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The Influence of Auditory Perceptual Simulation in L2 Reading Processing : An Eye-tracking Study

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Abstract

The Influence of Auditory Perceptual Simulation in L2 Reading Processing : An Eye-tracking Study

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The aim of this study is to investigate whether *Auditory Perceptual Simulation* (APS) reading can improve second language learners' reading processing by inducing more detailed syntactic processing. As readers can hear their own voice inside their heads through 'inner voice,' they also can hear other speakers' voice during silent reading, which is called *auditory perceptual simulation*. APS reading utilizes the auditory perceptual simulation, as a reading strategy (Zhou & Christianson, 2016). In APS reading, readers more consciously simulate the voice of other speakers reading out the text through imagination, instead of silently reading the text. Zhou and Christianson (2016) found that native speakers of English who used APS reading read faster and more accurately than those who did not. They

claimed that more salient prosodic representations induced by APS reading, which are closely related with syntactic representations, helped the readers to perform more accurate syntactic processing, leading to the faster reading rate and better comprehension.

Although L2 learners' syntactic processing was known to be deficient and less accurate compared to native speakers, a number of studies have demonstrated that L2 learners are able to overcome their weak syntactic processing and establish more accurate syntactic representations under certain circumstances (Leeser, Brandl, & Weissglass, 2011; Lim & Ahn, 2015; Lim & Christianson, 2013a, 2013b, 2015; Williams, 2006). One such an occasion was when L2 learners were involved in certain tasks such as a translation task (Lim & Ahn, 2015; Lim & Christianson, 2013a, 2013b, 2015). During a translation task, L2 learners paid more attention to the syntactic structure in process of translating L2 into L1, resulting in more accurate syntactic processing.

Those tasks such as a translation task, however, only focusing on inducing more detailed syntactic reading, missed the important goal of fast and efficient communication. Because of translating process, even though it might improve L2 readers' syntactic processing, they needed more time to read the sentences. In contrast, APS reading not only helped the readers pay more attention to the accurate syntactic processing, but also simultaneously increase the reading rate in Zhou and Christianson (2016). If L2 learners are also able to use APS during silent reading and gain advantages from APS reading, it would be a more efficient reading strategy for L2 learners whose syntactic processing is generally fragile. In this regard, this study

applied a similar paradigm to L2 learners in order to explore whether APS reading can also enhance L2 reading processing as in Zhou and Christianson (2016).

To this end, two eye-tracking experiments were conducted. In the first experiment, a group of participants (control group) read the sentences such as (1) and answered the verification sentence such as (2).

(1) a. The cat that chased the mouse was fast.

(Subject relative clause -Plausible)

b. The mouse that chased the cat was fast.

(Subject relative clause -Implausible)

c. The mouse that the cat chased was fast.

(Object relative clause -Plausible)

d. The cat that the mouse chased was fast.

(Object relative clause -Implausible)

(2) a. The cat chased the mouse. The cat was fast.

(The verification for 1a and 1c)

b. The mouse chased the cat. The cat was fast.

(The verification for 1b and 1d)

The sentences were designed to utilize the plausibility effect, in which implausible sentences inflate reading times. The increased reading time from plausibility effect means that, first, readers properly establish the structural relation

since they notice the implausibility of the sentences only after they interpret the sentence correctly (e.g. *mouse* as Agent and *cat* as Patient) and, second, their syntactic representation is weak or shallow, since they would require more time to recover from the difficulty when the constructed structural relation is not solid and less reliable. The former indication of the plausibility effect would be reflected in the early measures of eye-tracking, while the latter would be in the late measures.

In the second experiment, a group of participants (APS group) read the same sentences but under APS reading. They first listened to native speakers' recordings and then read the sentence while imagining that the speaker was reading it aloud to them. If APS reading improved L2 readers' syntactic processing, the plausibility effect would be found earlier and disappear faster in the APS group than in the control group. Moreover, if this syntactic advantage influenced overall reading process, the APS group would read the sentence faster and understand more accurately.

The results revealed that the APS group detected the implausibility earlier than the control group and, in addition, they were able to overcome difficulty they encountered from the implausibility faster than the control group. The analysis from early measures showed that while the control group did not notice the implausibility at the critical region in (1d) which consisted of a relatively more difficult structure, object relative clause, APS reading group did it from the critical region even in the object relative clause. It meant that APS reading group constructed the structural relation earlier than the control group. Meanwhile, on the late measures, APS reading group fixated on the critical regions shorter than the control group in all four

conditions, (1a) to (1d). It suggested that APS reading group had less difficulties not only in interpreting the implausibility but also overall in establishing the relative clause structure, compared to the control group. In sum, the results indicated that APS reading helped L2 learners to pay more attention to the syntactic processing and facilitated in establishing the more detailed syntactic structure during on-line processing.

The differences in syntactic processing of each region eventually led to the pattern difference in sentence reading times between two groups. The APS group showed no plausibility effect in sentence reading times, whereas the control group read significantly slower in the implausible sentences than in the plausible sentences. However, these pattern differences did not increase comprehension accuracy nor reading rate. Both groups showed equally high response accuracy, and the sentence reading time of the APS group was not longer than that of the control group.

In conclusion, APS reading improved second language learners' syntactic processing by inducing them to establish more concrete syntactic structure, while it did not harm their reading rate and comprehension accuracy. Thus, although there needs to be much further research to be done before applying APS reading to L2 instruction, APS reading can be considered as a reading strategy for L2 learners' faster and more accurate reading.

Keywords: Second Language Acquisition, Second language reading, Eye-tracking, Auditory perceptual simulation, Syntactic processing, Implicit prosody

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Chapter 1 Introduction

1.1. Background of research

The aim of the thesis is to investigate the reading strategy that assists in more accurate syntactic processing for second language learners. It has long been known that the on-line syntactic processing of second language learners is shallower, less detailed, or less accurate, resulting in erroneous global comprehension (Felser, Gross, Roberts, & Marinis, 2003; Felser, Sato, & Bertenshaw, 2009; N. Jiang, 2004; Papadopoulou & Clahsen, 2003; Roberts & Felser, 2011). Many studies showed that L2 learners often failed to construct proper syntactic representations during online sentence processing, primarily relying on semantic cues or world knowledge. For example, in Lim and Christianson (2013b), L2 learners failed to establish proper structural relations in interpreting relative clause sentences, particularly when the syntactic interpretation was discrepant from the world knowledge. They misinterpreted the object relative clause sentences such as *The cat that the mouse chased was fast* as the meaning of *The cat chased mouse*, rejecting the accurate syntactic interpretation and following their world knowledge instead. Because of this syntactic fragility and over-reliance on world knowledge, it was often argued that even highly proficient learners seemed to fail to acquire native-like detailed syntactic representations (Clahsen & Felser, 2006a, 2006b; Cunnings, 2017; Jacob & Felser, 2016).

Recent research on L2 learners' syntactic processing, however, has showed evidence that under certain circumstances, L2 learners are also able to process more

accurate syntactic representations, which is comparable to native speakers' syntactic processing (Felser et al., 2009; Jackson, 2008; Jackson & Bobb, 2009; Jacob & Felser, 2016; Lim & Christianson, 2013a, 2013b, 2015; Song, 2015; Williams, 2006). For example, when L2 learners were given more time to reflect on the syntactic structure, their syntactic processing was as accurate as that of native speakers (Felser et al., 2009). A certain task such as a translation task also proved to improve L2 learners' syntactic processing. In Lim and Christianson (2013b), when L2 learners implemented a translation task rather than mere reading for comprehension, they paid more attention to syntactic structure and comprehended the sentences more accurately.

However, those methods do not seem to be an appropriate reading strategy for enhancing more accurate syntactic processing. It may enable L2 learners to construct more detailed and less fragile syntactic representations, but it also inflates global reading times. For instance, a translation task, due to the characteristic of translating, increased the participants' reading times, compared to that of those who did not perform a translation task (Lim & Christianson, 2013b). It would not be an efficient way if readers should invest more time for accurate comprehension. Therefore, this study aims to explore a possible reading strategy that may strengthen L2 learners' syntactic processing but not inflate reading times.

Reading with *auditory perceptual simulation* (APS) would be one such possibility that can improve L2 syntactic processing. APS reading is a reading strategy, developed by Zhou and Christianson (2016). It is a reading method that helps readers elaborate their phonological representations by inducing them to

actively simulate the voice of other speakers. In APS reading, at first, readers carefully listened to the recordings of speakers with the corresponding photograph displayed. They then read and responded to sentences. Prior to each sentence, one of speakers' photograph was randomly presented to cue the speaker's voice. While silently reading a sentence, they imagined that the speaker was reading the sentence aloud to them. Zhou and Christianson (2016) found that native English readers using APS reading showed significantly better performance in both reading rate and comprehension accuracy, compared to the control group.

One advantage readers may gain from APS is that it induces a more salient prosodic structure during silent reading. A number of studies have showed that syntactic structure is closely interrelated with prosodic structure (Bader, 1998; Breen, 2014; Fodor, 2002; Hwang & Schafer, 2009; Steinhauer, 2003). According to Fodor's (2002) Implicit Prosody Hypothesis, readers create prosodic representations such as phrasing, intonation, stress, and rhythm even during silent reading, which can be used as an important cue to establish syntactic structure. However, it seems that silent reading, since it lacks actual articulation, is more abstract than overt speech, having weakened phonological properties (Oppenheim & Dell, 2008; Tian & Poeppel, 2013). Thus, readers may lose valuable phonological features such as prosodic information during silent reading. APS reading enhances the readers' involvement in auditory imagery processing. It is expected that when readers actively simulate other speakers' voice, compared to when they merely follow their unaware 'inner voice', they will fully utilize diverse and detailed phonological representations such as prosody or accent which might be otherwise missed during

silent reading. Aided with more fully specified phonological representations including appropriate prosodic structures, readers utilizing APS may be able to phrase sentence structures more easily and thus process the syntactic structure more accurately. In fact, Zhou and Christianson (2016) claimed that APS facilitated more accurate syntactic representations because the readers were able to activate richer phonological and prosodic information during APS reading.

