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The Interaction of Focus Prosody and Lexical Stress on Lexical Processing During Online Sentence Comprehension by Native and Non-native English Listeners*

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ABSTRACT

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This study investigated how English contrastive focus prosody interacts with lexical stress during online sentence processing among native English speakers and Korean speakers learning English as a second language (L2). In an eye-tracking study, participants heard instructions containing focused trisyllabic nouns with stress on the initial, medial, or final syllable (e.g., *cúcumber, banána, chimpanzée*). Both groups showed earlier target fixations when focus prosody was contextually felicitous, but only for words with initial or medial stress. The effect was more evident and emerged earlier for the English speakers than for the Korean speakers, suggesting greater difficulty in integrating prosodic cues in L2, as proposed by the Interface Hypothesis (Sorace, 2011). The Korean speakers were more sensitive to prosody on medial-stressed words, possibly reflecting an influence of L1 prosody. These findings suggest that L2 learners use prosody during online sentence comprehension, though their processing is relatively slower and modulated by L1 effects.

KEYWORDS

focus prosody, lexical stress, sentence processing, second language, visual world paradigm

1. Introduction

Spoken sentences comprise not only segmental information but also prosodic parameters such as pitch, intensity, and duration. The processing of auditory sentences therefore requires comprehending this prosodic information and integrating it into semantic and discourse representations. In English, a constituent under semantic focus—i.e., a phrase that carries new information or is contrasted with another phrase in discourse (Féry 2017, Krifka 2008, Rooth 1985, 1992)—is typically produced with a higher fundamental frequency (F0), greater intensity, and longer duration than words that convey given information. Focus prosody has been widely observed in the speech of first language (L1) speakers of English (e.g., Ito et al. 2004, Ladd 2008, Pierrehumbert 2000, Pierrehumbert and Hirschberg 1990), and it facilitates online sentence processing by native listeners (e.g., Dahan et al. 2002, Ito and Speer 2008, Sedivy et al. 1995).

A characteristic feature of English focus prosody is the placement of the F0 peak on the lexically stressed syllable of the focused word (Beckman and Pierrehumbert 1986, Cohan 2000, Jun 2011, Ladd 2008, Xu and Xu 2005). This alignment between word-level stress and phrase-level prosodic prominence is known to pose challenges for second or foreign language (L2) learners of English whose native languages exhibit prosodic patterns typologically distinct from English. For example, L2 English speakers whose first languages include Japanese, Korean, Mandarin or Spanish have been found to produce nonnative-like prosodic patterns when expressing focus in English (Baek 2024, Graham and Post 2018, Kao et al. 2016, Lu and Kim 2016, Ou 2016, Yeung et al. 2020). However, relatively little research has explored whether and how the interaction between lexical stress and focus prosody affects online sentence processing in both native and nonnative listeners of English. The present study therefore investigates the processing of English sentences containing prosodic focus on nouns with different lexical stress patterns (e.g., *cúcumber, banána, chimpanzée*) by native English speakers and Korean learners of English.

1.1 English Focus Prosody and its Effect on L1 Sentence Processing

To signal focus, English assigns a pitch accent to the focused word, which is acoustically realized as a particular pitch contour with increased duration and intensity, resulting in greater prominence of the word (Baek 2024, Katz and Selkirk 2011, Pierrehumbert and Hirschberg 1990, Wagner and Watson 2010). For example, in response to the question '*Who may know your niece?*', the sentence '*Nìna may know my niece*' assigns an H* pitch accent (a high tone aligned with lexical stress) to the subject *Nina*, with the peak placed on the word-initial stressed syllable (Xu and Xu 2005). In contrast, in the sentence '*Ramòna may know my niece*,' the F0 peak is placed on the second syllable, which carries lexical stress (Xu and Xu 2005). When a word is under contrastive focus (i.e., contrasted with a set of alternatives in the discourse), it may be assigned an L+H* pitch accent (a low plus high tone, with the high tone aligned with lexical stress; Pierrehumbert and Hirschberg 1990). For instance, in an utterance '*I made a reservation for fifteen, not fifty,*' the word *fifteen* is produced with an L+H* accent, with the F0 peak on the stressed syllable (Ito and Speer 2008).

Early research has shown that prosodic prominence signaling focus facilitates comprehension. In a phoneme detection task, listeners reacted more rapidly when the phoneme occurred in a focused word than in other parts of the sentence, suggesting that focus prosody enhances phoneme processing (Cutler and Fodor 1979). Terken and Nooteboom (1987) similarly found that, when participants were asked to verify spoken descriptions of pictures, given information was processed faster when the word was unaccented (i.e., no focus prosody), while new information was processed faster when the word was accented (i.e., produced with focus prosody). Additionally, listeners comprehended spoken sentences more efficiently when their focus prosody was appropriate to the discourse context compared to when it was neutral or contextually inappropriate (Bock and Mazzella 1983).

More recent studies have investigated how focus prosody affects real-time sentence processing using eye-tracking methodologies. Sedivy et al. (1995) used a visual world paradigm in which participants heard auditory instructions (e.g., *Touch the LARGE red square*) while viewing displays of four images (e.g., a large red square, a small red square, etc.). By manipulating the sentence prosody and the visual context, they found that contrastive focus prosody facilitated reference resolution by narrowing the set of potential referents even before the full segmental information was available. This study was one of the first to examine the online processing of information structure using prosody and has been followed by a number of related studies.

Dahan et al. (2002) also examined the role of focus prosody in reference resolution during online sentence processing. In their experiment, the target word was either anaphoric (e.g., *Put the candle below the triangle. Now, put the* <u>*candle*</u> *above the square*) or non-anaphoric (e.g., *Put the candy below the triangle. Now, put the* <u>*candle*</u> *above the square*) and was either prosodically focused or unfocused (referred to as 'accented' and 'deaccented' in their terminology). The visual display included a target item (candle), a competitor (candy), and two distractors (a necklace and a pear). Participants' eye movements revealed that accented nouns were more likely to be interpreted as non-anaphoric (new information), while deaccented nouns tended to be interpreted as anaphoric (given information). This effect emerged even before participants heard the entire sentence, indicating that prosodic cues had an immediate influence on reference resolution.

Ito and Speer (2008) extended this line of work with three eye-tracking experiments that examined the effect of contrastive pitch accents. In a tree-decorating task, participants heard pairs of auditory instructions, in which the use of an L+H* pitch accent on a color adjective was either felicitous (e.g., *Hang the green drum. Now, hang the BLUE drum*) or infelicitous (e.g., *Hang the green drum. Now, hang the blue DRUM*) given the context. Results showed that participants began fixating the target object more quickly in the felicitous than in the infelicitous condition, with the effect emerging as early as around 100 ms after noun onset. In a follow-up experiment, they compared sentences with and without the contrastive accent (e.g., *Hang the green drum. Now, hang the BLUE drum* vs. *blue drum*) and again found that target fixations started to increase more sharply in the presence of a felicitous pitch accent, and this effect was observed around 100 ms after noun onset. Based on these findings, Ito and Speer argued that listeners use contrastive pitch accents predictively to anticipate upcoming referents.

Together, these studies provide evidence that listeners actively exploit prosodic cues to understand information structure during real-time language comprehension. However, one factor that has received little systematic attention is the lexical pattern of focused words. Even in sentences with similar information structure, the phonetic details and timing of a contrastive pitch accent can vary depending on where stress falls within the focused word (Beckman and Pierrehumbert 1986, Cohan 2000, Jun 2011, Ladd 2008, Xu and Xu 2005). Prior studies have tended to avoid this source of variability by limiting target words to monosyllables (e.g., Sedivy et al., 1995) or using words with uniform stress patterns (e.g., Dahan et al. 2002, Ito and Speer 2008). The current study systematically manipulated the lexical stress patterns of focused target words (e.g., *cúcumber, banána, chimpanzée*) to investigate whether and how such prosodic variation influences the use of focus prosody in online sentence processing.

1.2 The Effect of English Focus Prosody on L2 Sentence Processing

Previous studies have also examined how L2 learners of English use focus prosody during auditory sentence processing. For example, building on earlier work on Mandarin speakers' pitch perception (e.g., Choi et al. 2019, Choi 2021, Tong et al. 2015), Hwang et al. (2022) hypothesized that, because Mandarin is a tone language, Mandarin-English L2 learners might have an advantage in using F0 cues to detect contrastive focus in English sentences. In their sentence processing task, Mandarin-English L2 learners and native English speakers listened to pairs of instructions containing contrastive focus (e.g., *Click on the purple mittens. Now, click on the SCARLET mittens*). Contrary to their predictions, the Mandarin speakers did not show any advantage in sentence processing compared to the native speakers, even when the critical segmental information was masked, requiring participants to rely solely on prosodic cues.

Ge et al. (2021) conducted an eye-tracking study examining how Dutch- and Cantonese-English L2 learners process English sentences containing the focus particle *only* (e.g., *The dinosaur is only carrying the BUCKET, not carrying the suitcase*). Native speakers of English began fixating the alternative referent (e.g., suitcase) upon hearing the word *not*, indicating that they used prosodic cues predictively. While L2 learners showed a similar effect of focus prosody, their fixations to the contrastive alternative were slower than those of native speakers. Among the L2 learners, Dutch speakers were even slower than Cantonese speakers in using prosody. The authors interpret this finding in support of the Prosodic Learning Interference Hypothesis (Tremblay et al. 2016), which posits that a higher degree of similarity between L1 and L2 in the use of prosodic cues may actually hinder L2 learning. Because Dutch is more similar to English in using prosody to signal focus (compared to Cantonese, which relies more heavily on morphosyntactic cues), this similarity may have posed greater learning challenges for Dutch speakers.

