situated less than one mile from the U.S.-Mexico border. The environment is primarily bilingual, with English and Spanish being the primary languages. According to the 2010 US Census, 80.7% of the population is ethnically Hispanic or Latino. Many residents are bilingual from an early age, whereas many others are in various stages of learning the heritage language.

In Table 1, we present information collected with the LHQ on the language background of the adult child-L2 speakers. Both groups of participants were assessed on their English proficiency (the language being examined here) using a subsection of the *Michigan English Language Institute College English Test* (MELICET). The MELICET examines ability in different English language areas including grammar, vocabulary, and reading competence in isolated sentences, as well as longer stretches of discourse. Only adult child-L2 speakers who scored more than 75% of correct answers on the MELICET were invited to participate in the eye-tracking study (mean = 42.2; range = 34–49; SD = 3.6).

Table 1. Experiment 1. Participant information: Mean (SD)

	Spanish – L1	**English – L2**
Age of exposure (number of participants)	0 y.o.	3 y.o.; 2/20
		4 y.o.: 2/20
		5 y.o.: 6/20
		6 y.o.: 5/20
		8 y.o.: 3/20
		9 y.o.: 1/20
		10 y.o.: 1/20
Length of residence in a country where the language is spoken	16 (7)	7 (6)
Speaking (% average daily)	44 (27)	56 (29)
Reading (% average daily)	35 (24)	65 (24)
Average daily exposure (%)	35 (25)	65 (25)
Speaking proficiency	10 (3)	8 (1)
Comprehension proficiency	9 (1)	9 (1)
Reading proficiency	9 (1)	8.5 (1)

2.2 Materials and design

Participants heard syntactically ambiguous sentences and unambiguous control sentences while their eye movements were recorded in the presence of a referential scene (depicted in Figure 1). The ambiguity concerned the interpretation of a syntactically ambiguous prepositional phrase, underlined in 'Put the frog on the napkin in the box.' The phrase 'on the napkin' can function as a destination or goal' (a verb-phrase modifier) or as a noun-phrase modifier (i.e., there is a frog on a napkin and something must happen to it). All critical trials had the same structure: the verb 'put', a definite noun phrase (e.g., 'the frog'), the syntactically ambiguous prepositional phrase always introduced by the preposition 'on' (e.g., 'on the napkin'), a final prepositional phrase always introduced by the preposition 'onto' and followed by a definite noun phrase (e.g., 'onto the box'), which disambiguated the sentence. The structure of the unambiguous experimental trials was the same as that of the ambiguous sentences, but included the relative pronoun 'that,' effectively disambiguating the ambiguous PP towards the noun phrase modifier interpretation. An example of the ambiguous sentence is repeated in (3); its unambiguous control is provided in (4):

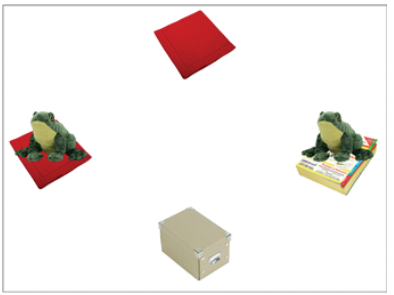
(3) Ambiguous: Put the frog on the napkin onto the box.

(4) Unambiguous: Put the frog that's on the napkin onto the box.

The referential context of the visual scene viewed by the participants while they heard the sentences was manipulated so that when participants heard a temporarily ambiguous sentence like (3), they saw either a 2-referent context, as shown in Figure (1A) or a 1-referent context, as shown in Figure (1B).

The experimental design, therefore, crossed two factors: temporary ambiguity (ambiguous vs. unambiguous) and referential context (1 referent vs. 2 referents). Each participant heard 24 experimental trials (6 per condition), 16 of which were followed by one type of filler continuation ('Now move it up and down'), and 8 which were followed by two filler continuations (e.g., (i) 'Now move it up and down;' (ii) 'Now drag it to the left'). In addition to the experimental trials, participants heard 2 practice trials, and 36 filler trials (e.g., 'Put the bowl onto the card') in a pseudo-randomized order. The 36 filler sentences included the verb 'put', a definite noun phrase (e.g., 'the bowl'), and a preposition ('on', 'onto', 'next to') followed by a definite noun phrase (e.g., 'on the card'). The structure of the filler trials was always associated with the verb phrase modification. Experimental sentences and fillers were counterbalanced across four experimental lists in a Latin Square design, and were presented in a pseudo-randomized order.

A.



B.

Figure 1. Example of a visual word scene for the Ambiguous 2-Referents context (1A), and Ambiguous 1-Referent context (1B) for the experimental sentence: "Put the frog on the napkin into the box" (source: Pozzan & Truswell, 2016)

To create the visual scenes, eighty pictures were normed with a group of ten native English speakers for naming agreement. The pictures represented everyday animate (animals) and inanimate (objects) entities. The participants had a 100% naming agreement on the objects (e.g., 'the frog') and platforms (e.g., 'the napkin') pictures. The sentences were recorded by a female native speaker of English trained in linguistics. The speaker used neutral intonation when recording the ambiguous sentences. Given the findings reported in Snedeker and Yuan (2008), it was important to ensure the lack of prosodic cues to disambiguation in our experimental materials. To this end, we verified that the pause between the verb 'put' and the noun phrase 'the frog' (henceforth VP/NP1) – which would be consistent with the interpretation of the PP as the modifier of the N – and that the pause between the NP1 'the frog' and the first PP 'on the napkin' (henceforth NP1/on) – which would be consistent with the interpretation of the PP as an argument of the verb – were of comparable length. A two-tailed t-test revealed no significant difference (p = .137) between the VP/NP1 pause (mean = 0.019, SD = 0.023) and the NP1/on pause (mean = 0.036; SD = 0.039).[1]

1. In contrast to Snedeker and Yuan (2008), in our stimuli there is a second PP, where a longer pause is found (mean = 0.25; SD = 0.089). The length of this pause is analyzed in Study 2.

2.3 Procedure

Stimuli were presented on a color monitor using an EyeLink 1000 desktop-mounted eye-tracker (SR Research). Participants sat in front of a computer screen and used a chin rest and a forehead pad to minimize head movement. Viewing was binocular, and monocular tracking of the right pupil and cornea was performed at a sampling rate of 1000 Hz. The eye-tracker was calibrated and validated for each participant at the beginning of the experimental block and after each break to calculate overall equipment accuracy. Following calibration, eye position errors were less than 0.30°.