Because phonological representations of better quality also play an important role in L2 syntactic processing, second language learners can also possibly benefit from APS reading as in Zhou and Christianson (2016). Prosodic representation is closely interrelated with sentence structures in L2 sentence processing. Nickels, Opitz, and Steinhauer (2013) demonstrated that L2 learners were sensitive to prosodic information and utilized it in order to construct sentence structures. In their ERP experiment, L2 learners' neural patterns revealed that cooperating prosody with syntactic structure eased syntactic reading, while discrepant one interfered the processing. Since prosodic information is also crucial in L2 syntactic processing, elaborating phonological representations of auditory imagery might improve L2 processing as well. When L2 learners take advantage of appropriate prosodic cues induced by APS reading, they would show more accurate syntactic processing.

To summarize, this study explores whether APS reading can improve L2 learners' syntactic processing and overall reading comprehension as in Zhou and Christianson (2016)'s native speakers of English. L2 learners' syntactic processing is often weak and shallow but a certain task such as a translation task can improve

its accuracy by helping them pay more attention to the syntactic structure. However, those few attempts to enhance L2 syntactic processing seem to be inappropriate in terms of ‘fast and frugal’ reading since they cost reading times as trade-off. On the other hand, APS reading induced more accurate syntactic reading while maintaining the reading rate, in fact, increasing it. Applying a similar paradigm to L2 learners is expected to improve their syntactic processing and overall comprehension. It is because during APS reading the readers seem to have richer prosodic information and L2 learners are also known to be able to use the prosodic information in establishing syntactic structure. Therefore, APS can be a possible reading strategy that enhances L2 readers’ phonological representations and the interrelated syntactic processing. Through the investigation, this study demonstrates whether, and if so, how APS influences L2 reading processing and can be applicable to L2 learners with weak syntactic processing.

1.2. Organization of the thesis

The current study is organized as follow. Chapter 2 reviews the theoretical background and empirical findings on L2 sentence processing and *auditory perceptual simulation*. Chapter 3 describes the methods and design of the experiment for the eye-tracking experiment. In Chapter 4, the results and statistical analyses of the experiment are reported. Chapter 5 discusses the findings of the present study. Lastly, Chapter 6 concludes the findings and implications of the study.

Chapter 2 Review of Literature

2.1. Auditory Perceptual Simulation (APS) in native sentence processing

Traditional theories assumed that language comprehenders built up a fully specified syntactic structure to understand sentence meaning (Ferreira, Bailey, & Ferraro, 2002). However, recent research showed that language processing is, in fact, sometimes only partial and syntactically incomplete (Malyutina & Den Ouden, 2016; Patson, Darowski, Moon, & Ferreira, 2009; Slattery, Sturt, Christianson, Yoshida, & Ferreira, 2013; Sturt, 2007). For example, when native English speakers were presented a sentence such as T*he dog was bitten by the man*, which meant *the man bit the dog*, they often mistook it as the meaning of *the dog bit the man* (Ferreira, 2003). Another experiment showed that when comprehenders read a sentence such as *While Anna dressed the baby played in the crib*, they often misinterpreted *the baby* as the object of the verb *dressed*, which was actually the subject of the verb *played* (Christianson, Hollingworth, Halliwell, & Ferreira, 2001). To account for these findings, Ferreira, Bailey & Ferraro (2002), proposed the "good enough" approach to language processing, claiming that comprehenders create a structure which is only "good enough" to understand the meaning of sentences rather than building an idealized structure with every detail included. In this respect, native speaker' syntactic processing is not always complete but often 'good-enough', weak, or shallow (Clahsen & Felser, 2006b).

The simplest way to prevent the misinterpretations from the weak syntactic processing is to invest more time in reading sentences. In fact, *the dog was bitten by*

the man was a considerably simple structure, and if the participants were allowed to contemplate it longer, they would establish an accurate structural relation—*the man* as Agent and *the dog* as Patient— despite its implausibility. However, spending longer time for accuracy is unproductive to apply for entire reading processing. Provided that most contents under common circumstances can be integrated with the world knowledge, trying to reduce incorrect reading will result in rather more inefficient and burdensome process. Moreover, it is also not possible to re-read only the sentence required to be careful, because readers would not know it before they read that sentence, and actually even after they do. For instance, when they misinterpreted a sentence such as *While Anna dressed the baby played in the crib* as *"Anna dressed the baby"* instead of *"Anna dressed herself"*, those who responded incorrectly were as confident in their answer as those who was accurate (Christianson et al., 2001). That is, the language processors read the sentence without noticing that they had difficulty understanding it. Therefore, merely spending more time constructing a detailed syntactic structure is not a desirable reading strategy. The important principle is to read accurately, maintaining 'fast and frugal' fashion of reading.

One such possible reading strategy is auditory perceptual simulation (APS), developed in Zhou and Christianson (2016). In a series of eye-tracking experiments, Zhou and Christianson (2016) showed that APS-induced reading, by deeper sentence processing, increased reading speed, and improved comprehension in comparison with normal silent reading. In the experiment, the participants of two different groups—normal reading group and APS reading group—read the sentences such as

(1) and were asked to judge whether those sentences could be paraphrased into the verification sentence such as (2).

(1) a. The cat that chased the mouse was fast.

(Subject relative clause -Plausible)

b. The mouse that chased the cat was fast.

(Subject relative clause -Implausible)

c. The mouse that the cat chased was fast.

(Object relative clause -Plausible)

d. The cat that the mouse chased was fast.

(Object relative clause -Implausible)

(2) a. The cat chased the mouse. The cat was fast.

(The verification for 1a and 1c)

b. The mouse chased the cat. The cat was fast.

(The verification for 1b and 1d)

While the normal reading group simply read the experimental sentences silently as they normally do, the APS reading group performed an experimental manipulation for APS. For the APS reading group, the experiments consisted of two phases. At the first phase, a group of native English readers listened to the recordings of two speakers with the corresponding photograph displayed. The recorded passages were about 500 words materials, not related with the experimental

sentences. One speaker spoke with fast rate and no accent, while the other speaker with slow rate and foreign accent. At the second phase, after being accustomed to two voices, participants read and responded to the experiment sentences. The important experimental control at this phase was that the participants, while reading sentences, were required to actively simulate the voice of speakers they heard at the first phase. Prior to each item, one of the two speakers' photographs was randomly presented to cue the speaker's voice, and the participants imagined that the displayed speaker was reading out loud the sentence.

The results showed that the participants who simulated the voice of speakers read faster than those who read without the simulation. In particular, their reading times were shorter when the participants simulated the faster speaker than when they did the slower one, which indicated that the results were originated from auditory simulation, not merely from the fact that they were involved in a language activity (listening) before they read. The results also revealed the response accuracy for the comprehension verification in the APS group was significantly higher than in the normal reading group, irrespective of the speakers' speech rate. Furthermore, the reading patterns were distinct between two groups, in that while the reading times for the normal reading group were affected largely by both plausibility and structure, those for the APS group were influenced less by the plausibility. This reading pattern difference showed that the APS reading group overcome the difficulties caused by the implausibility of sentences, since they were able to process the syntactic structures more accurately. From these results, Zhou and Christianson (2016) concluded that readers read faster and more accurately, and relied less on the good

enough interpretation, during APS reading.

2.2. The role of phonological representations in reading processing.

APS is a paradigm which enhances reading comprehension by inducing more conscious instantiation of the phonological representations (Zhou & Christianson, 2016). It has long been known that phonological representations play a crucial role in reading process. Numerous studies have demonstrated that readers always activate phonological representations during visual word recognition (Ashby, Sanders, & Kingston, 2009; Frost, 1998), continuously involving phonological processing in reading process. This involvement is so important that when readers fail to adequately develop these phonological representations, they often meet difficulties in reading such as experienced in dyslexia (Bonte & Blomert, 2004; Shaywitz et al., 2000). Moreover, there is much evidence that an awareness of phonological representations is strongly related to current and later reading success in readers (Blachman, 2000; Bradley & Bryant, 1983; Kirby, Desrochers, Roth, & Lai, 2008; Rasinski, Reutzel, Chard, & Linan-Thompson, 2010; Swanson, Trainin, Necoechea, & Hammill, 2003; Wagner, Torgesen, & Rashotte, 1994; Wagner et al., 1997). For instance, children who performed better on measures of phonological awareness demonstrated higher future reading achievement in the longitudinal correlation study (Wagner et al., 1997). Thus, the quality of phonological representations seems to be critical for reading processing and development (Goswami, 2000). In this regard, APS helps to improve the phonological quality, for readers' better understanding.

Among the advantages from enriched phonological representations, a notable one is that it induces more salient prosody during silent reading. Prosodic skills are strongly associated to reading fluency consisting of reading accuracy and reading rate (Rasinski et al., 2010; Schreiber, 1991). One of the reasons for this is that syntactic structure is closely interrelated with prosodic structure (Breen, 2014; Fodor, 2002; Hwang & Schafer, 2009; Jun, 2003; Steinhauer, 2003). Fodor (2002) claimed that readers activated prosodic information such as phrasing, intonation, stress, and rhythm during silent reading and this implicit prosody can affect readers' interpretation to the structures of text. Prosodic information guides the syntactic parser (Jun, 2003) and assists to guess upcoming information regarding the syntactic structure (Kerkhofs, Vonk, Schriefers, & Chwilla, 2007). Accordingly, when readers were given discrepant prosodic information with syntactic structure during silent reading (e.g. a misplaced word boundary cue such as a pause located in middle of a chunk of words.), they had more difficulty analyzing sentences. On the other hand, appropriate prosodic cues aided to understand the sentences (Steinhauer, 2003). Hence, the proper use of the implicit prosodic cues during silent reading is important in reflecting the syntactic features of the sentence, which in turn enables readers to read sentences more accurately and faster.