Moreover, both Hwang et al. (2022) and Ge et al. (2021) interpret their findings as being consistent with the Interface Hypothesis of L2 sentence processing (Sorace 2011). To explain why some L2 structures (or tasks) seem to be particularly harder to acquire than others, this hypothesis holds that L2 learners experience particular difficulty with language structures that require integrating information across multiple domains—lexical, semantic, syntactic, and prosodic—as opposed to structures restricted to a single domain. Using focus prosody to predict an upcoming referent during visual search is a highly integrative task; listeners must process linguistic information across several domains while also interpreting visual context, all in real time. The consistent findings demonstrating that L2 learners tend to show less nativelike use of prosodic cues (despite some group differences; Ge et al. 2021) suggest a general learning difficulty among L2 speakers in integrating multidimensional information during language processing.

In a related study, Perdomo and Kaan (2021) examined how Mandarin-English L2 speakers and native speakers of English processed sentences containing two proper names, with or without a contrastive pitch accent on the second name (e.g., *We ate Angela's ice cream but saved BENJAMIN's cake in the fridge*). The presence of a contrastive pitch accent led both groups to fixate more on the previously mentioned item (ice cream) than on the new object (cake), suggesting that both groups used focus prosody to restrict the set of referents. However, while this effect was observed within 0-200 ms from the onset of the second noun (*cake*) for native speakers, L2 learners showed the effect only after 200 ms. These results suggest that L2 learners are capable of using prosodic cues to build information structure, but not as predictively or rapidly as native speakers. Perdomo and Kaan interpret their findings within processing-based frameworks (Hopp 2013, Kaan 2014) and the complex mapping account (Patterson et al. 2017) of L2 language processing, which argue that although L2 learners can map prosodic and semantic information, such mappings are slower and more effortful compared to native processing.

While these studies provide valuable insights into how L2 learners process contrastive focus prosody, it remains unclear whether such processing is sensitive to the phonetic details of prosodic realization. Most previous studies have not systematically treated lexical stress pattern as a variable of interest, even though it likely affects the timing and availability of prosodic cues during real-time sentence processing. Production studies have shown that even

L2 speakers who are able to use prosody to mark focus may still produce acoustic cues that diverge from native patterns. For instance, L2 speakers may place the F0 peak consistently on the second syllable rather than on the lexically stressed syllable (Yeung et al. 2020), produce an extended F0 plateau across the entire word (Kao et al. 2016, Graham and Post 2018), align the F0 peak significantly later within the stressed syllable than native speakers (Graham and Post 2018), or express prominence using different acoustic cues compared to native speakers (Baek 2024).

To our knowledge, the present study is the first to examine whether and how the lexical stress pattern of focused words affects the use of focus prosody during online sentence processing by L2 learners of English. We focus specifically on Korean-English L2 learners, as Korean exhibits prosodic patterns that are typologically distinct from English at both the word and phrase levels. In the following section, we provide a brief overview of the Korean prosodic system and how focus is marked in Korean.

1.3 Korean Focus Prosody

Seoul Korean (hereafter 'Korean') does not exhibit a phonological word prominence system like lexical stress in English. Instead, it uses F0 tonal patterns to mark prosodic phrase boundaries (Jun 2005, 2014a, b). As illustrated in (1a), in a neutral sentence with no narrow focus, each word typically forms an Accentual Phrase (AP), which assigns the tonal pattern of Low-High-Low-High (LHLH) or High-High-Low-High (HHLH) on its syllables (Jun 1998, 2005, 2014a). The tone on the AP-initial syllable depends on the laryngeal feature of the initial segment. If the word begins with a fortis or aspirated consonant, the syllable is assigned a H tone; otherwise, it receives a L tone (Jun 1998, 2005, 2014a). The final H tone of the AP signals the right boundary of the phrase, while the sentence-final syllable bears an Intonational Phrase (IP) boundary tone (L%), which overrides any AP-final boundary tone.

(1)		Mina-nun	noransek-ul	coa-hay.
		Mina-TOP	yellow-ACC	like-DEC
a.	Neutral prosody:	(L L H)$_{AP}$	(L H L H)$_{AP}$	(LH L%)$_{AP}$
b.	Focus on 'yellow':	(L L H)$_{AP}$	(L↑ H↑	L%)$_{AP}$
		'Mina likes yellow.'		

Korean also differs from English in how it uses prosody to mark focus. While English assigns a phonological pitch accent to the focused word, Korean lacks such a system at the phrase level and instead relies on phonetic cues. In focused contexts, as shown in (1b), the focused word is acoustically marked by an expanded F0 range; the AP-assigned tones on the first two syllables are realized with higher F0 targets than in neutral prosody, as indicated by arrows (Lee and Cho 2020, Lee and Xu 2010). This prosodic expansion is followed by AP dephrasing; the AP boundary to the right of the focused word is deleted, so that the post-focus elements are grouped into the same AP as the focused word (Lee 2017, Lee and Xu 2010, Jeon and Nolan 2017, Jun 1993, Jun and Lee 1998, Oh 2008). The intermediate syllables, which do not carry specified tones, are produced with a gradually falling F0 contour that interpolates between the second H tone and the sentence-final L boundary tone (Jun 2014a).

Given these differences between Korean and English—both in terms of word-level prominence (absence of lexical stress) and focus marking (lack of phonological pitch accents)—it is unsurprising that Korean speakers often encounter difficulties in producing or perceiving English lexical stress (Guion 2005, Lee et al. 2019, Yun 2012) and focus prosody (Kang 2015, Kim 2004, Kim et al. 2002, Lee 2014, Um et al. 2001). However, relatively little research has addressed these two prosodic domains in combination. Baek (2024) found that Korean-English L2 learners use different acoustic cues to signal focus in production depending on the lexical stress pattern of the focused word. This suggests that their use of focus prosody in sentence processing may likewise vary as a function of stress pattern.

The present study tested this possibility by examining how both native English speakers and Korean-English L2 learners process focus prosody on trisyllabic English words with different lexical stress patterns (initial, medial, final stress) in an online sentence comprehension task.

1.4 The Present Study

This study investigated whether and how the use of focus prosody for reference resolution is influenced by the lexical stress pattern of the focused word during online sentence processing, comparing native English listeners and Korean-speaking L2 listeners of English. We predicted that native listeners would use focus prosody to process information structure relatively consistently, regardless of the stress pattern of focused word, due to their native experience with the alignment between focus prosody and lexical stress. However, their processing may still be influenced by the timing of prosodic cues. For example, if listeners rely on the F0 peak as the primary cue to focus, the effect of focus prosody may emerge earlier when the focused word bears initial stress than when it has final stress.

In the case of L2 learners, their productions of English focus prosody often diverge from native patterns, either by failing to place an F0 peak on the stressed syllable or by relying on different acoustic cues to mark prominence, as reviewed in the Introduction. Although little is known about how the lexical stress pattern of a focused word affects sentence processing, different predictions can be made for Korean-English L2 listeners, depending on theoretical perspectives on L2 sentence processing. On the one hand, because focus prosody in Korean is typically realized through enhanced F0 cues near the beginning of the focused word, followed by de-accenting toward the end of the sentence (due to AP dephrasing), learners may be more sensitive to focus cues that occur earlier in the word. On the other hand, this L1 prosodic pattern could lead to the opposite effect; an F0 peak aligned with the final syllable might be perceived as more salient or marked by Korean speakers, enabling better use of focus prosody in words with final stress than initial stress. This second possibility aligns with the Prosodic Learning Interference Hypothesis, which posits that L2 prosody is easier to acquire when the L1 and L2 prosodic systems are dissimilar, and harder when they use similar cues. In this hypothesis, the L1 and L2 prosodic systems are considered similar, but not identical, if a given prosodic cue signals the same linguistic information but does so differently (e.g., an F0 peak signaling the same word boundary, aligned earlier in Korean and later in French; Tremblay et al. 2016). Since an F0 peak near the beginning of words signals focus in both English and Korean but its phonetic details differ in the two languages (heightened F0 targets for the first two syllables in Korean vs. an increased F0 peak on the stressed syllable in English), this similarity may cause learning difficulty for Korean speakers learning English.

In addition, the Interface Hypothesis predicts that L2 learners may have greater difficulty in integrating prosodic cues with information from different linguistic domains or integrating linguistic and non-linguistic information (Sorace and Serratrice 2009, Sorace 2011). Since using prosodic cues to identify the reference requires the integration of multiple domains of linguistic (e.g., prosodic, syntactic, and semantic) and contextual information, Korean-English L2 learners may be less sensitive to or slower in using English focus prosody during online sentence processing.

2. Method

This study employed an eye-tracking visual world paradigm, similar to the methods of Dahan et al. (2002), Ito and Speer (2008), and Perdomo and Kaan (2021). Participants listened to pairs of auditory instructions directing them to click on a specific item displayed on the screen (e.g., *Click on the hamburger in a circle.* → *Now, click on the CUCUMBER in a circle*), in which the contrastive focus prosody was either felicitous or infelicitous given the context. The target words were always trisyllabic and varied in their lexical stress patterns. Participants' eye movements were recorded in real time, and fixations to the target item were analyzed across two factors: prosody type (felicitous vs. infelicitous) and stress pattern of the focused word (initial vs. medial vs. final). If listeners are sensitive to focus prosody for referent identification, they are expected to fixate on the target item more quickly in the felicitous condition than in the infelicitous condition.