Participants listened to temporarily ambiguous and unambiguous instructions similar to (3) and (4), and were asked to perform the action spoken in the instruction using a mouse to move the objects presented on the computer screen. The position of the objects was counterbalanced across the trials, so that the target object, correct goal, incorrect goal and distractor objects always appeared in different positions on the screen. At the start of the trial, the objects were presented on the screen and each was given a label (e.g., for (3), "a frog", "a napkin", "a book", "a box"). Next, participants were asked to look at the cross at the center of the screen and to listen to the instruction. Subsequently, they were allotted 2000 ms to act it out using the mouse; at the end of the 2000 ms, a beep was played and the objects disappeared from the screen. The actions were recorded during the experiment using a desktop recorder program. The experimenter wrote down the actions during the experiment and a research assistant unaware of the aim of the experiment checked the transcriptions based on the recordings.

2.4 Predictions and results

We followed past studies examining the same type of syntactic ambiguity (Pozzan & Trueswell, 2016; Woodard, Pozzan & Trueswell, 2016) in analyzing two measures: looks to the incorrect goal (e.g., the empty napkin in (3) above) in the 2000 ms following the onset of 'on' (e.g., 'on the napkin'), and the actions to the incorrect goal. The looks are a measure of early commitment during sentence processing that provides information on whether the bilingual parser is more likely to show a garden path effect than the monolingual parser. The actions to the incorrect goal represent an off-line measure of revision. With this analysis of the results, we explore three predictions. One is that the adult child-L2 speakers may be more likely to show a garden path effect than the native English speakers, exhibiting stronger commitments to the simplest syntactic analysis from the early stages of processing syntactic ambiguities, and possibly more actions to the incorrect goal, without consideration of other sources of potentially useful information. Another

possible scenario is that the adult child-L2 speakers may be less efficient than the native English speakers in abandoning an incorrect analysis by virtue of the fact that the former have fewer cognitive resources available to deploy (e.g., Pozzan & Trueswell, 2016; Sorace, 2011), and consequently may experience a higher processing cost associated with revision. In this case, we may expect the same early processing and commitments in ambiguous sentences for the two groups (i.e., similar looking pattern in the eye-tracking task), but the adult child-L2 speakers would exhibit more actions towards the incorrect goal than native English speakers. A third possibility is that the adult child-L2 speakers and the native participants show the same pattern of processing, and no differences are found either in the early commitments or in the later reanalysis. In this case, we expect similar results for the native English speakers and the adult child-L2 speakers, both in the online (eye tracking) measure and in the actions.

Eye-tracking data

We analyzed the looks toward the incorrect goal (e.g., 'the empty napkin') in the 2000 ms following the onset of the first PP (e.g., 'on the napkin'), following Pozzan and Trueswell (2016). Considering that it takes on average 200 ms to plan an eye movement, the 2000 ms that we analyzed included the first PP (measuring on average 1000 ms) and part of the second PP ('onto the box'). This time-window was chosen to be able to compare our results with previous findings (e.g., Pozzan & Trueswell, 2016), and because it does not include disambiguating information, which could later be used for revision. This approach allowed us to determine if the adult child-L2 speakers of English and the native English speakers consider the incorrect goal in their initial interpretation to a similar extent, i.e., if the adult child-L2 speakers are as likely as the native English speakers to interpret the first PP as the argument of the verb 'put' during the early phase of on-line processing. Additionally, the analysis of the 2000 ms window addresses how adult child-L2 speakers of English and native English speakers integrate the referential context in the 2-referents condition to avoid a garden path.

Trials with combined looking times of less than 30% during the entire 2000 ms time-window were discarded. These accounted for 5.9% of the trials. We used a linear mixed-effects model to analyze the e-logit-transformed proportion of looks to the incorrect goal using the lmer function[2] (*lme4* library, Bates & Sakar, 2007). The fixed effects in the model included Ambiguity (ambiguous vs. unambiguous),

2. Following the suggestion of an anonymous reviewer, we conducted the analyses of the eye-tracking data without the e-logit to address potential spurious interactions that may emerge with this transformation (see Donnelly & Verkuilen, 2017 for criticism on the e-logit transformation). Similar effects were found in the analyses with and without the e-logit.

Referential Context (1 vs. 2 referents) and Group (native English speakers vs. adult child-L2 speakers of English), together with all interactions. The fixed factors were sum-coded, and then mean-centered, due to imbalance in the data. All interactions were allowed. To recapitulate, we expect to observe more looks to the incorrect goal when only one referent is present in the visual scene, with participants likely interpreting the first PP as the argument of the verb 'put'. For the 2-referent context, we expect to observe fewer looks to the incorrect goal, because the presence of a second referent should be an early cue to sentence interpretation. In the case of the 2-referent context, if participants successfully integrate the referential context, they should not consider the interpretation in which the first PP is the argument of the verb.

Actions data

To code the actions, we counted actions to the incorrect goal that included a movement of a target object (e.g., 'a frog') to the incorrect goal (e.g., 'the empty napkin'). Separately, we counted those actions in which the participant dragged the incorrect goal onto the goal object (e.g., 'the box') and then moved the target object (e.g., 'a frog') on top of the two (about 5% of the total amount of incorrect goal actions). We hypothesize that this type of action (labeled 'incorrect goal action to goal object') is the result of a garden path and time pressure: as participants tried to find a faster way to drag the objects, they sometimes performed the 'incorrect goal action to goal object' following a garden path. Therefore, incorrect goal actions to goal object were analyzed together with the actions to the incorrect goal.

The number of incorrect goal actions per each subject and item was coded as 1 or 0, and was analyzed using the binomial glmer function (*lme4* library, Bates & Sarkar, 2007). We expected more actions to the incorrect goal in the one-referent context, which we suggest indicates that participants misinterpreted the first PP ('on the napkin') as the argument of the verb "put" and failed to revise their initial interpretation. We expected fewer actions to the incorrect goal in the two-referent conditions, in which the visual scene provides evidence incompatible with the interpretation in which the first PP is the argument of the verb.

Eye-tracking results

Figure 2 shows the proportion of looks toward the incorrect goal in the 2000 ms following the onset of the first PP (e.g., 'on the napkin'). The full model is presented in Table 2.

