Published in final edited form as:

Appl Psycholinguist. 2014 January 1; 35(1): 27–70. doi:10.1017/S0142716412000252.

Cross-linguistic differences in prosodic cues to syntactic disambiguation in German and English

Mary Grantham O'Brien¹, Carrie N. Jackson², and Christine E. Gardner²

¹University of Calgary

²Pennsylvania State University

Abstract

This study examined whether late-learning English-German L2 learners and late-learning German-English L2 learners use prosodic cues to disambiguate temporarily ambiguous L1 and L2 sentences during speech production. Experiments 1a and 1b showed that English-German L2 learners and German-English L2 learners used a pitch rise and pitch accent to disambiguate prepositional phrase-attachment sentences in German. However, the same participants, as well as monolingual English speakers, only used pitch accent to disambiguate similar English sentences. Taken together, these results indicate the L2 learners used prosody to disambiguate sentences in both of their languages and did not fully transfer cues to disambiguation from their L1 to their L2. The results have implications for the acquisition of L2 prosody and the interaction between prosody and meaning in L2 production.

Prosody—the rhythm, stress, and intonation of speech—enjoys a unique status in language. Infants show an exceptional sensitivity to prosody (e.g., Soderstrom, Seidl, Kemler Nelson, & Jusczyk, 2003), and this sensitivity remains relatively undisturbed even in the elderly (Hoyte, Brownell, & Wingfield, 2009). Broadly speaking, prosody performs a number of functions in language. These can be grammatical, affective, discourse-related, or sociolinguistic in nature. One important grammatical function that it serves is the segmentation of the speech stream into sentences and into smaller units or phrases. This role is especially relevant in the disambiguation of globally ambiguous sentences, such as the following:

- (1) Laura ran away with the man wearing a green robe.

Speakers who come across this sentence have two choices when they encounter the present participle *wearing*: along with the material that follows, it may provide additional material about *Laura* or *the man*. If it is interpreted as attaching to *Laura*, one would expect a break between *man* and *wearing*, as well as emphasis on the word *wearing*; however, an interpretation in which the man is wearing the robe would involve no boundary between *man* and *wearing*, since *wearing* provides additional information about *the man*, which directly precedes it. Experiments probing first language (L1) comprehension have shown that listeners make use of prosodic cues to disambiguate globally ambiguous sentences, like (1) above (e.g., Beach, Katz, & Skowronski, 1996; Streeter, 1978), and recent research by Dekydtspotter, Donaldson, Edmonds, Fultz and Petrusch (2008) and Fultz (2007) shows that

even beginning-level second language (L2) learners use auditory cues to disambiguate syntactically ambiguous sentences.

However, investigations into first language (L1) production show mixed results. In spite of an early sensitivity to prosody, Cruttenden (1986) showed that children generally master prosody later than other aspects of speech production. Moreover, native speakers of a language can rely on different prosodic cues to convey their intended meaning of an utterance (e.g., Schafer, Speer, Warren, & White, 2000; Scuffil, 1982). Therefore, it is not surprising that speakers' consistency in using prosodic cues to disambiguation may depend on the discourse situation and their awareness of ambiguity in the first place (e.g., Lingel, Pappert, & Pechmann, 2006; Snedeker & Trueswell, 2003; but see Kraljic & Brennan, 2005; Schafer, Speer, & Warren, 2005 for counterevidence). To date, we know of only one study that has compared bilingual participants' production of prosodic cues to disambiguation in their two languages (Fernández, 2005), and this was with early Spanish-English bilinguals. The question remains open as to whether and how late L2 learners will use prosodic cues to disambiguate utterances in each of their languages, especially considering research that suggest L2 prosody is acquired late (Pennington & Ellis, 2000) and that it is rarely acquired to nativelike levels (Gut, 2009; Mennen, 2004; Trofimovich & Baker, 2006).

The primary goal of the current study is to determine whether late English L2 learners of German and late German L2 learners of English reliably produce prosodic cues to disambiguate temporarily ambiguous prepositional phrase-attachment (PP-attachment) sentences when producing sentences in their L1 and their L2. Additionally, we seek to determine precisely which cues L2 learners use and whether these cues differ from those used by native speakers of the languages in question. As such, the present study speaks to broader questions regarding the ability of late L2 learners to acquire nativelike use of L2 prosody, and the issue of cross-language transfer of prosodic cues to syntactic disambiguation among speakers of more than one language.

Prosodic cues to disambiguation in English

The delimitation of speech into phrases is one central focus of prosody research (e.g., Selkirk, 2005; Watson, Breen, & Gibson, 2006).¹ Prosody is used by speakers, among other things, to group syntactic constituents together and to provide additional structure within sentences (e.g., Nespor & Vogel, 1986). Numerous studies have used explicit prosody to determine the extent to which listeners make use of various prosodic cues in their L1s. For example, the native English participants in Streeter's (1978) study relied on duration and pitch contour in an additive fashion to locate the phrase boundaries in globally ambiguous algebraic expressions such as *A plus (E times O)* and *(A plus E) times O*. In a series of studies, the speech samples were manipulated from their original versions on the three variables of pitch, amplitude, and duration. Manipulations of pitch and duration—both alone and in combination—affected the listeners' judgments, but amplitude manipulations did not produce cues that listeners could use reliably (see also Beach et al., 1996; Hoyte et al., 2009; Scott, 1982). The results of these and other comprehension studies show that listeners use prosodic cues to resolve syntactic ambiguity in their L1s (see also Kang & Speer, 2005; Kjølgaard & Speer, 1999; Lehiste, Olive, & Streeter, 1976; Schafer et al., 2000).

Recent investigations into PP-attachment show that listeners also rely on prosodic cues to determine which of the preceding elements the prepositional phrase modifies. For example,

¹The focus of the current research is intonational phrasing (as achieved through the presence of intonational boundaries marked by means of increased duration and pitch movements). We are not interested in describing with precision where those boundaries fall in the intonational hierarchy (as intonational phrases, major phrases, or minor phrases).

without additional information, it is ambiguous whether one should interpret example (2) to mean that one should tap the frog who is holding a flower—referred to here as NP-attachment—or whether one should use the flower to tap the frog—referred to here as VP-attachment.

- (2a) Tap the frog with the flower. (ambiguous)
- (2b) Tap | the frog with the flower. (NP-attachment)
- (2c) Tap the frog | with the flower. (VP-attachment)

However, the insertion of phrasal boundaries (marked above with “|”) can disambiguate these two different interpretations for listeners in English (e.g., Kraljic & Brennan, 2005; Pynte & Prieur, 1996; Schafer et al., 2005; Snedeker & Trueswell, 2003; Snedeker & Yuan, 2008; Straub, 1997). Thus, in example (2b), with a boundary between the verb and the direct object, the preferred interpretation is that the frog is holding a flower, and in (2c), with a boundary between the direct object and the prepositional phrase, the preferred interpretation is that the tapping is being done with the assistance of the flower. Results of comprehension studies show that listeners do rely on cues to disambiguation in sentences such as (2) above, especially when the cues to disambiguation are robust (e.g., Kraljic & Brennan, 2005; Snedeker & Trueswell, 2003; Snedeker & Yuan, 2008).

Complementing these results examining listening comprehension, PP-attachment production studies involving native speakers of English show variable results in terms of the strength and similarity of the cues produced across participants. Schafer et al. (2005) found that their 16 naïve participants lengthened the direct object noun and the following pause in VP-attachment sentences in a cooperative game task. Further, the authors found no effect of situational ambiguity, namely whether the sentence to be produced was globally ambiguous, unambiguous or biased toward NP- or VP-attachment (see also Kraljic & Brennan, 2005). Similarly, the four FM radio announcers who produced the stimuli in Price, Ostendorf, Shattuck-Hufnagel and Fong (1991) relied primarily on duration and pause as a cue to disambiguation in their PP-attachment sentences, four with each type of attachment. Although Price et al. investigated the role of an additional acoustic cue, pitch accent (i.e., the relative F0 prominence as related to the rest of the constituent), they did not find that participants used this cue consistently to disambiguate the target sentences.² Based on their findings, both studies concluded that speakers produced larger prosodic breaks for VP-than for NP-attachment sentences.

In contrast to Schafer et al. (2005), only the 32 female speakers of American English who were aware of the syntactic ambiguity in Snedeker and Trueswell's (2003) referential communication task reliably produced prosodic cues to disambiguation in their production of four sentences of each attachment type. In the NP-attachment condition, participants lengthened the verb and placed a pause before the direct object. In the VP-attachment condition, they placed a pause between the direct object noun and the preposition *with* and lengthened the direct object noun and prepositional phrase. Participants were also more likely to place a pitch accent on the preposition *with* in VP-attachment sentences, providing a further cue to VP-attachment. On the other hand, the 32 female participants who took part in the second experiment were only expected to produce one type of attachment: either NP- or VP-attachment. These speakers' cues to disambiguation—although still present—were not as reliable as were those produced by the participants in experiment 1 (see also Straub, 1997).

²In a prepositional phrase, a pitch accent on the preposition acts to delimit the left-edge boundary, thereby strengthening the boundary effect.

The acoustic analysis of experimental stimuli produced by a single speaker in a later comprehension study (Snedeker & Yuan, 2008) found similar phonetic realizations of prosodic boundaries with regard to duration, pausing, and the presence of a pitch accent on the preposition *with* in VP-attachment sentences. Using the ToBI prosodic labeling system (Beckman & Hirschberg, 1994), Snedeker and Yuan also reported an F0 rise on the verb in NP-attachment conditions. However, elsewhere there was no consistent use of F0 contour to distinguish NP- from VP-attachment sentences, leading them to argue that the pause may be the most reliable cue to disambiguation in English (see also Cooper & Paccia-Cooper, 1980; Snedeker & Trueswell, 2003; but see Straub, 1997 for counterevidence). To summarize, potential cues to indicate prosodic boundaries in PP-attachment sentences in English include lengthening (both of individual constituents and the use of pause) and pitch accent on the preposition after the boundary, with lengthening being the most robust cue in both perception and production. An additional cue to NP-attachment may be a rise in pitch on the verb in NP-attachment sentences. Some of the acoustic cues to disambiguate NP- from VP-attachment sentences in English are highlighted in Figures 1 and 2 below.

Prosodic cues to disambiguation in German

Since German is an intonation language like English, its speakers and listeners draw on a similar set of prosodic cues. Lingel, Scheepers, Mohr, and Pechmann (2007) and Lingel et al. (2006) found that native speakers of German can use prosodic information to disambiguate NP- from VP-attachment sentences, like (3) below, similar to findings reported for English. With regard to speech production, similar to Snedeker and Trueswell (2003), Lingel et al. (2006) found that speakers' awareness of the ambiguity played a role in the production of cues to disambiguation. The 16 female native speakers of German differed marginally in how they distinguished 12 NP- from 12 VP-attachment sentences when they were not explicitly instructed to do so when producing globally ambiguous PP-attachment sentences, like (3).

(3) Berühre den Adler mit der Socke.

“Touch the eagle with the sock.”

Those participants who reported being aware of the ambiguity relied on durational cues to disambiguation. They produced a postverbal boundary by lengthening the verb *berühre* “touch” and the pause that followed in NP-attachment sentences. In VP-attachment sentences, the boundary following the direct object was created via lengthening of the direct object noun *Adler* “eagle” and the pause that followed. Participants who were unaware of the ambiguity did not produce reliable cues to disambiguation and instead relied on a default VP-attachment prosody in both attachment conditions. However, when these same 16 participants were explicitly instructed to disambiguate, they produced more reliable cues. When they produced NP-attachment sentences, they lengthened the postverbal pause and produced a higher F0 on the article of the direct object *den* “the”. For VP-attachment sentences, they lengthened the preboundary (i.e., direct object) noun and the pause before the prepositional phrase *mit der Socke* “with the sock” and produced a higher F0 rise near the end of the direct object noun *Adler* “eagle”.

To summarize, similar to English, native speakers and listeners of German may use lengthening as a potential cue to PP-attachment disambiguation. Native speakers of German may also rely more on pitch rise than native speakers of English. Specifically, a rise in pitch on the direct object is an important cue to the disambiguation of German VP-attachment sentences. Previous studies have not investigated whether pitch accent on the preposition is a reliable cue to disambiguation in German. Some of the potential cues distinguishing NP- from VP-attachment sentences in German are shown in Figures 3 and 4 below.

Prosodic cues used in an L2

In general, research into L2 perception has shown that listeners use different auditory cues depending on their L1 backgrounds. This is true at the segmental level (e.g., Escudero, Benders, & Lipski, 2009; Flege, Bohn, & Jang, 1997), and it extends to the perception of words and word boundaries (e.g., Cutler, 2009; Tyler & Cutler, 2009; Weber & Cutler, 2006). However, fewer studies have investigated the perception or production of prosodic cues to disambiguation at the sentence level among L2 learners. Using an acceptability judgment task, Fultz (2007) investigated whether L2 learners of French (L1 English) were sensitive to mismatches between the prosodic structure of globally ambiguous PP-attachment sentences and a larger discourse context that biased the target sentence towards either a NP- or VP-attachment interpretation. Similarly, Dekydtspotter et al. (2008) reported that at least a subset of fourth-semester L2 learners of French was also sensitive to the use of prosodic cues to disambiguate ambiguous relative-clause attachment sentences, like *Nous adorons le secrétaire du psychologue qui se promène au centre ville* “We adore the secretary of the psychologist who walks downtown”, in which it is ambiguous whether the relative clause describes *le secrétaire* “the secretary” (high-attachment) or *le psychologue* “the psychologist” (low-attachment). The results of these studies indicate that even less-proficient L2 learners exhibit some sensitivity to prosodic cues to disambiguation when processing L2 auditory input. Further, as proficiency increases, L2 learners’ ability to use prosodic information to guide their interpretation and judgments of ambiguous L2 sentences becomes increasingly nativelike.