2.1 Participants

Two groups of participants took part in the experiment. The first group consisted of 49 native speakers of North American English (F: 39, M: 10), recruited from a pool of undergraduate students at a university in Virginia, USA. The average age of these participants was 19.3 years. The second group included 59 native speakers of Korean who were learning English as an L2 (F: 18, M: 41). They were undergraduate or graduate students at a university in Gwangju, South Korea, with a mean age of 21.2 years. To assess the English proficiency of the Korean speakers, they completed the Lexical Test for Advanced Learners of English (LexTALE; Lemhöfer and Broersma 2012) during the experimental session. Their scores ranged from 47.5 to 97.5, with an average score of 66.9.[1]

2.2 Auditory Stimuli

Fifteen trisyllabic English nouns were selected as target words, as shown in (2). The words varied in their stress patterns such that five were pronounced with word-initial stress, five with word-medial stress, and five with word-final stress. All target words referred to concrete nouns, ensuring that they could be easily represented by simple digital images and were sufficiently familiar to all participants.

(2) Target words
Word-initial stress: *cucumber, hamburger, microphone, octopus, parachute*
Word-medial stress: *banana, eraser, piano, tomato, umbrella*
Word-final stress: *chimpanzee, engineer, kangaroo, submarine, violin*

Each target word was used to create four instruction pairs. In two of the pairs, the second sentence carried contrastive focus prosody on the semantically appropriate word (felicitous prosody condition; e.g., *Click on the hamburger in a circle. Now, click on the CUCUMBER in a circle.*). In the other two pairs, the focus prosody was not semantically appropriate (infelicitous prosody condition; e.g., *Click on the cucumber in a square. Now, click on the CUCUMBER in a circle.*). This design yielded a total of 60 instruction pairs (5 target words × 3 stress

[1] Although the LexTALE scores showed a seemingly wide distribution, including proficiency as a predictor in the statistical models did not reveal any significant effects. Therefore, LexTALE scores were not treated as a variable of interest in the analyses reported in this article.

positions × 2 focus prosody types × 2 pairs per condition). In all sentences, the target noun was followed by a prepositional phrase (PP; e.g., *in a circle*) to avoid sentence-final intonation from interfering with the prosody of the target word. In addition to the target instruction pairs, 60 filler instruction pairs were included, in which the second sentence had focus prosody on the sentence-final noun referring to a geometric shape (e.g., *Now, click on the cucumber in a CIRCLE*).

The instructions were recorded by a male native speaker of North American English from Canada. After receiving a brief overview of the study design, the speaker was presented with printed sentences and instructed to use focus prosody on capitalized words. Recordings took place in a quiet room using a Zoom H6 digital recorder and an SM10A-CN dynamic head-mounted microphone at a 44.1 kHz sampling rate. Each sentence was recorded three times, and the token exhibiting the most consistent and prototypical prosody was selected as the final auditory stimulus.

To verify that the recorded sentences conveyed the intended focus prosody, we examined the F0 contours of the focused target words. A phonetically trained researcher manually segmented each syllable using Praat (Boersma and Weenink 2023, ver 6.3.2.0), and time-normalized F0 values in semitones were extracted using ProsodyPro (Xu 2013, ver 5.7.8.7). Figure 1 shows time-normalized mean F0 contours by stress position. For words with initial stress (solid line), the F0 peak occurred on the first syllable, followed by a gradual pitch fall. For medial-stress words (dashed line), the peak appeared on the second syllable, with a subsequent drop on the third syllable. For final-stress words (dotted line), there was a gradual F0 increase throughout the word, peaking on the final syllable. These patterns confirm that the alignment of the focus prosody peak with the lexically stressed syllable was reliably achieved in the experimental stimuli.

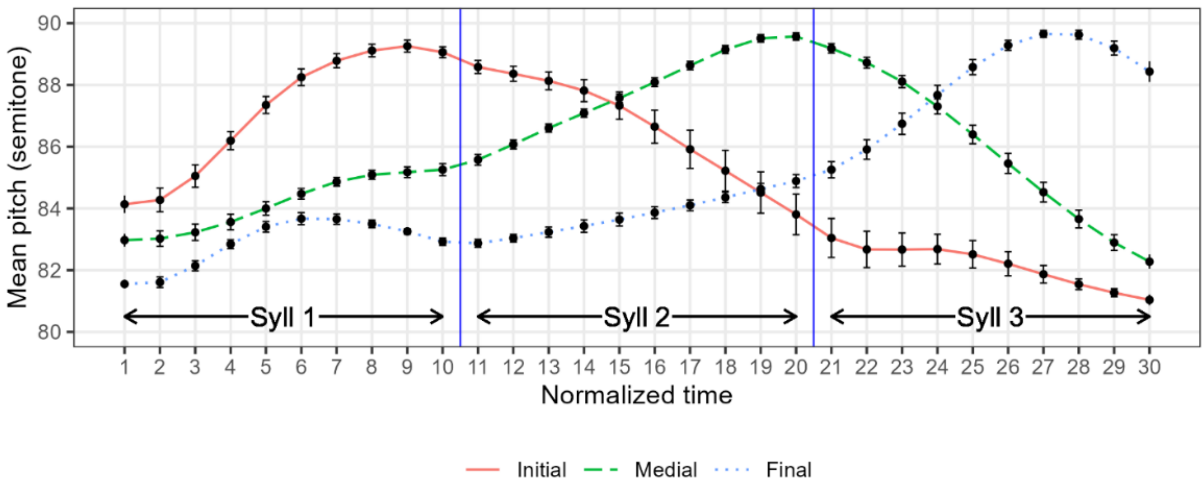


Figure 1. Time-Normalized Pitch (in Semitones) of Prosodically Focused Target Words by Stress Position

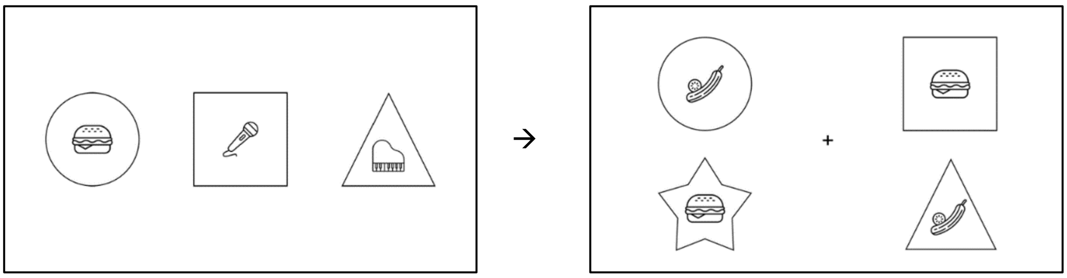
Among the target words, those with word-final primary stress also bear secondary stress on the first syllable (e.g., *chimpanzee* and *kangaroo*), whereas others carry primary stress alone (e.g., *cucumber* and *banana*). Although this stress pattern may affect prosody in neutral contexts, the F0 patterns in Figure 1 confirm that the auditory stimuli exhibited a focus prosody peak on a single syllable, as categorized in (2).

2.3 Procedure

All aspects of the experimental procedure were identical across the two groups of participants. The experiment was designed and conducted using Experiment Builder software (SR Research). After providing informed consent, participants were seated in front of a computer monitor and positioned their chin and forehead on a headrest. The session began with a calibration and validation process using a 3 × 3 grid. As in preceding similar studies (e.g., Dahan et al. 2002, Ito and Speer 2008, Perdomo and Kaan 2021), each trial consisted of a pair of auditory instructions accompanied by corresponding behavioral responses. When participants fixated on the central cross (+), three black-and-white images appeared on the screen, followed by auditory presentation of the first instruction to click on one of the images (Figure 2, left). After the participant responded by clicking on an image, a new set of four images was presented, and the second auditory instruction was played, directing them to click on one of the items (Figure 2, right).

The visual display for the second instruction included one target item (e.g., the cucumber in a circle) and a critical distractor of the same object but in a different geometric shape (e.g., the cucumber in a triangle). If the contrastive focus prosody on the noun (*CUCUMBER*) facilitates the expectation that the following PP will express given information, participants should be able to identify the target item more quickly in the felicitous prosody condition than in the infelicitous condition.

Eye movements were recorded from participants' right eye using the Eyelink 1000 Plus model (SR Research) at a sampling rate of 1,000 Hz. Visual stimuli were displayed on a 1920 × 1080 monitor with a white background. The participants were seated approximately 66 cm from the monitor and 51 cm from the camera. After completing the eye-tracking task, the Korean participants also completed the LexTALE test to assess their English proficiency.



Instruction 1:
Click on the hamburger in a circle.

Instruction 2:
Now, click on the CUCUMBER in a circle.

Figure 2. Example Trial Procedure

2.4 Analysis

As in previous L2 studies that used similar methods (Ge et al. 2021, Perdomo and Kaan 2021), we analyzed the data for English and Korean speakers separately. Our primary dependent variables were the participants' behavioral responses to the second instructions and the proportion of fixations to the target image during the second instruction of each trial. Trials in which participants made an incorrect response to the first instruction were excluded, as such trials did not establish the appropriate discourse context for determining whether the second instruction's prosody was felicitous or infelicitous. This resulted in the exclusion of three trials for English speakers and one for a Korean speaker.