However, phonological representations during silent reading are generally more abstract and weaker than reading with actual articulation. During silent reading, readers are known to code text into sound automatically, or generate an "inner voice" (Breen, 2014; Pollatsek, 2015). Inner voice, a form of mental imagery, refers to a soundless voice that people can hear inside their brain while thinking, reading,

writing, and remembering (Oppenheim & Dell, 2008). Eye movement (Ashby & Clifton, 2005; Ashby & Martin, 2008) and event-related potential (ERP) data (Ashby, 2010; Ashby et al., 2009) provide evidence that inner speech during silent reading entails rough phonological representations. There is no agreement on whether inner speech fully represents phonological features as overt speech does, but it seems that inner voice is impoverished at a surface level and more abstract than overt speech, having weakened phonological properties, since it is merely a form of mental imagery and lacks actual articulation (Oppenheim & Dell, 2008, 2010; Tian & Poeppel, 2013). Therefore, readers may lose valuable phonological features such as prosodic information during silent reading through mere 'inner voice'.

Research on mental imagery also supported the hypothesis that silent reading may lack detailed phonological representations. Mental imagery is an internal representation within the human mind. It was first regarded as an internal subjective experience, but it is now considered as more perceptual-like phenomenon (Hubbard, 2010). Several brain studies showed the similarity between imagery and perceptual processes (Dudschig, Mackenzie, Strozyk, Kaup, & Leuthold, 2016). With imagery process involved, a brain activates the same sensory-motor cortex in a brain which is stimulated by perceptual processing (Hubbard, 2010). Perception and imagery only vary in intensity rather than being categorically different. Both behavioral and neural evidence showed that auditory imagery also involves the same brain areas as auditory perception (Bunzeck, Wuestenberg, Lutz, Heinze, & Jancke, 2005; Janata, 2001; McGuire et al., 1996; Shergill et al., 2001; Zatorre, Halpern, Perry, Meyer, & Evans, 1996). However, auditory imagery and auditory perception

were not of the same quality. Auditory imagery processing generates similar but more abstract neural representations compared to physical sound processing (Dudschig et al., 2016). Some information of auditory properties such as loudness or melody is often omitted during auditory imagery processing (Hubbard, 2010). Thus, auditory imagery is similar processing with auditory perception, but it carries, to a certain degree, weaker and less detailed information than actual perception.

Nevertheless, the quality of auditory imagery processing is not consistently weak across any conditions. The quality varies in individuals, and text difficulty can modulate the extent of how detailed information will be included during imagery processing. Each individual reports different auditory quality in auditory imagery during silent reading (Vilhauer, 2016). Specific auditory qualities such as loudness, depth, tone, pitch or accent appear to have different qualities among language processors. Alexander and Nygaard (2008) also demonstrated that individual difference in general auditory imagery ability might change the details preserved in auditory imagery. In the experiment, participants read a short passage after listening to a brief prerecorded conversation that consisted of two different talkers' dialogue, in which one talker spoke at fast rate and the other spoke at slow rate. After familiarized with two talkers' voice, they read several passages while they imagined that one of the talkers were speaking to them. The results showed that the talkers' speaking rate influenced the reading rate for the passages, in that the participants read faster when they imagined the fast talker. In particular, the reading times varied according to individual differences in general auditory imagery ability. Those who were assessed to have higher auditory imagery scale revealed a lager influence from

the talkers' speaking rate than lower auditory imagery scale group. It indicates that those who have more vivid imagery preserve more detailed information of the talker's voice. Moreover, the quality of auditory imagery can be influenced by text difficulty. In the same experiment, when the participants read easy texts, whether they imagined the faster talker or the slower one did not significantly modulate the reading times. However, when they read difficult texts, the reading times were influenced by the talkers' speaking rate. They seemed to utilize the phonological details fully only when they encountered more difficult texts, or when they paid more attention to the reading process, which is also consistent with the previous findings (Hardyck & Petrinovich, 1970; Unsworth & Pexman, 2003).

To summarize, auditory imagery is a quasi-perceptual like activation of brain. However, its processing is not exactly the same with the auditory perception, since it is less detailed and lacks some auditory features. Nonetheless, the quality of the auditory imagery differs in readers and texts. Readers seem to unconsciously determine whether they engage in detailed phonological representations or to what extent they do, depending on text difficulty or some other factors.

In this regard, the primary goal of APS is to help readers comprehend a text by enhancing the readers' involvement in auditory imagery processing. It is expected that while readers actively simulate the speakers' voice, they will fully utilize diverse and detailed phonological representations such as prosody or accent which might be otherwise not fully utilized during silent reading. Since these phonological features are beneficial for reading processing, particularly in terms of syntactic analysis interwound with prosody, the APS will assist readers' comprehension on a text,

establishing more accurate syntactic processing.

2.3. Syntactic deficiency in second language sentence processing

It has long been known that the on-line syntactic processing of second language learners is weak and deficient. Many studies showed that L2 learners tended to miss detailed syntactic information, such as structural relations, subject-verb agreement, or binding restrictions (Felser et al., 2003; Felser et al., 2009; N. Jiang, 2004; Papadopoulou & Clahsen, 2003; Roberts & Felser, 2011). In Lim and Christianson (2013b), for example, L2 learners had difficulty establishing correct structural relation especially in the implausible conditions and in object relative clause structures during on-line processing. In the self-paced reading experiment, L2 learners were asked to evaluate if the sentences such as (2') correctly paraphrased the sentences such as (1') after reading the experimental sentences. (Below are the same examples with the (1) and (2) above, which are again presented for convenience.)

(1') a. The cat that chased the mouse was fast.

(Subject relative clause -Plausible)

b. The mouse that chased the cat was fast.

(Subject relative clause -Implausible)

c. The mouse that the cat chased was fast.

(Object relative clause -Plausible)

d. The cat that the mouse chased was fast.

(Object relative clause -Implausible)

(2') a. The cat chased the mouse. The cat was fast.

(The verification for 1a and 1c)

b. The mouse chased the cat. The cat was fast.

(The verification for 1b and 1d)

The results revealed that their comprehension response accuracy was lower for (1'b) and (1'd) that were less plausible than the other conditions and even lower for (1'd), object relative clause, which was considered more difficult to parse compared to subject relative clause.

Because L2 learners have less knowledge on the structure, less automatized in processing, and cognitively more burdened to processing, compared to the native speakers, their syntactic representation is even more fragile than that of native speakers. In fact, L2 learners' comprehension accuracy was lower than the native control group who read the same materials, and L2 learners' accuracy and processing were influenced greatly by the plausibility of the sentences (Lim & Christianson, 2013b). It seems that L2 learners' syntactic structure is relatively weaker or shallower, and thus they more depend on world knowledge to interpret the sentences. Because of these syntactic deficiencies and over-reliance on world knowledge during on-line processing, in most cases L2 learners result in more errors for global comprehension. Accordingly, it is often argued that even highly proficient learners seem to fail to acquire native-like detailed syntactic representations (Clahsen & Felser, 2006a,

2006b; Cunnings, 2017; Jacob & Felser, 2016).

Nevertheless, it is not that L2 learners are always impossible to process fully detailed syntactic representations. Much evidence showed that L2 speakers engaged in the same syntactic processing as native speakers, especially when the learners are highly proficient and when they process relatively easy structures (Felser et al., 2009; Jackson, 2008; Jackson & Bobb, 2009; Jacob & Felser, 2016; Lim & Ahn, 2015; Lim & Christianson, 2013a, 2013b, 2015; Song, 2015). Moreover, several studies demonstrated that L2 learners' weak syntactic processing can be improved under certain conditions (Felser et al., 2009; Leeser et al., 2011; Lim & Ahn, 2015; Lim & Christianson, 2013a, 2013b, 2015; Williams, 2006). First, when they were given sufficient time to reflect on the syntactic structure, their syntactic processing was not shallow any longer. In Felser et al. (2009), L2 learners showed nearly perfect performance on the untimed grammaticality judgment test where they judged whether the sentences involving the ill-formed reflexive structure were grammatical or not, although they failed to appropriately process reflexives on-line. Second, when they were required to find the ungrammaticality during processing, instead of simply understanding the meaning of sentences, their syntactic processing became more detailed and accurate. For example, in Leeser et al. (2011), English-speaking Spanish learners did not notice the ungrammaticality in noun-adjective agreement sentences during the comprehension task, whereas they were sensitive to the ungrammaticality during the grammaticality judgment task. Third, a certain task such as a translation task induced less weak and shallow syntactic processing. In Lim and Christianson (2013b), for instance, when L2 learners were given a translation

task rather than mere reading for comprehension, they paid more attention to syntactic structure while they translated L2 sentences into L1, resulting in more accurate comprehension (See also, Lim & Ahn, 2015; Lim & Christianson, 2013a, 2015). In short, although L2 syntactic processing is shallow and fragile, L2 learners are still able to establish solid syntactic representations if they are allowed to analyze the syntactic structure without time pressure, required to focus on grammaticality of sentences, or assisted with a certain task to pay more attention to it.

However, those previous attempts to enhance the accurate syntactic representations in L2 do not seem to be suitable to apply to L2 learners' reading processing. Above all, expending more time in order to process fully detailed syntactic structures is not an efficient reading strategy. It may assist more accurate comprehension, but also increase global reading times as a trade-off. A translation task and grammaticality judgment task also increased the reading times compared to a simple comprehension task, due to the characteristic of the tasks which involve the process of translating and finding the ungrammaticality (Leeser et al., 2011; Lim & Christianson, 2013b). Furthermore, the tasks such as a translation and grammaticality judgment are far from natural reading process. Under common situations, readers do not have to determine the ungrammaticality of sentences, since a primary goal of reading would be comprehension of contents and there would be few errors in the texts. As for a translation task, even though the simultaneous activation of L1 during L2 processing might be a part of natural reading processing (Jared, 2015), the conscious translation in which the participants needed to translate L2 into L1 verbally is burdensome and does not seem to be a typical process, at least

for advanced L2 readers. A translation task resembles the traditional grammar translation method in that they both focus on syntactic structures and involve translating process. Despite its advantages in the learners' acquisition of grammatical rules, the grammar translation method is often regarded as preventing them from developing their natural communicative competence (Chang, 2011). Although a translation task may be beneficial for focusing on the structure, constant involvement in translating may be detrimental for natural reading processing.

