

The effect of context speech rate in the recognition of English auxiliary verbs*

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Kim, Jungsun. 2014. The effect of context speech rate in the recognition of English auxiliary verbs. *Studies in Phonetics, Phonology and Morphology* 20.1. 83-97. This paper investigates the context-dependent speech rate to perceive function words (i.e., auxiliary verbs). Whether the rate-dependent recognition is affected by the sequence of words with or without auxiliary verbs is examined. The experiment used two types of spoken sentences: (1) those with an auxiliary verb and (2) those in which the auxiliary verb was phonetically deleted. The recognition of auxiliary verbs was not greater for contexts with a normal or fast speech rate than for context temporal information (e.g., speech rate). Interestingly, the shift of context was not focused on the speech rate of the target word (i.e., auxiliary verb). Rather, the shift between the target and context in speech rate functioned as a cue to perceive the auxiliary verb. That is, the proportion of correctly perceived auxiliary verbs was greater when the target was manipulated to have a different speech rate from the context. When an auxiliary verb was deleted in the context, the participants reported recognizing, although the proportion of responses was very low for both the normal and fast speech rates. In the normal speech, the proportion was unchanged in terms of the goodness rating. However, another interesting finding was that in the fast speech rate, the recognition of auxiliary verbs increased when the goodness ratings were close to the poorest exemplar. This result is a counter example to the case of American English speakers. In the current study, the Korean participants learning English at a primary level were not accustomed to the rate of speech in American English. Based on the experiment results, this study implies that Korean students learning English should be taught in terms of rate-dependent context so that they can perceive the function words with reduction or deletion in American English. (Yeungnam University)

Keywords: English auxiliary verbs, speech rate, temporal information,
a goodness rating task

1. Introduction

This paper investigates how function words, which are often reduced in the production of American English speakers, could be perceived to Korean English learners when they are presented with different speech rate. In the perception of function words, it is often difficult to understand the function word itself since the reduced forms in production are not recognized well enough for interpreting the phrase or sentence. When interpreting the context in American English, listeners tend to focus on content words such as nouns, adjectives, or adverbs, rather than

* I am very grateful to three anonymous reviewers of the journal for their helpful comments. All remaining errors are mine.

function words. This paper investigates how Korean students learning English as a second language perceive English auxiliary verbs. The study tests the role of temporal information with different speech rate when Korean ESL speakers perceive English auxiliary verbs.

The study deals specifically with auxiliary words, which are function words. The recognition of auxiliary verbs is affected by two factors: (1) the degree of reduction of the auxiliary verb dependent on speech rate and (2) the amount of functional load of the word in a sentence (i.e., content words vs. function words). In the current study, the auxiliary verbs can often be heard as ambiguous (i.e., reduced) forms in each rate of speech. Figure 1 shows the reduced forms of the auxiliary verb *can* in the phrase *we can go*. The phonemic form /kæn/ can be reduced in the course of a time-varying pattern, including the deletion of the vowel and a consonant, vowel reduction and place assimilation of the coda when followed by a consonant with a different place of articulation. As seen in Figure 1, [kŋ] ‘can’ is the examples of reduced forms in the speech materials used in the study.

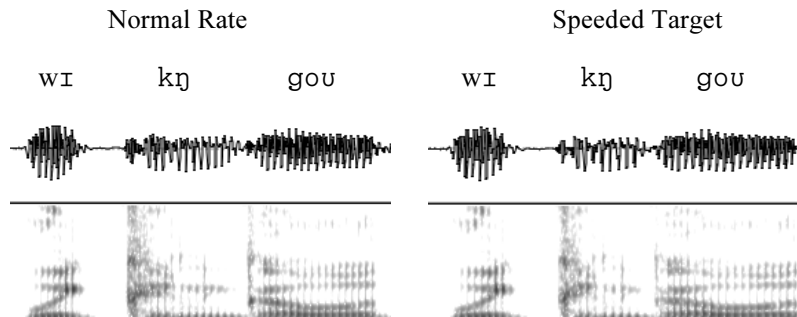


Figure 1. Waveforms and spectrograms showing the reduced forms of *can* in *we can go* in the time-varying pattern. The phonetic transcription is shown above each waveform. The y-axis represents the frequency (Hz) in the spectrogram and the x-axis, time(s).

