http://dx.doi.org/10.17959/sppm.2015.21.3.495

The effect of interpretation bias on the comprehension of disambiguating prosody

Wook Kyung Choe
(Dong-A University)

Choe, Wook Kyung. 2015. The effect of interpretation bias on the comprehension of disambiguating prosody. *Studies in Phonetics, Phonology and Morphology* 21.3. 495-516. Although interpretation biases are not frequently assumed in studies of prosodic disambiguation, research on syntactic processing indicates that the two possible meanings of a syntactically ambiguous sentence are not equally plausible. The goal of the current study is to investigate the effect of interpretation bias (which of the two meanings is preferred) and bias strength (how strongly one meaning is preferred to another) on the comprehension of disambiguating prosody. Thirty-two listeners were asked to identify a speaker's intended meaning using disambiguating prosodic cues, which were produced by multiple untrained speakers. The results showed an effect of bias strength on the listeners' performance on prosodic disambiguation: listeners more successfully identified the intended meaning for strongly-biased sentences than the intended meaning for weakly-biased sentences. The results from further analyses also revealed that listeners' strategies to disambiguate an ambiguous sentence using prosody varied depending on its bias strength. **(Dong-A University)**

Keywords: prosody, disambiguation, interpretation bias, comprehension

1. Introduction

Numerous studies have suggested that prosodic structure is affected by various linguistic factors, such as syntactic, pragmatic, and discourse information. Among these factors, syntactic structure is considered to be one of the most important factors and to even derive prosodic structure (Cooper and Paccia-Cooper 1980, Nespor and Vogel 1986, Selkirk 1986, Ferreira 1993). In order to support the argument that prosodic structure is strongly influenced by syntactic structure, researchers investigated the role of prosody on disambiguating syntactically ambiguous sentences and used it as an evidence of the argument (Lieberman 1967, Lehiste 1973, Lehiste et al. 1976, Price et al. 1991).

Although studies using syntactically ambiguous sentences showed that syntactic structure is closely mapped onto prosodic structure, it still remains questionable to conclude that prosodic information is sufficient enough to resolve syntactic ambiguity due to the contradictory results: prosody could successfully disambiguate syntactically ambiguous sentences in some cases (e.g., Price et al. 1991), but it rarely did in others (e.g., Allbritton et al. 1996). These contradictory results indicate that the degree of prosodic resolution of syntactic ambiguity could be affected by some factors other than its syntactic structure such as types of ambiguity (surface-structure vs. deep-structure; e.g., Lieberman 1967, Lehiste 1973, Lehiste et al. 1976, Wales and Toner 1979), types of task (reading vs. more natural setting; e.g., Schafer et al. 2000, Warren et al. 2000, Snedeker and Trueswell 2003), or types of stimuli (produced by trained vs. untrained or informed vs. naïve speakers; e.g., Allbritton et al. 1996, Fox Tree and Meijer 2000). For example, Fox Tree and Meijer (2000) investigated whether naïvely produced prosody could help listeners to disambiguate ambiguous sentences. They asked untrained and naïve speakers to produce ambiguous sentences such as *She saw a man eating fish* with one of its disambiguating contexts (*Tony went deep sea diving in the Pacific Ocean. She saw a man eating fish. It scared her.* vs. *Jenny went to the Seafood restaurant. She saw a man eating fish. He seemed to like it.*). Then, they asked listeners to match the context with production of ambiguous sentences. Compared to the results from the studies that used one or a few trained/informed speakers' production (e.g., Wales and Toner 1979, Price et al. 1991, Speer et al. 1996), their results indicated that listeners in general could not successfully choose the matched disambiguating context for the naïve/untrained production of disambiguating prosody (i.e., overall percent correct was 51%), but some productions by naïve speakers were able to be reliably used for prosodic disambiguation.

In spite of the findings about the various factors influencing the degree of prosodic disambiguation, most of the studies did not assume that one of the two possible meanings of an ambiguous sentence could be more preferred than the other. Although frequently ignored in prosodic disambiguation studies, this interpretation bias on syntactically ambiguous sentences was widely investigated in research on syntactic processing (e.g., Wanner 1980, Trueswell et al. 1994, Altmann et al. 1998). For example, see the ambiguous sentences in (1) and (2) below. The two sentences have the same syntactic structures, but the ambiguous sentence in (1) can be more equally interpreted with both possible meanings as in (1a) and (1b) while one

meaning—(2a) is preferred over the other meaning—(2b). Specifically, since it is more plausible to "hit" using "a stick" rather than to "hit" using "a hat", the prepositional phrase "with a stick" in the sentence in (2) is more likely to be interpreted as having an instrument role (attached to the verb phrase: 2a) rather than as having a theme role (attached to the noun phrase: 2b).

(1) The woman hit the man with a hat.
   a. The woman used a hat to hit the man.
   b. The woman hit the man who was wearing a hat.

(2) The woman hit the man with a stick.
   a. The woman used a stick to hit the man.
   b. The woman hit the man who was holding a stick.