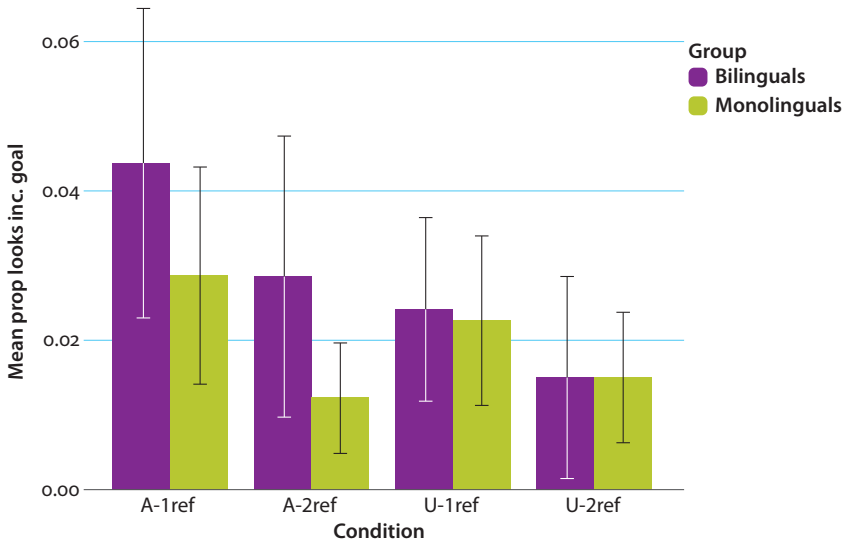


Figure 2. Experiment 1. Mean proportion of looks to the incorrect goal in the four conditions. Error bars represent 95% Confidence Intervals

Table 2. Experiment 1: Full model statistics for the analysis of looks to the IG (2000 ms following the first PP)

	Estimate	Std. Error	*t* value	*p* value
(Intercept)	−0.72	.02	−33.56	0.001***
Group	−0.002	.01	−0.15	0.8
Ref.Context	−0.007	.002	−3.74	0.01**
Ambiguity	−0.009	.002	−4.4	0.001***
Group*Ref.Context	−0.006	.002	−2.35	0.05*
Group*Ambiguity	0.002	.002	1.17	0.2
Ref.Context*Ambiguity	0.008	.002	3.88	0.001***
Group*Ambiguity*Ref.Context	0.002	.002	1.38	0.1

Notes
The maximal random effect structure leading to convergence includes by subject and by item random intercepts and by subject and by item random slopes for the effects of referential context and ambiguity.

In this time-window, we found a main effect of Referential Context, indicating overall more looks to the incorrect goal in the 1-Referent condition compared to the 2-Referent condition, and a main effect of Ambiguity, showing more looks to the incorrect goal in the ambiguous condition compared to the unambiguous condition. We also found an interaction between Group and Referential Context. We conducted planned comparisons to follow up on the interaction using linear mixed-effects models on each condition separately, comparing the two groups.

The alpha was set at 0.05. The planned comparisons did not show any difference between the two groups in either the 1-referent context (*Estimate* = 0.0003, *SD* = 0.00, $t = 0.6$, $p < .5$) or the 2-referent context (*Estimate* = 0.0003, *SD* = 0.00, $t = 0.74$, $p < .4$). The absence of significant differences in the results suggests that the two groups behave similarly in the early stages of ambiguity processing.

Actions results

Figure 3 shows the percentage of actions toward the incorrect goal in the ambiguous and unambiguous conditions, in the contexts with one and two referents. The actions are a measure of the off-line interpretation of the ambiguous/unambiguous sentences.

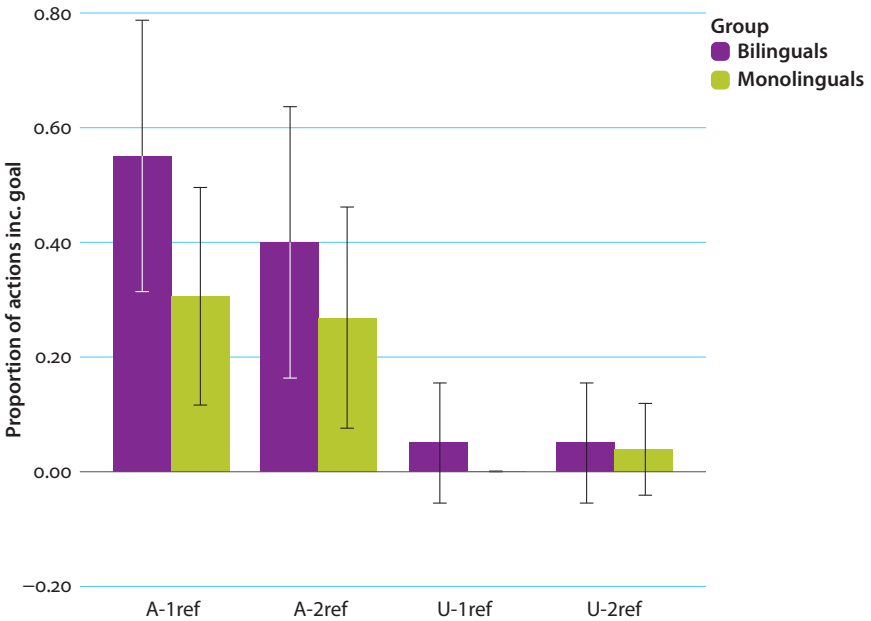


Figure 3. Experiment 1. Proportion of incorrect goal actions in the four conditions. Error bars represent 95% Confidence Intervals

The fixed effects in the model included Ambiguity (ambiguous vs. unambiguous), Referential Context (1 vs. 2 referents) and Group (native English speakers vs. adult child-L2 speakers of English) as main effects, together with all interactions. The fixed factors were sum-coded, and then mean-centered, due to imbalance in the data. All interactions were allowed. The results of the full model are presented in Table 3.

Table 3. Experiment 1: Full model statistics for the actions' analysis

Fixed effects:				
	Estimate	**Std. Error**	***t* value**	***p* value**
(Intercept)	.052	0.01	3.9	
Group	.023	0.01	2.36	0.05*
Ref.Context	−.008	0.006	−1.44	0.2
Ambiguity	−.04	0.006	−7.92	0.001***
Group*Ref.Context	−.01	0.005	−2.36	0.01**
Group*Ambiguity	−.02	0.005	−3.41	0.001***
Ref.Context*Ambiguity	.01	0.006	1.87	0.3
Group*Ambiguity*Ref.Context	.01	0.005	2.07	0.05*

Notes
Significance levels throughout the paper:
† $p < .10$;
* $p < 0.05$;
** $p < 0.01$,
*** $p < 001$.
The maximal random effect structure leading to convergence includes by subject and by item random intercepts, and by subject random slopes.