To our knowledge, Fernández (2005) is the only study to investigate prosodic cues in speech production—as opposed to comprehension—as it relates to the disambiguation of syntactically ambiguous sentences among speakers of more than one language. She examined the prosodic features of eight English and eight Spanish monolinguals and 12 early Spanish-English bilinguals when reading aloud four versions of eight different sentences containing RC-attachment ambiguities, similar to those studied by Dekydtspotter et al. (2008). Results showed that the bilingual participants produced clear prosodic breaks when producing sentences in both languages. However, differences appeared in how such prosodic breaks were realized between the monolingual and bilingual participants, both with regard to the duration of constituents preceding possible intonational boundaries and pitch movements prior to these boundaries. Whereas she attributes the differences in phrasing patterns to performance limitations, Fernández concludes that the differences in intonational patterns were due to the speakers’ underlying competence in the L2.

More broadly, research has shown that among late L2 learners, L2 prosody differs from that produced by native speakers in speed of delivery, with L2 speech being less fluent (e.g., Gut, 2009; Trofimovich & Baker, 2006). Further, researchers including Wennerstrom (1994) and Gut (2009) found that L2 learners are less consistent than native speakers in using pitch to signal meaningful contrasts. For example, in a study investigating the interaction between prosody and information structure, Gut (2009) reported that L2 learners of English often emphasized given information, including pronouns, in contrast to native speakers of English, who are more likely to place emphasis on new information. Additionally, the L2 learners of English differed from native speakers in the direction of pitch movement (i.e., rise vs. fall) on various sentence constituents (see Ramírez Verdugo, 2002, for similar findings).

There is some question regarding the extent to which such signs of non-nativeness in L2 prosody can be traced to prosodic aspects of L2 learners’ L1s. Some argue that there is evidence of transfer from the L1, especially in the early stages of acquisition (e.g., Gut, 2003, 2009; Jilka, 2007; Kim & Kim, 2001). Perhaps the most substantial evidence in favor of L1 transfer effects to L2 prosody comes from Atterer and Ladd (2004), who found that

native speakers of German differed in their tonal alignment patterns (i.e., the alignment of F0 troughs and peaks in relation to the individual segments within a syllable) in L2 English according to their L1 dialects. Further, even with L1–L2 pairings that are maximally similar in their tonal inventories and intonational contours, like English and German, studies have shown that L2 learners differ from native speakers in their phonetic realizations of these intonational contours in their L2 (e.g., Grosser, 1997; Gut, 2009; Mennen, 2007).

Present study

The languages paired in the current study are German and English, intonation languages that use prosodic cues including lexical stress, pitch accents, and boundary tones to express contrasts (e.g., Féry, 1993; Peters, 2006). In spite of apparent similarities in their prosodic systems, recent studies have shown acoustic differences between the two languages, including, most importantly, differences in pitch range and pitch variation over the course of an utterance (Gut, 2009; Jilka, 2000, 2007; Mennen, 2007). Therefore, an exploration into how English-German L2 learners and German-English L2 learners make use of prosodic cues, and pitch variation in particular, allows us to investigate potential transfer effects—both from the L1 into the L2 and from the L2 back onto the L1.

Additionally, by focusing on the production of temporarily ambiguous PP-attachment sentences, the present study can pinpoint how L2 learners use prosodic cues to disambiguate ambiguous sentences without the potential confound of cross-linguistic differences at the syntactic level. PP-attachment ambiguities are maximally similar between German and English, and previous sentence processing research has shown a generalized preference for VP-attachment in both languages, although this preference can be overridden with certain verbs (e.g., Konieczny, Hemforth, Scheepers, & Strube, 1997; Spivey-Knowlton & Sedivy, 1995). At the same time, studies have shown that native speakers in both languages can produce prosodic boundaries to help disambiguate ambiguous PP-attachment sentences, and further, that listeners will take advantage of such prosodic cues during comprehension (e.g., Kraljic & Brennan, 2005; Lingel et al., 2006; Price et al., 1991; Schafer et al., 2005; Snedeker & Trueswell, 2003).

If late L2 learners—like native speakers and early bilinguals—can use prosodic cues to disambiguate temporarily ambiguous sentences during speech production, one would predict that they should successfully disambiguate locally ambiguous PP-attachment sentences in an L2 (e.g., Fernández, 2005). At the same time, previous research has shown that a rise in pitch may not be a reliable cue to PP-attachment disambiguation in English (e.g., Lehiste et al., 1976; Schafer et al., 2005; Snedeker & Yuan, 2008).³ In contrast, the German participants in Lingel et al. (2006) reliably produced differences in the F0 contour to disambiguate both VP- and NP-attachment sentences, suggesting that a rise in pitch may play a more important role in syntactic disambiguation in German. Thus, if late L2 learners engage in the wholesale transfer of prosodic cues from their L1 to the L2, the prosodic cues used by English-German L2 learners may differ from those of German native speakers, especially with regard to intonational cues, like pitch rise (Fernández, 2005; Gut, 2009) and, conversely, the prosodic cues used by German-English L2 learners may differ from those used by English native speakers. However, if late L2 learners can successfully use specific prosodic cues, including intonational cues, to convey the intended meaning of an L2 utterance, then one would predict English-German L2 learners' and German-English L2 learners' cue use to parallel native speakers of each language when producing temporarily ambiguous German and English PP-attachment sentences.

³This is not to say that English does not rely on a rise in pitch for other purposes, most notably for yes-/no-questions.

Experiment 1a

Participants—Sixteen late-learning American English-L2 German learners were recruited from a study abroad program in Marburg, Germany. However, one participant had been in Germany less than a month at the time of testing and four participants scored at or below the B1 level on the accompanying proficiency task, so the data from these five participants were not included in any analyses reported here. The remaining 11 participants (7 females) were between 21 and 29 years old ($M = 22.8$) and had been living in Germany for at least three months prior to testing ($M = 15.4$ months; range: 3–78). To assess the participants' L2 German proficiency, they completed a 30-question multiple-choice German grammar and vocabulary test (Goethe Institut, 2004). All participants scored at least 18 points on this task ($M = 22.0$, $SD = 3.10$), which corresponds to the level B2 on the Common European Framework of Reference scale.

The proficiency test provides us with a measure of participants' grammatical accuracy. As this experiment probed participants' spoken language—in particular temporal aspects of speech including pauses and duration—it was also important to include a measure of their oral fluency. The participants therefore completed a picture description task, also known as the “suitcase narrative”, that has been used in previous studies (e.g., Derwing, Munro, Thomson, & Rossiter, 2009) to measure L1 and L2 fluency.⁴ In this task participants were presented with a series of drawings depicting a short story. In line with other studies that have investigated temporal aspects of fluency (e.g., Derwing et al., 2009; Derwing, Rossiter, Munro, & Thompson, 2004; Munro & Derwing, 1994; Munro, 1995; Piper & Cansin, 1988), the first twenty seconds of participants' recordings were analyzed for mean length run (MLR), the number of pauses per second, and speech rate—defined as the number of syllables divided by the total phonation time—as these measures have been shown to correlate with native speaker ratings of fluency (Cucchiari, Strik, & Boves, 2000). These measures were obtained using a script for Praat (Boersma & Weenink, 2009) developed by de Jong and Wempe (2009) that detects syllable nuclei and measures speech rate. Results from these analyses are reported in Table 1.

Temporal measures of speech are only one aspect of overall fluency, since these measures also include filled pauses and repetitions. For this reason, a second fluency analysis was run on the proportion of filled pauses and repair phenomena, as these have also been used as a fluency measure of L2 speech (Hasselgren, 2002; Temple, 2000). These include nonlexical fillers, such as *um*, and repetitions and self-corrections of one or more syllables. The resulting measures presented in Table 1 are a proportion of the total number of syllables produced. T-tests comparing fluency measures in their L1 English to their L2 German revealed no significant difference in the mean length run, speech rate and the proportion of filled syllables (MLR: $t(10) = 1.78$, $p = .106$; Speech rate and Filled syllables $t < 1$).⁵ However, the L2 participants paused more often and exhibited a greater proportion of repetitions in German than in English (Pause/sec: $t(10) = -3.48$, $p < .01$; Repetitions: $t(10) = -3.21$, $p < .01$). A second set of t-tests comparing the English-German L2 learners' fluency measures in their L2 German to the L1 German fluency measures from the German-English L2 learners in Experiment 1b revealed no significant difference in mean length run, pauses per second or the proportion of repetitions (all $ts < 1$). However, the English-German L2 learners exhibited a slower speech rate in their L2 German compared to the German-English L2 learners and the difference in the proportion of filled pauses was marginally significant (Speech rate: $t(22) = 3.36$, $p < .01$; Filled syllables: $t(15.21) = -1.82$, $p = .089$). These

⁴This task was used with permission from M. J. Munro and T. M. Derwing.

⁵For all between-group *t*-tests, equal variance between groups was assumed. When Levene's test for homogeneity of variance indicated that this assumption was not met, corrected degrees of freedom and *p*-values are reported.

comparisons suggest that while the English-German L2 learners were not near-native speakers of German, they spoke German with relative ease.

Materials—The main task in this study was a contextualized speaking task similar to that used by Straub (1997) (see also Price et al., 1991). Participants were recorded reading sentences, like (4b) and (5b), aloud. In half of the target sentences, the sentence-final prepositional phrase modified the direct object (NP-attachment), as in (4b), and in half of the sentences the prepositional phrase modified the verb (VP-attachment), as in (5b).⁶ Although presented together here, the participants completed all German language tasks in one testing session followed by a second session two weeks later in which they completed all English language tasks.

- (4a) Die Königin kaufte dem König zwei Kronen als Geschenk und versteckte sie. Eine Krone hatte große Edelsteine, die Andere war aus Silber. Der König suchte überall seine Geschenke.
 “The queen bought the king two crowns as presents. One crown had large jewels on it. The other was silver. The king searched everywhere for his presents.”
- (4b) Der König sah die Krone mit den großen Edelsteinen. (NP-attachment)
 “The king saw the crown with the large jewels.”
- (5a) Eine Krone war in einem Museum in England. Der König musste sich entscheiden, ob er sie selbst sehen wollte oder ob er seinen Diener schicken würde
 “A crown was in a museum in England. The king had to decide if he should see the crown himself or if he would send his servant.”
- (5b) Der König sah die Krone mit den eigenen Augen. (VP-attachment)
 “The king saw the crown with his own eyes.”
- (4'a) The queen bought the king two crowns as presents. One crown had large jewels on it. The other was silver. The king searched for his presents.
- (4'b) The king saw the crown with the large jewels. (NP-attachment)
- (5'a) A crown was in a museum in England. The king had to decide if he should go to the exhibit himself or send his servant to see it..
- (5'b) The king saw the crown with his very own eyes. (VP-attachment)

Each target sentence was preceded by a short context, like (4a) or (5a), that contextualized the target sentence and aided in the comprehension of the target sentences and provided the background knowledge necessary to interpret each target sentence as either an NP-attachment or a VP-attachment sentence. Participants read the context on a computer screen and listened to a recording of the context read aloud by a female native speaker of German in the German language task and by a female native speaker of American English in the English language task. After hearing and silently reading the context, the participant pressed the spacebar and the target sentence appeared below the context for the participant to read aloud. Participants were instructed to read the target sentence silently before reading it aloud and to produce the sentence in a manner that best matched the meaning of the target context.

To ensure that the target sentences were equally plausible in both their NP- and VP-attachment versions, 16 native speakers of German and 16 native speakers of English, none

⁶A complete list of stimuli is available on the first author's personal website (URL entered here).

of whom participated in the main experiment, rated the target sentences together with their contexts on a 7-point scale (1= *sehr plausibel* “very plausible”; 7 = *überhaupt nicht plausibel* “not at all plausible”). The target sentences were divided into two lists, so that participants only saw one version of any given item, and were presented along with 34 filler items in a semi-randomized order. The native speakers of German rated all target sentences lower than 5. The mean rating for all NP-attachment sentences in German was 2.98 and the mean rating for the VP-attachment sentences in German was 2.65, a difference that was not statistically significant ($t(13) = 1.03, p = .324$). The native speakers of English rated all items lower than 3. The mean rating for the NP-attachment sentences in English was 1.75 and the mean rating for the VP-attachment sentences in English was 1.72, a difference that was not statistically significant ($t < 1$).

While it is important to ascertain that all of the target sentences were plausible continuations of their preceding contexts, for the purposes of the present study it is also important to measure the relative implausibility of the alternative attachment site for each target sentence. Specifically, if the target sentences are only temporarily ambiguous and the intended attachment site is implied via the semantic content of the prepositional phrase, then the opposite interpretation—an NP-attachment interpretation of a VP-attachment sentence or a VP-attachment interpretation of an NP-attachment sentence—should be considered implausible. To test this hypothesis an additional plausibility task was conducted in which 16 native speakers of German and 16 native speakers of English, none of whom participated in the first plausibility task or the main experiment, rated the plausibility of such alternative interpretations, as in examples (6) below, using the same 7-point scale. These implausible alternatives were divided into two lists so that participants did not see more than one version of any item, and were presented in a semi-randomized order along with six plausible and two implausible filler items.

- (6a) Der König benutzte die großen Edelsteine, um die Krone zu sehen. (implausible VP interpretation of NP-attachment sentence)

“The king used the large jewels to see the crown.”

- (6'a) The king used the large jewels to see the crown.

- (6b) Der König sah die Krone, die eigene Augen hatte. (implausible NP interpretation of VP-attachment sentence)

“The king saw the crown that had its own eyes.”

- (6'b) The king saw the crown that had his very own eyes.

For the native speakers of German the mean rating for the NP interpretation of VP sentences was 5.9 and the mean rating for the VP interpretation of NP sentences was 4.5, a difference that was statistically significant ($t(13) = 2.68, p < .05$). For the native speakers of English the mean rating for the NP interpretation of VP sentences was 5.0 and the mean rating for the VP interpretation of NP sentences was 4.0, a difference that was not statistically significant ($t(13) = 1.68, p > .1$).