Since L2 learners' syntactic processing is generally known to be less detailed and shallower, it is more important to design a method for L2 learners that helps them to build more detailed syntactic structure, so that they can achieve more accurate comprehension. However, the method should not hinder overall fast processing as a trade-off and should suit well for natural reading processing. In this regard, APS might be an appropriate reading strategy for L2 learners. APS helped readers avoid misinterpretation and facilitate deeper syntactic processing while maintaining fast reading as shown in Zhou and Christianson (2016). Moreover, as it is utilizing a natural cognitive phenomenon of 'inner voice', it is not distinctive from natural reading processing. Therefore, if there is a comparable underlying mechanism between L1 and L2 sentence processing, in particular, in terms of phonological representations, APS reading can be a proper reading strategy to facilitate L2 syntactic processing.

2.4. The role of phonological representations in second language reading

Phonological representations are also an important part of second language reading processing. As phonological processing is continuously involved in L1 reading process, L2 readers likewise constantly activate L2 phonological representations as well as L1 during visual word recognition (Jared, 2015). This phonological processing is so crucial for the discrimination of speech sounds that limited L2 phonological abilities hinder word identification (Verhoeven, 2010), which may result in disruption in L2 reading. Phonological processing such as phonological awareness and prosodic skills is also positively correlated with L2 reading development both in adult and child L2 learners (Chen, 2013; DelliCarpini, 2011; Geva, Yaghoub-Zadeh, & Schuster, 2000; Gottardo, Yan, Siegel, & Wade-Woolley, 2001; Lee, 2015; Stuart-Smith & Martin, 1997). For example, L2 phonological awareness tasks such as segmentation and deletion predict L2 word decoding ability for the adult L2 learners who have low L1 literacy (DelliCarpini, 2011), which indicates that L2 phonological awareness is positively related with L2 reading processing regardless of L1 reading skills. Moreover, the presence of phonological cues seems to help L2 learners process morpho-syntax more accurately (Carrasco-Ortiz & Frenck-Mestre, 2014; Cormier & Kelson, 2000). In summary, the quality of phonological representations is also crucial for L2 reading processing and development as in L1 reading processing.

As phonological representations of better quality allow L1 readers more salient prosodic reading, L2 learners would also have benefit from more detailed phonological representations in an aspect of prosodic reading. L2 learners are also

sensitive to prosodic information and utilize it to construct sentence structures. In an ERP experiment (Nickels et al., 2013), participants read the sentences with prosodic boundaries which either cooperate or conflict with the syntactic structure. Their neural patterns revealed that cooperating prosody eased syntactic reading, while discrepant one interfered reading processing, which is similar to that of native controls. It indicated that prosody is closely interrelated with sentence structures also in L2 reading processing. Thus, when L2 learners take advantage of the appropriate prosodic cues during silent reading, they would read sentences syntactically more accurately.

Although relatively a few studies on L2 inner speech have been carried out, it is known that L2 learners are also involved in L2 inner speech (de Guerrero, 1999, 2004; Larsen, Schrauf, Fromholt, & Rubin, 2002). L2 learners reported that they experience the inner voice in L2 during listening and reading as well as in recall of language and they developed L2 inner speech from the early stage of learning (de Guerrero, 2004). Moreover, as the learners becomes more advanced in their proficiency, they are likely to be more involved in L2 inner speech (de Guerrero, 1999). Proficient L2 learners are able to develop a rich and useful inner speech in L2 as in L1 (de Guerrero, 2004). L2 inner speech, however, reveals more complex aspects, compared to L1 inner speech. It is occasionally presented mixed with the learners' L1 (de Guerrero, 1999) and it is accompanied by mental translation into L1 (de Guerrero, 2004; Shigematsu, 2010). For this reason, even though L2 reading processing involves the inner speech as L1 processing does, L2 inner speech is more likely to be disturbed and lacks detailed phonological information such as prosody.

Since phonological representations are also important in second language reading, elaborating phonological representations of auditory imagery, or inner speech, might improve L2 readers' reading processing. APS is one of the probable methods. It possibly enhances L2 readers' prosodic skills and prosodic parsing strategy, which in turn leads them to more detailed syntactic representations as it did native speakers' processing in Zhou and Christianson (2016).

2.5. The present study

This study explores how auditory perceptual simulation (APS) during silent reading has an effect on second language reading processing. Second language processing has similar, but shallower syntactic representations during on-line processing, compared to first language processing. In addition, phonological representations play an important role in L2 reading comprehension. Thus, as in Zhou and Christianson (2016), second language learners might also benefit from APS reading. In this respect, this paper examines whether using a similar paradigm can enhance second language leaners' reading comprehension, particularly in an aspect of more detailed syntactic reading, addressing the following research questions:

Research Question 1: Will APS reading induce faster and more accurate syntactic processing for L2 learners?

Research Question 2: Will APS reading enhance L2 learners' reading comprehension and reading rate during L2 sentence processing?

To examine the research questions, a series of eye-tracking experiments were conducted. Eye-tracking is an experimental method that monitors and records the eye movements during human cognitive processing (Keating, 2014). It has long been used and become increasingly popular for exploring how language processors acquire and process language especially during online, or incremental sentence processing. It is assumed that readers make structural decisions whenever they encounter words in order to integrate them into a sentence, and this process is reflected in the eye movement (Dussias, 2010). When people read, eyes do not move in a smooth and straight line but in a series of jumps (saccades) and fixating (fixations). Readers obtain meaningful information about a sentence mainly during fixations, but little during saccades (Keating, 2014). It is known that there are systematic relations between fixation times and the features of the fixated words (Dussias, 2010). Readers tend to read difficult words, important words, or unexpected words longer and at times regress into those words to confirm them. Spending more time on the fixated word, they seem to analyze and reanalyze the meaning or structural function of the word.

This study chooses the eye-tracking as a primary method to examine the effect of APS on L2 sentence processing for several reasons. First, the eye-tracking, since it allows the regression to the previous word, the early process of reading can be separated from the later process that is measured with the regression path. Thus, it is more proper to measure the detailed time course of syntactic processing. More importantly, it is necessary to present a sentence as a whole, as in an eye-tracking method, which is distinguished from other experimental methods such as self-paced

reading and event-related potential (ERP) experiments where only one word is showed up at a time. Although the meaningful information is retrieved mainly from the fixated word within a foveal area, which is generally limited to 7 to 8 characters, about one word, readers are also known to gain partial information about the next word, which is known as *a parafoveal preview benefit* that commonly gives readers reading time advantages (Keating, 2014). Since APS is supposed to help readers by enhancing their phonological awareness and prosodic parsing strategy, unable to see the upcoming word, readers may not gain benefits from APS reading because they cannot actively use the prosodic parsing strategy.

The experiments consisted of two eye-tracking experiments. In the first experiment, Korean English-learners as a control group read sentences such as (1') without any experimental manipulation and verify the related sentences such as (2'). The results would show the similar plausibility effect in Lim and Christianson (2013b), where the self-paced reading experiment with the similar sentences was conducted for L2 learners. The plausibility effect, where the readers spend longer reading implausible sentences than plausible sentences, indicated that they notice the implausibility of the sentence that contradicts their world-knowledge and give an effort to comprehend the meaning of the sentence. Thus, the increased time on the implausible conditions means, first, that they correctly interpret the sentence, or clause, and notice the incongruity with their knowledge, and second, how long they need to overcome the difficulties caused by the implausibility. If readers eventually overcome the difficulties and interpret the sentence as written despite contradiction to their knowledge, they would correctly respond to the comprehension questions.

Otherwise if they fail to overcome it, or they rather prefer to interpret the sentence as consistent with their knowledge, they would be incorrect for the comprehension questions.

In Lim and Christianson (2013b), the participants overall took longer times to read implausible conditions (1'b, 1'd) than plausible conditions (1'a, 1'c). For more details, there were a main effect of plausibility and an interaction between plausibility and structure at relative clause region, "*chased the cat*" or "*the mouse chased*," which means that the implausible conditions yielded longer reading times than the plausible ones only within the subject relative structure at this region. At main clause verb region, "*was*", there was a main effect of structure and plausibility with no interaction. L2 readers read slower in the implausible conditions than in the plausible ones and in the object relative structure than subject relative structure. It indicates that L2 readers noticed the implausibility of sentences such as *The mouse that chased the cat was fast* or *The cat that the mouse chased was fast*, from earlier parts of the sentences when reading the subject relative structure, which was relatively easier to grasp the structural relation than when reading the object relative structure. In the object relative structure, they did not recognize the implausibility at the very region in which it occurred, but at the next region after spending a while establishing structural relation—*the mouse*, as Agent, and *the cat*, as Patient. In particular, they failed so often to overcome the difficulties they encountered from the implausibility, the readers showed lower accuracies for implausible conditions (1b, 1d) than for plausible conditions.

We predicted that this study would show the similar results. First, the

readers will overall read slower in the implausible sentences than in the plausible sentences. Second, in the object relative structure, they will notice the implausibility of sentences at later parts of sentence, or the implausibility effect will be found from late measure of eye-tracking, because they take more times to construct the structural relation in the object relative sentences. Third, failing to overcome the difficulties, they will respond less accurately in the implausible sentences and the object relative structure.

In the second experiment, the experimental group, as in a paradigm used in Zhou and Christianson (2016), were familiarized with the voice of speakers before reading the sentences, and then were instructed to imagine the voice while reading. If APS improves readers' reading processing, the results will be different from the control group. First, the participants will read sentences faster than the control group and the implausibility will not result in longer reading times, since they rely more on accurate syntactic processing. Second, they will find the implausibility at the region causing it, or its effect will be reflected on early measures of eye-tracking, because they focus more on the syntactic processing so that they are able to establish the structural relation faster. In particular, this prediction can be compared with the results of the translation group in Lim and Christianson (2013b), in which they used the translation task to reduce L2 learners' dependency on the good-enough processing. In their study, the translation group detected the implausibility of the sentence at the relative clause region, different from the control group. Third, as they more easily overcome the difficulties, their comprehension accuracy will be higher than the control group, and it will not be influenced by the implausibility.