The analysis revealed a main effect of Ambiguity, showing more actions to the incorrect goal in the ambiguous conditions, and a main effect of Group, indicating more actions to the incorrect goal in the adult child-L2 speakers than in the native English-speaking group. We also found significant interactions between Group and Ambiguity, Group and Referential Context, and a three-way interaction between Group, Ambiguity and Referential Context. We followed up on the three-way interaction by comparing the two groups in each condition separately. The number of incorrect goal actions per each subject and item was coded as 1 or 0, and was analyzed using the binomial glmer function (*lme4* library, Bates & Sarkar, 2007). The alpha was set at 0.05. The planned comparisons showed a significant difference between the native English speakers and the adult child-L2 speakers in the ambiguous condition with one referent (*Estimate* = 0.06, *SD* = 0.02, *t* = 3.313, p = 0.0018), with adult child-L2 speakers performing significantly more incorrect goal actions than the native English speakers. No significant effect emerged for the other conditions (Ambiguous, 2-referent: *Estimate* = 0.01, *SD* = 0.01, *t* = 0.945, $p < 0.34$; Unambiguous, 1-referent: *Estimate* = 0.004, *SD* = 0.003, *t* = 1.149, $p < 0.2$; Unambiguous, 2-referents: *Estimate* = 0.0009, *SD* = 0.005 *t* = 0.182, $p < 0.8$).

We also analyzed the data for the adult child-L2 speakers of English and the native English speakers separately. For the child-L2 adults, we found a main effect of Ambiguity (*Estimate* = 1.77, *SD* = 0.9, t=−3.891, $p < 0.0001$), a main effect of

Referential Context (*Estimate* = −4.2, *SD* = 1.08, *t* = 1.970, $p < 0.048$) and an interaction between Ambiguity and Referential Context (*Estimate* = 5.4, *SD* = 1.82, *t* = 2.953, $p < 0.003$). The interaction revealed a difference in the ambiguous condition approaching significance (*Estimate* = −0.5, *SD* = 0.2, t=−1.858, $p < 0.06$), with more actions to the incorrect goal in the ambiguous sentences compared to the unambiguous sentences. For the native English speakers, we did not find any main effect or interaction.

In addition, age of first exposure to English was included in the analysis of actions to understand if age of acquisition modulated the bilinguals' ability to revise temporarily ambiguous sentences. To this end, we fitted a generalized linear mixed-effect model to the adult child-L2 speakers' incorrect goal actions only, adding English Age of Acquisition as a main factor (*z*-scored), with all interactions allowed. For the analysis including Age of Acquisition, no significant effects or interactions were found (all $p > .1$).

Interim discussion

The goal of Experiment 1 was to shed light on how adult child-L2 speakers of English integrate the referential context when processing temporarily ambiguous sentences in their dominant language. By collecting on-line and off-line data, we aimed to understand if these bilinguals experience increased processing costs compared to native English speakers, and which stage of processing is most impacted during ambiguity resolution. Let us first review the results of the native English participants. We replicated the results of past studies for the on-line (early) measure of processing. For the native English speakers and the adult child-L2 speakers alike, the eye tracking data revealed more looks to the incorrect goal in the ambiguous condition compared to the unambiguous condition in the early time-window (2000 ms after the onset of the first PP). Moreover, looks to the incorrect goal in the ambiguous condition were comparable between the two groups, indicating that adult child-L2 speakers do not consider the incorrect goal interpretation more than the native English speakers when only the first PP has been presented.

Our results of the actions, however, did not replicate findings from previous studies using a similar method with monolingual English speakers (e.g., Trueswell et al. 1999; Pozzan & Trueswell, 2016). Specifically, the results of the actions did not show an effect of referential context, and native English speakers did not perform significantly fewer actions towards the incorrect goal in the 2-referent condition compared to the 1-referent ambiguous condition. The present study used a similar computer-based task as in Pozzan and Trueswell (2016), in which the effect was found. However, for reasons having to do with software constraints, in our task we

introduced a 2000 ms response time in comparison to the 1500 ms used by Pozzan and Trueswell. Although we maintained the time-pressure, participants had an additional 500 ms to perform an action. We hypothesize that the increased time may have had an impact on the amount of incorrect goal interpretations found in native English speakers. Notice that a lack of the referential context effect in off-line interpretation has also been reported in another study comparing younger and older monolingual participants using a similar task, as a result of increased response time (Zeidan, Nakamura & Rossi, 2016).

With regards to the adult child-L2 speakers of English, the analysis of the actions demonstrated that when one referent was present in the visual scene, they performed significantly more actions towards the incorrect goal compared to the native English speakers. This finding suggests that in the absence of disambiguating contextual information, the adult child-L2 speakers persist with the incorrect goal interpretation more than the native English participants. Conversely, when the context provides a second referent, the adult child-L2 speakers are as successful as the native English speakers at revising the ambiguous instructions, showing that they integrate referential information and use it to disambiguate the syntactic structure. These observations confirm that ambiguity resolution preferences in the child L2 speaker can be modulated by the referential context in the off-line task, as demonstrated by the analysis of the actions. In all, the results of Experiment 1 suggest that even at high levels of proficiency, adult child-L2 speakers processing in their dominant language can differ from native English speakers in the revision of temporarily ambiguous sentences when the referential context is not informative.

We noted earlier that the adult child-L2 speakers had different age of exposure to the L2 (ages 3 to 10). Given this, we included individual participants' age of first exposure to English in the analysis, as a way to understand whether individual differences in age of acquisition modulated the accuracy with revision in the L2 (see Montrul, 2008b for the effects of timing on variable age of exposure). Interestingly, we did not find any effect of age of first exposure to English, suggesting that age of acquisition may not be a contributing factor for the pattern of revision observed in the temporarily ambiguous sentences in adult child-L2 speakers.

In Experiment 2 we explore the role of prosody, and how prosodic cues to interpretation change native English speakers' and adult child-L2 speakers' interpretation of the same temporarily ambiguous sentences tested in Experiment 1.

3. Experiment 2

Previous studies on bilingual sentence processing have only recently begun to address the use of prosody in syntactic ambiguity resolution and revision (e.g.,

Dekydtspotter et al., 2008; Henry, DiMidio & Jackson, 2017). In Experiment 2, we use the same design as in Experiment 1 but added prosodic cues that could be used to guide listeners to resolve the PP-attachment ambiguity. The goal is to investigate the interplay between prosodic cues and contextual information by concurrently presenting both types of information to participants. As in Experiment 1, we look at early and later effects of syntactic ambiguity during listening, and compare on-line processing and off-line comprehension to understand if adult child-L2 speakers' interpretation is guided by prosodic information. A similar sample of adult child-L2 speakers as in Experiment 1 was recruited and compared to a native English-speaking group.