As the examples above showed, it is obvious that the two possible meanings of an ambiguous sentence are not always equally plausible, that is most ambiguous sentences have an interpretation bias. However, only a few studies examined the hypothesis that an interpretation bias may influence the extent to which prosodic information disambiguates syntactically ambiguous sentences (e.g., Wales and Toner 1979, Jeon and Yoon 2012, Kang 2013, Choe and Redford 2015). For example, Choe and Redford (2015) examined the effect of interpretation bias strength on the patterns of disambiguating prosody. After the interpretation bias and its strength was established for 18 ambiguous sentences, the sentences were divided into 2 groups: when more than 90% of speakers interpreted an ambiguous sentence with one meaning, the sentence was categorized as having a strong interpretation bias, otherwise an ambiguous sentence was categorized as having a weak interpretation bias. Choe and Redford then specifically asked speakers to disambiguate these sentences only using prosody. The acoustic analyses revealed that speakers were able to use different prosodic patterns to disambiguate syntactically ambiguous sentences, but disambiguating prosodic patterns were consistent across speakers only for the sentences with a weak interpretation bias. That is, speakers could use reliable and consistent temporal juncture cues to disambiguate alternate meanings only when the two possible meanings of an ambiguous sentence are more equally plausible.

In addition to the effect of interpretation bias on the production of disambiguating prosody, a few studies investigated the listeners' different ability to interpret

syntactically ambiguous sentences with the preferred meaning versus the unlikely meaning. Wales and Toner (1979), as one example, hypothesized that listeners might use "markedness strategy" for prosodic disambiguation—where a listener detects the prosodic pattern of a sentence is "unusual/marked", he/she matches this marked pattern of prosody with the "unlikely" meaning of the sentence. They expected that the percent correct that listeners detect the preferred meaning of an ambiguous sentence using disambiguating prosody would be similar to the bias strength of native speakers for the preferred meaning. However, the percent correct that listeners detect the unlikely meaning would be higher than the bias strength of native speakers for the unlikely meaning[1]. The results indicated that their expectation was correct, and Wales and Toner suggested that listeners depended more on their own interpretation bias when the provided prosodic pattern was "unmarked/normal." However, listeners were able to detect the markedness of the provided prosodic pattern and then to use the marked pattern to interpret the sentence with the unlikely meaning, which then caused the better performance of prosodic disambiguation.

Another interesting analysis from Wales and Toner (1979) was that they divided the ambiguous sentences into two groups, the strongly biased sentences (i.e., the sentences that more than 90% of native speakers interpreted with one meaning) and the weakly biased ones, and then compared their percent corrects for both the preferred and the unlikely meanings. The results, of course, showed that the percent correct for the preferred meaning of sentences with a strong interpretation bias was higher than that of sentences with a weak interpretation bias (80% vs. 68%). However, the percent correct for the unlikely meaning of sentences with a weak interpretation bias was slightly higher than that of sentences with a strong interpretation bias (58% vs. 51%). Although it is difficult to argue that the difference was significant enough without the statistical analyses, the results suggested that listeners were more likely to use prosodic cues to disambiguate alternate meanings

[1] Take an ambiguous sentence from Wales and Toner (1979), *He hit the man with the stick*, as an example. They mentioned that 75% of the participants preferred the meaning—*He used the stick to hit the man* while only 25% of them interpreted the sentence with the meaning—*The man was carrying the stick*. In this case, the bias strength for the preferred meaning became 75, and the bias strength for the unlikely meaning became 25. Although the exact percent correct for each meaning of each sentence was not provided, the average percent correct for the preferred meaning was 74%, and the average percent correct for the unlikely meaning was 55%.

when the alternate meanings were equally plausible than when one meaning was strongly preferred over another.

Kang (2013) also investigated the relationship between interpretation biases and how successfully listeners use prosodic cues to disambiguate ambiguous sentences. She used ambiguous sentences with a participle construction as in (3), which are more likely to be interpreted with a low attachment meaning as in (3a) than with a high attachment as in (3b) (Kang 2007). The listeners were divided into two groups, and the listeners in each group listened to productions either with low attachment prosodic cues or with high attachment prosodic cues. They then were asked to choose the intended meaning of what they just heard as a comprehension task.

(3) Aaron followed a poor guy drinking his soda.
  a. [Aaron followed] [a poor guy drinking his soda][2].
    Preferred: *Aaron followed a poor guy who was drinking his soda.*
  b. [Aaron followed a poor guy] [drinking his soda].
    Unlikely: *Aaron was drinking his soda when he followed a poor guy.*

The results in Kang (2013) indicated that when the disambiguating prosodic cues associated with the preferred meaning (as in (3a)) were presented—when a prosodic phrase boundary was not located right before the critical word/phrase like the bracketing in (3a), listeners were much more likely to interpret ambiguous sentences with the preferred meaning. On the other hand, when the disambiguating prosodic cues associated with the unlikely meaning (as in (3b)) were presented—when a prosodic phrase boundary was located right before the critical word/phrase like the bracketing in (3b), listeners were less likely to successfully understand the intended meaning (the unlikely one), and they rather chose the answer that the sentence is ambiguous. She suggested the reason why the prosodic cues for the unlikely meaning was less effective than those for the preferred meaning was because the disambiguating prosodic pattern for the unlikely meaning is less frequently used in the real life as well as because there could be conflicts between the provided disambiguating prosodic cues and the listeners' own interpretation bias towards the preferred interpretation.