Response accuracy for the second instructions in the remaining data was analyzed using logistic mixed-effects regression models built with the glmer() function from the lme4 package (Bates et al. 2015) in R (version 4.2.3; R Core Team 2023). Two models were fit (one per participant group) with stress position and focus prosody and their interactions as fixed effects. Both predictors were treatment-coded, with 'initial stress' and 'felicitous prosody' as the reference levels. The maximal random effect structure that allowed model convergence was adopted; the English speakers' model included by-participant and by-item random intercepts, and the Korean speakers' model included only by-participant random intercepts. *P*-values were obtained using the lmerTest package (Kuznetsova et al. 2017).

The fixation proportion analysis included only the trials in which both the first and second responses were correct, excluding 55 trials (less than 1% of the total). Fixations to each of the four interest areas were extracted in 20 ms time bins for each trial. Then, following previous studies (e.g., Ito and Speer 2008, Tang et al. 2023), the fixation data were time-aligned to the onset of the target noun in the auditory instruction, with 0 ms representing word onset. For each 20 ms bin within a 2,000 ms time window, a separate logistic mixed-effects model was fitted to test whether target fixations were significantly influenced by prosody type. The dependent variable was target fixation (1 = fixation to the target area; 0 = fixation elsewhere), and the fixed effect was focus prosody (treatment-coded with 'felicitous prosody' as the reference level). This analysis was conducted separately for each participant group across the three stress-position conditions. The same random effect structures used in the accuracy analyses were adopted to maximize model convergence.

3. Results

3.1 Response Accuracy Results

Table 1 presents the mean accuracy rates and standard deviations for responses to the second instructions across conditions. Mean accuracy was close to 1.00 in all conditions, indicating that the participants in both groups were able to comprehend the instructions and perform the task with no substantial difficulty. The results of the logistic mixed-effects regression analysis on response accuracy (Table 2) revealed no significant effects of stress position or focus prosody. This suggests that the participants were able to select the target item correctly even when the auditory instruction contained focus prosody that was inappropriate given the context (e.g., *Click on the cucumber in a square. Now, click on the CUCUMBER in a circle*.)

Table 1. Mean Response Accuracy for Each Condition

	English speakers			Korean speakers		
	Initial stress	Medial stress	Final stress	Initial stress	Medial stress	Final stress
Felicitous prosody	0.99 (0.09)	0.99 (0.09)	0.98 (0.13)	0.99 (0.10)	0.99 (0.07)	0.99 (0.10)
Infelicitous prosody	0.99 (0.08)	0.99 (0.09)	0.99 (0.12)	1.00 (0.06)	1.00 (0.00)	0.99 (0.08)

Note. Numbers in parentheses are standard deviations.

Table 2. Estimated Effects of Stress Position and Focus Prosody on Response Accuracy for Each Speaker Group (Reference Levels: Stress Position = Initial, Focus Prosody = Felicitous)

English speakers				
	Estimate	SE	*z*	*p*
(intercept)	6.483	0.898	7.218	
Stress position = medial	0.087	0.898	0.097	0.923
Stress position = final	-0.818	0.809	-1.010	0.312
Focus prosody = infelicitous	0.327	0.936	0.350	0.726
Stress position = medial : Focus prosody = infelicitous	-0.328	1.303	-0.252	0.801
Stress position = final : Focus prosody = infelicitous	-0.155	1.186	-0.131	0.896
Korean speakers				
	Estimate	SE	*z*	*p*
(intercept)	5.161	0.502	10.291	
Stress position = medial	0.707	0.809	0.874	0.382
Stress position = final	0.000	0.661	0.000	1.000
Focus prosody = infelicitous	1.113	0.933	1.193	0.233
Stress position = medial : Focus prosody = infelicitous	15.060	2136.000	0.007	0.994
Stress position = final : Focus prosody = infelicitous	-0.710	1.190	-0.597	0.551

3.2 Target Fixation Proportions

Mean target fixation proportions for each 20 ms time window, by stress position and focus type, are shown in Figure 3 (English speakers) and Figure 4 (Korean speakers).

For the English speakers (Figure 3), target fixation proportions varied by lexical stress position. When the target words carried word-initial or medial stress, fixations to the target item increased more rapidly in the felicitous prosody condition compared to the infelicitous condition. This divergence emerged shortly after the end of the auditory sentences. In contrast, for final-stressed words, there was no noticeable difference in target fixation patterns between the two prosody conditions. Logistic mixed-effects regression models for each time bin (see Appendix 1 for full results) revealed a statistically significant effect of focus prosody on target fixations around 1380-1980 ms after the onset of the target word for initially stressed words, and around 1460-1700 ms for medially stressed words (indicated by shaded areas in Figure 3). For final-stressed words, a significant difference was observed only briefly, between 1720-1740 ms after the word onset.

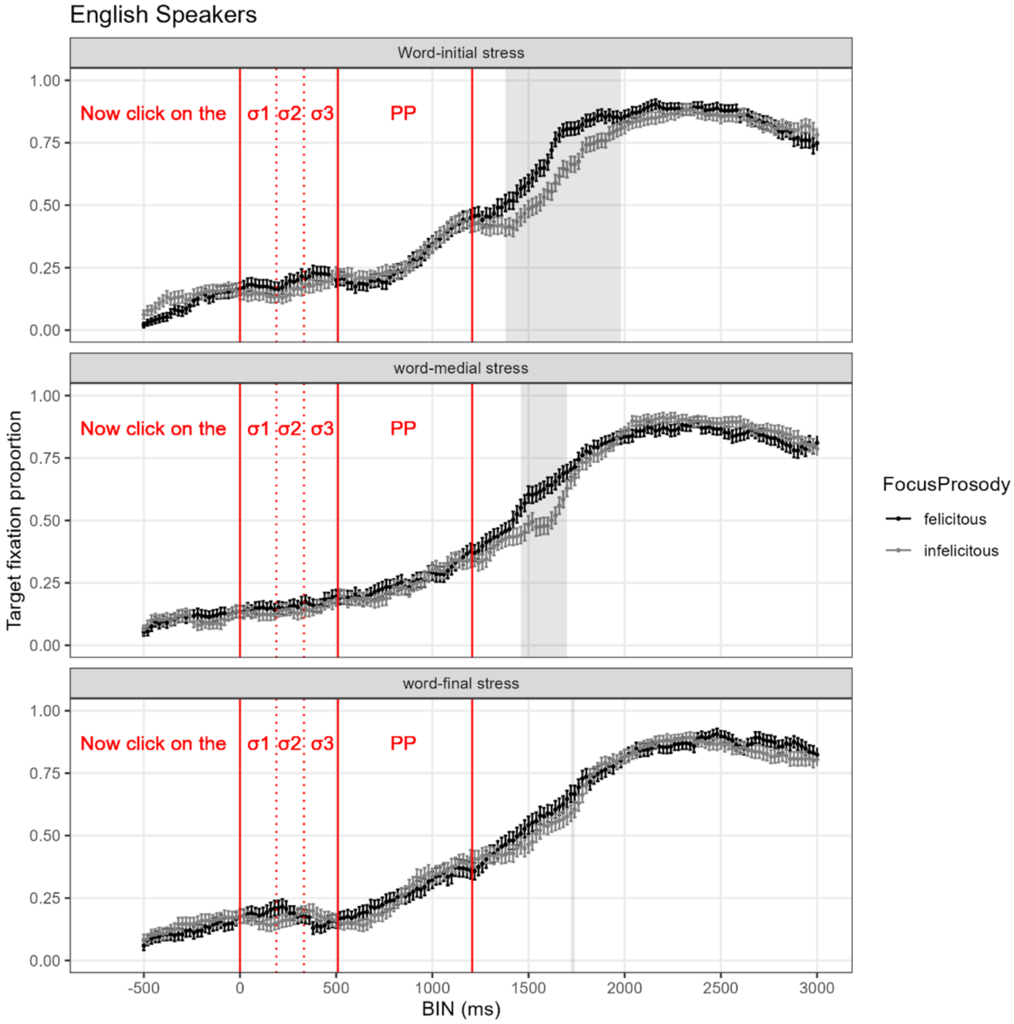


Figure 3. Mean Target Fixation Proportions for English Speakers in Each 20 ms Time Bin, by Stress Position and Focus Prosody Type

Note. Error bars represent standard errors. Vertical lines mark the average time points of syllable boundaries in the target nouns and the end of the auditory instructions. Shaded areas indicate time windows in which the effect of focus prosody on fixation proportions was statistically significant.

For the Korean speakers (Figure 4), target fixations also increased more rapidly in the felicitous focus prosody condition when the target words had initial or medial stress, although this effect was observed relatively later than for the native speakers. According to the logistic mixed-effects regression models (Appendix 2), focus prosody had a significant effect on target fixations between 1620-1740 ms for initially stressed words and between 1560-1820 ms for medially stressed words (shaded areas in Figure 4). For words with medial stress, two earlier time windows (320-340 ms and 400-420 ms) showed higher fixation proportions in the infelicitous than in the felicitous condition. However, given the brevity of these time windows and their early occurrence relative to sentence presentation, they are likely spurious fluctuations rather than true effects of prosody. A similar observation was made for final-stressed words; fixations were significantly higher in the infelicitous condition between 100-180 ms, which is too early to reflect a meaningful prosodic effect.