When the speech is fast, the phonetic forms of function words may be reduced or deleted. Given this fact, the current study presumed that auxiliary verbs may also be reduced or deleted. Therefore, stimulus materials in the study were classified into two types, according to the presence or deletion of an auxiliary verb. The target (i.e., auxiliary verb) and context were manipulated to have different speech rates. The auxiliary verb was adjusted to the speech rate to compare perception based on various conditions of the interval of the auxiliary verb in the sentence. Six conditions in the two stimulus types were examined, with participants in Korea who were learning English as a second language in Korea.

(1) Six conditions of auxiliary verbs according to speech rate

a. Presence of an auxiliary verb

- 1) The target and context at a normal speech rate
- 2) The target and context at a fast speech rate
- 3) The target at a fast speech rate and context at a normal rate
- 4) The target at a slow speech rate and context at a fast rate

b. Deletion of an auxiliary verb

- 1) The target and context at a normal speech rate
- 2) The target and context at a fast speech rate

The six conditions listed in (1) are basically based on the shift in speech rate, for instance, focused on conditions (1a-3) and (1a-4). (1a-4) was constructed to show the clear difference between the target and context with different speech rate. (1a-2) and (1b-2) were manipulated to have a fast speech condition with and without auxiliary verbs. These two conditions will show whether there is the difference of recognition in a fast speech rate when the auxiliary verbs are deleted in a sentence.

Mostly, the effect of speech rate concerns deletion of schwa or function words. If the speech rate is increased, the deletion or reduction of schwa or functions words are increased accordingly (Patterson et al. 2003, Dilley and Pitt 2010, Coetzee et al. 2011). As an extension of schwa deletion, the more frequently words occur, the greater the reduction of schwa contained in those words (Hooper 1976, Coetzee et al. 2011). However, Dilley and Pitt (2010) revealed that although the deletion of function words is dependent on the rate of speech, the function words reported were increased in the fast speech with deletion in the context. The expectation of the function words in fast speech reflected the rhythmic structure of the participants' native language. Coetzee et al. (2011) showed that when there was a faster speech rate, the perceptual responses for schwa deletion were restored as the higher proportion. The current study deals with the context speech rate to investigate whether the target (i.e., an auxiliary verb) is affected by it.

Bell et al. (2003) found that, regardless of the rate of speech, when function words had reduced forms, monosyllabic function words with high frequency tended to be more strongly reduced. Additionally, as the context effect, the function words were likely to be produced as the reduced forms in utterance-initial or utterance-final position. However, Bell et al.'s study did not focus on the change of speech rate. Moreover, in their study, the less predictable environment triggered the fuller forms of the function words.

The ambiguous forms, such as coarticulation, are restored with perceptual recoverability in the time-varying course (Remez et al. 1981, Cutler et al. 1983, Shannon et al. 1995, Saltzman and Byrd 2000,

Ernestus et al. 2002). Ernestus et al. (2002) revealed that, in Dutch, reduced forms were highly recognized in complete contexts. When reduced forms were correlated in the limited contexts which the word forms are not realized as a complete sentence, listeners recognize the degree of reduction for their intelligibility. Ernestus et al. emphasized that the context conveys the crucial interpretability instead of the meaning of the reduced form itself. Shannon et al. (1995) observed almost complete speech recognition, though they presented the reduced forms in the time-varying condition.

Thus, according to the existing literature, reduced forms can be recognized without problem when the context is related to them. The present paper aims at observing whether there is an effect of speech rate when the time is varied through the context. To this end, the following three research questions are addressed: First, if the target and context differ in speech rate, are the English auxiliary verbs recognized? Second, in fast speech, is the recognition of auxiliary verbs increased, even when the auxiliary verbs are deleted? Finally, is there a difference between Korean speakers learning English as a second language at the primary level and American English or non-English speakers discussed in the previous literatures, in terms of their recognition of English function words? On a basis of these research questions, this study discusses differences in the recognition of function words for Korean and American English speakers

2. Experimental Method

2.1 Subjects

For this experiment, 23 Korean students (mean age: 19, SD: 1.22) took part in the session on the recognition of English auxiliary verbs relative to the rate of speech. They were 13 females and 10 males. All the participants had lived in Korea for their entire lives. Only one male student had the experience of living in an English-speaking country for two months. To assess their ability of English communication, the participants were asked questions about English experience information. The mean values were based on self-assessment in Table 1. Seven participants had taken an English proficiency test such as TOEIC. The test scores were about 600 for four of these participants and about 400 for the remaining three. All the participants were given extra credit in the course for taking part in the experiment. They were university students who were beginning learners of English grammar and conversation.