Chapter 3 Methodology

3.1. Participants

38 Korean native speakers were recruited in Seoul National University (SNU). They all have no experience of living in an English-speaking country more than a year. Those who major in linguistics or English education were excluded from participation. For English proficiency control, only those whose TEPS (Test of English Proficiency developed by Seoul National University) score was over 701 were allowed to participate in the experiment. All of the students in SNU are required to perform the test for English course classification, and the score 701 to 800 means high-intermediate and over 801, advanced level. More proficient level L2 learners were chosen because they were less like to be affected by the lack of the syntactic knowledge. Although the required knowledge was relatively a simple syntactic rule (relative clause structure), more proficient learners were regarded more suitable for evaluating on-line syntactic processing. Moreover, the participants possibly need to have prosodic skills or reading fluency in order to carry out APS task where the participants actively simulate the voice of imagined speakers. Without proper prosodic skills or reading fluency, it might be difficult to utilize the auditory imagery. Accordingly, the learners considered more proficient in communicative competence are appropriate for this experiment.

The participants were randomly assigned to two groups (control group and APS group). Two participants were excluded from the data analysis; one for experimental error and the other for the overall low accuracy for comprehension

questions (less than 70%). As a result, 18 participants for the control group and 17 participants for the APS group were included in the data analysis. The mean age of the participants (20 female and 15 male) was 23.44 years old, ranging from 19 to 29. Their mean score on TEPS was 793.53, ranging from 706 to 921. For their oral reading fluency evaluation, post-test was administered (for details, see *procedure*). The mean score was 2.70 out of 4. The self-reported English proficiency was also gained from the participants. They reported their proficiency for speaking, listening and reading, based on given criteria, which were created by modifying Common European Framework of Reference for Languages (CEFR). There was no statistical significant difference in age, TEPS score, oral reading fluency, and self-reported proficiency between two groups ($p > .1$) (table 1).

Table 1. Participants information

	Age	**TEPS score**	**Oral Reading fluency**	**Speaking**	**Reading**	**Listening**
Control	23.72 (2.56)	787.50 (59.12)	2.71 (0.45)	2.89 (1.13)	4.17 (1.10)	3.67 (1.03)
APS	23.17 (2.60)	799.56 (63.98)	2.69 (0.59)	3.28 (1.36)	4.50 (0.86)	3.94 (1.21)

3.2. Materials

Thirty two items (Appendix A) such as (1’) were selected among 48 items from Lim and Christianson (2013b). (Below are the same examples with the (1) and (2) in Chapter 2, which are again presented for convenience.)

(1') a. The cat that chased the mouse was fast.

(Subject relative clause -Plausible)

b. The mouse that chased the cat was fast.

(Subject relative clause -Implausible)

c. The mouse that the cat chased was fast.

(Object relative clause -Plausible)

d. The cat that the mouse chased was fast.

(Object relative clause -Implausible)

(2') a. The cat chased the mouse. The cat was fast.

(The verification for 1a and 1c)

b. The mouse chased the cat. The cat was fast.

(The verification for 1b and 1d)

The vocabulary difficulties were controlled for second language learners. Less frequent, or difficult words were excluded from the original items. The target items were controlled with respect to structure and plausibility, resulting in a 2 (subject-relative, object-relative) × 2 (plausible, implausible) factorial design. Plausibility was manipulated only in the relative clauses. The participants would notice the implausibility at the second noun, *the cat*, in the subject relative clause condition (1'b), or at the relative clause verb, *chased*, in the object relative clause condition (1'd), which would cause them to read longer at those regions. Materials were quasi-randomly distributed for each participant according to a Latin square. Each participant saw only one condition from each item. 64 filler items were also

included.

For the APS control, a total of 16 recordings were created. Two female American English native speakers (Speaker A: age- 28, Florida, Speaker B: age- 51, Florida) read four short narrative passages. They recorded each passage twice; one for slower rate and the other time for faster rate. The reading passages were about 150 words long. They were selected from Korean SAT English section, on topics such as *night eating habit*s and *the ways to exercise in everyday life* (Appendix B). Given the participants' English proficiency and the difficulty of the passages, the text would not be challenging to them. The photos of the speakers were retrieved from the Internet. Both were Caucasian women.

3.3. Procedure

Participants were individually tested at a sound-attenuated room. Before the experiment, they provided informed consent and were given an instruction. Their eye-movements were then calibrated using a nine-point calibration procedure. The eye-tracking experiment was administered. It included the instruction session and practice session before the main experiment. After the main experiment, the survey for the subjective report on the task, and the post-test for oral reading fluency were given in the same room. The entire experiment lasted for about an hour, and they were paid 10,000 won for the participation.

3.3.1. Control group experiment

For the control group, the participants read the sentences presented as a whole on the screen. They were instructed not to read aloud. Once finishing reading the sentence, they stared at “NEXT” on the screen for the certain amount of time, which would automatically trigger presenting a paraphrase verification sentence. Participants answered the verification by fixating their eyes on “TRUE” or “FALSE” on the screen. When the question was answered, the next item was automatically presented. The whole session was separated by three break times. The participants were ensured to rest as long as necessary during the break times to prevent fatigue. After the second break time, their eye-movements were recalibrated.

3.3.2. APS group experiment

The experiment for APS group consisted of four blocks and each block has two sections (Figure 1). In the first section, the participants listened to a recording of one of two English native speakers via a loudspeaker with the matching photograph displayed. The photograph included the speaker’s name and figure. While listening, they learned the figure and name, and the speaker’s tone, informed that those would be used for the second section. After listening, the participants answered the comprehension questions on what they heard, and then were asked to imagine the voice with the photograph presented. In the second section, they read the sentences under APS manipulation. Before a sentence was presented, they saw the talker’s photograph they saw in the first section, and recalled her name and voice. When they read sentences, they were instructed to imagine that the speaker was reading the

sentence out loud to them. After reading the sentence, they answered the verification question. Each block was followed by the break time. After breaks, the subsequent block began with another first section. The eye-movements were recalibrated after the second break.

Among the blocks, the recordings of Speaker A and Speaker B were alternately presented. For example, participants listened to Speaker A in the first block, Speaker B in the next block, again Speaker A in the third block and then Speaker B for the last block. The rates of speech were also alternated. Once participants listened to the fast talk in one block, they listened to the slow talk in the subsequent block. Accordingly, the speech rate was always matched with the speaker. For instance, when participants listened to the fast version of Speaker A's talk in the first block, then, in the third block, they would listened to the Speaker A's recording of the same fast version but of the different passage (Figure 1). As a result, four possible sets were created (2 speakers x 2 rates). Each block randomly included one of four narrative passages and the order of recordings was counterbalanced across participants. No participant listened to the same passage.

In Zhou and Christianson (2016), the experiment consisted of two blocks and the participants listened to the recordings of both speakers, a slow and fast speaker, within the same block. Then, one of the speakers' photographs was randomly given prior to each sentence in the second sections. However, this experiment, as an L2 study, displayed only one speaker in each block in order to reduce the participants' cognitive burden to identify the speaker and then recall her voice. Practicing the same speaker consecutively within a block would even facilitate

the participants' auditory imagery perception.

Figure 1. The example of the procedure for APS group. The order of the speakers, rates, and texts was quasi-randomized and counterbalanced across the participants.

	BLOCK 1		BLOCK 2		BLOCK 3		BLOCK 4
	SECTION 1		SECTION 1		SECTION 1		SECTION 1
SET 1	Speaker A – Fast	B R E A K	Speaker B – Slow	B R E A K	Speaker A – Fast	B R E A K	Speaker B – Slow
SET 2	Speaker A – Slow		Speaker B – Fast		Speaker A – Slow		Speaker B – Fast
SET 3	Speaker B – Fast		Speaker A – Slow		Speaker B – Fast		Speaker A – Slow
SET 4	Speaker B – Slow		Speaker A – Fast		Speaker B – Slow		Speaker A – Fast
	SECTION 2		SECTION 2		SECTION 2		SECTION 2

3.3.3. Survey and Post-test

A survey was conducted to measure the participants' attitudes toward the APS task and their English reading experience with 1-4 Likert scale (Appendix C). First, they read a sentence under APS manipulation and were asked whether they were able to recall the voice, whether the APS helped them read the sentence, and why it does so. Then, they read the same sentence with their own reading style, and compared it with the APS reading. They answered whether they can notice difference between the two reading styles, whether the APS aided them compared to their own style, and whether they utilize the inner speaking when they read as usual. Both control group and APS group implemented the survey, but while the APS group listened to the voice of the speakers in the main experiment, the control group did

not. They saw the picture, and then recalled the speaker's voice only through their imagination, without having listened to actual voices. They served as a control group also in the survey. All survey items were presented in Korean.

After the survey, the participants performed the post-test for evaluating their oral reading fluency. They read out loud a 125 word-long English text (Appendix D). The text was adapted from Pinnell et al. (1995), which was developed to measure L1 children oral reading fluency. Their readings were recorded and later assessed by 10 native English speakers. All evaluators were recruited from Amazon Mechanical Turk, the crowd-sourcing web-platform, and they were paid $1.70 for the evaluation. They scored the reading fluency according to four levels of the adapted version of the NAEP's oral reading fluency scale (Pinnell et al., 1995) modified by X. Jiang (2016) that examined the ESL students' oral reading fluency (Appendix D). The adapted version was further designed to capture L2 learners' variations in pitch and stress patterns.

3.4. Apparatus

Participants were seated approximately 70 cm from a color monitor running at 60 Hz. At this distance, 1.1° of visual angle subtended approximately 3 characters (Hope, 2012). A chin rest was used to minimize participants' head movements. Black Courier New monotype font (16 pt) was used for presenting the sentences. They were displayed on a white background in the form of 1920x1280 size images. Eye movement data were collected using an SMI RED250 eye tracker with a sampling rate of 250 Hz running SMI Experiment Center software. Although the data from

both eyes were recorded, the ones from right eye were used in the analysis.