---

[2] Bracketing indicates a critical prosodic phrase boundary, which was used as disambiguating prosodic cues in Kang (2013).

The results from the previous research suggested that listeners' ability to use disambiguating prosody is highly influenced by interpretation biases. In addition, Wales and Toner (1979) revealed that the bias strength of an ambiguous sentence could possibly affect the extent to which disambiguating prosody is successfully comprehended. However, since the stimuli were produced by only one professionally trained speaker in both studies (i.e., Wales and Toner 1979, Kang 2013), it is still unclear whether these effects could remain even when disambiguating prosodic cues are provided by various naïve/untrained speakers.

Therefore, the goal of the current study is to investigate the effects of interpretation biases (i.e., whether the intended meaning is preferred or unlikely) and bias strength (i.e., how strongly one meaning of an ambiguous sentence was preferred to another) on the comprehension of disambiguating prosody. Also, the current study examined whether or not the obtained patterns from the previous studies could be replicated when disambiguating prosodic cues were provided by more than one naïve/untrained speaker. Eventually, the results of the current study suggest the factors affecting listeners' ability and strategies to use prosodic cues when disambiguating syntactically ambiguous sentences.

2. Methods

The experiment included two tasks: a same-different task and a meaning-judgment task. The same-different task was used to assess whether naïve/untrained speakers could provide sufficiently different prosodic patterns to convey alternate meanings of an ambiguous sentence and whether listeners could detect the different prosodic renditions of a sentence. The meaning-judgment task was used to investigate the effects of interpretation biases and bias strength on listeners' ability to understand disambiguating prosodic cues to correctly comprehend the intended meaning of ambiguous sentences.

2.1 Subject

Thirty-two undergraduate students of the University of Oregon participated in both the same-different task and the meaning-judgment task. All participants were native speakers of English, and none of the participants reported to have hearing disability. All received course credit for their participation.

2.2 Stimuli

The test stimuli were the sentences produced in the production experiment in Choe and Redford (2015). More detailed procedures of how interpretation biases and bias strength of ambiguous sentences were established and how various speakers produced the test stimuli are described in their study, but the relevant information with respect to the current study is provided in the followings.

Eighteen heterogeneous syntactically ambiguous sentences, taken from Lehiste et al. 1976 and Price et al. 1991, were used in the current study. Each stimulus sentence had two possible meanings: one meaning could be associated with a low attachment which is frequently produced with a critical prosodic phrase boundary at other place (usually earlier) than right before the critical word/phrase (e.g., [Aaron followed] [a poor guy drinking his soda] as in (3a)), while the other could be associated with a high attachment, which is frequently produced with a critical phrase boundary right before the critical word/phrase (e.g., [Aaron followed a poor guy] [drinking his soda] as in (3b)). Following Kang's (2013) term, the current study called the former as "Early Intonational Phrase (Early IP)" and the latter as "Late Intonational Phrase (Late IP)[3]".

[3] The Early IP meaning was referred to as Meaning A, while the Late IP meaning was as Meaning B in Choe and Redford (2015). The detailed meanings, the preferred meaning, and the bias strength of each ambiguous sentence were described in Table 1 and Table 2 of Choe and Redford and the appendix of the current study.

Table 1. Stimulus Sentences with Interpretation Bias and Bias Strength

Bias strength	No.	Sentence	Preferred meaning
Strong	1	The children rolled up the rug.	Early IP
	2	I like visiting relatives.	Late IP
	3	They like more active children than Alex.	Early IP
	4	She saw a man eating fish.	Late IP
	5	Taylor raised tiny dogs and cats.	Early IP
	6	The old men and women stayed home.	Early IP
	7	There are excited students and teachers in the room.	Early IP
	8	The coach knows you realize your goals.	Early IP
	9	We need more creative teachers.	Early IP
	10	The teacher greeted the girl with a smile.	Late IP
	11	Boiling water makes me nervous.	Early IP
Weak	12	Pat knew by the way he was driving.	Early IP
	13	Put the dog food in the bowl on the floor.	Early IP
	14	Carrie doesn't know how good meat tastes.	Early IP
	15	Flying planes can be dangerous.	Early IP
	16	Max speaks several languages you know.	Early IP
	17	I know more talented soccer players than Jo.	Early IP
	18	I saw an elephant in my pajamas.	Late IP

Each ambiguous sentence and its interpretation bias (Early IP vs. Late IP) are shown in Table 1. Moreover, the 18 sentences were categorized into two groups based on its bias strength. Following Wales and Toner's (1979) criteria, an ambiguous sentence was categorized as the sentence with a strong interpretation bias when more than 90% of the 40 native speakers interpreted a particular sentence into a certain meaning. Otherwise, the sentence was categorized as the sentence with a weak interpretation bias.

Ten untrained native speakers of English produced the test stimuli by reading the 18 syntactically ambiguous sentences after a short training session about prosody. A sentence with one of the possible meaning was presented in a flash card, and each speaker was asked to read aloud the ambiguous sentence with the intended meaning in mind. Speakers produced each sentence twice in a row with the same intended meaning. These production procedures yielded a total of 720 sentences (18 sentences × 2 intended meanings × 2 repetitions × 10 speakers).