Table 1. English experience information

Questions	Mean values
English daily use (%) per day	13
English TV (hours) per day	0.3
English press (minutes) per day	8.9
Scale: 1(the least) - 10 (the best)	
Use of English at home	2.1
Use of English at school	3.5
Use of English socially	2.8

2.2 Speech materials

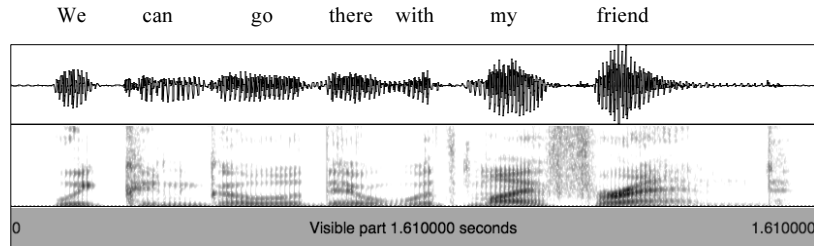
The materials used in the experiment were 10 sentences that include auxiliary verbs. One male American English native speaker recorded the speech materials at a normal speech rate. These sentences were manipulated for each portion, target, context or both. The target, an auxiliary verb, was compressed to 0.7 times the original duration or expanded to 1.3, using Praat (Boersma and Weenink 2012). In the same way, the compressed and expanded factors were applied to the contexts that excluded the target. Additionally, for the fast speech rate with auxiliary verbs, the whole context, including the target, was compressed. Specifically, as seen in Figure 2, the target, that is, the auxiliary verb was compressed or expanded. The context except the target was also compressed for the fast speech. The following sentences shown in (2a) to (2j) were the speech materials used in the experiment.¹

(2) speech materials

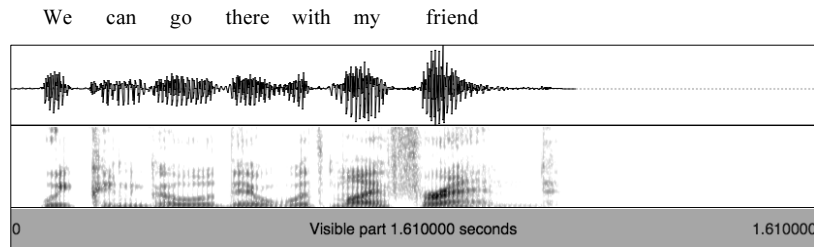
- a. There must be some things at the candy store across the street around the corner of bank.
- b. We can go there with my friend.
- c. Mary and I would like to go to the cinema next Sunday.
- d. This is an animal, which can take an apple when people throw it.
- e. We had shut down the door at the corner of the house completely.
- f. What will you put in the soup made by my grandma?
- g. I can do nothing for it but laugh at the sight.
- h. Michael will sit for hours without saying a word.
- i. I should go there this month when I'm attending art school.
- j. You should have taken her advice if you agree with her words.

¹ Two anonymous reviewers mentioned that some sentences without an auxiliary verb are ungrammatical and they wanted to identify whether the recognition of participants had the effect from this fact. On a basis of a statistical analysis (i.e., one-way ANOVA) for each sentence without an auxiliary verb, the goodness rating from the participants was not affected in a normal speech rate (i.e., S1: $F(1,8) = .53, p = .487$, S2: $F(1,8) = 3.063, p = .118$, S3: $F(1,8) = 30.75, p < .001$, S4: $F(1,8) = .05, p = .828$, S5: $F(1,8) = .076, p = .79$, S6: $F(1,8) = 2.06, p = .189$, S7: $F(1,8) = .04, p = .847$, S8: $F(1,8) = 5.986, p < .05$, S9: $F(1,8) = 2.187, p = .177$, S10: $F(1,8) = .74, p = .415$).