Chapter 4 Results

4.1. Analysis

4.1.1. Region of Interest

There were four specific interest regions (Table 2); the first noun region (FN), the relative clause verb region (RCV), the second noun region (SN), and the main clause verb region (MCV). In subject relative structures, RCV precedes SN, and SN is the region on which the implausibility has an effect, whereas in object relative structures, RCV follows SN, and RCV is the critical region.

Table 2. Regions of Interest

Region of Plausibility Effect							Critical	Post	
SRC	**Plausible**	The	cat	that	chased	the	mouse	was	fast.
	Implausible	The	mouse	that	chased	the	cat	was	fast.
Region of Interest			FN		RCV		SN	MCV	
ORC	**Plausible**	The	mouse	that	the	cat	chased	was	fast.
	Implausible	The	cat	that	the	mouse	chased	was	fast.
Region of Interest			FN			SN	RCV	MCV	

Note : SRC = Subject relative clause, ORC= Object relative clause, FN = First noun, RCV = Relative clause verb, SN = Second noun, MCV = Main clause verb

Reading times for each region were trimmed before analysis. First, fixation times that were abnormally low (under 80 ms) or high (over 800 ms) were excluded and outliers more than 2.5 standard deviations from the mean of each region were

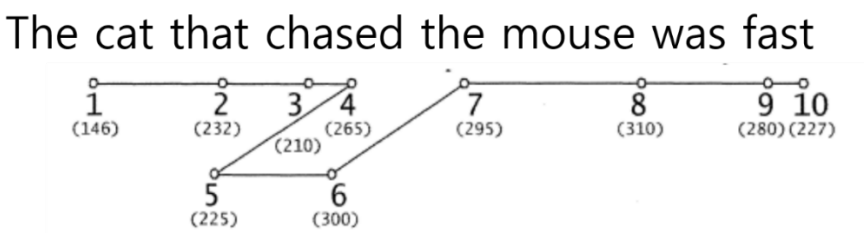
subsequently removed, resulting in 2.33% and 2.61% data loss each for control and APS group. Then, the trials with the error response for comprehension question were removed, which represented 10.61% of data.

4.1.2. Eye-movement measurements

Four eye movement measures were involved in the region of interest analyses; *First-fixation duration, gaze duration, go-past time,* and *total reading time* (Figure 2). *First-fixation duration* only includes the first fixation that enters the region. *Gaze duration* includes all fixations in the region from when the eyes first enter until they move to another region in either direction. *Go-past time*, or regression path duration, is the sum of all fixations in the region from when the eyes first fixate until they progress, or exit to the right. It include fixations on previous regions that are re-fixated when the eyes regress. *Total reading time* includes all fixations in the region during the trial. Among them, first fixation duration and gaze duration are generally known as 'early' measure, while total reading time as 'late' measure. Early measures are considered to reveal readers' initial processing and interpretations of each word when first encountered, while late measures are believed to reflect reanalysis caused by processing difficulty (Keating, 2014). Go-past time is known to be indicative both of an early effect and late effect. Regression out of a region to previous regions reflects readers' initial difficulties and an additional reading time in regressed region indicates their later effort to overcome difficulties (Keating, 2014). If there is an effect on go-past time but not on gaze duration, it would mean that regressions to earlier parts of the sentence influenced go-past time

(Pickering, Frisson, McElree, & Traxler, 2004). In this study, we will report these four measures at each region, but we will not analyze early measures and go-past time at first noun region since there would be no structural, or plausibility difference when the participants first encounter the word at this region.

Figure 2. Sample fixation sequence for *"The cat that chased the mouse was fast."* For example, first fixation duration for 'chased' is 210 ms (3), gaze duration 475 ms (3+4), go-past time 1000 ms (3+4+5+6), and total reading times 775 ms (3+4+6).



4.1.3. Sentence reading times

Reading times for the entire sentence, *sentence reading times*, were trimmed before analysis. Sentences reading times under 1000 ms or over 25000 ms and outliers more than 2.5 standard deviations were removed. Total data loss for sentence reading times was 2.81 %.

4.1.4. Statistical analysis

For the analysis, generalized linear mixed model was conducted, using the lme4 library (Bates, Maechler, Bolker, & Walker, 2015) in the R environment (R Core Team, 2016). The analysis consisted of two steps. First, we separated the

control group and the aps group and established the separate model for each group. Then, we conducted the integrated model including both groups and observed group effect. Each model assumed fixed effects for plausibility, structure, rate (for APS) and group (for group comparison), and random effects for participants and items. A stepwise selection method was implemented to decide the best fitted linear mixed-effects model.

4.2. Results

4.2.1. Response accuracy

The best fitted model of control group revealed a significant main effect of plausibility (*estimate*= 1.673, *SE*= 0.389, *z*= 4.301, $p<0.001$) and structure (*estimate*= 1.080, *SE*= 0.353, *z*= 3.060, $p<0.01$). The accuracy rate was higher in the subject relative clause than in the object relative clause, and in the plausible conditions than in the implausible conditions. The participants tended to be most likely to misinterpret sentences in the implausible, object relative clause condition, but no interaction between plausibility and structure was found. APS group also showed a significant main effect of plausibility (*estimate*= 0.990, *SE*= 0.358, *z*= 2.769, $p<0.01$) and structure (*estimate*= 0.857, *SE*= 0.357, *z*= 2.399, $p<0.05$) on response accuracy. The participants responded more correctly in subject relative clause than in objective relative clause and in the plausible sentences than in the implausible sentences. There was no effect of rate in speakers and no interaction among factors. When both groups were included in the generalized linear mixed

model for group comparison, there was a main effect of plausibility (*estimate*= 1.274, *SE*= 0.258, *z*= 4.947, *p*<0.001) and structure (*estimate*= 0.878, *SE*= 0.257, *z*= 3.414, *p*<0. 001). However, no group effect nor interactions were found. Overall accuracy of two groups was unexpectedly high regardless of conditions. Their average accuracy, 90.81%, was even higher than both native control group, 80.75%, and native APS group, 87.5%, in Zhou and Christianson (2016) and L2 learners, about 77%, in Lim and Christianson (2013b).

Table 3. Means and standard errors of sentence reading times (ms) and response accuracy (%) in control and APS group

Plausibility	**Structure**	**Control**		**APS**	
		SRT	Accuracy	SRT	Accuracy
Plausible	SRC	5072.93 (212.8)	97.18% (0.01)	5294.07 (232.72)	96 % (0.02)
Implausible	SRC	5766.04 (300.07)	92.08% (0.02)	4987.61 (218.62)	90 % (0.03)
Plausible	ORC	5293.15 (271.42)	95.68% (0.02)	4758.16 (194.78)	91 % (0.02)
Implausible	ORC	5712.32 (270.01)	79.86% (0.03)	5040.43 (202.46)	84 % (0.03)

Note : SRC = Subject relative clause, ORC= Object relative clause, SRT = Sentence reading times

4.2.2. Sentence reading times

As for control group, only plausibility had significant effects on the sentence reading time (*estimate*= -562.7, *SE*= 234.0, *t*= -2.405, *p*<0.05). The participants read the plausible sentences faster than the implausible sentences irrespective of structure conditions. On the other hand, no effect or interaction was

found in APS group. There was no difference of sentence reading times in plausibility, structure, and rate. Sentence reading times did not differ across the speakers' rate, and the slow rate induced rather numerically faster reading times than the fast rate did.

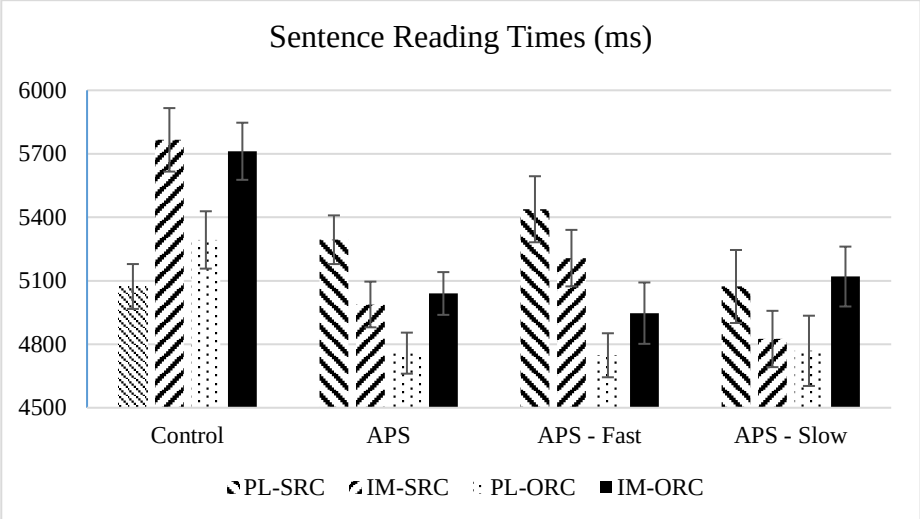
Table 4. Means and standard errors of sentence reading times (ms) and response accuracy (%) in APS group by speaker's rate.

Plausibility	**Structure**	**APS - Fast**		**APS - Slow**	
		SRT	Accuracy	SRT	Accuracy
Plausible	SRC	5437.52 (312.13)	96 % (0.02)	5073.14 (345.52)	96 % (0.03)
Implausible	SRC	5207.22 (367.91)	90 % (0.04)	4825.29 (266.43)	90 % (0.04)
Plausible	ORC	4747.69 (208.99)	91 % (0.03)	4768.82 (332.34)	91 % (0.04)
Implausible	ORC	4947.35 (290.35)	81 % (0.05)	5120.41 (283.43)	86 % (0.04)

Note : SRC = Subject relative clause, ORC= Object relative clause, SRT = Sentence reading times

The group comparison revealed a marginal plausibility effect (*estimate*= -290.43, *SE*= 154.10, *t*= -1.885, $p<0.1$) and an interaction between group and plausibility (*estimate*= 537.68, *SE*= 308.19, *t*= 1.745, $p<0.1$). The participants took longer reading times to read the implausible sentences than the plausible sentences, and this tendency seemed to be driven mostly by the control group (*estimate*= -717.5, *SE*= 460.9, *t*= -1.557) which was consistent with the separated models. However, there was no main effect of group, even though the sentence reading times of APS group were numerically shorter than those of control group (APS : 5023.81 ms vs. control : 5461.43ms).