In one final norming task, the same 16 native speakers of German and 16 native speakers of English who rated the relative implausibility of the alternative NP- and VP-attachment sentences were then presented with the actual NP- and VP-attachment target sentences along with their corresponding context and asked to judge whether the sentence-final prepositional phrase provided more information about the direct object or the primary action of the sentence. For instance, with examples (4) and (5), participants were asked: *Informiert uns der unterstrichene Teil des Satzes mehr über die Krone oder die Art und Weise, wie der König die Krone sah?* “Does the underlined portion of the sentence provide more

information about the crown or the way the king saw the crown?" These target sentences were presented with eight filler items. The native speakers of German chose the intended meaning of the prepositional phrase 94.1% of the time for NP-attachment sentences and 98.1% of the time for VP-attachment sentences, a difference that was statistically significant ($t(13) = 2.26, p < .05$). The native speakers of English chose the intended meaning of the prepositional phrase 90.2% of the time in NP-attachment sentences and 97.3% of the time in VP-attachment sentences, a difference that was not statistically significant ($t(13) = 1.67, p > .1$). The fact that both the German and the English native speakers chose the intended interpretation of the prepositional phrase over 90% of the time highlights that although there was a difference in the relative plausibility of an alternative NP- or VP-interpretation of the target sentence when presented in isolation, once the target sentences were presented together with their preceding context, the intended attachment site for the prepositional phrase was unambiguous for both NP- and VP-attachment sentences.

The primary contextualized speaking task in each language contained 14 target sentence-context pairs. These 14 sentences were divided into two lists so that participants read seven NP-attachment and seven VP-attachment sentences, but they never read more than one version of any given item. These 14 target sentences were interspersed with 34 filler items. Only four of the filler items were identical to those used in the German experiment, and participants did not report recognizing these materials. As with the experimental items, the filler items were similar in both languages. For each of the two lists, the target and filler items appeared in a pseudo-randomized order, such that all experimental items were separated by at least one filler item. Each resulting presentation list was divided into two equal blocks, with half of the filler and target items presented in each block. To control for possible order effects, which block of items participants received first was varied across participants. All participants began the experiment with one practice item to familiarize them with the nature of the task.

Procedure—At the beginning of the experiment, participants filled out a language background questionnaire and completed the German proficiency task. At the first session participants completed the contextualized speaking task and picture description task in their L2 German. In a second session two weeks later the participants completed the contextualized speaking task and the picture description task in their L1 English. Care was taken in assigning lists in the English contextualized speaking experiment so that the participants did not receive the same list of target sentences in both German and English.

At each session, participants completed the first block of the contextualized speaking task, followed by the picture description task. Then they completed the second block of the contextualized speaking task. The situational contexts and target sentences were presented via PowerPoint. All recordings were completed in a sound-proof booth, using Audacity 1.2 for Mac OS X. All data were automatically digitized at a sampling rate of 44.1 kHz.

Prosodic analysis—Participants' utterances were analyzed in Praat 5.1.21 (Boersma & Weenink, 2009), using a visual inspection of the waveform displays and spectrograms to annotate constituent boundaries and rises in fundamental frequency (F0) values, the acoustic correlate of pitch. All utterances were annotated by one coder, and then checked for accuracy by a second coder. The resulting measurements were then automatically obtained via a second Praat script. In line with previous studies that have examined the production of PP-attachment sentences in English and German (e.g., Kraljic & Brennan, 2005; Lingel et al., 2006; Snedeker & Trueswell, 2003; Snedeker & Yuan, 2008), we analyzed the duration of each critical constituent—the verb (V), the direct object (DO), and the prepositional phrase (PP)—as well as the percentage of pauses between the verb and the direct object (V-DO) and between the direct object and the prepositional phrase (DO-PP). A pause was

considered a silence of at least 20 milliseconds.⁷ Similar to Price et al. (1991), Snedeker and Trueswell (2003), and Snedeker and Yuan (2008), participants' data were also coded for the presence of a pitch accent on the preposition *mit* "with". That is, if *mit* was produced with the highest F0 in the prepositional phrase, it was coded as carrying the pitch accent of the phrase. This prominence signaled by the presence of the pitch accent was most often accompanied by the highest intensity in the prepositional phrase. Finally, since Lingel et al. (2006) reported significant differences in fundamental frequency (F0) values at the direct object noun in VP-attachment sentences relative to NP-attachment sentences in their L1 German data, we also analyzed pitch excursion on the verb and on the direct object. This rise in pitch was annotated in Praat, following conventions set out in the literature on tonal alignment (e.g., Atterer & Ladd, 2004; Braun, 2006). This was done by marking the location of the F0 local rise (i.e., the F0 minimum) following the onset of the stressed syllable, but not later than the end of the stressed vowel, as well as the end of the F0 rise (i.e., the F0 maximum). In syllables that contained no rise, the F0 values were measured at the beginning of the stressed vowel and at the midway point between that vowel and the end of the constituent. We obtained all F0 values in Hz and then converted them to Equivalent Rectangular Bandwidth (ERB) values, which allows for the normalization of speaker data (Barry, 2007; Daly & Warren, 2001).⁸

Data analysis—To analyze whether the English-German L2 learners used one or more of these prosodic cues to differentiate NP-attachment from VP-attachment sentences, we ran mixed-effects regression analyses for each prosodic cue outlined above.⁹ The duration and pitch excursion data were analyzed using mixed-effects linear regression models (e.g., Baayen, Davidson & Bates, 2008) and the pitch accent data—as a categorical variable—were analyzed using mixed-effects logistic regression models (e.g., Dixon, 2008; Jaeger, 2008). All mixed-effects analyses were conducted using the lme4 package in R version 2.11.1 (R Development Core Team, 2010).

We ran separate statistical analyses for the English-German L2 learners (Experiment 1a) and the German-English L2 learners (Experiment 1b) rather than running a single set of analyses across both participant groups. Due to differences in group sizes between the English-German L2 learners ($n = 11$) and the German-English L2 learners ($n = 13$), as well as greater variation in each groups' L2 data, combining the data from each speaker group could have masked potential effects and interactions in both groups. Further, although the English sentences were translations of the German sentences, it was not possible to control for differences in lexical items across languages, such as syllable length. Therefore, we also ran separate analyses on the German and English data from the participants (see Gut, 2009 for similar treatment of L2 vs. native speaker and cross-linguistic data). In addition, analyzing the participant groups and each language separately allowed for the inclusion of individual participant variables as an additional predictor variable in the analysis of the participants' L2 utterances.

⁷As will become apparent in the results section, participants did not pause frequently enough to warrant statistical analyses of pause length. Statistical analyses in which any pauses were analyzed together with the duration of the preceding constituent were identical to analyses on the duration of the constituent alone. Therefore, they are not reported here. As is evident from the results reported in Tables 2, 7 and 12, even with this more liberal definition of a pause, participants did not use pauses to mark a prosodic boundary more than 15% of the time.

⁸ERB = $21.4 * \text{LOG}_{10}((0.00437 * x) + 1)$ (where x is the value in Hz). We opted for purely phonetic analyses of the intonational contours, given that previous L2 research has shown difficulties in analyzing L2 intonational phonology via models such as ToBI (e.g., Gut, 2009).

⁹We also measured and analyzed the amplitude of each constituent. However, there were no systematic differences in amplitude as a function of attachment type at any point in the target sentences in either language. This corroborates the hypothesis from previous research that F0 and duration may be stronger cues to disambiguation than amplitude (e.g., Streeter, 1978). Therefore, the amplitude results will not be reported here.

Results

L2 German data—We started with 154 utterances for analysis. Six utterances were excluded due to repetitions in the subject, verb or direct object, such that the final analyses reported here were based on 148 observations. Repetitions in the prepositional phrase led to the exclusion of 14 additional observations from the analyses of the prepositional phrase, such that the analyses of this constituent are based on 134 observations. However, data from these 14 sentences were still included in the primary analyses of the verb and direct object, as the disfluency in the prepositional phrase did not have an impact on speakers' productions earlier in the sentence. The mean duration for each critical constituent, the percentage of V-DO pauses and DO-PP pauses, the mean pitch excursion on the verb and direct object, and the percentage of pitch accents on *mit* "with" for the English-German L2 learners are presented in Table 2. A visual inspection of the percentage of V-DO and DO-PP pauses suggests that the English-German L2 learners paused less than 15% of the time overall in their German productions. Therefore, no statistical analyses were run on the English-German L2 learners' pause data in German. For all other analyses, both participants and items were treated as random effects and condition (NP-attachment vs. VP-attachment) was treated as a fixed effect. For the duration analyses of the verb, the direct object and the prepositional phrase, the number of syllables for each constituent was also entered as a fixed effect to control for differences in word length across items. These values were centered at the mean value for each constituent across all of the L2 German data from the German-English L2 learners (V: $M = 1.93$ syllables, range: 1–4; DO: $M = 3.12$ syllables, range: 2–5; PP: $M = 5.38$ syllables, range: 3–8; Hoffman & Rovine, 2007; Kreft, de Leeuw, & Aiken, 2007). Preliminary analyses indicated that the length of time participants had been living in Germany had a significant impact on their productions. Therefore, we included the length of time in Germany, calculated in terms of months abroad, as an additional fixed effect. This value was centered at the sample mean of 15.63. All models were estimated using restricted maximum likelihood. For each fixed and random effect included in the final model, a likelihood ratio test comparing the -2 restricted log likelihood values of the model including the variable to a version of the model without the variable was used to confirm the improvement in the goodness-of-fit of the final model (Hoffman & Rovine, 2007; Quené & van den Bergh, 2008).

As seen in Table 3, there was a significant effect of syllable on the duration of each constituent because the participants took longer to produce words and phrases containing more syllables than words or phrases containing fewer syllables. The inclusion of syllable also significantly improved the explanatory value of the model for the duration of each constituent (V: $\chi^2(1) = 34.09$, $p < .0001$; DO: $\chi^2(1) = 21.02$, $p < .0001$; PP: $\chi^2(1) = 114.79$, $p < .0001$). There was also a significant effect of study abroad on the duration of the verb and the direct object because L2 participants who had been living abroad for longer at the time of testing were faster than those who had not been living abroad for as long. The inclusion of months abroad also significantly improved the explanatory value of the model for the duration of the verb and the direct object (V: $\chi^2(1) = 4.50$, $p < .05$; DO: $\chi^2(1) = 8.65$, $p < .01$). In contrast, there was no significant effect of study abroad for the duration of the prepositional phrase, so this variable was dropped from the final model reported here ($p > .1$). In the duration of the direct object there was a significant effect of condition because the participants took longer to produce the direct object for VP-attachment than NP-attachment sentences. The inclusion of condition also significantly improved the explanatory value of the model for the duration of the direct object ($\chi^2(1) = 4.91$, $p < .05$). We tested for an interaction between condition and study abroad, however this interaction was not significant for any constituent (all $ps > .5$).

As seen in Table 4, in the analysis of pitch excursion and pitch accent data neither the inclusion of study abroad, nor the interaction between study abroad and condition improved the explanatory value of the model and was dropped from all analyses (all $ps > .2$). Similarly, the inclusion of items as a random effect did not improve the explanatory value of the model of pitch excursion on the direct object or the pitch accent data, and therefore was dropped from these analyses. The final model of pitch excursion on the verb revealed no effect of condition. However, there was a significant effect of condition in the final model of pitch excursion on the direct object because the participants exhibited a greater rise in F0 for VP-attachment sentences than NP-attachment sentences. The inclusion of condition also marginally improved the explanatory value of the model for pitch excursion on the direct object ($\chi^2(1) = 3.83, p = .05$).

Finally, results from the mixed-effects logistic regression analysis of the pitch accent data revealed a main effect of condition because the participants were more likely to place a pitch accent on *mit* “with” in VP-attachment than NP-attachment sentences.¹⁰ The inclusion of condition also significantly improved the explanatory value of the model for pitch accent on *mit* “with” ($\chi^2(1) = 17.84, p < .0001$).

L1 English data—We started with 154 observations for analysis. Three utterances were excluded due to repetitions in the subject, verb or direct object, such that the final analyses reported here were based on 151 observations. Repetitions in the prepositional phrase led to the exclusion of eight additional observations from the analyses of the prepositional phrase, such that the analyses of this constituent are based on 143 observations. However, as in the previous analyses, data from these eight sentences were still included in the primary analyses of the verb and direct object. The mean values for all acoustic measures for the English-L2 German learners’ English production data are presented in Table 2. Similar to the German results, the participants paused less than 8% of the time overall in English, and there is no apparent difference in the percentage of pauses on NP-versus VP-attachment sentences. Therefore, no statistical analyses were run on the pause data. For all other analyses, both participants and items were treated as random effects, and condition (NP-attachment vs. VP-attachment) was treated as a fixed effect. For the duration analyses, the number of syllables for each constituent was also entered as a fixed effect. These values were centered at the mean value for each constituent across all of the L1 English data from the German-English L2 learners (V: $M = 1.5$ syllables, range: 1–3; DO: $M = 2.65$ syllables, range: 2–5; PP: $M = 4.75$ syllables, range: 3–7).

As seen in Table 5, there was a significant effect of syllable on the duration of each constituent because the English-German L2 learners took longer to produce words or phrases containing more syllables than words or phrases containing fewer syllables. The inclusion of syllable also significantly improved the explanatory value of the model for the duration of these constituents (V: $\chi^2(1) = 20.50, p < .0001$; DO: $\chi^2(1) = 24.03, p < .0001$; PP: $\chi^2(1) = 128.74, p < .0001$). There was no significant difference in duration as a function of condition for the verb or the direct object. However, there was a significant effect of condition on the prepositional phrase because the English-German L2 learners took longer to produce the prepositional phrase in NP-attachment than VP-attachment sentences. The inclusion of condition also significantly improved the explanatory value of the model for the duration of the prepositional phrase ($\chi^2(1) = 9.06, p < .01$).

An initial inspection of the mean pitch excursion values at the verb and the direct object in Table 2 shows that, unlike their production of the German sentences, the English-German

¹⁰In mixed-effects logistic regressions, positive coefficients indicate a greater likelihood of the outcome 1 (pitch accent) and negative coefficients indicate a greater likelihood of 0 (no pitch accent).