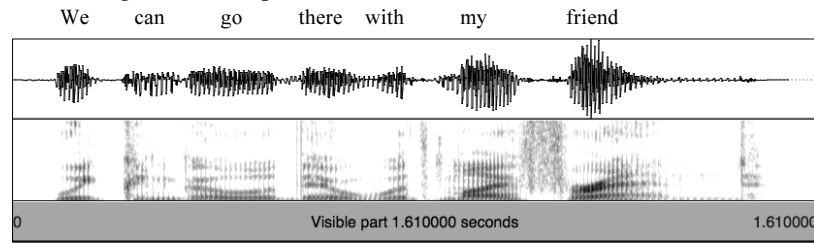
a. The target and context at a normal speech rate



b. The target and context at a fast speech rate



c. The target at a fast speech rate and context at a normal rate



d. The target at a slow speech rate and context at a fast rate

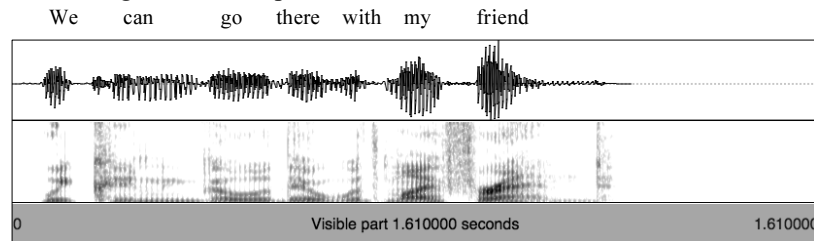


Figure 2. Waveforms and spectrograms of a time-manipulated stimulus across the four conditions in (1a). A sample sentence is *We can go there with my friend*. The x-axis represents time (s) and the y-axis, frequency (Hz) (in the spectrogram).

2.3 Procedure

The speech materials manipulated for speech rate were assessed on a 10-point scale, representing the goodness rating. The first one on the scale was the best exemplar for the recognition of an auxiliary verb and the last (i.e., tenth) one was the poorest exemplar. In the goodness rating task, participants selected one number on a scale from one to ten when they perceived an auxiliary verb. They marked the number on an answer sheet.

3. Results and Discussion

The data from the experiment were divided into two categories according to the experimental conditions, presence of an auxiliary verb and deletion of an auxiliary verb. For the data analysis, a univariate analysis of variance (ANOVA) was employed, presenting the assessment of goodness rating for each condition. The values in terms of a goodness rating were evaluated by the proportion of correct responses for sentences with auxiliary verbs. The proportion of responses for sentences with the deletion of auxiliary verbs was also calculated according to the participants' responses. To clearly identify the best and poorest exemplars from the participants' responses, a logistic regression analysis was used for the estimated intercept. The higher values at the estimated intercept represented the higher proportion for the best exemplar and the lower values indicate the poorest exemplar. The sections below describe the study results with a brief discussion related to the figures.

3.1 Presence of an auxiliary verb

A statistical analysis was conducted to determine whether the rate of speech in the context had an effect on the perception of auxiliary verbs. The first two conditions were the normal and fast speech rates with auxiliary verbs. The goodness rating was significantly different ($F(1, 8) = 6.598, p = .0332$) at the 0.05 significance level for the perception of auxiliary verbs related to both the target and context in the normal speech rate condition. The goodness rating in the fast speech rate condition was significantly different ($F(1, 8) = 5.111, p = .0537$) at the 0.1 level. The mean squared error (MSE) was also significantly different between the two conditions (MSE = .10909 for a normal rate vs. MSE = .06136 for a fast rate). The MSE was lower in the fast speech than in the normal speech rate condition. The normal speech rate condition was more perceivable for the targets, (i.e., auxiliary verbs), but also more variable. However, in the fast rate condition, the participants tended not to perceive the targets (i.e., auxiliary verbs), even though there was less variability.

In the shift of duration manipulation, when the target was slowed in a fast context, the goodness rating was not significantly different (p

= .0759) at the 0.05 level, but the MSE (0.15633) in this shift condition was greater than in the two conditions, where both the target and context were the same, either normal or fast. The proportion of correct recognition of the auxiliary verb was the highest in this condition as well. Moreover, the target with a fast rate in the normal speed context was not significant at the 0.05 level, but it was different ($F(1, 8) = 4.4, p = .0692$) at the 0.1 level. The MSE was 0.1382. This value was lower than in the shift condition in which the target had a slow speed in a fast speed context, but it was much higher than in the conditions where both the target and context had the same speech rate. In addition, as the duration of the target was manipulated as a compressed factor, 0.7, the proportion of correct recognition of the auxiliary verb was still higher than in the conditions where the context and target had the same speech rate (i.e., normal and fast).