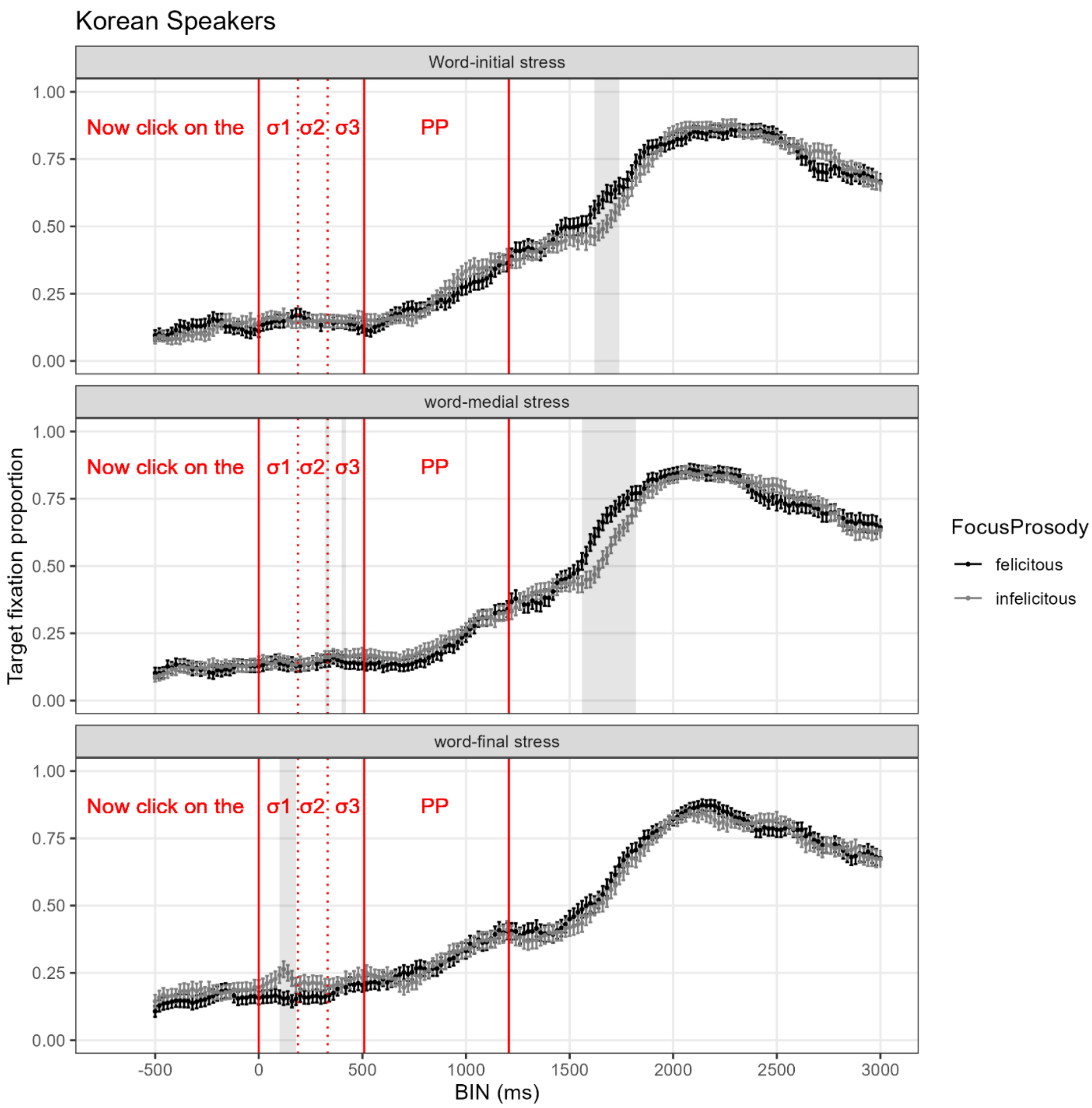


Figure 4. Mean Target Fixation Proportions for Korean Speakers in Each 20 ms Time Bin, by Stress Position and Focus Prosody Type

Note. Error bars represent standard errors. Vertical lines mark the average time points of syllable boundaries in the target nouns and the end of the auditory instructions. Shaded areas indicate time windows in which the effect of focus prosody on fixation proportions was statistically significant.

4. Discussion

This study examined the effects of felicitous versus infelicitous contrastive focus prosody on the processing of spoken English words that varied in their lexical stress patterns. The study compared native English listeners to Korean-English L2 listeners, whose first language is prosodically quite distinct from English. In an eye-tracking visual-world listening task, English listeners fixated on the target item earlier when sentences contained felicitous focus prosody compared to infelicitous prosody, particularly when the focused target word had lexical stress on the word-initial or -medial syllable. This facilitatory effect of focus prosody emerged approximately 1,500 ms after the onset of the target word. Korean-English L2 listeners showed a similar effect of focus prosody, albeit somewhat later compared to the native listeners. However, when the focused word carried final stress, neither group exhibited a reliable effect of prosody.

The fixation patterns of the English speakers suggest that both the onset and duration of their use of focus prosody for reference resolution varied by the stress pattern of words. The effect of focus prosody appeared earlier and lasted longer for words with initial stress, slightly later and shorter for medial-stress words, and was barely detectable for final-stress words. This gradient pattern likely reflects the relative usefulness of prosodic cues depending on how much segmental information is available. When a word is initially stressed, the F0 peak signaling focus occurs early, when listeners have access to the segmental cues of only the first syllable or less. For medial-stressed words, the F0 peak occurs when segmental cues have identified the first two syllables, while for final-stressed words, most segmental content is already available by the time the F0 peak is perceived. Therefore, the utility of prosodic cues for reference resolution diminishes as stress shifts toward the end of the word.

The result that the English speakers used focus prosody during sentence processing aligns with prior findings (Dahan et al. 2002, Ito and Speer 2008, Sedivy et al. 1995), confirming that native listeners integrate prosodic cues to anticipate upcoming referents. However, the effect in this study emerged around 1,380 or 1,460 ms after the word onset, which is substantially later than reported in earlier studies, which observed prosodic effects around 300 ms after word onset (Dahan et al. 2002) or 100-200 ms after word offset (Ito and Speer 2008, Perdomo and Kaan 2021). Even taking into account the 200-300 ms required to plan and launch saccades (Viviani 1990), the observed latency here is relatively long. This delay may be attributed to the characteristics of both the auditory stimuli and the visual task. To counterbalance their lexical stress patterns, our target words were phonetically longer and had relatively low frequency compared to those used in prior work (e.g., *blue ball, candy-candle*). Also, our visual stimuli were black-and-white images enclosed in geometric shapes, which are potentially less salient than colored objects or standalone objects used in earlier studies.

The Korean speakers also showed facilitatory use of focus prosody, especially when the focused words had initial or medial stress. This indicates that L2 listeners can employ prosodic cues to resolve referents during real-time sentence processing. These results parallel those of Perdomo and Kaan (2021), who found that Mandarin-English L2 listeners utilized contrastive pitch accents to identify the set of alternative referents in the discourse. The current findings suggest that even learners whose L1 lacks lexical stress or pitch accent systems can perceive these prominence domains and access their semantic function during L2 sentence comprehension.

Interestingly, the Korean speakers demonstrated slightly earlier and more sustained prosodic effects for medial-stress words than for initial-stress words. As discussed in the Introduction, focus in Korean is phonetically marked by enhanced tonal targets on the first two syllables and by post-focus dephrasing. Crucially, the second syllable consistently receives an H tone, while the first syllable may receive either an L or H tone depending on the segmental feature. If Korean speakers are particularly attuned to F0 rises on the second syllable, this perceptual bias may influence their L2 prosody processing. This explanation contradicts the Prosodic Learning Interference Hypothesis (Tremblay et al. 2016), which proposes that similarity in L1 and L2 prosodic cues hinders L2 acquisition. Instead, our findings support a more traditional view that prosodic similarity between L1 and L2 can facilitate learning. A relevant factor to consider is that the AP-initial tone in Korean is determined by the laryngeal feature of the word-initial segment; if a word begins with a fortis or aspirated consonant, the syllable is assigned an H tone; otherwise, it receives an L tone (Jun 1998, 2005, 2014a). The English target words in the current study varied with respect to this feature. Whether the association between these segmental and prosodic features in Korean transfers to L2 acquisition remains a question for future research.

Overall, the Korean speakers were generally slower than the native speakers in using prosodic cues to locate the target items. This supports the Interface Hypothesis (Sorace 2011), which argues that L2 learners face more challenges when processing required integration of information across multiple linguistic domains. Our task required simultaneous integration of segmental and prosodic cues, and lexical, semantic, and syntactic information of sentences, all in relation to a visual display. This high processing load likely posed a greater challenge for L2 listeners. Similar delays and reduced anticipatory use of contrastive focus prosody by L2 learners have been reported in other studies (Hwang et al. 2022, Perdomo and Kaan 2021).

It is worth noting that, although this study focused on F0 peaks as cues to contrastive focus, they are not the only acoustic indicators of focus. Native productions involve complex combinations of cues, including F0 height and contour, as well as general acoustic prominence resulting from increased intensity and duration on stressed syllables (Baek 2024). Therefore, prosodic information likely included not just peak F0 on a stressed syllable, but broader patterns across the word. The fact that the Korean speakers exhibited nativelike processing patterns (although with slower timing) suggests that they are sensitive to this interplay of acoustic features signaling English contrastive focus that are distinct from their L1 prosody.