L2 learners' F0 values fall rather than rise on the verb and the direct object in both NP- and VP-attachment sentences in English. We fitted the models for pitch excursion on the verb and the direct object, which did not show any significant differences between the NP- and VP-attachment conditions.

In the analysis of pitch accent data, as summarized in Table 6, the inclusion of items as a random effect did not improve the explanatory value of the model, and therefore was dropped from these analyses. The final model of the pitch accent data revealed a main effect of condition because the participants were more likely to place a pitch accent on *with* in VP-attachment than NP-attachment sentences. Further, the inclusion of condition significantly improved the explanatory value of the model for pitch accent on *with* ($\chi^2(1) = 27.58, p < .0001$).

Post-hoc analysis: The durational effects reported on the prepositional phrase, in which the English-German L2 learners exhibited longer durations on the NP- than the VP-attachment sentences, is the opposite pattern of what has been reported in previous English studies (Snedeker & Trueswell, 2003; Snedeker & Yuan, 2008). One possible explanation for this difference is that even though the length of the prepositional phrase did not differ between NP-attachment and VP-attachment sentences when averaged across all items (NP-attachment: $M = 4.8$ syllables; VP-attachment: $M = 5.0$ syllables), within individual items there were differences in both lexical content and the number of syllables. To control for these lexical and length differences across individual items, a post-hoc analysis was conducted on the duration of the preposition itself, *with*, as this was the word that was present in all target sentences in both conditions. Descriptively, the mean length of *with* was the same for both NP- and VP-attachment sentences (NP-attachment: $M = 163\text{ms}$, $SD = 33.2$; VP-attachment: $M = 167\text{ms}$, $SD = 32.9$). A mixed-effects linear regression analysis of the durations for *with* revealed no significant difference in duration on *with* as a function of condition.¹¹

Experiment 1b

Method

Participants—Sixteen German-English L2 learners completed the same experiment as the English-German L2 learners. However, three of the participants did not complete the experiment in both languages. Therefore, all analyses reported here are based on the remaining 13 participants (mean age: 23.9 years; range: 19–30; 11 females). The German-English L2 learners were all from Hessen, Germany. They all scored at least 56 points ($M = 79.8$, $SD = 13.6$) on the Oxford Online Placement Test (Oxford University Press, 2009), indicating intermediate to advanced L2 English proficiency. Six of the participants had lived abroad in an English-speaking country for an average of eight months (range: 6–10). The remaining seven participants had never lived abroad in an English-speaking country.

These participants also completed the same picture description fluency task as the English-German L2 learners (see Table 1). T-tests comparing fluency measures in their L1 German to their L2 English revealed no significant difference in the proportion of repetitions but a significant or marginally significant difference in all other fluency measures (Repetitions: $t < 1$; MLR: $t(12) = 2.17, p = .051$; Pauses/sec: $t(12) = -2.57, p < .05$; Speech rate: $t(12) = 3.75, p < .01$; Filled syllables: $t(12) = -3.64, p < .01$). A second set of t-tests comparing the German-English L2 learners' fluency measures in their L2 English to the L1 English fluency

¹¹For both the English-German L2 speakers in Experiment 1a and the German-English L2 speakers in Experiment 1b similar durational analyses were conducted on the preposition *mit* "with" in their German productions. However, these results did not reveal any significant difference in duration as a function of attachment type for either group.

measures from the English-German L2 learners in Experiment 1a revealed no significant difference in speech rate or the proportion of filled pauses (Speech rate: $t(22) = -1.01, p = .326$; Filled pauses: $-1.25, p = .225$). However, there was a significant difference between the two groups with regard to mean length run, pauses per second and the proportion of repetitions (MLR: $t(22) = 3.20, p < .01$; Pauses/sec: $t(17.97) = -3.93, p < .01$; Repetitions: $t(12.52) = -2.45, p < .05$). Taken together, these comparisons suggest that the German-English L2 learners spoke English with relative ease, but their overall L2 English fluency may not have been at the same level as the L2 German fluency of the English-L2 German learners in Experiment 1a.

Materials—The materials used in Experiment 1b were the same as the German and English language materials described in Experiment 1a.

Procedure—The experimental procedure was the same as described for Experiment 1a except that the German-English L2 learners completed the contextualized speaking task and the picture description task in their L2 English in the first session, followed by the L1 German tasks in a second session two weeks later. However, for ease of exposition and to parallel the presentation of results from Experiment 1a, the German-English L2 learners' L1 German results from the second session will be presented first.

Results

L1 German data—We started with 182 utterances for analysis. Three utterances were excluded due to repetitions in the subject, verb or direct object, such that the final analyses reported here were based on 179 observations. Repetitions in the prepositional phrase led to the exclusion of three additional observations from the analyses of the prepositional phrase, such that the analyses of this constituent are based on 176 observations. However data from these three sentences were still included in the primary analyses of the verb and direct object. The mean values for all acoustic measures for the German-English L2 learners' German production data are presented in Table 7. The German-English L2 learners paused less than 6% of the time overall in German, and there is no apparent difference in the percentage of pauses on NP-versus VP-attachment sentences. Therefore, no statistical analyses were run on the pause data. For all other analyses, both participants and items were treated as random effects and condition (NP-attachment vs. VP-attachment) was treated as a fixed effect. For the duration analyses, the number of syllables for each constituent was also entered as a fixed effect. These values were centered at the mean value for each constituent (V: $M = 1.93$ syllables, range: 1–4; DO: $M = 3.13$ syllables, range: 2–5; PP: $M = 5.42$ syllables, range: 3–8).

As seen in Table 8, there was a significant effect of syllable on the duration of each constituent because the German-English L2 learners took longer to produce words or phrases containing more syllables than words or phrases containing fewer syllables. The inclusion of syllable also significantly improved the explanatory value of the model for the duration of each constituent (V: $\chi^2(1) = 28.97, p < .0001$; DO: $\chi^2(1) = 26.72, p < .0001$; PP: $\chi^2(1) = 182.35, p < .0001$). There was no significant difference in duration as a function of condition for any of the constituents (all $ps > .8$).

Table 9 displays the results from the mixed-effects linear models for pitch excursion and the mixed-effects logistic model for pitch accent. In the analysis of the pitch excursion data on the direct object and the pitch accent data, the inclusion of items as a random effect did not improve the explanatory value of the model and was dropped from these analyses. While there was no effect of condition in pitch excursion on the verb, this effect was significant on the direct object because at the direct object, the German-English L2 learners exhibited a

higher rise in F0 for VP-attachment than NP-attachment sentences. The inclusion of condition also significantly improved the explanatory value of the model for pitch excursion at the direct object ($\chi^2(1) = 4.17, p < .05$).

Finally, results from the mixed-effects logistic regression analysis of the pitch accent data revealed a main effect of condition because the German-English L2 learners were more likely to place a pitch accent on *mit* “with” in VP-attachment than NP-attachment sentences in German. The inclusion of condition significantly improved the explanatory value of the model for pitch accent on *mit* “with” ($\chi^2(1) = 7.26, p < .01$).

L2 English data—We started with 182 utterances for analysis. Twelve utterances were excluded due to repetitions in the subject, verb or direct object, such that the final analyses reported here were based on 170 observations. Repetitions in the prepositional phrase led to the exclusion of 19 additional observations from the analyses of the prepositional phrase, such that the analyses of this constituent are based on 151 observations. However data from these 19 sentences were still included in the primary analyses of the verb and direct object. The mean values for all acoustic measures for the L2 English data from the German-English L2 learners is presented in Table 7. As seen in Table 7, the German-English L2 learners paused 13% of the time overall in their English productions, and there is no apparent difference in the percentage of pauses on NP-versus VP-attachment sentences. Therefore no statistical analyses were run on the pause data. For all other analyses, both participants and items were treated as random effects and condition (NP-attachment vs. VP-attachment) was treated as a fixed effect. For the duration analyses, the number of syllables for each constituent was also entered as a fixed effect. These values were centered at the mean value for each constituent (V: $M = 1.52$ syllables, range: 1–3; DO: $M = 2.66$ syllables, range: 2–5; PP: $M = 4.84$ syllables, range: 3–7). Preliminary analyses indicated that participants’ speech rate on the English picture description task had a significant impact on their productions so this was added as an additional fixed effect, centered at the sample mean of 4.10.

As seen in Table 10, there was a significant effect of syllable on the duration of each constituent, because the participants took longer to produce words and phrases containing more syllables than words or phrases containing fewer syllables. The inclusion of syllable also significantly improved the explanatory value of the model for the duration of each constituent (V: $\chi^2(1) = 18.94, p < .0001$; DO: $\chi^2(1) = 17.75, p < .0001$; PP: $\chi^2(1) = 117.62, p < .0001$). There was also a significant effect of speech rate on the duration of each constituent because those participants with faster speech rates on the English picture description task were faster overall than those with slower speech rates on the English picture description task. The inclusion of L2 speech rate also significantly improved the explanatory value of the model for each constituent (V: $\chi^2(1) = 7.08, p < .01$; DO: $\chi^2(1) = 4.19, p < .05$; PP: $\chi^2(1) = 8.97, p < .01$). There was no significant difference in duration as a function of condition for the verb or the direct object. However, there was a significant effect of condition on the prepositional phrase because the German-English L2 learners took longer to produce the prepositional phrase in NP-attachment than VP-attachment sentences. The inclusion of condition also significantly improved the explanatory value of the model for the duration of the prepositional phrase ($\chi^2(1) = 19.37, p < .0001$). We also tested for an interaction between condition and L2 speech rate, however this 2-way interaction was not significant for the duration of any constituent (all $ps > .2$).

An initial inspection of the mean pitch excursion values at the verb and the direct object in Table 7 shows that, unlike their production of the German sentences, the German-English L2 learners’ F0 values fall rather than rise on the verb in their English productions. Further, while their F0 values still rise on the direct object in English, there is no apparent difference in the pitch excursion values on NP- vs. VP-attachment sentences. We fitted the models for

pitch excursion on the verb and the direct object, including L2 speech rate as an additional fixed effect, but these analyses did not show any significant differences in pitch excursion between the NP- and VP-attachment conditions on either the verb or the direct object.

In the analysis of pitch accent data, as summarized in Table 11, the inclusion of items as a random effect did not improve the explanatory value of the model and was dropped from these analyses. The final model of the pitch accent revealed a main effect of condition because the German-English L2 learners were more likely to place a pitch accent on *with* in VP-attachment than NP-attachment sentences. Further, the inclusion of condition significantly improved the explanatory value of the model for pitch accent on *with* ($\chi^2(1) = 17.93, p < .0001$). There was also a main effect of L2 speech rate because participants with a faster L2 speech rate on the English picture description task were less likely to place a pitch accent on *with* than participants with a slower L2 speech rate. The inclusion of L2 speech rate also marginally improved the overall explanatory value for pitch accent on *with* ($\chi^2(1) = 3.67, p = .055$). However, there was no significant interaction between condition and L2 speech rate ($p > .7$).

Post-hoc analysis: Similar to the English-German L2 learners, a post-hoc analysis was conducted on the duration of the preposition *with*. Descriptively, the mean length of *with* was longer on VP- than NP-attachment sentences (NP-attachment: $M = 158\text{ms}$, $SD = 30.0$; VP-attachment: $M = 164\text{ms}$, $SD = 31.8$). We ran a mixed-effects linear regression analysis of the durations for *with*, treating participants and items as random effects and condition and L2 speech rate as fixed effects. As seen in Table 10, there was a main effect of condition because the duration of *with* on VP-attachment sentences was longer than on NP-attachment sentences. The inclusion of condition also significantly improved the explanatory value for the duration of *with* ($\chi^2(1) = 4.08, p < .05$). There was a main effect of L2 speech rate because faster participants had shorter durations overall than slower participants. The inclusion of L2 speech rate also significantly improved the explanatory value for the duration of *with* ($\chi^2(1) = 9.17, p < .01$). However, there was no significant interaction between condition and L2 speech rate ($p > .3$).

Discussion—The goal of Experiments 1a and 1b was to explore whether English-German L2 learners and German-English L2 learners would transfer the use of specific prosodic cues to disambiguation in each of their languages. To summarize the results, the English-German L2 learners in Experiment 1a used F0 and pitch accent placement on the preposition *mit* “with” as cues to disambiguation in their L2 German, producing a rise on the direct object noun and a pitch accent on *mit* in the VP-attachment condition. They also lengthened the duration of the direct object in VP-attachment sentences compared to NP-attachment sentences. In contrast, when producing similar PP-attachment sentences in their L1 English, the English-German L2 learners did not produce an F0 rise in either NP- or VP-attachment sentences. In fact, they exhibited a fall in pitch at both possible boundary locations—the verb in NP-attachment sentences and the direct object in VP-attachment sentences—regardless of attachment type. They also exhibited no durational differences on the verb or the direct object as a means of disambiguation in their L1 English. However, they were more likely to place a pitch accent on *with* in VP-attachment than NP-attachment sentences, similar to their L2 German productions. Finally, the English-German L2 learners took longer to produce the prepositional phrase in NP- than VP-attachment sentences, although post-hoc analyses on the preposition *with* revealed no significant differences in duration as a function of attachment type.

The results from the German-English L2 learners in Experiment 1b were remarkably similar to the results from the English-German L2 learners in both languages. In their L1 German productions, the German-English L2 learners exhibited a greater F0 rise at the direct object

and a greater proportion of pitch accents on the preposition *mit* “with” on VP-attachment compared to NP-attachment sentences. However, there were no durational differences at any constituent in their L1 German data as a function of attachment type. In their L2 English productions, the German-English L2 learners did not use a rise in pitch to distinguish VP- from NP-attachment sentences at either the verb or the direct object, but they were more likely to place a pitch accent on the preposition *with* in VP-attachment than NP-attachment sentences. Finally, the German-English L2 learners took longer to produce the prepositional phrase in NP- than VP-attachment sentences, although post-hoc analyses on the preposition *with* revealed the reverse effect, with longer durations on VP-compared to NP-attachment sentences.