Two possible scenarios may arise for adult child-L2 speakers when faced with both types of information (i.e., referential context and prosody) simultaneously. In one scenario, the integration of the prosodic information could aid the revision difficulties observed in Experiment 1; this would result in no differences in the eye-movement patterns or the off-line actions between the adult child-L2 speakers and the native English speakers. In a second scenario, the interpretation of the adult child-L2 speakers may be positively affected by the use of prosody, which would be expected to be manifested by a general decrease in looks and actions to the incorrect goal. However, the bilinguals may still adopt the simplest syntactic structure (i.e., the VP interpretation structure) more often than the native English speakers, even when the prosodic cues support a more complex syntactic structure. In this case, the results would support the hypothesis that the adult child-L2 speakers, unlike the native controls, have taxed cognitive resources in order to perform syntactic reanalysis (Novick et al., 2005).

3.1 Participants

Twenty-two native English speakers (mean age: 22 years; SD: 6) and 26 adult child-L2 speakers of English (mean age: 20 years; SD: 2) participated in the study. Both groups of speakers were undergraduate students at a large US university, and received course credits for their participation. We only included in the native English-speaking group, participants who reported not being fluent in any language other than English. The sample of adult child-L2 speakers resembled the sample recruited for Experiment 1 in that the societal background and language learning context of these participants was very similar in the two samples. The child-L2 adults were highly proficient in English and had childhood exposure to English, similar to the participants in Experiment 1 (age range: 3–10 years; mean age: 6; SD: 3). As in Experiment 1, we do not have information on whether the child-L2 adults had any school instruction in Spanish. As in Experiment 1only the adult child-L2 speakers who scored more than 75% of correct answers on

the MELICET were invited to participate in the eye-tracking study (mean = 41; range = 38–47; SD = 2.5). As an additional check to ensure that the two groups of child-L2 adults were similar, we compared their scores of the MELICET. The scores did not differ significantly ($p = 0.08$), indicating that the two groups had comparable proficiency in English.

In Table 4, we present information collected with the LHQ on the language background of the adult child-L2 speakers.

Table 4. Experiment 2: Participant information: Mean (SD)

	Spanish – L1	**English – L2**
Age of exposure (participants number)	0 y.o.	3 y.o.; 4/26
		4 y.o.: 4/26
		5 y.o.: 3/26
		6 y.o.: 6/26
		8 y.o.: 5/26
		9 y.o.: 2/26
		10 y.o.: 2/26
Length of residence in a country where the language is spoken	11 (9)	16 (8)
Speaking (% average daily)	45 (28)	55 (29)
Reading (% average daily)	21 (21)	79 (21)
Average daily exposure (%)	47 (20)	55 (22)
Speaking proficiency	9 (1)	8 (1)
Comprehension proficiency	9 (1)	9 (1)
Reading proficiency	8 (2)	8 (2)

3.2 Materials and procedure

The materials and procedure were the same as in Experiment 1. In the audio files, in addition to the disambiguating prosody used by the speaker, a 200 ms pause was inserted after the verb 'put' and a 300 ms pause was inserted after the first PP (e.g., Put *PAUSE* the frog on the napkin *PAUSE* into the box). The pause insertions provided a prosodic contour that favored an interpretation in which the first PP was the complement of the NP (frog), rather than of the verb 'put.'

To ensure that the prosodic manipulation resulted in the desired outcome, we compared the ambiguous stimuli in Experiment 1 and in Experiment 2. The digital waveforms of the recordings were examined to verify the presence/absence of breaks between (a) the verb 'put' and the first NP, (b) between the first NP1 and the preposition 'on,' and (c) between the second NP and the preposition 'onto'.

Additionally, word length was measured and compared across the ambiguous stimuli in the two experiments to verify that there were differences between the two types of utterances. In Snedeker and Yuan (2008), the VP attachment interpretation in a sentence such as 'You can feel the frog with the feather' included the following prosodic features: (a) the verb was shorter, (b) the post-verbal pause was longer, (c) the first NP and the following pause were longer, and (d) the PP was longer. Because our stimuli included a second PP that the Snedeker and Yuan's stimuli did not have, we expected a difference also in the length of the second PP. The measures and the statistical analysis are presented in Table 5.

Table 5. Mean length of words and pauses and SD in parentheses, by condition

Word	Ambiguous sentences Prosody Condition	Ambiguous sentences No Prosody Condition	Analysis
Put	0.17(0.05)	0.18(0.03)	$p < 0.41$
Verb pause	0.19(0.06)	0.019(0.02)	$p < 0.0001$
NP1	0.55(0.09)	0.66(0.09)	$p < 0.0001$
NP1 pause	0.01(0.03)	0.036(0.03)	$p < 0.062$
On	0.16(0.02)	0.18(0.03)	$p < 0.02$
NP2	0.69(0.09)	0.75(0.03)	$p < 0.048$
NP2 pause	0.05(0.03)	0.25(0.08)	$p < 0.0001$
Onto	0.30(0.02)	0.37(0.04)	$p < 0.0001$
NP3	0.72(0.12)	0.88(0.15)	$p < 0.0001$

The statistical analysis shows differences between the ambiguous sentences in Experiment 1 and Experiment 2, with the stimuli in Experiment 1 having significantly longer NP1 (e.g., 'the frog'), NP2 (e.g., 'the napkin'), NP3 (e.g., 'the box') and prepositions (i.e., 'on,' 'onto'). The analysis of the pauses shows longer breaks in the stimuli where prosody was manipulated between the verb and NP1, and between NP2 and 'onto,' consistent with the interpretation in which NP2 is the modifier of NP1. The analysis of the pause between the NP1 and the preposition 'on' shows the opposite pattern, even though the results of the statistical analysis only approach significance.

3.3 Results

Eye-tracking results

For consistency with Experiment 1, in Experiment 2 we compared the two groups on the proportion of looks to the incorrect goal in the 2000 ms following the onset

of the first PP[3] (e.g., 'on the napkin'), as shown in Figure 4. Trials with combined looking times of less than 30% for the whole 2000 ms time-window were discarded. These accounted for 4% of the trials.