Lastly, although we assessed the Korean speakers' English proficiency using the LexTALE, no significant effects of LexTALE scores were found on either response accuracy or fixation patterns. This null result may reflect limited variation in proficiency within the sample, as all participants were students from the same institution. Thus, the absence of a proficiency effect should not be taken to imply that learning has plateaued. Future research is needed to explore how sensitivity to prosodic cues develops across proficiency levels during L2 sentence processing.

5. Conclusion

This study demonstrates that both native English speakers and Korean-English L2 learners are capable of using contrastive focus prosody to facilitate real-time reference resolution during sentence processing, particularly when the prosodic prominence aligns with word-initial or -medial lexical stress. While the native speakers showed earlier and more robust use of prosodic cues, the Korean speakers exhibited delayed but qualitatively similar effects, suggesting that L2 learners can acquire and utilize prosodic information that is absent in their L1. The sensitivity of Korean listeners to words with medial stress, in particular, highlights the influence of L1 prosodic structure on L2 processing. These findings contribute to our understanding of cross-linguistic prosody processing and support the view that prosodic cue integration in L2 comprehension is shaped by both universal processing mechanisms and language-specific experience. Further research is needed to examine how these abilities develop across proficiency levels and how multiple acoustic cues interact during L2 sentence comprehension.

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Examples in: English, Korean
Applicable Languages: English
Applicable Level: Intermediate, High-intermediate

Appendix 1

Results of logistic mixed-effects regression analysis on the effect of focus prosody type on English speakers' target fixation proportions in each 20 ms time bin

BIN (ms)	word-initial stress				word-medial stress				word-final stress			
	Estimate	SE	z	p	Estimate	SE	z	p	Estimate	SE	z	p
0	0.129	0.277	0.465	0.642	0.041	0.294	0.140	0.889	0.019	0.264	0.071	0.943
20	0.184	0.277	0.664	0.507	0.066	0.293	0.226	0.821	-0.002	0.266	-0.008	0.994
40	0.308	0.274	1.123	0.261	0.036	0.281	0.129	0.897	0.072	0.260	0.278	0.781
60	0.299	0.269	1.114	0.265	0.055	0.288	0.191	0.849	0.144	0.263	0.547	0.585
80	0.233	0.270	0.862	0.389	(Model failed to converge.)				0.073	0.264	0.278	0.781
100	0.243	0.274	0.886	0.376	0.260	0.290	0.895	0.371	0.232	0.273	0.851	0.395
120	0.209	0.276	0.758	0.448	0.264	0.290	0.912	0.362	0.268	0.273	0.983	0.326
140	0.294	0.280	1.049	0.294	0.197	0.290	0.678	0.497	0.374	0.276	1.356	0.175
160	(Model failed to converge.)				0.247	0.289	0.856	0.392	0.448	0.274	1.636	0.102
180	(Model failed to converge.)				0.177	0.290	0.610	0.542	0.452	0.271	1.668	0.095
200	0.216	0.277	0.778	0.437	0.130	0.279	0.467	0.641	0.402	0.267	1.505	0.132
220	0.336	0.281	1.198	0.231	0.078	0.279	0.278	0.781	0.386	0.265	1.454	0.146
240	0.375	0.275	1.361	0.173	0.043	0.280	0.155	0.877	0.340	0.270	1.258	0.208
260	0.385	0.270	1.426	0.154	0.113	0.276	0.411	0.681	0.184	0.270	0.681	0.496
280	(Model failed to converge.)				0.243	0.282	0.861	0.389	0.136	0.265	0.514	0.607
300	(Model failed to converge.)				0.239	0.285	0.838	0.402	-0.057	0.262	-0.217	0.828
320	0.345	0.256	1.344	0.179	0.312	0.275	1.134	0.257	(Model failed to converge.)			
340	0.179	0.254	0.704	0.481	0.268	0.268	0.999	0.318	-0.101	0.259	-0.389	0.697
360	0.258	0.252	1.024	0.306	0.214	0.274	0.784	0.433	-0.162	0.261	-0.623	0.534
380	0.344	0.248	1.385	0.166	0.125	0.273	0.458	0.647	-0.516	0.277	-1.860	0.063
400	0.248	0.242	1.025	0.305	0.025	0.267	0.094	0.925	-0.345	0.276	-1.248	0.212
420	0.281	0.245	1.148	0.251	0.058	0.267	0.217	0.828	-0.323	0.282	-1.145	0.252
440	0.204	0.244	0.839	0.402	0.116	0.261	0.443	0.658	-0.229	0.283	-0.807	0.420
460	0.173	0.239	0.725	0.468	0.051	0.258	0.199	0.842	-0.130	0.272	-0.479	0.632
480	-0.002	0.234	-0.007	0.994	0.174	0.255	0.681	0.496	-0.035	0.274	-0.129	0.897
500	-0.148	0.231	-0.642	0.521	0.079	0.249	0.316	0.752	-0.031	0.278	-0.110	0.912
520	-0.063	0.231	-0.273	0.785	-0.020	0.248	-0.080	0.936	0.126	0.275	0.459	0.646
540	(Model failed to converge.)				0.007	0.249	0.029	0.977	0.176	0.272	0.645	0.519
560	-0.206	0.236	-0.871	0.384	0.139	0.257	0.541	0.589	0.175	0.268	0.652	0.514
580	-0.198	0.237	-0.836	0.403	0.047	0.251	0.185	0.853	0.137	0.270	0.509	0.611
600	-0.190	0.246	-0.770	0.442	0.135	0.246	0.546	0.585	0.196	0.270	0.727	0.467
620	-0.152	0.240	-0.634	0.526	0.074	0.251	0.294	0.769	0.321	0.266	1.206	0.228
640	-0.149	0.238	-0.627	0.531	-0.005	0.251	-0.020	0.984	0.382	0.266	1.436	0.151
660	-0.153	0.241	-0.635	0.525	0.062	0.244	0.254	0.800	0.341	0.264	1.291	0.197
680	-0.079	0.241	-0.328	0.743	0.137	0.242	0.565	0.572	(Model failed to converge.)			
700	-0.049	0.241	-0.202	0.840	0.253	0.243	1.040	0.298	0.207	0.252	0.822	0.411
720	-0.129	0.238	-0.542	0.588	0.283	0.243	1.166	0.244	0.184	0.248	0.741	0.459
740	-0.217	0.236	-0.918	0.358	0.261	0.243	1.074	0.283	0.248	0.249	0.996	0.319
760	-0.268	0.238	-1.123	0.262	0.307	0.244	1.255	0.209	0.242	0.245	0.985	0.325
780	-0.099	0.238	-0.417	0.676	0.130	0.236	0.552	0.581	0.214	0.240	0.888	0.374
800	-0.076	0.238	-0.317	0.751	0.052	0.232	0.223	0.823	0.097	0.238	0.408	0.683
820	0.023	0.231	0.101	0.920	0.131	0.234	0.560	0.575	0.095	0.233	0.407	0.684
840	-0.044	0.230	-0.189	0.850	0.139	0.232	0.602	0.547	0.019	0.229	0.084	0.933
860	-0.001	0.225	-0.003	0.997	0.049	0.238	0.205	0.838	-0.055	0.226	-0.244	0.807
880	0.024	0.219	0.111	0.911	0.089	0.238	0.374	0.708	-0.135	0.221	-0.610	0.542
900	0.059	0.218	0.270	0.787	0.080	0.226	0.356	0.722	-0.126	0.224	-0.560	0.576
920	-0.038	0.214	-0.179	0.858	0.110	0.229	0.481	0.630	-0.216	0.219	-0.985	0.325
940	-0.067	0.212	-0.317	0.751	0.080	0.226	0.354	0.723	-0.218	0.215	-1.013	0.311