The results for both L2 participant groups suggest that they did not engage in the wholesale transfer of prosodic cues from their L1 to the L2. Most importantly, speakers in both groups did not produce an F0 rise in either the NP- or VP-attachment condition when producing temporarily ambiguous PP-attachment sentences in English. Nonetheless, these same speakers reliably produced a rise in F0 on the direct object in VP-attachment sentences in German, similar to findings reported by Lingel et al. (2006) for native speakers of German. The only cue that the participants consistently used in both languages was placing a pitch accent on *mit* “with” or *with* in VP-attachment sentences, paralleling previously reported findings in English (Snedeker & Trueswell, 2003; Snedeker & Yuan, 2008). Taken together, the present results—when combined with results from these previous L1 English and L1 German studies—suggest that pitch may play a more important role to syntactic disambiguation in German than in English, a possibility that will be discussed in greater detail in the General Discussion.

At the same time, the participants did not produce durational differences as reliably as has been reported in previous English and German studies, nor did they use pauses in either language (e.g., Cooper & Paccia-Cooper, 1980; Kraljic & Brennan, 2005; Lingel et al., 2006; Price et al., 1991; Schafer et al., 2005; Snedeker & Trueswell, 2003; Snedeker & Yuan, 2008). We hypothesize that this is a task-induced effect. Like previous studies in which speakers only reliably used prosodic cues to disambiguate sentences when the situational context or the task instructions highlights the need for structural disambiguation (e.g., Albritton, McKoon, & Ratcliff, 1996; Lingel et al., 2006; Snedeker & Trueswell, 2003; Straub, 1997), the participants in the present study may have been less likely to rely on pauses or duration because the context may not have required them to do so (see also Schafer et al., 2005). However, in light of the significant effects for pitch excursion and pitch accent, the lack of pauses should not be taken as an indication that the participants were unable to disambiguate the target sentences. Moreover, the paucity of pauses in the speech in participants L2 may speak to their overall L2 fluency.

While there were no significant duration effects on either the verb or the direct object in English for either the English-German L2 learners or the German-English L2 learners, both groups took longer to produce prepositional phrases in NP- than VP-attachment sentences in English. Given that several previous studies have reported the reverse pattern, with longer durations on prepositional phrases in VP-attachment than NP-attachment sentences in both English and German (Lingel et al., 2006; Snedeker & Trueswell, 2003; Snedeker & Yuan, 2008), this effect is somewhat surprising. Possible reasons for this effect of duration on the prepositional phrase will be addressed in the General Discussion. At the same time, this effect does not detract from the more important finding that neither group of participants used a rise in pitch when producing sentences in English. As such, this finding does not undermine the larger conclusion that the L2 participants did not simply transfer the use of L1 prosodic cues when producing similarly ambiguous sentences in their L2.

Experiment 2

In the English results from Experiments 1a and 1b neither participant group used duration, pauses or an F0 rise to disambiguate temporarily ambiguous English PP-attachment sentences, similar to previous experiments involving more constrained reading tasks (e.g., Albritton et al., 1996; but see Straub, 1997). However, the lack of significant differences in the English data, especially with regard to the duration of critical constituents, could stem from the fact that both participant groups were living in a German-dominant environment at the time of testing. Thus, to corroborate the English data from Experiments 1a and 1b, in Experiment 2 we tested non-immersed native English speakers with little foreign language learning experience using the same materials and procedure as the previous experiments. If the lack of significant differences between NP- and VP-attachment sentences in the English data from Experiments 1a and 1b is the result of participants living in a German-dominant environment, then we predict to find significant effects of duration and pauses in the speech production of monolingual English participants. On the other hand, if the lack of duration and pause effects in Experiments 1a and 1b is the result of task-based constraints, then we expect to see no duration or pause effects, even among monolingual English speakers.

Method

Participants—Sixteen native speakers of American English were recruited from a large university in the northeastern United States (mean age: 21.4 years; range: 19–23 years; 6 females). All participants reported learning a foreign language in high school or in college. However, none of them considered themselves fluent in any language other than English and none had spent more than six weeks in an L2 environment. For this reason, we will refer to this group of participants as English monolinguals. These participants also completed the same picture description fluency task in English as the previous participants. These results are presented in Table 1.

Materials—The materials used in Experiment 2 were the same as the English language materials described in Experiment 1a.

Procedure—The experimental procedure was the same as in Experiment 1a except that participants filled out the language background questionnaire after completing the English contextualized speaking task and the English fluency task. All recordings were made in a quiet room using Audacity 1.2 for Windows XP. All data were automatically digitized at a sampling rate of 44.1 kHz.

Results—The data from the monolingual English participants were coded and analyzed in the same manner as the previous experiments. We started with 224 utterances for analysis. Two utterances were excluded due to repetitions in the subject, verb or direct object, such that the final analyses reported here were based on 222 observations. Repetitions in the prepositional phrase led to the exclusion of nine additional observations from the analyses of the prepositional phrase, such that the analyses of this constituent are based on 213 observations. However data from these nine sentences were still included in the primary analyses of the verb and direct object. The mean values for all acoustic measures for the monolingual English participants' production data are presented in Table 12. Similar to the previously reported results, the monolingual English participants paused less than 12% of the time, regardless of location or condition. Therefore, no statistical analyses were run on the pause data. For the duration analyses, the number of syllables for each constituent was also entered as a fixed effect. These values were centered at the mean value for each constituent (V: $M = 1.5$ syllables, range: 1–3; DO: $M = 2.64$ syllables, range: 2–5; PP: $M = 4.79$ syllables, range: 3–7).

As seen in Table 13, there was a significant effect of syllable on the duration of the verb and the direct object because the monolingual English participants took longer to produce words containing more syllables than words containing fewer syllables. The inclusion of syllable also significantly improved the explanatory value of the model for the verb and the direct object (V: $\chi^2(1) = 16.30, p < .0001$; DO: $\chi^2(1) = 17.29, p < .0001$). However, there was no significant effect of condition on the verb or the direct object (all $ps > .3$). On the prepositional phrase there was a significant effect of length because the monolingual English participants took longer to produce phrases containing more syllables than phrases containing fewer syllables. On the prepositional phrase there was also a significant effect of condition. Like the English-L2 German learners and the German-L2 English learners, the monolingual English participants took longer to produce the prepositional phrase in NP- than VP-attachment sentences. The inclusion of condition and syllable also significantly improved the explanatory value of the model for the duration of the prepositional phrase (syllable: $\chi^2(1) = 104.11, p < .0001$; condition: $\chi^2(1) = 17.47, p < .0001$).

An initial inspection of the mean pitch excursion values at the verb and the direct object for the monolingual English participants in Table 12 shows that, similar to the L1 English data from the English-German L2 learners, the monolingual English participants' F0 values fall rather than rise on the verb and the direct object in both NP- and VP-attachment sentences. We fitted the models for pitch excursion on the verb and the direct object, which did not show any significant differences between the NP- and VP-attachment conditions.

In the analysis of pitch accent data, as summarized in Table 14, the inclusion of items as a random effect did not improve the explanatory value of the model, and therefore was dropped from these analyses. The final model for the pitch accent data revealed a main effect of condition because, like the English-German L2 learners and the German-English L2 learners, the monolingual English participants were more likely to place a pitch accent on *with* in VP-attachment than NP-attachment sentences. Further, the inclusion of condition significantly improved the explanatory value of the model for pitch accent on *with* ($\chi^2(1) = 23.40, p < .0001$).

Post-hoc analysis: Similar to Experiments 1a and 1b, a post-hoc analysis was conducted on the duration of the preposition *with*. Descriptively, the mean length of *with* was nearly the same for both NP- and VP-attachment sentences (NP-attachment: $M = 180\text{ms}$, $SD = 37.9$; VP-attachment: $M = 179\text{ms}$, $SD = 36.1$). A mixed-effects linear regression analysis of the durations for *with* revealed no significant difference in duration on *with* as a function of condition.

Discussion—The results of Experiment 2 indicate that the cues used by the English-German L2 learners and the German-English L2 learners when producing English sentences were not just an anomaly stemming from living in a German-dominant environment. The monolingual English speakers, like the L2 participants, placed a pitch accent on the word *with* in the VP-attachment sentences to distinguish VP- from NP-attachment sentences. Also similar to the L2 participants, the monolingual English speakers took longer to produce the prepositional phrase on NP-attachment than VP-attachment sentences. However, the monolingual English speakers exhibited no other durational differences between NP- and VP-attachment sentences, nor did they rely on pauses to disambiguate the target sentences.

General Discussion

The main goal of the current study was to determine whether late English L2 learners of German and late German L2 learners of English reliably produce prosodic cues to disambiguate temporarily ambiguous PP-attachment sentences when producing sentences in

their L1 and their L2. A second goal was to determine precisely which cues they would use and whether these cues differ from those used by native speakers of their respective L2s. Results from Experiments 1a and 1b showed that the L2 learners prosodically disambiguated the target sentences and that they relied upon similar cues as native speakers. Both participant groups relied on an F0 rise on the direct object and pitch accent placement on the preposition *mit* “with” in VP-attachment sentences relative to NP-attachment sentences in German. In English, both participant groups relied on pitch accent placement on “with” as the primary cue to disambiguate VP-attachment sentences.

In Experiment 2, the analysis of the production data from monolingual English speakers paralleled the English results from both L2 participant groups in Experiments 1a and 1b in that the monolingual English speakers primarily made use of pitch accent on the preposition *with* in VP-attachment sentences. This rules out the possibility that the English results from the L2 participants in Experiments 1a and 1b stemmed from living in a German-dominant environment at the time of testing. As such, the findings from Experiment 2 lend additional support to the claim that the English-German L2 learners did not simply transfer disambiguation strategies from their L1 English when completing the German contextualized speaking task, and they confirm that the German-English L2 learners performed similarly to English native speakers when completing the production task in their L2 English.

One unexpected finding in the English data has to do with the durational effects on the prepositional phrase in the NP-attachment condition. This finding stands counter to previous studies in both English and German (e.g., Lingel et. al., 2006; Snedeker & Trueswell, 2003; Snedeker & Yuan, 2008), which have shown that speakers often take longer to produce prepositional phrases in VP-attachment sentences than NP-attachment sentences. The present findings may stem from differences in the length and lexical content of the prepositional phrase across conditions, which could have led to the emergence of durational differences independent of the primary manipulation of attachment type. Post-hoc analyses of the preposition *with* support this hypothesis. Comparisons of the duration of *with*—the word that was identical across conditions for all NP- and VP-attachment items—revealed no significant difference in duration according to attachment type among either the English-German L2 learners or the monolingual English speakers, paralleling the lack of durational differences according to attachment type on the verb and the direct object. For the German-English L2 learners, the duration of *with* was longer on VP-attachment than NP-attachment sentences, similar to findings from previous native English and German studies in which participants have lengthened the prepositional phrase in VP-attachment sentences (Lingel et. al., 2006; Snedeker & Trueswell, 2003) and Snedeker and Yuan (2008), in which they reported durational differences directly on the preposition *with*. More importantly, the presence of durational differences on the prepositional phrase in English does not undermine the more important finding, namely the absence of significant effects related to pitch rise, in contrast to the German findings from Experiment 1. Thus, the effect of duration on the prepositional phrase will not be discussed further.

Prosodic cues to disambiguation in German

Returning to the German findings from Experiments 1a and 1b, both the English-German L2 learners and the German-English L2 learners produced a prosodic boundary between the direct object and the prepositional phrase in VP-attachment sentences via an F0 rise and the placement of a pitch accent on *mit* “with”. In placing a break between the direct object and the prepositional phrase, both participant groups indicated in German that the direct object and the sentence-final prepositional phrase should not be construed as a single unit, thereby facilitating an interpretation in which the prepositional phrase modified the verb.

At the same time, there was no corresponding break between the verb and the direct object in NP-attachment sentences for either L2 participant group in German. This contrasts with prior research that has found evidence of a prosodic break at this location in both languages (Lingel et al., 2006; Snedeker & Trueswell, 2003; Snedeker & Yuan, 2008). One reason for these findings may be that NP interpretations may have been possible for sentences we classified as VP-attachment sentences. Thus, participants may have produced more robust cues to disambiguation to highlight the VP-attachment interpretation of these sentences. At the same time, even studies that have reported a break between the verb and the direct object in NP-attachment sentences, this break is both smaller and less reliable than the break between the direct object and the prepositional phrase in VP-attachment sentences (Lingel et al., 2006; Snedeker & Trueswell, 2003; Snedeker & Yuan, 2008). Similarly, research has shown that speakers may be less likely to produce a prosodic boundary between verbs and direct objects to begin with, either because the direct object is often an obligatory argument of the verb (e.g., Watson et al., 2006; Watson & Gibson, 2005) or because of the semantic closeness of the verb and the direct object (e.g., Selkirk, 1984). Nonetheless, the lack of a significant difference in prosodic cues between NP- and VP-attachment sentences at the verb in the present study is not entirely out of line with previous findings.

Perhaps more unforeseen was the fact that participants in the present study produced few durational differences on critical constituents according to attachment type, and pauses between the critical constituents were rare. The only exception to this was that the English-German L2 learners produced longer direct objects for VP-attachment than NP-attachment sentences in German. The reliability of duration as a cue to disambiguation has been shown in comprehension (Lehiste et al., 1976; Scott, 1982; Hoyte et al., 2009) and in production (Lingel et al., 2006; Snedeker & Trueswell, 2003), and the importance of pauses has been reported in a number of previous studies in both English and German (e.g., Cooper & Paccia-Cooper, 1980; Lingel et al., 2006; Snedeker & Trueswell, 2003; Snedeker & Yuan, 2008). That our participants rarely disambiguated via lengthening or pausing may be a task-related effect. Unlike a number of studies that have reported durational effects (e.g., Schafer et al., 2005; Snedeker & Trueswell, 2003; Snedeker & Yuan, 2008), the task in the current study did not involve an interlocutor. Thus, participants were not engaged in other-directed, hyper-speech (Lindblom, 1998), in which the inclusion of redundant cues would aid in the interpretation of the utterance. Further, the nature of the contexts preceding the target sentences may have constrained the possible interpretations of the target sentence, thereby limiting the need to use pauses and durational cues for disambiguation (Straub, 1997). In spite of the potential drawbacks of doing so, we relied upon read speech to guarantee comparable utterances across speakers. Future research involving a more spontaneous speech task could ascertain whether L2 learners would rely on duration and pauses to disambiguate utterances in the presence of an interlocutor.