The estimated intercept in the logistic regression analysis for the four conditions discussed above was greater for the first exemplar (i.e., the best exemplar) on a goodness scale than the other two conditions without the target. The estimation of intercept was 1.36 for both target and context with the normal speech rate and 1.29 for the fast rate. Regarding the shift in speech rate, the target slowed in a fast context rate showed a value of 1.37, but the target with a fast rate in a normal context rate showed 1.40. Thus, when there was a shift in speech rate, the estimated intercept was a bit higher than when there was no shift.

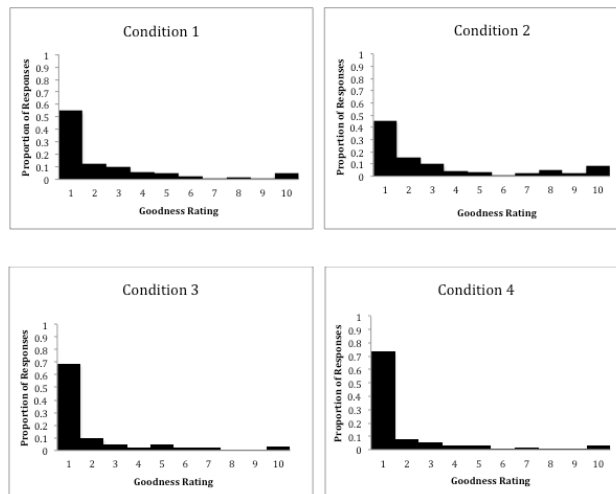


Figure 3. Proportion of auxiliary verbs perceived correctly in the goodness rating task. Condition 1 shows the results for the normal speech rate for both the target and context. Condition 2 shows the results for the fast speech rate. Condition 3 shows the results for the fast (i.e., speeded) target in a normal context rate. Condition 4 shows the results for the slow target in a fast context.

As seen in Figure 3 and discussed above, overall, the recognition of auxiliary verbs was not dependent on the same speech rate for both target and context. However, there is evidence that a shift in speech rate aided the participants' recognition of auxiliary verbs. Specifically, Condition 2 presents the fast speech rate condition and, in the goodness rating of auxiliary verbs, the best exemplar had lower proportion than in the normal speech rate condition seen in Condition 1. Interestingly, as seen in the result of Condition 3, the best exemplar of stimulus in auxiliary verbs had much higher scores for the recognition of auxiliary verbs than in Condition 1 or 2. In this example, the best exemplar in goodness rating represents the context with a normal speech rate and the target exemplar with a fast speech rate. That is, the difference of Condition 1 or 2 and Condition 3 shows that the best exemplar, that is, the first exemplar and the environment for it was a different speech rate for the target and context, in contrast to a uniform speech rate, such as normal, slow, or fast. The more obvious evidence is presented by the results of Condition 4. In this condition, the target was slowed and the context had a fast speech rate. The speech rate for the shift of the target and context in Condition 3 or 4 differed, compared to the results in Condition 1 or 2. This result means that the recognition of auxiliary verbs did not rely on speech rate itself, but on the change of rhythm of the words built in the context. That is, speech rate shows the effect of built-in speed in the context.

Function words such as auxiliary verbs showing reduction present this rate effect of the word on the whole context such as a sentence or a phrase. In short, it seemed to be the shift of rate in spontaneous speech that cued the recognition of function words.

3.2 Deletion of an auxiliary verb

In this subsection, the last two conditions were the cases without auxiliary verbs. The context with a normal speech rate without the target was not significant ($p = .452$) in goodness rating. And the MSE was 0.0004436 and the proportion of correctly perceived auxiliary verbs was low. However, the context with a fast speech rate without the target was significantly different ($F(1, 8) = 6.953, p = .0299$), although the MSE was 0.02339. The estimated intercept was 0.40 in the normal speech rate condition and 0.32 in the fast speech rate condition. Thus, in the comparison of estimated intercepts, the contexts with the target (i.e., auxiliary verbs) had greater values than those without the target (deleted auxiliary verbs).

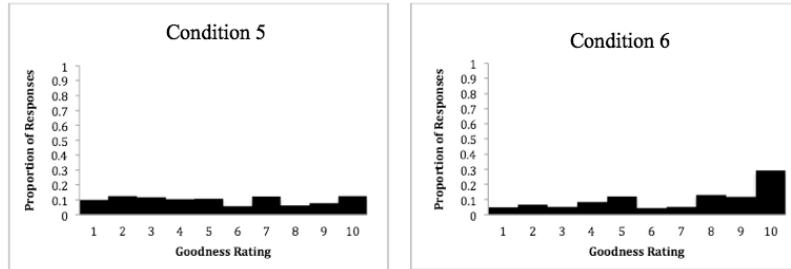


Figure 4. Condition 5 shows the results for the context with a normal speech rate without auxiliary verbs and Condition 6 shows the results for a fast speech rate without auxiliary verbs.