960	-0.050	0.212	-0.235	0.814	0.027	0.226	0.118	0.906	-0.212	0.216	-0.981	0.327
980	0.057	0.210	0.273	0.785	0.081	0.222	0.366	0.714	-0.155	0.215	-0.719	0.472
1000	0.015	0.206	0.071	0.943	0.014	0.220	0.062	0.950	-0.050	0.217	-0.230	0.818
1020	0.012	0.204	0.057	0.954	-0.072	0.220	-0.327	0.744	-0.027	0.215	-0.128	0.898
1040	-0.052	0.204	-0.255	0.799	-0.028	0.222	-0.126	0.899	-0.034	0.213	-0.160	0.873
1060	0.005	0.200	0.023	0.982	-0.039	0.225	-0.172	0.863	-0.025	0.213	-0.115	0.908
1080	-0.018	0.199	-0.089	0.929	-0.096	0.225	-0.425	0.671	-0.103	0.214	-0.483	0.629
1100	-0.031	0.199	-0.157	0.875	-0.050	0.218	-0.231	0.817	-0.135	0.210	-0.642	0.521
1120	0.008	0.203	0.040	0.968	0.040	0.217	0.184	0.854	-0.022	0.206	-0.108	0.914
1140	-0.033	0.199	-0.168	0.867	0.052	0.214	0.245	0.806	-0.081	0.207	-0.395	0.693
1160	0.046	0.198	0.232	0.817	0.121	0.212	0.569	0.569	-0.089	0.204	-0.437	0.662
1180	-0.005	0.195	-0.024	0.981	0.174	0.206	0.843	0.399	-0.082	0.202	-0.403	0.687
1200	0.121	0.194	0.624	0.532	0.178	0.205	0.867	0.386	(Model failed to converge.)			
1220	0.139	0.196	0.707	0.480	0.133	0.207	0.641	0.521	-0.206	0.201	-1.025	0.305
1240	0.129	0.197	0.655	0.513	0.247	0.207	1.195	0.232	(Model failed to converge.)			
1260	0.094	0.194	0.483	0.629	0.278	0.208	1.338	0.181	-0.125	0.202	-0.620	0.535
1280	0.178	0.194	0.917	0.359	0.294	0.204	1.444	0.149	-0.072	0.202	-0.355	0.723
1300	0.180	0.194	0.928	0.354	0.218	0.202	1.078	0.281	0.014	0.198	0.072	0.943
1320	0.205	0.193	1.063	0.288	0.161	0.199	0.810	0.418	0.035	0.197	0.180	0.857
1340	0.297	0.194	1.532	0.126	0.080	0.199	0.403	0.687	0.047	0.200	0.238	0.812
1360	0.293	0.192	1.528	0.127	0.107	0.195	0.549	0.583	0.122	0.203	0.602	0.547
1380	0.393	0.197	1.998	**0.046**	0.116	0.195	0.592	0.554	0.155	0.202	0.766	0.444
1400	0.424	0.194	2.184	**0.029**	0.131	0.195	0.673	0.501	0.203	0.202	1.008	0.313
1420	0.467	0.196	2.378	**0.017**	0.295	0.198	1.491	0.136	0.225	0.202	1.112	0.266
1440	0.496	0.200	2.478	**0.013**	0.384	0.198	1.940	0.052	0.213	0.202	1.054	0.292
1460	0.503	0.203	2.481	**0.013**	0.475	0.200	2.370	**0.018**	0.214	0.204	1.051	0.293
1480	0.486	0.204	2.389	**0.017**	0.542	0.206	2.633	**0.008**	0.347	0.206	1.683	0.092
1500	0.469	0.200	2.346	**0.019**	0.603	0.214	2.811	**0.005**	0.342	0.207	1.654	0.098
1520	0.515	0.202	2.546	**0.011**	0.512	0.213	2.409	**0.016**	0.327	0.208	1.572	0.116
1540	0.613	0.207	2.964	**0.003**	0.628	0.211	2.981	**0.003**	0.236	0.209	1.133	0.257
1560	0.638	0.206	3.098	**0.002**	0.674	0.210	3.206	**0.001**	0.286	0.210	1.363	0.173
1580	0.546	0.205	2.659	**0.008**	0.676	0.210	3.214	**0.001**	0.174	0.205	0.845	0.398
1600	0.584	0.208	2.802	**0.005**	0.731	0.212	3.456	**0.001**	0.258	0.204	1.266	0.205
1620	0.871	0.217	4.024	**0.000**	0.673	0.214	3.139	**0.002**	0.200	0.203	0.988	0.323
1640	0.988	0.231	4.287	**0.000**	0.675	0.215	3.136	**0.002**	0.262	0.205	1.281	0.200
1660	1.014	0.239	4.244	**0.000**	0.595	0.220	2.707	**0.007**	0.271	0.203	1.335	0.182
1680	1.028	0.243	4.234	**0.000**	0.566	0.222	2.554	**0.011**	0.300	0.204	1.468	0.142
1700	1.033	0.241	4.281	**0.000**	0.336	0.219	1.532	0.125	0.378	0.211	1.790	0.073
1720	0.944	0.243	3.891	**0.000**	0.271	0.222	1.219	0.223	0.421	0.215	1.962	**0.050**
1740	0.981	0.246	3.983	**0.000**	0.254	0.221	1.146	0.252	0.331	0.213	1.553	0.120
1760	1.012	0.001	760.73	**0.000**	0.251	0.233	1.080	0.280	0.369	0.219	1.683	0.092
1780	0.817	0.265	3.089	**0.002**	0.208	0.240	0.870	0.384	0.420	0.230	1.825	0.068
1800	0.854	0.273	3.127	**0.002**	0.357	0.243	1.469	0.142	0.253	0.229	1.102	0.271
1820	0.831	0.272	3.052	**0.002**	0.198	0.241	0.822	0.411	-0.091	0.225	-0.405	0.686
1840	0.877	0.276	3.174	**0.002**	0.208	0.259	0.804	0.422	-0.028	0.228	-0.124	0.901
1860	1.018	0.294	3.466	**0.001**	0.203	0.254	0.798	0.425	-0.072	0.234	-0.308	0.758
1880	0.969	0.290	3.347	**0.001**	0.282	0.262	1.078	0.281	-0.158	0.240	-0.656	0.512
1900	0.892	0.283	3.153	**0.002**	0.258	0.264	0.979	0.328	-0.149	0.242	-0.616	0.538
1920	0.720	0.291	2.476	**0.013**	0.134	0.265	0.506	0.613	-0.054	0.244	-0.221	0.825
1940	0.604	0.285	2.119	**0.034**	0.162	0.269	0.603	0.547	-0.156	0.252	-0.618	0.536
1960	0.580	0.290	2.001	**0.045**	0.037	0.282	0.131	0.896	-0.067	0.264	-0.255	0.799
1980	0.447	0.286	1.566	0.117	-0.048	0.286	-0.169	0.866	-0.091	0.264	-0.344	0.731
2000	0.486	0.292	1.665	0.096	-0.098	0.291	-0.335	0.738	-0.069	0.271	-0.255	0.799

Appendix 2

Results of logistic mixed-effects regression analysis on the effect of focus prosody type on Korean speakers' target fixation proportions in each 20 ms time bin

BIN (ms)	word-initial stress				word-medial stress				word-final stress			
	Estimate	SE	z	p	Estimate	SE	z	p	Estimate	SE	z	p
0	-0.336	0.291	-1.152	0.249	-0.122	0.270	-0.452	0.651	-0.289	0.251	-1.151	0.250
20	-0.131	0.268	-0.489	0.625	-0.128	0.264	-0.484	0.629	-0.300	0.247	-1.211	0.226
40	-0.137	0.262	-0.524	0.600	(Model failed to converge.)				-0.350	0.247	-1.420	0.156
60	-0.149	0.260	-0.575	0.566	0.030	0.266	0.114	0.909	-0.399	0.242	-1.644	0.100
80	-0.065	0.265	-0.244	0.807	0.042	0.261	0.161	0.872	-0.432	0.242	-1.787	0.074
100	-0.067	0.261	-0.258	0.797	(Model failed to converge.)				-0.558	0.247	-2.255	**0.024**
120	-0.151	0.259	-0.584	0.559	-0.086	0.264	-0.326	0.744	-0.734	0.248	-2.957	**0.003**
140	0.044	0.264	0.166	0.868	(Model failed to converge.)				-0.630	0.248	-2.543	**0.011**
160	0.182	0.262	0.697	0.486	0.047	0.264	0.177	0.860	-0.595	0.251	-2.370	**0.018**
180	0.255	0.262	0.973	0.331	-0.054	0.271	-0.201	0.841	-0.410	0.251	-1.631	0.103
200	0.211	0.261	0.806	0.420	-0.101	0.267	-0.377	0.706	-0.339	0.246	-1.377	0.169
220	0.154	0.265	0.579	0.562	0.004	0.264	0.014	0.989	-0.400	0.244	-1.636	0.102
240	0.061	0.267	0.227	0.820	-0.030	0.261	-0.117	0.907	-0.368	0.246	-1.493	0.136
260	0.034	0.268	0.125	0.900	0.008	0.261	0.031	0.975	-0.349	0.239	-1.458	0.145
280	0.007	0.265	0.025	0.980	-0.138	0.262	-0.526	0.599	-0.328	0.246	-1.333	0.182
300	-0.138	0.271	-0.510	0.610	-0.021	0.261	-0.082	0.935	-0.388	0.245	-1.584	0.113
320	-0.009	0.264	-0.034	0.973	-0.084	0.003	-32.399	**0.000**	-0.289	0.244	-1.184	0.237
340	0.004	0.263	0.016	0.988	-0.073	0.247	-0.298	0.766	(Model failed to converge.)			
360	-0.091	0.275	-0.332	0.740	-0.040	0.243	-0.163	0.871	(Model failed to converge.)			
380	-0.039	0.274	-0.142	0.887	-0.092	0.246	-0.375	0.707	(Model failed to converge.)			
400	-0.016	0.266	-0.061	0.951	-0.079	0.003	-30.300	**0.000**	(Model failed to converge.)			
420	-0.050	0.268	-0.189	0.850	-0.198	0.248	-0.800	0.424	-0.188	0.228	-0.826	0.409
440	-0.134	0.268	-0.503	0.615	-0.183	0.246	-0.744	0.457	-0.070	0.226	-0.310	0.757
460	-0.106	0.272	-0.390	0.697	-0.216	0.244	-0.883	0.377	-0.143	0.224	-0.638	0.523
480	-0.359	0.268	-1.339	0.181	-0.247	0.248	-0.994	0.320	-0.187	0.222	-0.841	0.400
500	-0.295	0.268	-1.099	0.272	-0.265	0.246	-1.076	0.282	-0.191	0.226	-0.844	0.399
520	-0.339	0.278	-1.221	0.222	-0.259	0.247	-1.050	0.294	-0.256	0.225	-1.139	0.255
540	-0.377	0.280	-1.349	0.177	-0.240	0.246	-0.975	0.330	-0.171	0.221	-0.775	0.438
560	-0.240	0.269	-0.891	0.373	-0.249	0.246	-1.013	0.311	-0.130	0.221	-0.588	0.557
580	-0.133	0.269	-0.496	0.620	-0.173	0.243	-0.713	0.476	-0.135	0.220	-0.614	0.539
600	-0.126	0.261	-0.484	0.628	-0.269	0.253	-1.063	0.288	-0.053	0.217	-0.245	0.807
620	-0.052	0.252	-0.208	0.835	-0.221	0.252	-0.877	0.381	-0.194	0.220	-0.883	0.377
640	0.039	0.244	0.159	0.874	-0.168	0.247	-0.680	0.497	-0.062	0.222	-0.279	0.780
660	0.075	0.243	0.308	0.758	-0.153	0.248	-0.616	0.538	0.052	0.218	0.240	0.810
680	0.063	0.243	0.259	0.796	-0.158	0.254	-0.622	0.534	0.220	0.221	0.995	0.320
700	0.154	0.241	0.640	0.522	-0.247	0.250	-0.985	0.325	0.334	0.223	1.497	0.134
720	0.277	0.251	1.105	0.269	-0.281	0.246	-1.142	0.254	0.243	0.220	1.107	0.268
740	0.326	0.251	1.299	0.194	-0.235	0.246	-0.957	0.339	0.217	0.213	1.018	0.309
760	0.181	0.245	0.741	0.459	-0.242	0.242	-1.003	0.316	0.283	0.211	1.343	0.179
780	0.064	0.236	0.271	0.786	-0.252	0.245	-1.030	0.303	0.191	0.207	0.922	0.357
800	0.032	0.233	0.137	0.891	-0.326	0.246	-1.326	0.185	0.074	0.207	0.358	0.721
820	0.052	0.230	0.225	0.822	-0.222	0.241	-0.922	0.357	-0.018	0.209	-0.087	0.930
840	-0.010	0.224	-0.043	0.966	-0.202	0.236	-0.856	0.392	-0.050	0.202	-0.245	0.806
860	-0.104	0.221	-0.469	0.639	-0.184	0.232	-0.793	0.428	-0.122	0.202	-0.607	0.544
880	-0.102	0.221	-0.462	0.644	-0.290	0.231	-1.259	0.208	-0.077	0.201	-0.383	0.702
900	-0.302	0.219	-1.379	0.168	-0.085	0.219	-0.387	0.699	-0.007	0.200	-0.037	0.971
920	-0.249	0.216	-1.154	0.249	-0.156	0.218	-0.716	0.474	-0.106	0.196	-0.539	0.590
940	-0.258	0.211	-1.224	0.221	-0.206	0.219	-0.938	0.348	-0.103	0.194	-0.534	0.593