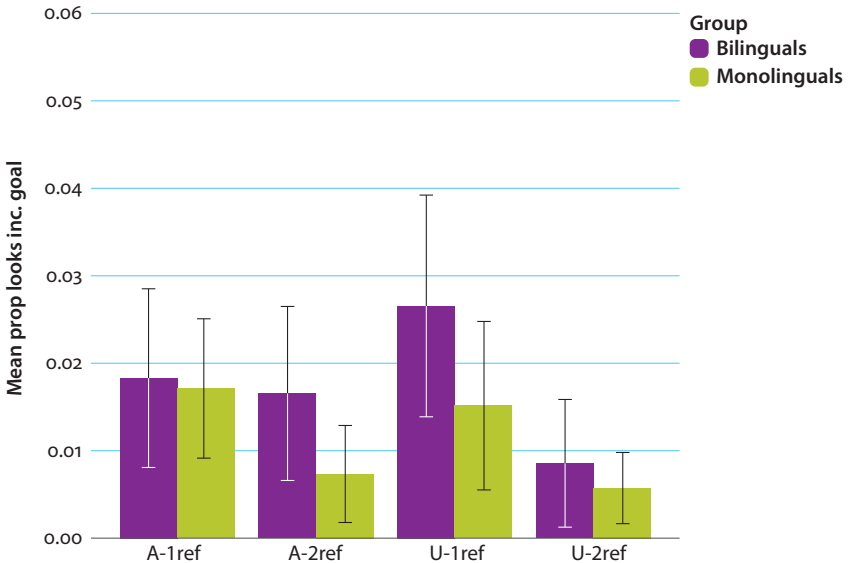


Figure 4. Experiment 2. Mean proportion of looks to the incorrect goal in the four conditions. Error bars represent 95% Confidence Intervals

The 2000 ms time-window included the first PP (measuring on average 1000 ms), the 300 ms pause inserted after the first PP, and the first 500 ms of the second PP (onto the box). We used a linear mixed-effects model to analyze the e-logit-transformed looks to the incorrect goal using the lmer function (*lme4* library, Bates & Sakar, 2007). The fixed effects in the model included Ambiguity (ambiguous vs. unambiguous), Referential Context (1 vs. 2 referents) and Group (native English speakers vs. adult child-L2 speakers of English), together with all interactions. The fixed factors were sum-coded, and then mean-centered, due to imbalance in the data. All interactions were allowed. The full model is presented in Table 6.

3. We analyzed a 2300 ms time-window in Experiment 2. Because a 300 ms pause was inserted in the audio stimuli after the first PP, a 2300 ms time-window includes exactly the same amount of lexical information compared to the stimuli in Experiment 1. Given that the findings did not change, we report here the results of the 2000 ms time-window for comparability with Experiment 1 and with previous studies (e.g., Pozzan & Trueswell, 2016).

Table 6. Experiment 2: Full model statistics for the analysis of looks to the IG (2000 ms following the first PP)

	Estimate	Std. Error	*t* value	*p* value
(Intercept)	−0.61	0.03	−17.87	0.001***
Group	−0.03	0.06	−0.53	0.5
Ref.Context	−0.01	0.01	−0.61	0.5
Ambiguity	0.01	0.02	0.82	0.4
Group*Ref.Context	−0.01	0.02	−0.51	0.6
Group*Ambiguity	−0.005	0.03	−0.16	0.8
Ref.Context*Ambiguity	−0.02	0.03	−0.72	0.4
Group*Ambiguity*Ref.Context	−0.01	0.04	−0.23	0.8

Notes
Significance levels throughout the paper:
† $p < .10$;
* $p < 0.05$;
** $p < 0.01$,
*** $p < 001$
The maximal random effect structure leading to convergence includes by subject and by item random intercepts, with by subject random slopes for the effects of referential context and ambiguity and their interaction and by item random slopes for the effects of ambiguity and referent and their interaction.

Given the small amount of looks to the incorrect goal in Experiment 2, and the high group variability, the model did not show any significant effect or interaction. Furthermore, the absence of a main effect of Group indicates a comparable number of looks to the incorrect goal by native English speakers and adult child-L2 speakers in all conditions.

Off-line actions

The scoring and analysis of the actions followed the same procedure and criteria described in Experiment 1. Figure 5 summarizes the action results.

The fixed effects in the model included Ambiguity (ambiguous vs. unambiguous), Referential Context (1 vs. 2 referents) and Group (native English speakers vs. adult child-L2 speakers of English), together with all interactions. The fixed factors were sum-coded, and then mean-centered, due to imbalance in the data. All interactions were allowed. The results of the full model are given in Table 7.

The analysis revealed a main effect of Ambiguity, showing more actions to the incorrect goal in the ambiguous conditions, and a main effect of Group, indicating more actions to the incorrect goal in the bilingual than in the monolingual group. We also found a significant interaction between Group and Ambiguity. We followed up on the interaction between Group and Ambiguity by comparing the two groups on the ambiguous vs. unambiguous condition. The number of incorrect

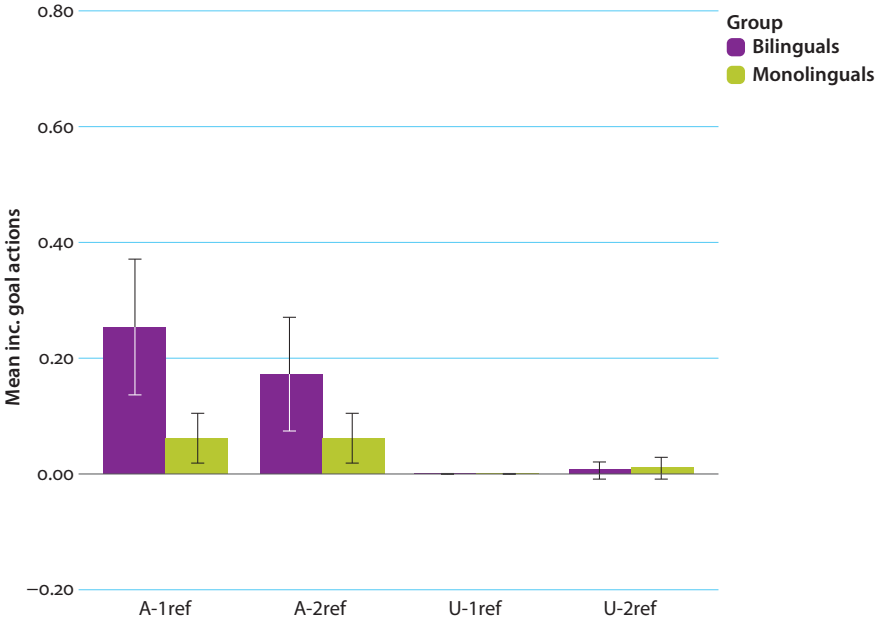


Figure 5. Experiment 2. Proportion of incorrect goal actions in the four conditions. Error bars represent 95% Confidence Intervals

Table 7. Experiment 2: Full model statistics for the actions' analysis

Fixed effects:				
	Estimate	**Std. Error**	***t* value**	***p* value**
(Intercept)	.006	0.01	3.8	
Group	.07	0.02	2.48	0.01**
Ref.Context	−.01	0.01	−1.03	0.3
Ambiguity	−.12	0.03	−3.73	0.001***
Group*Ref.Context	−.03	0.02	−1.49	0.1
Group*Ambiguity	−.14	0.05	−2.58	0.01**
Ref.Context*Ambiguity	−.04	0.02	1.60	0.11
Group*Ambiguity*Ref.Context	.07	0.05	1.43	0.1

Notes
Significance levels throughout the paper:
† $p < .10$;
* $p < 0.05$;
** $p < 0.01$,
*** $p < 001$
The maximal random effect structure leading to convergence includes by subject and by item random intercepts, with by subject random slopes for the effects of referential context and Ambiguity and their interaction and by item random slopes for the effects of Ambiguity and Referent.

goal actions per each subject and item was coded as 1 or 0, and was analyzed using the binomial glmer function (*lme4* library, Bates & Sarkar, 2007). The alpha was set at 0.05.