As seen in Figure 4, the responses in Condition 6 showed an increase in the poorest exemplar in the context with a fast speech rate without auxiliary verbs, whereas there was neither an increase nor decrease for the normal speech rate. The increase of poorest exemplars in perceiving auxiliary verbs seemed to be dependent on speech rate. In the American English rhythmic (i.e., prosodic) system, Korean participants showed that the deletion of the target word was increased in the fast speech rate compared to the normal speech rate. That is, in the present study, I did not create the condition of a slow context, but such a condition would be expected to yield similar or lower proportion of perceived auxiliary verbs, compared to the condition of fast speech rate. In other words, in fast speech, Korean participants tended to recognize the deletion of the target verbs. However, the proportion of responses related to the deletion of auxiliary verbs was not as high as for the presence of auxiliary verbs in the contexts that had shift in rhythm such as prosodic factors. Thus, the participants showed that they relied on the greater shift in speech rate between the context and the target, rather than a constant rhythm such as a fast, normal, or slow speech rate.

4. General Discussion

This study tested the effect of speech rate shift on the recognition of auxiliary verbs. The recognition was assessed in terms of a goodness rating from 1 to 10 for best and poorest exemplars, respectively. The speech materials were classified into one of two categories, the presence or deletion of an auxiliary verb. An interesting result was produced from the second experimental type, deletion of an auxiliary verb: The best exemplar was increasingly low, whereas the poorest exemplar gradually increased in the fast speech rate condition. The current study was dependent on the speed of context. The duration manipulation between the target (i.e. an auxiliary verb) and context was controlled as the rate of

speech. The speech rate shift of the target in the context with a normal or fast speech rate was the important factor (e.g., rather than the target being slowed). Dilley and Pitt (2010) implied that speech rate in the recognition of function words was encoded in one's native language. However, in this paper, Korean participants learning English were not accustomed to the rate of speech as a cue to perceive auxiliary verbs. Rather, the shift in speech rate of the target and context, regardless of the uniform speech rate, was recognized.

4.1 The shift of rhythm in the rate of speech

The generalization of the rate of speech is determined by the articulation rate of a speaker. This study is the first to investigate the effect of speech rate shift on the recognition of English function words (i.e., auxiliary verbs) by Korean speakers learning English at the primary level. Most of the previous studies focused on a constant speech rate, such as slow, fast and normal, for segments, syllables, or words. None has investigated the relation between the target and its context. In the current study, the interesting factor was the timing between the target and its context. The timing of the target was the compression factor of 0.7 when the value of the rate in normal speech was 1. The proportion of correctness was higher than those of the fast and normal speech rates when there was the shift in the rhythm between the target and context. Particularly, the recognition of an auxiliary verb changed with the context when the context was derived with a different rate. That is, auxiliary verbs in the fast speech rate with the context in the normal rate were perceived better than both context and target in the fast rate (Remez et al. 1981, Shannon et al. 1995, Ernestus et al. 2002). When the target's rate was expanded to 1.3 and the context's rate was compressed to 0.7, the proportion of correct perception was greater than in the other rate. On a basis of this result, it can be concluded that the Korean participants learning English were sensitive to the shift of duration manipulation associated with speech rate. On the other hand, according to Dilley and Pitt (2010), American English speakers showed that the percentage reported function words in the normal-rate condition was very high, but the percentage in the slowed-context condition tended to decrease. Function words in the fast speech rate with the context in the normal rate were perceived much less than in the normal-rate condition. The percentage for both target and context with a fast speech rate was close to the level in the normal-rate condition. At this point, as observed in Dilley and Pitt (2010), American English speakers were not sensitive to speech rate shift for recognizing function words.