2.3 Procedure

Recall that one purpose of the current study was to examine the listeners' ability to use disambiguating prosodic cues provided by multiple naïve/ untrained speakers. However, due to the limited time allowed to each participant, the 720 sentences were divided into two sets by randomly assigning the 10 speakers into two different groups. Half of the listeners (n = 16) completed the same-different and the meaning-judgment task using one set of stimuli (i.e., randomly assigned 5 speakers' production), and the other half (n = 16) did so using the other set of stimuli. Task order was also manipulated. Half of the listeners performed the same-different task first, and half performed the meaning-judgment task first. The two tasks took about 90 minutes to complete, and 5-minute break was provided between training session and the first task as well as between the two tasks. The specific procedures for each task are outlined below.

Before starting either task, each listener was taught about prosody. The author explained that prosody included speech rhythm, phrasing and intonation. The author explained the parameters of prosody with reference to pre-recorded productions of a sentence with different timing and intonational patterns. These patterns were quite salient to the listeners although the different patterns did not convey different meanings of the sentence. Both tasks were completed in a quiet experiment room and stimulus sentence presentation was mediated using the Multiple Forced Choice (MFC) function in Praat. Sentences were delivered binaurally through headphones. Listeners were able to adjust the volume at which they listened to the sentences.

2.3.1 Same-different task

Two productions of a single sentence from a single speaker were presented in each trial. The two productions represented either repetitions of a sentence with a single intended meaning or renditions of the sentence with different meanings. For example, the "same" pair was composed of repetitions of an ambiguous sentence, spoken with a single intended meaning. The "different" pair was composed of different renditions of a sentence, spoken with different intended meanings. Listeners were informed that the wording of sentences in each pair was exactly same, but that prosody may differ. They were asked to make a judgment about whether the prosody was the same or different across the sentence pair by clicking the relevant button on the computer monitor.

2.3.2 Meaning-judgment task

In this task, sentences were aurally presented one at a time. After a sentence was presented, a disambiguating question was displayed on a monitor. The listener read the questions to him/herself and then chose one of the two possible answers to the question. The answers, which were also displayed on the screen, were used to assess a listener's interpretation of what they had heard. A list of the questions and the two possible answers are presented for each ambiguous sentence in Appendix A.

3. Results

Proportion correct in the same-different task was calculated across sentences and speakers within each listener. The effect of stimulus set, task order and prosodic condition (same/different) were analyzed in a mixed ANOVA with prosodic condition as the within-subjects variable. The results indicated significant main effects of set, $F(1, 28) = 4.37$, $MSE = 0.04$, $p = .046$, $p\eta^2 = .14$ and prosodic condition, $F(1, 28) = 15.04$, $MSE = 0.22$, $p = .001$, $p\eta^2 = .35$, on proportion correct, but no significant effect of task order and no higher order interactions between any of the variables.

With respect to set, the two groups of listeners differed somewhat in their overall performance in the task. One group responded correctly to 79% of the stimuli ($M = 0.79$, $SD = 0.40$) and the other group to 85% of the stimuli ($M = 0.85$, $SD = 0.36$). This result suggests that either (1) the 5 speakers from one set were less effective at manipulating prosody than the 5 speakers from the other set or (2) the 16 listeners from one set were less sensitive to detect the similar and different prosodic patterns than the 16 listeners from the other set. With respect to condition, proportion correct was higher when the paired sentences were productions associated with the different intended meanings ($M = 0.88$, $SD = 0.33$) than when they were productions associated with the same intended meanings ($M = 0.76$, $SD = 0.43$). This result indicates that listeners had a small bias towards a "different" response. The finding that proportion correct was so high overall suggests that naïve/untrained speakers modified prosody when producing different intended meanings of a sentence as well as that listeners were able to categorize prosodic patterns of various speakers' production. Below, we see whether the different productions effectively conveyed a speaker's intended meaning, and to assess the extent to which this interacted with interpretation bias and bias strength.

Listeners' responses in the meaning-judgment task were coded as "correct" when a listener's response matched a speaker's intended meaning. The first analysis tested the effect of set and task order on listeners' performance. Proportion correct was calculated by sentence and across speakers, meaning, and repetitions. Results from a two-way ANOVA indicated that neither set nor task order had a significant effect on listeners' performance. This result allowed us to exclude the factors related to the practical and controlled design features of the study from further analyses.

Overall, listeners were able to correctly understand the speaker's intended meaning for 62% of the stimulus sentences (M = 0.62, SD = 0.49). The overall performance of the current experiment was much higher than the overall performance (51%) from Fox Tree and Meijer (2000). However, the overall performance of the current experiment was slightly lower than that of Wales and Toner (1979) which used one professional speaker's production of disambiguating prosody (64.5%).