The planned comparisons showed a significant difference between the native English speakers and the child-L2 adults on the ambiguous condition (*Estimate* = 0.07, *SD* = 0.02, $t = 2.653$, $p < 0.01$), with child-L2 adults performing significantly more incorrect goal actions than the native English speakers in the ambiguous conditions. No significant effects emerged for the unambiguous condition (*Estimate* = −0.00, *SD* = 0.002, t=−0.127, $p < 0.89$). We also analyzed the data for the child-L2 adults and the native speakers of English separately. For the adult child-L2 speakers, the analysis revealed a main effect of Ambiguity (*Estimate* = −2.4, *SD* = 0.7, t=−3.361, $p < 0.0007$). For the native English speakers, we did not find any main effect or interaction.

As in Experiment 1, we tested the role of age of acquisition in the off-line accuracy of adult child-L2 speakers. We fitted models to the off-line actions, adding Age of Acquisition as a main factor (*z*-scored), with all interactions allowed. For the analysis including Age of Acquisition, no significant effects or interactions with this factor were found (all $p > .1$).

Interim discussion

The eye-tracking data in Experiment 2 did not reveal any difference between the native English-speaking participants and the adult child-L2 speakers of English. We can conclude, then, that the adult child-L2 speakers are not more prone to show a garden path effect than the native English speakers when prosody is present in the ambiguous conditions. However, the overall low amount of looks to the incorrect goal in the eye-tracking task and the variability across participants did not produce any effect across the four experimental conditions. The fact that overall there were very few looks to the incorrect goal in both groups is additional confirmation that our prosodic manipulation was consistent with the NP-modifier interpretation of 'on the napkin'.

For both groups, we observed an overall decrease in incorrect goal actions resulting from the presence of the prosodic information included in the spoken instructions. In the native English-speaking group, the percentage of actions to the incorrect goal dropped to about 5% in Experiment 2 in both ambiguous conditions. These results confirm the active use of prosodic cues observed in previous studies on temporarily ambiguous sentences with monolingual English speakers (e.g., Snedeker & Yuan, 2008). In comparison to Snedeker and Yuan (2008), the native English speakers who participated in the current study seemed to have performed more accurately on the ambiguous sentences (5% of incorrect goal actions

compared to about 20% in Snedeker and Yuan). In Snedeker and Yuan (2008), listeners were tested on potentially ambiguous sentences that were produced by a participant in the experiment, and although the speakers used disambiguating prosody in most of their (potentially ambiguous) utterances (68%), the cue was not as reliable as in our experiment, where it was consistent across all ambiguous trials. Therefore, our results show that when prosodic disambiguation is consistent in all ambiguous sentences, monolingual speakers use it as a reliable cue. The decrease in actions also confirms that our prosodic manipulation was consistent with the NP-modifier interpretation of 'on the napkin'.

The bilingual group demonstrated use of the prosodic information, with an overall decrease in incorrect goal actions. However, the action results revealed an interaction between Group and Ambiguity, suggesting that bilingual participants perform more incorrect goal actions in the ambiguous condition in Experiment 2 compared to the native English participants. The results suggest that despite the additional prosodic cues, the adult child-L2 speakers of English are guided to the target (NP attachment) interpretation significantly less often than the native English speakers in both referential contexts, even if they are processing their dominant language. Interestingly, the action analysis in Experiment 2 revealed that the additional prosodic information was used significantly less efficiently by the child-L2 speakers, even when there were two referents in the context (i.e., when the integration of the referential information should have helped towards re-analysis to an NP attachment interpretation). Furthermore, the bilingual group in Experiment 2 is not only highly proficient in English but is also immersed in the L2, and has been exposed to the L2 since childhood. Despite this, we did not find any effect of referential context in the action analysis, showing that the adult child-L2 speakers seem to experience a processing cost associated with the revision process in comparison to native English speakers in both ambiguous conditions, when both prosodic and referential information is provided. Additionally, age of first exposure to English did not seem to play a role in the adult child-L2 speakers' off-line accuracy.

Even though the prosody manipulation was not designed within-participants across Experiment 1 and 2, the native English speaking group and the bilingual participants in the two experiments have comparable age and language profiles. Therefore, we performed a comparison of the native English speakers' and adult child-L2 speakers' results across the two experiments to provide a clearer picture on the effect of prosodic cues on the processing of temporary ambiguous sentences.

4. Comparison between Experiment 1 and Experiment 2

To compare the results of the two experiments, we focused on the action results in the two ambiguous conditions. We used the statistical analysis described in Experiment 1 and 2. The fixed effects in the model included Prosody (No Prosody/Experiment 1 vs. Prosody/Experiment2), Referential Context (1 vs. 2 referents) and Group (native English speakers vs. adult child-L2 speakers of English), together with all interactions. The results of the full model are presented in Table 8.

Table 8. Full model statistics for the analysis of Actions to the IG in Experiment 1 and Experiment 2

	Estimate	Std. Error	*t* value	*p* value
(Intercept)	−2.92	0.26	−10.97	0.001***
Prosody	−0.71	0.28	−2.51	0.01**
Ref.Context	−0.36	0.22	−1.65	0.09
Group	1.10	0.39	2.80	0.001***
Ref.Context* Prosody	0.20	0.44	0.46	0.6
Group* Prosody	0.63	0.48	1.29	0.1
Group*Ref.Context	−0.72	0.44	−1.63	0.1
Group* Prosody *Ref.Context	0.38	0.88	0.42	0.6

Notes
Significance levels throughout the paper:
† $p < .10$;
* $p < 0.05$;
** $p < 0.01$,
*** $p < 001$
The maximal random effect structure leading to convergence includes by subject and by item random intercepts.