Figure 3. Mean sentence reading times in APS and control group and APS fast and slow rate session.



Note : PL-SRC = Plausible - Subject relative clause, IM -SRC = Implausible - Subject relative clause, PL-ORC = Plausible - Object relative clause, IM-ORC = Implausible - object relative clause

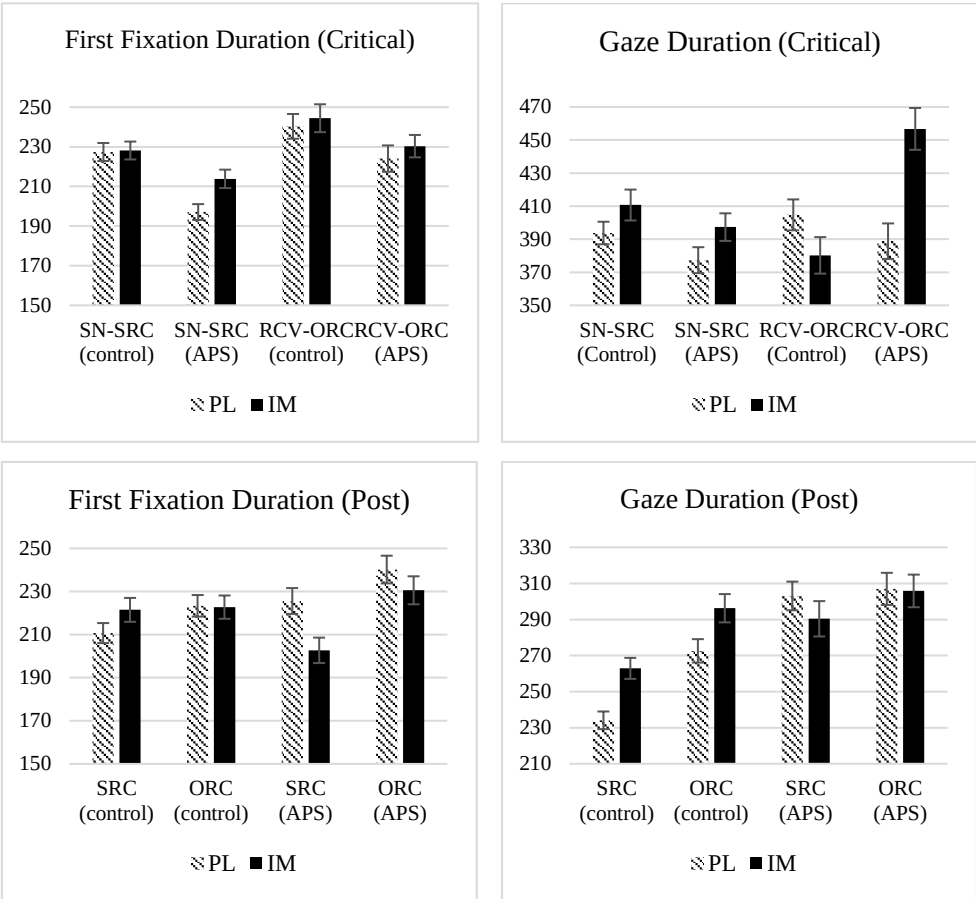
4.2.3. Region reading times

4.2.3.1. Early measures

As for the control group, there was no effect on first fixation duration. On gaze duration, structure had a marginal effect at relative clause verb region (*estimate*= 31.75, *SE*= 17.37, *t*= 1.827, $p<0.1$), in which the participants read slower in the subject relative structure then in the object relative clause conditions. At second noun region on gaze duration, there were a marginal structure effect (*estimate*= 25.80, *SE*= 13.45, *t*= 1.919, $p<0.1$) where readers fixated longer in the subject relative structure and significant interaction between structure and plausibility (*estimate*= -71.12, *SE*= 26.88, *t*= -2.646, $p<0.05$), which is explained by shorter fixation duration in implausible condition with objective relative clause

(*estimate*= 51.92, *SE*= 19.12, *t*= 2.716). In main clause verb region, a marginal plausibility effect (*estimate*= -23.442, *SE*= 10.975, *t*= -2.136, *p*<0.1) and significant structure effect (*estimate*= -40.487, *SE*= 11.079, *t*= -3.654, *p*<0.001) were found. The participants fixated longer on the implausible condition than the plausible condition, and the object relative structure than the subject relative structure.

Figure 4. Mean of first fixation duration and gaze duration at the critical region (SN in subject relative structure and RCV in the object relative structure) and post region (MCV) in APS and control group.



Note : SN-SRC = Second Noun region in Subject Relative Clause, RCV-ORC = Relative Clause Verb in Object Relative Clause, SRC = Subject Relative Clause, ORC = Object Relative Clause

The best fitted model of APS group revealed a marginal structure effect at main clause verb region on first fixation duration (*estimate*= -19.117, *SE*= 11.208, *t*= -1.706, *p*<0.1). On gaze duration, there were a marginal effect of structure (*estimate*= -37.283, *SE*= 18.884, *t*= -1.974, *p*<0.1) and a significant interaction between plausibility and structure (*estimate*= 79.64, *SE*= 37.83, *t*= 2.105, *p*<0.05) at relative clause region. The participants read the object relative structure slower than the subject relative structure and this tendency seemed to be caused by the longer fixations in the implausible condition of the object relative structure (*estimate*= -67.855, *SE*= 27.417, *t*= -2.475). At second noun region, structure had a significant effect on gaze duration (*estimate*= 44.897, *SE*= 14.457, *t*= 3.105, *p*<0.01), where readers fixated longer in subject relative structure than object relative structure in contrast with relative clause verb region. Meanwhile, there was no effect of rate in early measure.

The group comparison showed that the structure influenced on first fixation duration marginally at relative clause verb region (*estimate*= -13.402, *SE*= 7.222, *t*= -1.856, *p*<0.1) and significantly at main clause verb region (*estimate*= -14.829, *SE*= 7.143, *t*= -2.076, *p*<0.05). The object relative clause yielded longer fixation times at both regions. No group difference was found. On gaze duration, there was an interaction between structure and group (*estimate*= 71.400, *SE*= 25.367, *t*= 2.815, *p*<0.01) at relative clause region. It seemed that while APS group had longer fixations in the object relative structure than the subject relative structure (*estimate*= -38.949, *SE*= 18.313, *t*= -2.127), control group read longer in the subject relative structure (*estimate*= 30.862, *SE*= 17.580, *t*= 1.756). Furthermore, there was also an

interaction among structure, plausibility, and group (*estimate*= -125.669, *SE*= 50.532, *t*= -2.487, *p*<0.05), which can be accounted for by APS group's longer reading times in the implausible conditions of the object relative structure (*estimate*= -67.461, *SE*= 26.520, *t*= -2.544). At second noun region, structure (*estimate*= 36.331, *SE*= 9.810, *t*= 3.703, *p*<0.001) and interaction between plausibility and structure (*estimate*= -39.611, *SE*= 19.561, *t*= -2.025, *p*<0.05) had a significant effect on gaze duration. The subject relative structure was read slower than the object relative structure, and additionally, the subject relative structure with the implausible condition was fixated longer compared to the object relative structure in the same condition (*estimate*= 56.061, *SE*= 14.206, *t*= 3.946). At main clause verb region, a marginal effect of group (*estimate*= -36.986, *SE*= 21.398, *t*= -1.728, *p*<0.1) and a significant effect of structure (*estimate*= -24.440, *SE*= 9.735, *t*= -2.511, *p*<0.05) were found. The control group read faster than the APS group at this region and the object relative structure was fixated longer than the subject relative structure.

4.2.3.2. Go-past time

On go-past time of the control group, there were a significant main effect of plausibility (*estimate*= -117.34, *SE*= 42.26, *t*= -2.777, *p*<0.01) and structure (*estimate*= -107.77, *SE*= 42.70, *t*= -2.524, *p*<0.05) at relative clause region. The participants read slower in the implausible condition than in the plausible condition and in the object relative clause than in the subject relative clause, which was reversed from gaze duration where the subject relative clause was fixated longer. At second noun region, there were a significant structure effect (*estimate*= 175.98, *SE*=

40.51, t= 4.345, p<0.001) and interaction between structure and plausibility (*estimate*= -266.18, *SE*= 80.95, t= -3.288, p<0.01). They took longer reading times in the subject relative clause than in object relative clause. The interaction between structure and plausibility appeared to indicate that implausible condition yielded longer reading times than the plausible condition within the subjective relative structure (*estimate*= -155.79, *SE*= 57.18, t= -2.725), whereas it led to shorter reading times within objective relative structure (*estimate*= 110.38, *SE*= 57.12, t= 1.933).

The APS group showed a main effect of structure at relative clause (*estimate*= -219.55, *SE*= 49.86, t= -4.404, p<0.001), second noun (*estimate*= 126.29, *SE*= 33.88, t= 3.726, p<0.001) and main clause region (*estimate*= -157.24, *SE*= 55.52, t= -2.832, p<0.01). While the reading times were increased in object relative structure at relative clause verb region and main clause region, they were inflated in subject relative structure at second noun region, which was similar trend with the results on gaze duration. At second noun region, an interaction between structure and rate was also found (*estimate*= 217.01, *SE*= 69.40, t= 3.127, p<0.01). The difference between the structures seemed to be larger in slow speaker simulation (*estimate*= 237.31, *SE*= 49.68, t= 4.777), there was little difference in structures when the participants recalled the fast speaker. Moreover, plausibility (*estimate*= -72.29, *SE*= 33.78, t= -2.140, p<0.1) and rate (*estimate*= 64.82, *SE*= 34.67, t= 1.870, p<0.1) had a marginal effect at second noun region. The readers spent less time reading this region when the sentence was plausible and when they simulated fast speaker. At main clause verb region, when participants simulated fast speaker, their reading times became shorter (*estimate*= 103.88, *SE*= 56.01, t= 1.855, p<0.05).