One additional factor that potentially affected the durational differences was the number of syllables in each constituent. Although the number of syllables was included as a variable in the statistical analyses, this may not have completely eliminated the possibility that differences in number of syllables across items played a role. A follow-up study is currently underway to explore whether durational effects appear in German, once syllable length is controlled for.

Cross-linguistic differences in pitch as a cue to disambiguation

Whereas pitch accent placement on the preposition is a cue to disambiguation in both languages, the question remains as to why both the English-German L2 learners and the German-English L2 learners used pitch to disambiguate VP- from NP-attachment sentences when producing German sentences, while such effects were not apparent in the English results of any participant group. It may be that the F0 rise on the direct object noun in VP-

attachment sentences is a more fixed pattern or tune in German. In contrast, this same contour may be just one potential tune of many to signal VP-attachment in English. Given the differences in the current production data between English and German, along with previous research that has shown that pitch may not be the most reliable cue for English listeners (e.g., Cooper & Pacia-Cooper, 1980; Sedeker and Trueswell, 2003; Snedeker & Yuan, 2008), future perceptual research could help determine whether pitch alone can aid disambiguation for listeners in German.

When extended to the L2 pronunciation literature, the results of the current study make two important contributions. First, both the English-German L2 learners and the German-English L2 learners used prosodic features to convey meaning in their respective L2, and these features were the same cues to disambiguation used by native speakers in each language. This stands in contrast to previous studies that have shown that L2 learners are less consistent and differ significantly from native speakers in their use of prosodic cues to meaning (e.g., Gut, 2009; Ramírez Verdugo 2002; Wennerstrom, 1994). Secondly, a comparison of the German and English results from Experiments 1a and 1b suggest that the L2 participants did not use precisely the same cues to differentiate NP- from VP-attachment sentences in both of their languages. While not completely speaking against transfer, this supports the results of previous studies showing that transfer is not an all-or-nothing phenomenon (e.g., Gut, 2003, 2009; Jilka, 2007; Kim & Kim, 2001).

Conclusion

The L2 learners in the current study were able to produce prosodic cues to disambiguation in their L2, and they relied on the same cues as those used by native speakers. Further, they did so even though they were late-learning L2 learners who, while fluent, had arguably not yet reached asymptote, as demonstrated by the results from the independent measure of L1 and L2 fluency. While the reliability of these prosodic cues must be validated through future perceptual studies involving both intelligibility tasks and foreign accent ratings, the present findings represent a valuable step toward determining precisely how L2 learners make use of prosodic cues during L2 production. As such, these results complement the findings of comprehension studies (Dekydtspotter et al., 2008; Fultz, 2007) that point to the salience of prosodic cues in L2 processing and highlight how, at least in certain situations, even L2 learners who have not achieved near-native levels of L2 proficiency grasp the important role prosody can play in expressing the meaning of an utterance.

References

- Albritton DW, McKoon G, Ratcliff R. Reliability of prosodic cues for resolving syntactic ambiguity. *Journal of Experimental Psychology: Learning, Memory and Cognition*. 1996; 22:714–735.
- Atterer M, Ladd DR. On the phonetics and phonology of ‘segmental anchoring’ of F0: Evidence from German. *Journal of Phonetics*. 2004; 32:177–197.
- Baayen RH, Davidson DJ, Bates DM. Mixed-effects modeling with crossed random effects for subjects and items. *Journal of Memory and Language*. 2008; 59:390–412.
- Bader, M. Understanding language: Syntax and prosody during reading. Opladen: Westdeutscher Verlag; 1996. Sprachverstehen: Syntax und Prosodie beim Lesen.
- Barry, AS. Unpublished Doctoral Dissertation. University of Sheffield; 2007. The form, function and distribution of high rising intonation in Southern Californian and Southern British English.
- Beach CM, Katz WF, Skowronski A. Children’s processing of prosodic cues for phrasal interpretation. *Journal of the Acoustical Society of America*. 1996; 99:1148–1160. [PubMed: 8609299]
- Beckman, ME.; Hirschberg, J. The ToBI annotation conventions. Columbus, OH: Ohio State University; 1994. Retrieved from < http://www.ling.ohio-state.edu/~tobi/ame_tobi/annotation_conventions.html > [30 July, 2010]

- Boersma, P.; Weenink, D. [15 December 2009] Praat: doing phonetics by computer (Version 5.1.21). 2009. [Computer program]. Retrieved from: <<http://www.praat.org/>>
- Braun B. Phonetics and phonology of thematic contrast in German. *Language and Speech*. 2006; 49:451–493. [PubMed: 17326588]
- Cooper, WE.; Paccia-Cooper, J. *Syntax and speech*. Cambridge, MA: Harvard University Press; 1980.
- Cruttenden, A. *Intonation*. Cambridge: Cambridge University Press; 1986.
- Cucchiari C, Strik H, Boves L. Quantitative assessment of second language learners' fluency by means of automatic speech recognition technology. *Journal of the Acoustical Society of America*. 2000; 107:989–999. [PubMed: 10687708]
- Cutler A. Greater sensitivity to prosodic goodness in non-native than in native listeners. *Journal of the Acoustical Society of America*. 2009; 125:3522–2525. [PubMed: 19507933]
- Daly N, Warren P. Pitching it differently in New Zealand English. *Journal of Sociolinguistics*. 2001; 5:85–96.
- de Jong NH, Wempe T. Praat script to detect syllable nuclei and measure speech rate automatically. *Behavior Research Methods*. 2009; 41:385–390. [PubMed: 19363178]
- Dekydspotter L, Donaldson B, Edmonds AC, Fultz AL, Petrusch RA. Syntactic and prosodic computations in the resolution of relative clause attachment ambiguity by English-French learners. *Studies in Second Language Acquisition*. 2008; 30:453–480.
- Derwing TM, Rossiter MJ, Munro MJ, Thomson RI. Second language fluency: Judgments on different tasks. *Language Learning*. 2004; 54:655–679.
- Derwing TM, Munro MJ, Thomson RI, Rossiter MJ. The relationship between L1 fluency and L2 fluency development. *Studies in Second Language Acquisition*. 2009; 31:533–557.
- Dixon P. Models of accuracy in repeated-measures designs. *Journal of Memory and Language*. 2008; 59:447–456.
- Escudero P, Benders T, Lipski SC. Native, non-native and L2 perceptual cue weighting for Dutch vowels: The case of Dutch, German, and Spanish listeners. *Journal of Phonetics*. 2009; 37:452–465.
- Fernández E. The prosody produced by Spanish-English bilinguals: A preliminary investigation and implications for sentence processing. *Revista da ABRALIN*. 2005; 4:109–141.
- Féry, C. *German intonational patterns*. Tübingen: Max Niemeyer Verlag; 1993.
- Féry, C. *Laute und leise Prosodie [Loud and quiet prosody]*. In: Blüdhorn, H., editor. *Institut für deutsche Sprache Jahrbuch 2005*. Berlin: DeGruyter; 2005. p. 164–183.
- Flège JE, Bohn O-S, Jang S. Effects of perception on non-native speakers' production and perception of English vowels. *Journal of Phonetics*. 1997; 25:437–470.
- Fultz A. Prosody in syntactic ambiguity in English-French interlanguage. *Proceedings of the Annual Boston University Conference on Language Development*. 2007; 32:394–405.
- Goethe-Institut. [30 October 2006] Einstufungstest [Placement test]. 2004. Retrieved from: <<http://www.goethe.de/cgi-bin/einstufungstest/einstufungstest.pl>>
- Grosser, W. On the acquisition of tonal and accentual features of English by Austrian learners. In: James, A.; Leather, J., editors. *Second language speech: Structure and process*. Berlin: Mouton de Gruyter; 1997. p. 211–228.
- Gut U. Prosody in second language speech production: The role of the native language. *Fremdsprachen lehren und lernen*. 2003; 32:133–151.
- Gut, U. *Non-native speech: A corpus-based analysis of phonological and phonetic properties of L2 English and German*. Frankfurt: Peter Lang; 2009.
- Hasselgren, A. Learner corpora and language testing. In: Granger, S.; Hung, J.; Petch-Tyson, S., editors. *Computer learner corpora, second language acquisition and foreign language teaching*. Amsterdam: Benjamins; 2002. p. 143–173.
- Hoffman L, Rovine MJ. Multilevel models for the experimental psychologist: Foundations and illustrative examples. *Behavioral Research Methods*. 2007; 39:101–117.
- Hoyle KJ, Brownell H, Wingfield A. Components of speech prosody and their use in detection of syntactic structure by older adults. *Experimental Aging Research*. 2009; 35:129–151. [PubMed: 19173106]

- Jaeger FT. Categorical data analyses: Away from ANOVAs (transformation or not) and towards logit mixed models. *Journal of Memory and Language*. 2008; 59:387–556.
- Jilka M. The contribution of intonation to the perception of foreign accent: Identifying intonational deviations by means of F0 generation and resynthesis. *Arbeitspapiere des Instituts für Maschinelle Sprachverarbeitung*. 2000; 6(3)
- Jilka, M. Non-native prosody: Phonetic description and teaching practice. Berlin: Mouton de Gruyter; 2007. Different manifestations and perceptions of foreign accent in intonation; p. 77-96.
- Kang S, Speer S. Effects of prosodic boundaries on syntactic disambiguation. *Studia Linguistica*. 2005; 59:244–258.
- Kim JS, Kim SH. Remarks on Korean speaker's realization of English intonation: Focusing on declarative sentences. *Journal of the Pan-Pacific Association of Applied Linguistics*. 2001; 5:187–207.
- Kjelgaard MM, Speer SR. Prosodic facilitation and interference in the resolution of temporary syntactic closure ambiguity. *Journal of Memory and Language*. 1999; 40:153–194.
- Konieczny L, Hemforth B, Scheepers C, Strube G. The role of lexical heads in parsing: Evidence from German. *Language and Cognitive Processes*. 1997; 12:307–348.
- Kraljic T, Brennan SE. Prosodic disambiguation of syntactic structure: For the speaker or for the addressee? *Cognitive Psychology*. 2005; 50:194–231. [PubMed: 15680144]
- Kreft IGG, de Leeuw J, Aiken LS. The effect of different forms of centering in hierarchical linear models. *Multivariate Behavioral Research*. 2007; 30:1–21.
- Lehiste I, Olive JP, Streeter LA. The role of duration in disambiguation in disambiguating syntactically ambiguous sentences. *Journal of the Acoustical Society of America*. 1976; 60:1199–1202.
- Lindblom, B. Systemic constraints and adaptive change in the formation of sound structure. In: Hurford, JR.; Studdert-Kennedy, M.; Knight, C., editors. *Approaches to the evolution of language: Social and cognitive bases*. England: Cambridge University Press; 1998. p. 242-264.
- Lingel, S.; Pappert, S.; Pechman, T. The prosody of German pp-attachment ambiguities: Evidence from production and perception. Poster presentation at the 12th Annual Conference on Architectures and Mechanisms for Language Processing (AMLaP); Nijmegen, The Netherlands. 2006.
- Lingel, S.; Scheepers, C.; Mohr, S.; Pechmann, T. The influence of prosody and verb placement on resolving global PP-attachment ambiguities in German: A visual-world study. Poster presentation at the 20th Annual CUNY Conference on Human Sentence Processing; La Jolla, California. 2007.
- Mennen I. Bi-directional interference in the intonation of Dutch speakers of Greek. *Journal of Phonetics*. 2004; 32:543–563.
- Mennen, I. Phonological and phonetic influences in non-native intonation. In: Trouvain, J.; Gut, U., editors. *Non-native prosody: Phonetic description and teaching practice*. Berlin: Mouton de Gruyter; 2007. p. 53-76.
- Munro M. Nonsegmental factors in foreign accent: Rating of foreign speech. *Studies in Second Language Acquisition*. 1995; 17:17–33.
- Munro MJ, Derwing TM. Evaluations of foreign accent in extemporaneous and read material. *Language Testing*. 1994; 11:253–266.
- Nespor, M.; Vogel, I. *Prosodic phonology*. Dordrecht: Foris Publications; 1986.
- Oxford University Press. [5 May 2011] Oxford Online Placement Test. 2009. Retrieved from: <www.oxfordenglishtesting.com>
- Pennington MC, Ellis NE. Cantonese speakers' memory for English sentences with prosodic cues. *Modern Language Journal*. 2000; 84:372–389.
- Peters, J. *Intonation deutscher Regionalsprachen [Intonation of German regional languages]*. Berlin/ New York: Walter de Gruyter; 2006.
- Piper T, Cansin D. Factors influencing the foreign accent. *The Canadian Modern Language Review*. 1988; 44:334–342.
- Price PJ, Ostendorf M, Shattuck-Hufnagel S, Fong C. The use of prosody in syntactic disambiguation. *Journal of the Acoustical Society of America*. 1991; 90:2956–2970. [PubMed: 1787237]