The next analysis focused on the effect of interpretation bias strength on listeners' performance. This time, proportion correct was calculated across speakers for each sentence and listener. Since the normality was not assumed for the proportion correct for each group (strongly-biased vs. weakly-biased sentences), non-parametric Mann-Whitney U test was conducted to compare the average proportion correct for the strongly-biased sentences with that for the weakly-biased sentences. The result indicated that the proportion correct for strongly-biased sentences (M = 0.63, SD = 0.17) were significantly higher than that for weakly-biased sentences (M = 0.60, SD = 0.15), z = -2.01, p = .04.

In order to specifically identify what made the significant difference between the proportion correct for strongly-biased and weakly-biased sentences, listeners' performances of the preferred and the unlikely meanings were compared. Another goal of the analysis is to investigate which factor (i.e., listeners' own interpretation bias and/or disambiguating prosodic cues) influenced the listeners' performance of understanding the intended meanings. The analysis was conducted including both bias strength (strong vs. weak) and meaning preference (preferred vs. unlikely) as factors. The proportion correct was calculated across speakers and sentence for each factor (bias strength and meaning preference). A mixed ANOVA with one between-subject factor, bias strength, and one within-subject factors, meaning preference, indicated a significant main effect of meaning preference, $F(1, 62) = 52.13$, MSE = 0.12, $p < .001$, $p\eta^2 = .46$, and bias strength, $F(1, 62) = 4.75$, MSE = 0.08, $p = .033$, $p\eta^2 = .07$ on proportion correct, and a significant interaction between bias strength

and meaning preference, $F(1, 62) = 24.40$, $MSE = 0.12$, $p < .001$, $p\eta^2 = .28$. The interaction is shown in Figure 1.

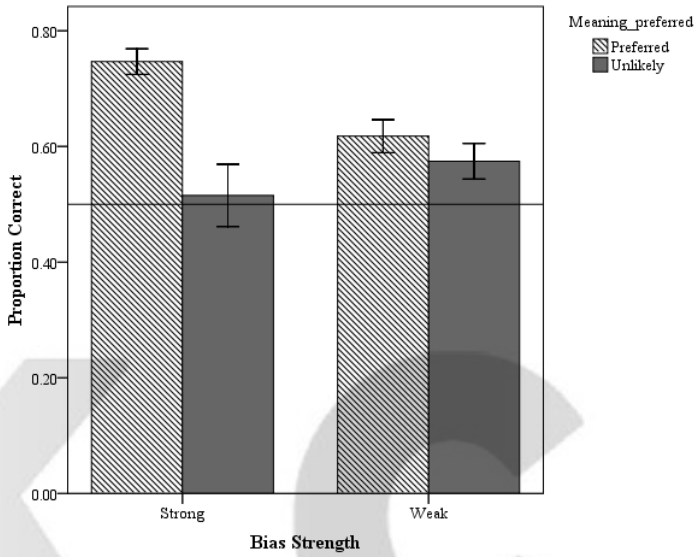

Figure 1. Proportion correct as a function of bias strength and meaning preference with the 95% confidence interval error bars. The solid line indicates performance levels at chance (0.5).

Figure 1 shows that listeners' ability to correctly identify a speaker's intended meaning was influenced by whether the intended meaning was the preferred or the unlikely one in sentences with strong interpretation biases. But, the effect was not evident in sentences with weak interpretation biases. That is, when a sentence was strongly biased toward one meaning, listeners more successfully identified the preferred intended meaning than the unlikely intended meaning. However, when a sentence was weakly biased, listeners' performance to correctly identify the preferred and the unlikely meanings were not significantly different. These patterns were quite similar to the findings in Wales and Toner (1979), and therefore, could suggest that listeners were more apt to use their own interpretation bias towards strongly preferred meanings rather than to comprehend the provided disambiguating prosodic cues when one meaning of an ambiguous sentence was strongly more plausible than the other. However, it is still questionable what strategy listeners used to correctly

identify the intended meanings of weakly-biased sentences. The last analysis was conducted to identify the possible strategies of prosodic disambiguation for weakly-biased sentences.

In her study, Kang (2013) indicated that sentences with a participle construction (e.g., *Aaron followed a poor guy drinking his soda*) had an interpretation bias towards low attachment meaning (i.e., late closure attachment in Choe and Redford 2015; e.g., *Aaron followed a poor guy who was drinking his soda*) and the low attachment meaning frequently was marked with so-called Early IP pattern, in which a prosodic phrase boundary was placed not right after the critical word/phrase but right after the verb (e.g., [*Aaron followed*] [*a poor guy drinking his soda*]). In addition, Kang reported that this Early IP prosodic pattern could boost the listeners' ability to correctly identify the intended meaning (i.e., low attachment). If this prosodic disambiguation pattern (i.e., marking a low attachment meaning with an Early IP pattern) could be consistently applied to not only sentences with a participle construction but also syntactically ambiguous sentences in general, then it is possible to hypothesize that listeners' ability to identify the intended meaning of the low attachment could be increased when "Early IP" prosodic pattern is used. In order to test this hypothesis, the analysis was conducted including both bias strength (strong vs. weak) and meaning (Early IP vs. Late IP) as factors. The proportion correct was calculated across speakers and sentence for each factor (bias strength and meaning). A mixed ANOVA with one between-subject factor, bias strength, and one within-subject factors, meaning, indicated a significant main effect of meaning, $F(1, 62) = 21.81$, $MSE = 0.01$, $p < .001$, $p\eta^2 = .26$, and bias strength, $F(1, 62) = 4.76$, $MSE = 0.08$, $p = .033$, $p\eta^2 = .07$ on proportion correct, and a significant interaction between bias strength and meaning preference, $F(1, 62) = 6.47$, $MSE = 0.01$, $p = .013$, $p\eta^2 = .10$. The interaction is shown in Figure 2.