960	-0.271	0.211	-1.280	0.200	-0.126	0.219	-0.577	0.564	-0.039	0.195	-0.200	0.841
980	-0.239	0.207	-1.153	0.249	-0.082	0.214	-0.382	0.702	-0.006	0.195	-0.032	0.974
1000	-0.288	0.204	-1.416	0.157	-0.084	0.209	-0.402	0.688	-0.049	0.194	-0.251	0.802
1020	-0.294	0.202	-1.460	0.144	-0.055	0.203	-0.273	0.785	0.067	0.192	0.351	0.726
1040	-0.265	0.200	-1.328	0.184	-0.069	0.198	-0.351	0.725	-0.031	0.195	-0.157	0.876
1060	-0.214	0.200	-1.070	0.285	-0.019	0.193	-0.100	0.920	0.020	0.192	0.106	0.916
1080	-0.211	0.199	-1.061	0.289	0.011	0.193	0.059	0.953	-0.050	0.191	-0.263	0.792
1100	-0.180	0.198	-0.913	0.361	-0.026	0.194	-0.133	0.894	-0.038	0.189	-0.203	0.839
1120	-0.221	0.194	-1.139	0.255	-0.005	0.191	-0.024	0.981	-0.008	0.190	-0.041	0.967
1140	-0.093	0.193	-0.480	0.631	0.108	0.191	0.563	0.573	0.057	0.190	0.297	0.766
1160	-0.054	0.191	-0.285	0.776	0.013	0.190	0.066	0.947	0.042	0.193	0.220	0.826
1180	0.000	0.191	-0.001	0.999	0.013	0.191	0.066	0.948	0.018	0.195	0.092	0.927
1200	-0.084	0.191	-0.442	0.659	0.050	0.188	0.264	0.792	-0.038	0.193	-0.196	0.845
1220	0.073	0.190	0.383	0.702	0.158	0.189	0.837	0.403	0.011	0.194	0.057	0.955
1240	0.157	0.189	0.832	0.405	0.141	0.186	0.760	0.447	0.068	0.193	0.352	0.725
1260	0.144	0.188	0.768	0.443	-0.009	0.186	-0.049	0.961	-0.005	0.194	-0.025	0.980
1280	0.121	0.190	0.637	0.524	-0.098	0.185	-0.528	0.598	0.074	0.194	0.380	0.704
1300	0.069	0.186	0.372	0.710	-0.166	0.186	-0.891	0.373	0.149	0.191	0.779	0.436
1320	0.049	0.183	0.269	0.788	-0.107	0.187	-0.574	0.566	0.120	0.190	0.635	0.526
1340	0.009	0.184	0.052	0.959	-0.181	0.186	-0.977	0.329	0.180	0.189	0.950	0.342
1360	(Model failed to converge.)				-0.202	0.188	-1.071	0.284	0.059	0.190	0.309	0.758
1380	-0.020	0.182	-0.109	0.913	-0.119	0.187	-0.634	0.526	0.011	0.189	0.061	0.952
1400	0.016	0.183	0.088	0.929	-0.139	0.189	-0.736	0.462	-0.029	0.189	-0.151	0.880
1420	(Model failed to converge.)				-0.075	0.184	-0.406	0.685	-0.037	0.191	-0.192	0.848
1440	0.167	0.178	0.938	0.348	0.070	0.181	0.388	0.698	0.009	0.188	0.046	0.964
1460	0.210	0.182	1.156	0.248	0.052	0.181	0.290	0.772	0.051	0.187	0.272	0.786
1480	0.216	0.181	1.195	0.232	0.063	0.181	0.351	0.726	0.050	0.184	0.269	0.788
1500	0.135	0.181	0.745	0.456	0.115	0.180	0.639	0.523	0.118	0.184	0.642	0.521
1520	0.170	0.182	0.935	0.350	0.124	0.179	0.694	0.488	0.133	0.186	0.714	0.475
1540	0.229	0.184	1.246	0.213	0.238	0.181	1.317	0.188	0.175	0.182	0.965	0.334
1560	0.166	0.183	0.908	0.364	0.365	0.183	1.995	**0.046**	0.201	0.182	1.103	0.270
1580	0.262	0.185	1.415	0.157	0.404	0.185	2.182	**0.029**	0.153	0.184	0.831	0.406
1600	0.326	0.186	1.756	0.079	0.606	0.188	3.220	**0.001**	0.144	0.183	0.786	0.432
1620	0.426	0.187	2.282	**0.023**	0.639	0.188	3.396	**0.001**	-0.010	0.186	-0.056	0.956
1640	0.425	0.183	2.323	**0.020**	0.652	0.190	3.433	**0.001**	0.001	0.189	0.004	0.997
1660	0.454	0.186	2.435	**0.015**	0.610	0.191	3.192	**0.001**	0.078	0.188	0.416	0.678
1680	0.480	0.188	2.547	**0.011**	0.702	0.193	3.637	**0.000**	0.120	0.192	0.625	0.532
1700	0.415	0.190	2.188	**0.029**	0.561	0.199	2.813	**0.005**	0.101	0.193	0.525	0.600
1720	0.381	0.191	2.001	**0.045**	0.499	0.199	2.507	**0.012**	0.123	0.197	0.623	0.533
1740	0.375	0.192	1.957	0.050	0.531	0.202	2.625	**0.009**	0.120	0.200	0.597	0.550
1760	0.253	0.190	1.329	0.184	0.511	0.205	2.487	**0.013**	0.159	0.199	0.798	0.425
1780	0.340	0.195	1.745	0.081	0.542	0.208	2.609	**0.009**	0.149	0.201	0.743	0.457
1800	0.297	0.200	1.486	0.137	0.483	0.217	2.223	**0.026**	0.108	0.207	0.521	0.603
1820	0.323	0.208	1.553	0.120	0.382	0.222	1.720	0.085	0.160	0.204	0.787	0.431
1840	0.380	0.213	1.780	0.075	0.244	0.222	1.097	0.272	0.141	0.207	0.681	0.496
1860	0.370	0.221	1.677	0.094	0.174	0.238	0.733	0.463	0.177	0.220	0.804	0.421
1880	0.433	0.223	1.941	0.052	0.314	0.252	1.244	0.214	0.062	0.221	0.281	0.779
1900	0.330	0.224	1.476	0.140	0.342	0.251	1.366	0.172	0.041	0.226	0.183	0.855
1920	0.145	0.228	0.636	0.525	0.198	0.257	0.770	0.441	0.019	0.229	0.081	0.935
1940	0.137	0.231	0.591	0.555	0.203	0.264	0.769	0.442	-0.079	0.241	-0.329	0.742
1960	-0.141	0.244	-0.578	0.563	0.127	0.266	0.479	0.632	-0.058	0.245	-0.236	0.813
1980	-0.217	0.258	-0.842	0.400	0.104	0.278	0.374	0.708	-0.050	0.256	-0.197	0.844
2000	-0.257	0.256	-1.004	0.315	0.063	0.281	0.223	0.824	-0.103	0.268	-0.384	0.701