- Pynte J, Prieur B. Prosodic breaks and attachment decisions in sentence parsing. *Language and Cognitive Processes*. 1996; 11:165–191.
- Quené H, van den Bergh H. Examples of mixed-effects modeling with crossed random effects and with binominal data. *Journal of Memory and Language*. 2008; 59:413–425.
- R Development Core Team. R: A language and environment for statistical computing. Vienna: R Foundation for Statistical Computing; 2010. Retrieved from: <<http://www.R-project.org>> [10 July 2010]
- Ramírez Verdugo D. Non-native interlanguage intonation systems: a study based on a computerized corpus of Spanish learners of English. *ICAME Journal*. 2002; 26:115–132.
- Schafer AJ, Speer SR, Warren P, White SD. Intonational disambiguation in sentence production and comprehension. *Journal of Psycholinguistic Research*. 2000; 29:169–182. [PubMed: 10709182]
- Schafer, AJ.; Speer, SR.; Warren, P. Prosodic influences on the production and comprehension of syntactic ambiguity in a game-based conversation task. In: Tanenhaus, M.; Trueswell, J., editors. *Approaches to studying world situated language use: Psycholinguistic, linguistic and computational perspectives on bridging the product and action tradition*. Cambridge, MA: MIT Press; 2005. p. 209–226.
- Scott D. Duration as a cue to the perception of a phrase boundary. *Journal of the Acoustical Society of America*. 1982; 71:996–1007. [PubMed: 7085988]
- Scaffil, M. *Experiments in comparative intonation: A case study of English and German*. Tübingen: Max Niemeyer Verlag; 1982.
- Selkirk, EO. *Phonology and syntax: The relation between sound and structure*. Cambridge, MA: MIT Press; 1984.
- Selkirk, E. Comments on intonational phrasing in English. In: Frota, S.; Vigario, M.; Freitas, J., editors. *Prosodies : with special reference to Iberian languages*. Berlin: Mouton de Gruyter; 2005. p. 11–58.
- Snedeker J, Trueswell J. Using prosody to avoid ambiguity: Effects of speaker awareness and referential context. *Journal of Memory and Language*. 2003; 48:103–130.
- Snedeker J, Yuan S. Effects of prosodic and lexical constraints on parsing in young children (and adults). *Journal of Memory and Language*. 2008; 58:574–608. [PubMed: 19190721]
- Soderstrom M, Seidl A, Kemler Nelson DG, Jusczyk PW. The prosodic bootstrapping of phrases: Evidence from prelinguistic infants. *Journal of Memory and Language*. 2003; 49(2):249–267.
- Spivey-Knowlton M, Sedivy J. Resolving attachment ambiguities with multiple constraints. *Cognition*. 1995; 55:227–267. [PubMed: 7634760]
- Straub, KA. Unpublished doctoral dissertation. University of Rochester; 1997. The production of prosodic cues and their role in the comprehension of syntactically ambiguous sentences.
- Streeter L. Acoustic determinants of phrase boundary perception. *Journal of the Acoustical Society of America*. 1978; 64:1582–1592. [PubMed: 739094]
- Temple L. Second language learner speech production. *Studia Linguistica*. 2000; 54:288–297.
- Trofimovich P, Baker W. Learning second language suprasegmentals: Effect of L2 experience on prosody and fluency characteristics of L2 speech. *Studies in Second Language Acquisition*. 2006; 28:1–30.
- Tyler MD, Cutler A. Cross-language differences in cues for speech segmentation. *Journal of the Acoustical Society of America*. 2009; 126:367–376. [PubMed: 19603893]
- Watson D, Gibson E. Intonational phrasing and constituency in language production and comprehension. *Studia Linguistica*. 2005; 59:279–300.
- Watson D, Breen M, Gibson E. The role of syntactic obligatoriness in the production of intonational boundaries. *Journal of Experimental Psychology: Learning, Memory, and Cognition*. 2006; 32:1045–1056.
- Weber A, Cutler A. First-language phonotactics in second-language listening. *Journal of the Acoustical Society of America*. 2006; 119:597–607. [PubMed: 16454313]
- Wennerstrom A. Intonational meaning in English discourse: A study of non-native speakers. *Applied Linguistics*. 1994; 15:399–420.

Appendix A. English contexts and target sentences

Situational contexts and experimental sentences used in the German contextualized sentence production task.

Context	Target sentence
1a. Two criminals robbed a jewelry store on the same night. One stole an expensive diamond and the other stole a ring.	The policeman discovered the criminal with the expensive diamond. (NP-attachment)
1b. A criminal had been hiding out in an apartment for months. A policeman watched the apartment with a hidden microphone and a video camera.	The policeman discovered the criminal with the hidden microphone. (VP-attachment)
2a. A knight saw two queens were in trouble. One queen had a big heart and was very kind. The other queen was cruel.	The knight rescued the queen with the big heart. (NP-attachment)
2b. A knight saw his queen was in trouble. In his hands he carried a sword and a bow that he could use to free her.	The knight rescued the queen with the sword. (VP-attachment)
3a. A deer found two trails that crossed in the woods. One trail was older but the other was covered in fresh footprints.	The deer smelled the trail with the footprints. (NP-attachment)
3b. A deer came across an animal's trail in the woods. The deer sensed danger.	The deer smelled the trail with careful attention. (VP-attachment)
4a. The fortuneteller was afraid to look into the future. Either it would be a lovely future or a future with many new problems.	The fortuneteller saw the future with its new problems. (NP-attachment)
4b. The fortuneteller had cards and a crystal ball at her disposal.	The fortuneteller saw the future with the cards. (VP-attachment)
5a. A professor could not remember who had the first appointment of the semester. Was he tutoring the freshman with the black bag or the freshman with the red backpack?	The professor taught the freshman with the red backpack. (NP-attachment)
5b. The professor met with a freshman from his course, who had brought a book and a calculator to the professor's office hours. The freshman clearly needed a lot of help.	The professor taught the freshman with the help of the book. (VP-attachment)
6a. The manager of a large company had two secretaries: one with two children who worked very diligently and one without children who always went home at 4:00.	The manager thanked the secretary with two children. (NP-attachment)
6b. The manager of a large company had a secretary who had worked quite a bit of overtime in the last few months. He wanted to thank her.	The manager thanked the secretary with a bouquet of flowers. (VP-attachment)
7a. Nina absolutely wanted to see a soccer game. She had two options: either a really big game with a lot of fans or a smaller game in her home town.	Nina saw the game with a lot of spectators. (NP-attachment)
7b. Nina absolutely wanted to see the soccer game. But there were only two tickets left. So she could either go with her mother or with her brother.	Nina saw the game with her brother. (VP-attachment)
8a. During a hold-up, a thief wanted money from two men. One man gave the thief twenty dollars. The other man had no money.	The thief hit the man with no money. (NP-attachment)
8b. A man surprised a thief. The thief knew he could hit the man with a chair or a computer.	The thief hit the man with a chair. (VP-attachment)
9a. A gangster saw two of his rivals in a park at night. One wore a yellow hat. The other wore a black sweater.	The gangster followed his rival with the black sweater. (NP-attachment)
9b. A gangster saw his rival in a park at night. The gangster had a motorcycle and a bicycle.	The gangster followed his rival with the motorcycle. (VP-attachment)
10a. Two kittens walked into Stephan's garden. One kitten had a brownish tail and the other had a white tail. Stephan really didn't like cats.	Stephan kicked the kitten with the brownish tail. (NP-attachment)
10b. A kitten walked into Stephan's garden. To scare it away, Stephan could kick it or spray it with water.	Stephan kicked the kitten with his foot. (VP-attachment)
11a. The cook needed to hold one kind of cheese over the stove. The cook had blue cheese and a cheese with a rind.	The cook held the cheese with the rind. (NP-attachment)

Context	Target sentence
11b. The cook needed to hold cheese over the stove so that he could melt it into the pan. He could use a fork or a spoon.	The cook held the cheese with the fork. (VP-attachment)
12a. The queen bought the king two crowns as presents. One crown had large jewels on it. The other was silver. The king searched for his presents.	The king saw the crown with the large jewels. (NP-attachment)
12b. A crown was in a museum in England. The king had to decide if he should go to the exhibit himself or send his servant to see it.	The king saw the crown with his very own eyes. (VP-attachment)
13a. Up until now the actor had only landed funny roles. This time he decided to play a more serious role. He had two options: he could either play the role of a sick boy or that of a boy from the slums.	The actor portrayed the boy with a blood disease. (NP-attachment)
13b. Up until now the actor had only landed funny roles. This time he decided to play a more serious role. He wanted to play it as well as he could.	The actor portrayed the boy with enthusiasm. (VP-attachment)
14a. A doctor went into the waiting room and saw two men. One had broken his leg and the other had a fever.	The doctor examined the man with the fever. (NP-attachment)
14b. A man has been sick since yesterday and had problems with his heart and his breathing. The doctor wanted to examine everything.	The doctor examined the man with the stethoscope. (VP-attachment)

Appendix B. German contexts and target sentences

Situational contexts and experimental sentences used in the German contextualized sentence production task.

Context	Target sentence
1a. Zwei Betrüger raubten einen Juwelierladen in derselben Nacht aus. Einer stahl einen teuren Diamanten und der Andere stahl einen schönen Ring.	Der Polizist entdeckte den Betrüger mit dem teuren Diamanten. (NP-attachment)
1b. Ein Betrüger versteckte sich Monate lang in einer Wohnung. Ein Polizist war auf der Suche und beobachtete die Wohnung mit einem versteckten Mikrofon und einer Videokamera.	Der Polizist entdeckte den Betrüger mit dem versteckten Mikrofon. (VP-attachment)
2a. Ein Ritter sah zwei Königinnen in Gefahr. Eine Königin hat ein großes Herz und war sehr gütig. Die Andere war sehr gemein.	Der Ritter rettete die Königin mit dem großen Herz. (NP-attachment)
2b. Der Ritter sah, dass seine Königin in Gefahr war. In seinen Händen trug er ein Schwert und einen Bogen, mit denen er sie befreien konnte.	Der Ritter rettete die Königin mit dem Schwert. (VP-attachment)
3a. Ein Reh kam auf einige Wanderwege im Wald. Einer war älter. Der Andere enthielt Essensreste.	Das Reh roch die Spur mit den Essensresten. (NP-attachment)
3b. Ein Reh fand eine Spur von anderen Tieren im Wald. Es spürte Gefahr.	Das Reh roch die Spur mit Aufmerksamkeit. (VP-attachment)
4a. Die Wahrsagerin hatte Angst, in die Zukunft zu schauen. Entweder wäre es eine schöne Zukunft oder eine mit vielen neuen Problemen.	Die Wahrsagerin sah die Zukunft mit ihren neuen Problemen. (NP-attachment)
4b. Der Wahrsagerin standen Karten und eine Glaskugel zur Verfügung.	Die Wahrsagerin sah die Zukunft mit den Karten. (VP-attachment)
5a. Ein Professor konnte sich nicht daran erinnern, wer zuerst in die Sprechstunde kam. War es die Studentin mit der schwarzen Tasche oder die Studentin mit dem roten Rucksack?	Der Professor lehrte die Studentin mit dem roten Rucksack. (NP-attachment)
5b. Der Professor traf sich mit einer Studentin aus seinem Kurs, die ein Buch und einen Taschenrechner mit in die Sprechstunde gebracht hat. Die Studentin brauchte viel Hilfe.	Der Professor lehrte die Studentin mit Hilfe des Buches. (VP-attachment)
6a. Der Geschäftsführer einer großen Firma hatte zwei Sekretärinnen: eine mit zwei Kindern, die sehr fleißig arbeitete und eine ohne Kinder, die jeden Tag um 16.00 Uhr nach Hause ging.	Der Geschäftsführer dankte der Sekretärin mit zwei Kindern. (NP-attachment)

Context	Target sentence
6b. Der Geschäftsführer einer großen Firma hatte eine Sekretärin, die in den letzten Monaten viele Überstunden gearbeitet hat. Er wollte sich bei ihr bedanken.	Der Geschäftsführer dankte der Sekretärin mit einem Blumenstrauß. (VP-attachment)
7a. Nina wollte unbedingt ein Fußballspiel sehen. Sie hatte die Wahl: entweder ein sehr großes Spiel mit vielen Fans oder ein kleineres Spiel in ihrer kleinen Heimatstadt.	Nina besuchte das Spiel mit den vielen Zuschauern. (NP-attachment)
7b. Nina wollte das Fußballspiel unbedingt sehen. Aber es gab nur noch zwei Karten-- also konnte Nina mit ihrer Mutter oder mit ihrem Bruder gehen.	Nina besuchte das Spiel mit ihrem Bruder. (VP-attachment)
8a. Bei einem Überfall forderte ein Dieb Geld von zwei Männern. Ein Mann gab dem Dieb zwanzig Euro. Der andere Mann hatte nur einen Euro.	Der Dieb schlug den Mann mit einem Euro. (NP-attachment)
8b. Ein Mann überraschte den Dieb. Der Dieb wusste, dass er den Mann mit einem Stuhl oder einem Computer schlagen konnte.	Der Dieb schlug den Mann mit einem Stuhl. (VP-attachment)
9a. In der Nacht sah der Gangster zwei von seinen Gegnern in einem Park. Ein Gegner trug einen gelben Hut. Der Andere trug einen schwarzen Pulli.	Der Gangster folgte seinem Gegner mit dem schwarzen Pulli. (NP-attachment)
9b. In der Nacht sah der Gangster seinen Gegner in einem Park. Der Gangster hatte ein Motorrad und ein Fahrrad.	Der Gangster folgte seinem Gegner mit dem Motorrad. (VP-attachment)
10a. Zwei Katzen kamen in Stephans Garten. Eine hatte einen braunen Schwanz und die Andere einen weißen. Stephan hatte Katzen überhaupt nicht gern.	Stephan schlug die Katze mit dem braunen Schwanz. (NP-attachment)
10b. Eine Katze kam in Stephans Garten. Um sie wegzujagen, konnte Stephan sie mit seinem Fuß schlagen oder mit Wasser nass spritzen.	Stephan schlug die Katze mit seinem Fuß. (VP-attachment)
11a. Der Koch musste eine Käsesorte über dem Herd	Der Koch hielt den Käse mit der Rinde. (NP-attachment)
halten, damit er ihn in den Topf schmelzen konnte. Er hatte einen Schimmelkäse und einen Käse mit einer Rinde.	
11b. Der Koch musste Käse über dem Herd halten, damit er ihn in den Topf schmelzen konnte. Er hatte eine Gabel und einen Löffel.	Der Koch hielt den Käse mit der Gabel. (VP-attachment)
12a. Die Königin kaufte dem König zwei Kronen als Geschenk und versteckte sie. Eine Krone hatte große Edelsteine, die Andere war aus Silber. Der König suchte überall seine Geschenke.	Der König sah die Krone mit den großen Edelsteinen. (NP-attachment)
12b. Eine Krone war in einem Museum in England. Der König musste sich entscheiden, ob er sie selbst sehen wollte oder ob er seinen Diener schicken würde.	Der König sah die Krone mit den eigenen Augen. (VP-attachment)
13a. Der Schauspieler hatte bis jetzt nur lustige Rollen. Dieses Mal hat er sich entschieden, eine ernstere Rolle zu spielen. Er hatte die Möglichkeit, entweder die Rolle von einem kranken Jungen oder von einem Jungen aus einem Armenviertel zu spielen.	Der Schauspieler spielte den Jungen mit einer Blutkrankheit. (NP-attachment)
13b. Der Schauspieler hatte bis jetzt nur lustige Rollen. Dieses Mal hat er sich entschieden, eine ernstere Rolle zu spielen. Er wollte sie so gut wie möglich spielen.	Der Schauspieler spielte den Jungen mit Begeisterung. (VP-attachment)
14a. Ein Arzt ging ins Wartezimmer und sah zwei Männer. Einer hat sich das Bein gebrochen und der Andere hatte Fieber.	Der Arzt untersuchte den Mann mit Fieber. (NP-attachment)
14b. Ein Mann ist seit gestern krank und hatte Probleme mit seinem Herzen und beim Atmen. Der Arzt wollte alles untersuchen.	Der Arzt untersuchte den Mann mit dem Stethoskop. (VP-attachment)

Figure 1.
English NP-attachment sentence.