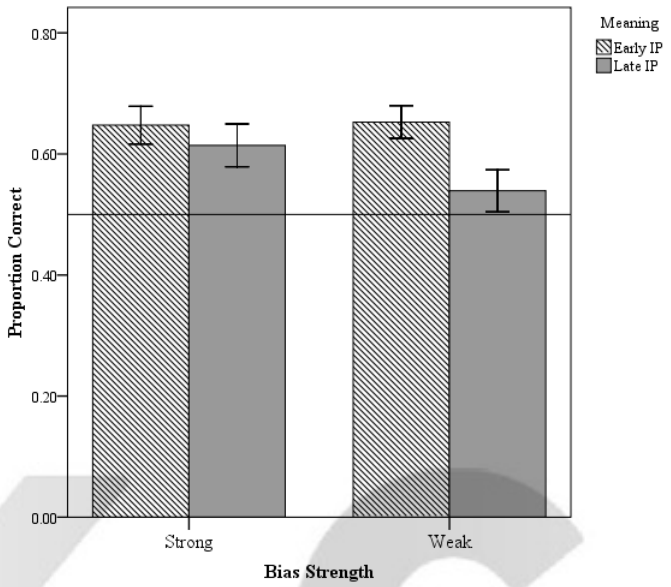

Figure 2. Proportion correct as a function of bias strength and meaning with the 95% confidence interval error bars. The solid line indicates performance levels at chance (0.5).

Figure 2 indicates that listeners' ability to correctly identify a speaker's intended meaning was influenced by whether the intended meaning was the low attachment meaning, associated with an Early IP pattern or the high attachment meaning, associated with a Late IP pattern when the sentences had weak interpretation biases. But, the effect was not evident in sentences with strong interpretation biases. Specifically, the proportion correct for the low attachment meaning (M = 0.65, SD = 0.07) was significantly higher than that for the high attachment meaning for sentences with weak interpretation biases (M = 0.54, SD = 0.10). These results supported the hypothesis that Early IP disambiguating prosodic pattern successfully boosted the listeners' ability to correctly identify the intended meaning of the low attachment for sentences with weak interpretation bias.

4. Discussion

The current study was designed to investigate the effects of interpretation biases and bias strength on the comprehension of disambiguating prosody produced by multiple naïve/untrained speakers. The main findings of the current study are as follows: (1) the overall performance in the same-different task was quite high, (2) the overall proportion correct in the meaning-judgment task was above chance level, but it was not as high as that in the previous studies about the comprehension of disambiguating prosody, and (3) the listeners' ability to correctly identify a speaker's intended meaning of an ambiguous sentence was influenced by the interpretation biases and bias strength of ambiguous sentences. These findings will be discussed with respect to listeners' (and speakers') strategies about the comprehension of disambiguating prosody.

First, the overall high performance in the same-different task confirmed that untrained speakers successfully used different enough prosodic patterns to disambiguate ambiguous sentences. In addition, the results suggested that listeners were able to distinguish sentences with different prosodic patterns although never presented with identical utterances.

In spite of the listeners' ability to distinguish different prosodic patterns of a lexically identical sentence, the findings from the meaning-judgment task showed that listeners were not quite good at decoding the prosodic cues to find the speaker's intended meaning of an ambiguous sentence. One possible reason for this finding is that understanding the intended meanings of ambiguous sentences using prosodic cues from more than one naïve/untrained speaker was somewhat more difficult than comprehending one professional speaker's prosodic cues. That is, our listeners were required to adjust to multiple speakers' strategies for disambiguation over a short period time and in the absence of supporting context of feedback from an interlocutor. This possibility itself is meaningful, though, since it is more likely for a listener to interpret the intended meaning of various speakers' production in the real life setting than to interpret the intended meaning of one professionally trained speaker's production.

The most important findings of the current study are that the extent to which listeners could correctly identify the intended meanings of ambiguous sentences using disambiguating prosody was significantly affected by the interpretation bias strength (i.e., whether one of the two possible meanings is much more plausible than

the other or both of the possible meanings are equally plausible). In addition, series of analysis revealed that listeners tended to use different strategies to find a speaker's intended meaning of an ambiguous sentence based on how easily the two possible meanings of an ambiguous sentence can rise in their mind.

The first group of ambiguous sentences is the sentences one of whose meaning is strongly favored over another. The findings with respect to this type of ambiguous sentences indicated the significantly high proportion correct for the preferred meaning and the slightly above chance level proportion correct for the unlikely meaning. As suggested in Wales and Toner (1979), the current findings were because listeners were likely to rely primarily on their own interpretation bias rather than provided disambiguating prosodic cues since the alternate meaning is hard to rise. However, in spite of similar patterns of proportion correct to Wales and Toner's, the current findings did not support their suggestion of "markedness strategy" (i.e., listeners were able to detect an unusual/marked prosodic pattern and to match this with the unlikely meaning). In order to correctly interpret the intended meaning of a sentence, listeners may need more systematic disambiguating prosodic cues rather than roughly unusual/marked prosodic patterns.