Additionally, in the fast speech without auxiliary verbs, the participants recognized the auxiliary verb was absent, more often than in the context spoken at a normal rate. The proportion of the poorest

exemplar was increased in the fast speech rate condition. Moreover, when the context was constant in the normal speech, there was no change in the recognition of auxiliary verbs. From this point of a view, the fundamental factor of rhythm likely served as a cue for the participants who took part in the experiment (Shannon et al. 1995). When the context was fast, the context itself was the unit for recognition of an auxiliary verb. Hence, the participants recognized the absence of auxiliary verbs in fast speech. However, although a few participants recognized auxiliary verbs as the best exemplar in fast speech, the proportion of responses in the best exemplars was not as high as the poorest exemplars. It is not clear whether the best exemplars were perceived as the first ones in the goodness rating task. In the normal speech rate condition, the auxiliary verbs were not particularly well perceived by the participants in this study. Overall, in the normal speed condition, the context rhythm was not captured as the prosodic unit of the auxiliary verbs. However, with the presence of auxiliary verbs, the goodness rating was significant and the best exemplar in the goodness rating had the highest proportion of correct response. The best one in the goodness rating task was not concentrated on the word itself, but rather on the shift in rhythm. That is, the participants who perceived the best exemplar were those who listened to the rhythm of the context (Bell et al. 2003).

Moreover, the high proportion of shift for the target and context speech rate resulted in a prosodic unit relative to rhythm. The prosodic rhythm was produced as the duration of each word in the current study. The difference of speed was the cue of the prosodic unit that consisted of a stretch of sentence. The Korean participants tended to recognize the shift in intonation (i.e., focused on duration) which they perceived as the prosodic unit.

4.2 More about function words in the fast rate of speech

Dilley and Pitt (2010) focused on the recognition of function words even in fast speech rates. In following the findings of their study, the current study also expected that for Korean participants, the auxiliary verb would be recognized well in fast speech. However, the results of this study differ from those of Dilley and Pitt (2010). The interpretation of function words for the best exemplar depends on the rate of speech (Dilley and Pitt 2010), but at the primary level, the Korean participants did not rely on speech rate in the same way that increases in function words were recognized in fast speech when the function words were deleted. Interestingly enough, the Korean participants increasingly reported deletion of the auxiliary verbs toward the poorest exemplar level. Their responses did not recognize the auxiliary verb, but the deletion of the auxiliary verb was affected by the rate of speech, compared to the responses in the normal speech rate condition. In the normal speech rate

condition, the function words, including auxiliary verbs, were deleted and they did not show the high proportion of responses. In the goodness rating task, the proportion was not increased for either the best or poorest exemplar. The rapid context was related to the interpretation of the deletion of the auxiliary verbs. The results of this study seem to imply that the speed of spoken language can affect the recognition of ambiguous forms. Although the Korean participants in this study were at a beginning level of English, the rapid time-varying course tended to be a considerable cue for them to understand the ambiguous forms or deletion in the complete context.

Function words such as auxiliary verbs are partially reduced in fast speech, but in American English, native speakers recognize that function words are reduced when speech is fast. Therefore, the reduced forms are not focused in perception, regardless of the segmental string. With respect to the phonological properties, the rate of speech is the intrinsic unit for American English and other languages (Remez et al. 1981, Shannon et al. 1995, Ernestus et al. 2002, Dilley and Pitt 2010). However, for Korean speakers learning English, the rate of speech is the time-varying factor of perceiving the presence or deletion of auxiliary verbs. The role of phonological elements can appear in contexts when the speech is fast for American English speakers. The rate normalization is the articulatory rhythm of a native language. On the other hand, for the Korean participants in this study, the absence of auxiliary verbs was the lack of the phonological factor when the speech rate was increased. However, for Korean speakers, the learning of English function words may rely on the interaction between temporal information related to the rate of speech and segmental string. It should be to a lesser extent more investigated whether temporal elements are overlaid with spectral information for Korean speakers learning English at the highest level.

5. Conclusion

This paper focused on Korean speakers' recognition of English auxiliary verbs, in varying rates of speech. The most interesting finding is that the shift of temporal information between the context and target was the crucial cue in the participants' recognition of the function words. The other interesting finding was the increasing amount along the scale of the goodness rating toward the poorest exemplar in fast speech. There was an effect of context, rather than of the word itself, compared to the normal speech rate condition. Overall, it was clear that the participants in this experiment recognized the deletion of the auxiliary verbs in the fast rate of speech, but not in the normal rate of speech. Thus, it is recommended that Korean learners of English become accustomed to the rate of speech in order to perceive English function words. In conversational speech of American English, reduction is common in content words as well as

function words. In future research, content words with different speech rate in the context also should be investigated for Korean speakers learning English.

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received: March 8, 2014
revised: April 6, 2014
accepted: April 9, 2014