Figure 2.
English VP-attachment sentence.

Figure 3.
German NP-attachment sentence (“The king saw the crown with the large jewels”).

Figure 4.
 German VP-attachment sentence ("The king saw the crown with his own eyes").

Table 1

Fluency measures for all participants in Experiments 1a, 1b and 2

	German	English
	<i>M (SD)</i>	<i>M (SD)</i>
English-German L2 learners (Exp 1a)		
Mean length run (in seconds)	0.871 (0.129)	1.002 (0.292)
Pauses/second	0.254 (0.080)	0.186 (0.048)
Speech rate (syllables/phonation time)	3.933 (0.499)	3.919 (0.231)
Filled pauses	1.18 (1.17)	0.91 (1.14)
Repetitions (of words)	1.73 (1.62)	0.09 (0.30)
German-English L2 learners (Exp 1b)		
Mean length run (in seconds)	0.912 (0.309)	0.691 (0.180)
Pauses/second	0.238 (0.079)	0.309 (0.099)
Speech rate (syllables/phonation time)	4.581 (0.446)	4.103 (0.570)
Filled pauses	0.46 (0.66)	1.62 (1.56)
Repetitions (of words)	0.85 (2.51)	1.62 (2.22)
Monolingual English speakers (Exp 2)		
Mean length run (in seconds)		0.606 (0.187)
Pauses/second		0.278 (0.088)
Speech rate (syllables/phonation time)		5.136 (1.674)
Filled pauses		0.40 (1.12)
Repetitions (of words)		0.47 (0.74)

Note: As the monolingual English speakers did not complete the picture description task in German, we do not report any German fluency results for this group.

Table 2

Mean values of acoustic measures from the contextualized speaking task for the English-German L2 learners (standard deviations in parentheses)

	NP-attachment	VP-attachment
L2 German		
Subject length (in ms)	604 (225)	598 (210)
Verb length (in ms)	409 (130)	409 (124)
DO length (in ms)	592 (154)	605 (178)
PP length (in ms)	1238 (323)	1097 (290)
Verb pitch excursion (in ERB)	0.72 (2.28)	0.86 (1.73)
DO pitch excursion (in ERB)	0.02 (1.90)	0.63 (1.87)
Subject-Verb pause %	5.4 (22.8)	8.1 (27.5)
V-DO pause %	9.5 (29.5)	9.5 (29.5)
DO-PP pause %	8.1 (27.5)	14.9 (35.8)
Pitch accent on <i>mit</i> %	19.7 (40.1)	53.7 (50.2)
L1 English		
Subject length (in ms)	441 (133)	449 (147)
Verb length (in ms)	306 (112)	304 (99)
DO length (in ms)	445 (104)	456 (103)
PP length (in ms)	978 (215)	918 (250)
Verb pitch excursion (in ERB)	-0.26 (1.04)	-0.34 (1.52)
DO pitch excursion (in ERB)	-0.20 (2.08)	-0.15 (1.16)
Subject-Verb pause %	0.0 (0.0)	2.7 (16.2)
V-DO pause %	7.9 (27.1)	1.3 (11.5)
DO-PP pause %	1.3 (11.5)	5.3 (22.6)
Pitch accent on <i>with</i> %	8.2 (27.7)	45.7 (50.2)

Estimated coefficients from the multilevel model analyses of duration data from the English-German L2 learners in L2 German (standard errors in parentheses)

Table 3

	Verb		DO		Prep. phrase	
	Coefficient	t	Coefficient	t	Coefficient	t
(Intercept)	411 (15.5)	26.49 *****	587 (22.9)	25.63 *****	1177 (43.4)	27.16 *****
Syllable	106 (9.1)	11.60 *****	136 (20.8)	6.52 *****	198 (14.1)	13.98 *****
Condition	-2 (9.1)	-0.20	28 (12.7)	2.23 *	20 (28.7)	0.69
Study abroad	-1 (0.6)	-2.16 *	-2 (0.6)	-3.41 *****		

Syllable refers to the number of syllables in the target word. *Condition* refers to attachment type (NP- vs. VP-attachment). *Study abroad* refers to months spent abroad (as the number of months spent abroad was not included in the final model for the prepositional phrase, this cell has been left blank).

* $p < .05$
*** $p < .001$
***** $p < .0001$

Estimated coefficients from the mixed-effects model analyses of F0 excursion and pitch accent data from the English-German L2 learners in L2 German (standard errors in parentheses)

Table 4

Verb: Pitch excursion		DO: Pitch excursion		Pitch accent on <i>mit</i> ^{1,2}	
Coefficient	<i>t</i>	Coefficient	<i>t</i>	Coefficient	Wald <i>Z</i>
(Intercept)	0.74 (0.331)	2.23 *	0.01 (0.246)	0.03	-1.494 (0.385) ***
Condition	0.14 (0.319)	0.45	0.62 (0.309)	2.02 *	1.673 (0.409) 4.09 *****

Condition refers to attachment type (NP- vs. VP-attachment).

* $p < .05$
*** $p < .001$
***** $p < .0001$

Table 5

Estimated coefficients from the multilevel model analyses of duration data from the English-German L2 learners in L1 English (standard errors in parentheses)

Verb		DO		Prep. phrase	
	Coefficient	t		Coefficient	t
(Intercept)	308 (14.7)	21.04 *****	449 (13.6)	32.95 *****	976 (32.8) 29.78 *****
Syllable	115 (18.1)	6.36 *****	93 (12.4)	7.50 *****	149 (10.0) 14.86 *****
Condition	-5 (6.7)	-0.72	3 (6.94)	0.43	-51 (16.8) -3.05**

Syllable refers to the number of syllables in the target word. Condition refers to attachment type (NP- vs. VP-attachment).

**
 $p < .01$

 $p < .0001$

Table 6

Estimated coefficients from the mixed-effects model analyses of pitch accent data from the English-German L2 learners in L1 English (standard errors in parentheses)

Pitch accent on <i>mit</i>		
	Coefficient	Wald Z
(Intercept)	-2.413 (0.426)	-5.66****
Condition	2.241 (0.489)	4.58****

Condition refers to attachment type (NP- vs. VP-attachment).

 $p < .0001$

Table 7

Mean values of acoustic measures from the contextualized speaking task for the German-English L2 learners (standard deviations in parentheses)

	NP-attachment	VP-attachment
L1 German		
Subject length (in ms)	542 (173)	529 (168)
Verb length (in ms)	327 (107)	329 (110)
DO length (in ms)	523 (124)	508 (139)
PP length (in ms)	1104 (244)	992 (199)
Verb pitch excursion (in ERB)	0.52 (1.74)	0.14 (1.80)
DO pitch excursion (in ERB)	0.51 (1.25)	0.91 (1.36)
Subject-Verb pause %	1.1 (10.6)	1.1 (10.5)
V-DO pause %	4.5 (20.8)	5.6 (23.0)
DO-PP pause %	1.1 (10.6)	5.6 (23.0)
Pitch accent on <i>mit</i> %	31.4 (46.7)	50.0 (50.3)
L2 English		
Subject length (in ms)	530 (162)	513 (150)
Verb length (in ms)	344 (125)	362 (144)
DO length (in ms)	506 (132)	511 (144)
PP length (in ms)	1052 (243)	977 (272)
Verb pitch excursion (in ERB)	-0.19 (1.10)	-0.14 (1.21)
DO pitch excursion (in ERB)	0.35 (1.63)	0.39 (1.58)
Subject-Verb pause %	12.8 (33.6)	10.7 (31.1)
V-DO pause %	11.6 (32.2)	11.9 (32.6)
DO-PP pause %	9.3 (29.2)	10.7 (31.1)
Pitch accent on <i>mit</i> %	13.0 (33.8)	41.9 (49.7)

Estimated coefficients from the multilevel model analyses of duration data from the German-English L2 learners in L1 German (standard errors in parentheses)

Table 8

Verb		DO		Prep. phrase	
Coefficient	t	Coefficient	t	Coefficient	t
(Intercept)	328 (12.5)	26.25 *****	516 (16.8)	30.72 *****	1056 (29.7)
Syllable	97 (10.5)	9.25 *****	124 (14.7)	8.43 *****	152 (8.3)
Condition	0 (5.1)	0.07	-1 (5.9)	-0.10	-5 (14.8)

Syllable refers to the number of syllables in the target word. Condition refers to attachment type (NP- vs. VP-attachment).

p < .0001

Estimated coefficients from the mixed-effects model analyses of F0 excursion and pitch accent data from the German-English L2 learners in L1 German (standard errors in parentheses)

Table 9

Verb: Pitch excursion		DO: Pitch excursion		Pitch accent on <i>mit</i> ¹²	
		Coefficient	t	Coefficient	Wald Z
(Intercept)		0.54 (0.269)	2.02 *	0.52 (0.169)	3.07 **
Condition		-0.37 (0.260)	-1.43	0.39 (0.192)	2.05 *
				0.987 (0.354)	2.79 **

Condition refers to attachment type (NP- vs. VP-attachment).

* $p < .05$
** $p < .01$

Table 10

Estimated coefficients from the multilevel model analyses of duration data from the German-English L2 learners in L2 English (standard errors in parentheses)

	Verb		DO	
	Coefficient	<i>t</i>	Coefficient	<i>t</i>
(Intercept)	345 (19.4)	17.75****	504 (20.9)	24.07****
Syllable	139 (23.5)	5.91****	110 (19.7)	5.58****
Speech rate	-48 (16.5)	-2.92**	-44 (20.8)	-2.10*
Condition	15 (8.2)	1.81	13 (10.0)	1.27
	Prep. phrase		<i>with</i>	
	Coefficient	<i>t</i>	Coefficient	<i>t</i>
(Intercept)	1075 (29.1)	36.96****	157 (4.9)	31.92****
Syllable	149 (10.9)	13.63****		
Speech rate	-104 (30.8)	-3.37**	-17 (4.3)	-3.48***
Condition	-83 (18.4)	-4.53****	9 (4.9)	2.09*

Syllable refers to the number of syllables in the target word (as there was no difference in syllable length on the preposition *with*, this cell has been left blank). *Condition* refers to attachment type (NP- vs. VP-attachment). *Speech rate* refers to L2 speech rate.

*
 $p < .05$

**
 $p < .01$

 $p < .001$

 $p < .0001$

Table 11

Estimated coefficients from the mixed-effects model analyses of pitch accent data from the German-English L2 learners in L2 English (standard errors in parentheses)

Pitch accent on <i>mit</i> ¹³		
	Coefficient	Wald Z
(Intercept)	-2.025 (0.388)	-5.23****
Speech rate	-0.962 (0.489)	-1.97*
Condition	1.734 (0.436)	3.98****

Condition refers to attachment type (NP- vs. VP-attachment). *Speech rate* refers to L2 speech rate.

*
 $p < .05$

 $p < .0001$

Table 12

Mean values of acoustic measures from the contextualized speaking task for the monolingual English speakers (standard deviations in parentheses)

	NP-attachment	VP-attachment
Subject length (in ms)	458 (138)	455 (140)
Verb length (in ms)	322 (113)	317 (109)
DO length (in ms)	478 (111)	473 (113)
PP length (in ms)	1024 (248)	949 (249)
Verb pitch excursion (in ERB)	−0.52 (2.10)	−0.24 (2.29)
DO pitch excursion (in ERB)	−0.57 (2.67)	−0.64 (2.65)
Subject-Verb pause %	4.5 (20.8)	6.3 (24.4)
V-DO pause %	11.7 (32.3)	9.9 (30.0)
DO-PP pause %	6.3 (24.4)	6.3 (24.4)
Pitch accent on <i>mit</i> %	14.3 (35.2)	42.6 (49.7)

Estimated coefficients from the multilevel model analyses of duration data from the monolingual English speakers (standard errors in parentheses)

Table 13

Verb		DO		Prep. phrase	
	Coefficient	t		Coefficient	t
(Intercept)	324 (17.4)	18.66****		477 (17.4)	27.38****
Syllable	110 (21.2)	5.18****		88 (16.1)	5.47****
Condition	-7 (6.8)	-1.04		-1 (7.4)	-0.07

Syllable refers to the number of syllables in the target word. Condition refers to attachment type (NP- vs. VP-attachment).

p < .0001

Table 14

Estimated coefficients from the mixed-effects model analyses of pitch accent data from the monolingual English speakers (standard errors in parentheses)

Pitch accent on <i>mit</i> ⁸		
	Coefficient	Wald Z
(Intercept)	-1.980 (0.344)	-5.75 ****
Condition	1.633 (0.354)	4.61 ****

Condition refers to attachment type (NP- vs. VP-attachment).

 $p < .0001$