Unlike listeners' strategies to use disambiguating prosody for sentences with strong interpretation biases, listeners' ability to correctly identify the intended meanings for sentences with weak interpretation biases was more influenced by whether the intended meaning was associated with the low attachment or the high attachment. More specifically, when the two possible meanings of an ambiguous sentence are more equally plausible, listeners were significantly better at identifying the intended low attachment meaning than the intended high attachment meaning. This result suggested that Kang's (2013) finding with respect to the interpretation bias and disambiguating prosody for sentences with participle constructions could be extended to the prosodic disambiguation of ambiguous sentences with other constructions. However, the findings of the current study proposed that this way of prosodic disambiguation could be possible only when both the preferred and the unlikely meanings of an ambiguous sentence are equally plausible.

Although the overall performance to correctly identify the intended meanings for sentences with weak interpretation biases was lower than for sentences with strong interpretation, it is possible to argue that true "prosodic" disambiguation may be available for weakly-biased sentences rather than strongly-biased sentences. As the findings of the current study and of Wales and Toner (1979) suggested, the higher

performance on identifying the intended meanings for strongly-biased sentences might be due to the listeners' own interpretation bias towards the (strongly) preferred meaning. On the other hand, the situation when a listener can easily come up with both possible meanings of an ambiguous sentence could encourage the listener to be aware of the ambiguity, which then helps the listener more rely on additional cues (e.g., prosodic cues) to identify a speaker's intended meaning. In addition to the results of the current study, this hypothesis is also supported by the production study in Choe and Redford (2015), in which speakers were able to use consistent and reliable temporal juncture cues only for sentences with weak interpretation biases. The combined findings from the production and the comprehension studies here suggest (1) that both speakers and listeners successfully use disambiguating prosodic cues only for the sentences whose two possible meanings are equally plausible and (2) that the disambiguating prosodic patterns for these sentences—a boundary marking strategy—are even so grammaticalized that untrained listeners are able to decode various untrained speakers' production of disambiguating prosody. To more systematically test the hypotheses from both the production and perception studies, further investigation is needed to examine whether the obtained disambiguating prosodic patterns can be replicated with more thoroughly controlled data such as sentences whose ambiguity comes from the homogeneous syntactic structure.

5. Conclusion

The present results indicate that prosodic disambiguation is strongly influenced by interpretation biases. Also, the results suggest that listeners use different strategies to disambiguate an ambiguous sentence using prosody based on the bias strength of the sentence. Specifically, listeners effectively use prosody for sentences with weak interpretation biases, but they rely primarily on their own interpretation bias for sentences with strong interpretation biases. Combining the production and comprehension results, we tentatively conclude that speakers and listeners share the way of prosodic disambiguation only when alternate interpretations of a syntactically ambiguous sentence are (more) equally plausible.

Appendix A. Disambiguating questions and the two possible answers for each ambiguous sentence

The percentage of speakers who interpreted the sentence according to the preferred meaning is provided in parentheses next to each sentence. Recall that the meaning associated with a low attachment was referred to as Early IP and the meaning associated with a high attachment was Late IP. Also, the preferred meaning of each sentence is in bold type.

No.	Sentence Question Answer for Early IP/ Answer for Late IP
1	The children rolled up the rug. (100%) What were the children doing? **Rolling the rug into a cylinder**/ Rolling across the rug
2	I like visiting relatives. (100%) What do you like? Relatives visiting me/ **To visit relatives**
3	They like more active children than Alex. (97.5%) Do you think Alex is an active child? **No**/ Can't tell
4	She saw a man eating fish. (97.5%) What did she see? A big fish/ **A man enjoying fish**
5	Taylor raises tiny dogs and cats. (95%) What tiny animals does Taylor raise? **Dogs and cats**/ Only dogs
6	The old men and women stayed home. (95%) What old people stayed home? **Men and women**/ Only men
7	There are excited students and teachers in the room. (95%) What excited people are in the room? **Students and teachers**/ Only students
8	The coach knows you realize your goals. (92.5%) What does the coach know? **You achieve your goals**/ You have goals

9	We need more creative teachers. (92.5%)
	What do we need?
	Teachers who are more creative/ More teachers
10	The teacher greeted the girl with a smile. (92.5%)
	Who was smiling?
	The girl/ **The teacher**
11	Boiling water makes me nervous. (90%)
	What makes you nervous?
	Water that is boiling/ To boil water
12	Pat knew by the way he was driving. (80%)
	What did Pat know?
	Something about him/ That Pat was driving
13	Put the dog food in the bowl on the floor. (80%)
	Where was the bowl?
	On the floor/ Not on the floor
14	Carrie doesn't know how good meat tastes. (75%)
	Why doesn't Carrie know how good meat tastes?
	Carrie is a vegetarian/ Carrie buys low quality meat
15	Flying planes can be dangerous. (65%)
	What can be dangerous?
	Planes that are flying/ To fly planes
16	Max speaks several languages you know. (62.5%)
	What languages does Max speak?
	Several languages that I know/ Several languages
17	I know more talented soccer players than Jo. (57.5%)
	Do you think Jo is a good soccer player?
	No/ Can't tell
18	I saw an elephant in my pajamas. (55%)
	Who was wearing pajamas?
	The elephant was/ **I was**

REFERENCES

ALLBRITTON, DAVID W., GAIL MCKOON and ROGER RATCLIFF. 1996. Reliability of prosodic cue for resolving syntactic ambiguity. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 22, 714-735.