The analysis revealed a main effect of Prosody, indicating more actions to the incorrect goal in the ambiguous conditions in Experiment 1 (no prosody condition) compared to Experiment 2 (prosody condition). We also found a main effect of Group, indicating more actions to the incorrect goal in the ambiguous conditions in the bilingual group compared to the monolingual group. None of the interactions were statistically significant.

General discussion

In Experiment 1, we found that when adult child-L2 speakers of English processed in their dominant language, they experienced increased revision difficulties in the

1-referent condition relative to native English speakers. Specifically, in this condition the adult child-L2 speakers performed significantly more actions towards the incorrect goal compared to the native group. However, when the context provided an alternative referent (as in the 2-referent condition), the bilingual speakers were as successful as the native English speakers at revising the ambiguous instructions, showing that they can integrate referential information and use it to disambiguate the syntactic structure. In Experiment 1, the on-line results showed a similar pattern as the off-line actions, confirming that referential context contributes to the processing and the interpretation of ambiguous syntactic structures. The analysis of the looks to the incorrect goal revealed that adult child-L2 speakers are not led down the garden path more than native English speakers; rather, they experience more difficulties with the revision process, as demonstrated by the action analysis. While referential information is integrated successfully in adult child-L2 speakers of English and native English speakers alike, the absence of disambiguating information is associated with less efficient revision in the former group compared to the latter.

In Experiment 2, the temporary ambiguous sentences contained prosodic cues to the NP attachment interpretation. We found a statistically significant decrease in incorrect goal actions in both the native English speakers and the adult child-L2 speakers of English in Experiment 2 compared to Experiment 1, indicating successful use of prosodic information. However, the adult child-L2 speakers still performed significantly more incorrect goal actions than the native English speakers in the ambiguous conditions. The eye-tracking data in Experiment 2 suggest no difference between the native English-speaking participants and the adult child-L2 speakers in the early stages of processing the syntactic ambiguity when prosody is salient. The results of the prosodic manipulation suggest that prosody aids the interpretation of temporary ambiguous sentences in both groups of participants. As observed in Experiment 1, adult child-L2 speakers generally produced more incorrect goal interpretations. In Experiment 2, they seemed to benefit less from the presence of the prosodic cues in comparison to native English speakers. Future studies should replicate this finding with a within-subject prosody manipulation, since this factor was not fully crossed in the present study.

Experiment 2 showed that when the integration of multiple sources of information (prosodic and contextual) can aid syntactic ambiguity resolution, adult child-L2 speakers still experience a processing cost associated with the revision process relative to native English speakers. Additionally, the analysis of the actions seems to suggest that the contextual information may be weighed less in the condition in which prosody is informative; groups with comparable proficiency in English performed differently between the incorrect goal actions in the ambiguous condition with either one or two referents. Even though this result should be taken

cautiously given the high individual variability in the responses of the bilingual group, the absence of a three-way interaction in the action analysis in Experiment 2 seems to suggest that when prosody is present, the referential context may not be integrated as efficiently in the revision process. Future research should address this observation in more detail and explore how adult child-L2 speakers adapt their use of different cues as properties of the input change (e.g., Fine, Jaeger, Farmer & Qian, 2013).

The eye-tracking results suggest that when adult child-L2 speakers select the syntactically simplest structure (i.e., VP attachment), they do so as often as native speakers of the target language, regardless of the cues available (referential context; referential context and prosody). We also found that higher processing costs with revision can be found in adult child-L2 speakers who process their proficient and dominant language, as shown by the action results.

The results of Experiment 2 showed that adult child-L2 speakers integrate multiple cues (referential context, prosody), but they do so less efficiently than native speakers. Like the native English speakers, the adult child-L2 speakers used non-syntactic information to constrain initial commitments in temporarily ambiguous sentences. Even though our participants had variable age of exposure to English, age of acquisition was not a reliable predictor of the observed performance.

The results of Experiment 1 and Experiment 2 raise important questions about bilingual syntactic processing and language dominance, suggesting that despite early exposure and high proficiency, adult child-L2 speakers revised an initial (erroneous) interpretation differently from native speakers. We discuss here three factors that may account for our results: (i) a potential cross-linguistic influence from Spanish; (ii) reduced exposure to English; (iii) a less efficient use of cognitive resources in adult child-L2 speakers of English compared to native English speakers.

Concerning the hypothesis that adult child-L2 speakers may have experienced cross-linguistic interference from Spanish, notice that in Spanish the equivalent structure of the ambiguous English sentences is not syntactically ambiguous when the preposition 'de' (English 'of') is used. However, if the preposition 'en' is used instead of 'de,' the Spanish counterpart of "Put the frog on the napkin into the box" is also syntactically ambiguous. Even though a similar syntactic ambiguity exists in Spanish, the L1 of the participants, we cannot completely rule out cross-linguistic influence as a potential underlying cause of the effect reported here. Notice that we did not test Spanish monolingual speakers in the present study. Although Spanish and English similarly favor attachment of a prepositional phrase introduced by a locative preposition to the main verb, one question is whether the bias of the verb in addition to a high attachment preference in Spanish may result in a stronger verb phrase attachment preference in Spanish relative to English. This, in turn,

may have influenced the parsing of the ambiguous sentences in Experiment 1 in absence of referential information. However, this explanation may not entirely account for the results of Experiment 2, and in particular for the observation that the adult child-L2 speakers showed lower accuracy in revising unambiguous sentences in English in the presence of referential and informative prosody. It seems unlikely that a parsing preference from the non-dominant language may have overridden the use of salient information, as are the referential context and prosody.

Concerning the two remaining factors, our participants had less exposure and later exposure to English than the native English participants; this has been shown to play a role in word and sentence production by previous research (e.g., Gollan, Slattery, Goldenberg, Van Assche, Duyck & Rayner, 2011). Additionally, as proposed by Sorace (2011), adult child-L2 speakers may have fewer cognitive resources to deploy for the reanalysis process even at the highest levels of proficiency, which may result in lower accuracy in the revision process (e.g., Novick et al., 2005; Pozzan & Trueswell, 2016). Our study confirms that adult child-L2 speakers of English do not show the same pattern of actions as native English speakers when performing syntactic processing of structures that require abandoning a preferred interpretation in favor of a less preferred one. The bilingual (i) language configuration and fluctuating exposure to the two languages, and (ii) the need to constantly manage language co-activation may impose high demands on the language control system of a bilingual, and consequently less cognitive resources may be available to perform concurrent tasks that also rely on cognitive control mechanisms (Novick et al., 2005; Woodard et al., 2015).

Our results underline the importance of extending the study of syntactic processing to a range of bilinguals with different degrees of dominance. Future studies should compare different bilingual populations to confirm if the effects observed are a general consequence of bilingualism, as we propose here.

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