ALTMANN, GERRY T. M., KATHY Y. VAN NICE, ALAN GARNHAM and JUDITH-ANN HENSTRA. 1998. Late closure in context. *Journal of Memory and Language* 38, 459-484.

CHOE, WOOK KYUNG and MELISSA A. REDFORD. 2015. The effect of interpretation bias on the production of disambiguating prosody. *Journal of the Korean Society of Speech Sciences* 7.3, 55-64. The Korean Society of Speech Sciences.

COOPER, WILLIAM E. and JEANNE PACCIA-COOPER. 1980. *Syntax and Speech*. Cambridge, MA: Harvard University Press.

FERREIRA, FERNANDA. 1993. Creation of prosody during sentence production. *Psychological Review* 100, 233-253.

FOX TREE, JEAN E. and PAUL MEIJER. 2000. Untrained speakers' use of prosody in syntactic disambiguation and listeners' interpretations. *Psychological Research* 63, 1-13.

JEON, YOON-SHIL and KYUCHUL YOON. 2012. Prosodic disambiguation of low versus high syntactic attachment across lexical biases in English. *Journal of the Korean Society of Speech Sciences* 4.1, 55-65. The Korean Society of Speech Sciences.

KANG, SOYOUNG. 2007. *Effects of Prosody and Contexts on the Comprehension of Syntactically Ambiguous Sentences in English and Korean.* PhD Dissertation. Ohio State University.

KANG, SOYOUNG. 2013. Prosodic disambiguation of participle constructions in English. *Korea Journal of English Language and Linguistics* 13.3, 717-740. The Korean Association for the Study of English Language and Linguistics.

LEHISTE, ILSE. 1973. Phonetic disambiguation of syntactic ambiguity. *Glossa* 7, 197-22.

LEHISTE, ILSE, JOSEPH P. OLIVE and LYNN A. STREETER. 1976. Role of duration in disambiguating syntactically ambiguous sentences. *Journal of the Acoustical Society of America* 60, 1199-1202.

LIEBERMAN, PHILIP. 1967. *Intonation, Perception and* Language. MIT Research Monograph.

NESPOR, MARINA and IRENE VOGEL. 1986. *Prosodic Phonology*. Dordrecht: Foris Publications.

PRICE, PATTI J., MARY OSTENDORF, STEPHANIE SHATTUCK-HUFNAGEL and CYNTHIA FONG. 1991. The use of prosody in syntactic disambiguation. *Journal of the Acoustical Society of America* 90, 2956-2970.

SCHAFER, AMY J., SHARI R. SPEER, PAUL WARREN and S. DAVID WHITE. 2000. Intonational disambiguation in sentence production and comprehension. *Journal of Psycholinguistic Research* 29, 169-182.

SELKIRK, ELISABETH. 1986. On derived domains in sentence phonology. *Phonology* 3, 371-405.

SNEDEKER, JESSE and JOHN TRUESWELL. 2003. Using prosody to avoid ambiguity: Effects of speaker awareness and referential context. *Journal of Memory and Language* 48, 103-130.

SPEER, SHARI. R., MARGARET M. KJELGARRD and KATHRYN M. DOBROTH. 1996. The influence of prosodic structure on the resolution of temporary syntactic closure ambiguities. *Journal of Psycholinguistic Research* 25, 249-271.

TRUESWELL, JOHN C., MICHAEL K. TANENHAUS and SUSAN M. GARNSEY. 1994. Semantic influences on parsing: Use of thematic role information in syntactic ambiguity resolution. *Journal of Memory and Language* 33, 285-318.

WALES, ROGER and HUGH TONER. 1979. Intonation and ambiguity. In William E. Cooper and Edward C. T. Walker (eds.). *Sentence Processing: Psycholinguistic Studies Presented to Merril Garrett*, 135-158. Hillsdale, NJ: Erlbaum.

WANNER, ERIC. 1980. The ATN and the sausage machine: Which one is baloney? *Cognition* 8, 209-225.

WARREN, PAUL, AMY J. SCHAFER, SHARI R. SPEER and S. DAVID WHITE. 2000. Prosodic resolution of prepositional phrase ambiguity in ambiguous and unambiguous situations. *UCLA Working Papers in Phonetics* 99, 5-33.

Wook Kyung Choe
Center of Liberal Education
Dong-A University
37 Nakdong-Daero 550 beon-gil, Saha-gu, Busan
Korea 604-714
e-mail: regina1004@dau.ac.kr

received: November 15, 2015
revised: December 20, 2015
accepted: December 21, 2015

KCI