The group comparison revealed that structure influenced on go-past time at relative clause region (*estimate*= -164.43, *SE*= 32.53, *t*= -5.055, *p*<0.001), second noun region (*estimate*= 157.21, *SE*= 26.98, *t*= 5.828, *p*<0.001), and main clause verb region (*estimate*= -124.09, *SE*= 47.53, *t*= -2.611, *p*<0.01). As in separated models, the reading times of object relative structure were longer at relative clause region and main clause verb region, but they were shorter at second noun region. Plausibility also had a significant effect on go-past time at relative clause region (*estimate*= -77.66, *SE*= 32.51, *t*= -2.389, *p*<0.05), and a marginal effect at main clause verb region (*estimate*= -88.62, *SE*= 47.41, *t*= -1.869, *p*<0.1). Fixations were longer in the implausible conditions than the plausible conditions. In addition, there were also an interaction between plausibility and structure (*estimate*= -156.92, *SE*= 53.98, *t*= -2.907, *p*<0.01) and an interaction between plausibility, structure and group at second noun region (*estimate*= -240.58, *SE*= 108.00, *t*= -2.228, *p*<0.05). It seemed that the implausibility effects were larger when readers read the subject relative clauses (*estimate*= -131.23, *SE*= 38.30, *t*= -3.427) and those were even larger within control group (*estimate*= -161.67, *SE*= 52.61, *t*= -3.070). At relative clause region an interaction between group and structure marginally influenced go-past time (*estimate*= 120.76, *SE*= 65.29, *t*= 1.849, *p*<0.1), in which the structure effect seemed to be larger for APS (*estimate*= -225.69, *SE*= 47.48, *t*= -4.754) than for control (*estimate*= -100.03, *SE*= 45.00, *t*= -2.223).

4.2.3.3. Late measures

The readers of the control group took longer total reading time in the

Table 5. Means and standard errors of first-fixation duration, gaze duration, go-past time, second-pass time, and total reading times on four interest areas in control and APS group.

P	S	Control				APS			
		FN	RCV	SN	MCV	FN	RCV	SN	MCV
					First fixation duration				
PL	SRC	213.37 (9.33)	243.05 (10.76)	227.39 (9.11)	210.71 (9.3)	220.82 (11.85)	206.72 (9.80)	197.09 (8.01)	225.60 (11.96)
IM	SRC	211.39 (12.17)	219.43 (12.61)	228.14 (9.04)	221.49 (11.08)	198.75 (9.47)	215.51 (12.83)	213.83 (9.14)	202.70 (11.81)
PL	ORC	218.87 (11.3)	240.32 (12.55)	214.64 (10.38)	223.36 (9.98)	210.07 (9.01)	224.05 (13.34)	207.91 (10.17)	240.19 (12.85)
IM	ORC	211.21 (12.03)	244.44 (14.07)	213.58 (9.20)	222.75 (10.82)	204.49 (9.46)	230.33 (11.27)	199.33 (9.18)	230.56 (12.99)
					Gaze duration				
PL	SRC	291.47 (11.64)	413.25 (16.66)	393.75 (13.65)	234.09 (9.82)	370.64 (20.16)	386.44 (18.20)	377.31 (15.77)	303.05 (15.87)
IM	SRC	303.65 (14.59)	428.48 (21.07)	410.68 (18.78)	262.9 (11.65)	312.91 (17.17)	383.28 (20.82)	397.32 (16.25)	290.39 (19.66)
PL	ORC	326.78 (17.75)	404.73 (18.69)	405.00 (15.17)	272.6 (12.99)	366.15 (26.39)	388.81 (21.56)	338.27 (13.71)	306.98 (17.83)
IM	ORC	305.15 (14.86)	380.21 (22.10)	346.66 (14.05)	296.24 (15.77)	343.29 (18.93)	456.72 (25.31)	348.88 (15.76)	305.84 (18.13)
					Go-past time				
PL	SRC	332.18 (25.68)	480.36 (23.62)	561.54 (35.23)	447.83 (56.36)	408.49 (27.28)	468.14 (25.22)	530.10 (35.20)	408.72 (39.18)
IM	SRC	315.76 (17.57)	527.46 (41.60)	708.83 (69.5)	636.74 (95.62)	331.12 (19.47)	492.09 (31.60)	626.61 (48.21)	454.51 (48.17)
PL	ORC	342.81 (20.09)	511.30 (34.63)	528.43 (35.28)	606.57 (70.7)	381.30 (27.39)	675.42 (66.76)	419.57 (26.23)	552.45 (71.1)
IM	ORC	311.48 (15.37)	693.67 (80.72)	409.61 (26.32)	644.51 (84.82)	374.29 (23.43)	743.26 (71.26)	474.59 (36.71)	632.25 (70.66)
					Total reading times				
PL	SRC	658.3 (39.09)	868.51 (40.84)	868.98 (51.03)	402.8 (28.5)	589.54 (38.95)	680.66 (37.40)	639.96 (37.67)	450.9 (30.45)
IM	SRC	753.83 (69.1)	1211.72 (85.97)	1022.27 (67.20)	481.34 (42.13)	638.00 (51.62)	910.32 (57.78)	849.96 (48.06)	488.27 (36.21)
PL	ORC	725.41 (67.94)	937.73 (59.04)	873.93 (45.33)	553.41 (44.3)	618.72 (52.96)	758.15 (48.44)	720.03 (47.97)	473.93 (29.56)
IM	ORC	774.83 (63.87)	1268.09 (93.69)	1272.7 (95.32)	574.1 (45.99)	799.55 (60.03)	1115.15 (77.56)	1015.49 (60.36)	589.44 (38.59)

Note. P=Plausibility, S=Structure, FN= first noun, RCV= relative clause verb, SN= second noun, MCV=main clause verb, PL = plausible, IM= implausible, SRC = subject relative clause, ORC = object relative clause

Table 6. Means and standard errors of first-fixation duration, gaze duration, go-past time, second-pass time, and total reading times on four interest areas in APS group by rates.

P	S	Fast				Slow			
		FN	RCV	SN	MCV	FN	RCV	SN	MCV
					First fixation duration				
PL	SRC	224.23 (14.82)	206.53 (11.75)	199.77 (9.48)	216.54 (15.44)	215.92 (19.67)	206.99 (17.05)	192.92 (14.32)	238.20 (18.92)
IM	SRC	217.29 (15.7)	221.26 (18.53)	219.00 (14.99)	197.64 (18.13)	182.98 (11.06)	210.52 (17.9)	209.06 (11.56)	207.66 (15.36)
PL	ORC	217.49 (13.37)	210.47 (17.26)	217.52 (14.68)	247.54 (18.28)	202.06 (11.98)	238.68 (20.53)	195.89 (13.66)	231.17 (17.89)
IM	ORC	204.82 (15.29)	223.99 (14.06)	194.78 (12.99)	227.00 (20.03)	204.21 (11.85)	235.57 (17.09)	203.06 (12.94)	233.59 (17.13)
					Gaze duration				
PL	SRC	350.73 (24.07)	375.39 (23.19)	377.87 (19.79)	290.47 (21.88)	399.91 (34.91)	403.61 (29.51)	376.43 (26.31)	321.05 (22.56)
IM	SRC	340.61 (25.83)	389.26 (27.02)	379.45 (25.5)	248.66 (24.82)	289.59 (22.71)	378.21 (31.10)	411.55 (20.99)	333.02 (29.56)
PL	ORC	407.61 (42.15)	378.67 (27.86)	342.08 (19.66)	304.59 (24.05)	321.23 (29.77)	400.67 (33.82)	333.48 (18.83)	309.93 (26.88)
IM	ORC	334.33 (30.6)	484.15 (39.52)	352.31 (26.37)	309.45 (28.07)	351.23 (23.45)	432.77 (32.51)	346.13 (19.16)	302.73 (23.79)
					Go-past time				
PL	SRC	376.89 (27.69)	458.60 (33.29)	493.30 (39.57)	359.43 (34.4)	455.9 (53.79)	483.75 (38.5)	588.98 (65.74)	477.05 (79.89)
IM	SRC	375.45 (31.82)	485.77 (45.48)	510.95 (57.65)	484.63 (75.82)	293.12 (22.79)	497.21 (44.09)	724.48 (72.19)	425.07 (60.39)
PL	ORC	418.99 (43.62)	763.74 (105.92)	444.16 (38.70)	457.09 (57.86)	340.48 (31.42)	559.10 (63.98)	388.71 (33.66)	665.56 (138.5)
IM	ORC	369.99 (34.46)	787.22 (104.27)	492.46 (64.23)	543.31 (86.27)	378.09 (32.23)	700.19 (97.97)	460.05 (41.69)	709.83 (108.42)
					Total reading times				
PL	SRC	551.5 (46.37)	637.64 (48.59)	657.92 (51.00)	407.41 (39.39)	649.08 (68.42)	752.36 (57.23)	608.41 (52.95)	511.20 (46.95)
IM	SRC	619.12 (53.09)	978.98 (91.89)	761.98 (69.22)	467.10 (51.55)	653.11 (83.05)	849.29 (72.18)	926.10 (65.49)	510.41 (51.19)
PL	ORC	679.64 (70.62)	773.17 (70.65)	810.10 (69.07)	465.16 (36.76)	555.20 (78.97)	740.26 (65.54)	605.40 (61.08)	484.33 (48.13)
IM	ORC	660.01 (61.82)	1203.71 (128.45)	1028.52 (104.21)	589.90 (60.61)	924.85 (96.65)	1035.82 (91.38)	1005.40 (71.34)	589.04 (49.68)

Note. P=Plausibility, S=Structure, FN= first noun, RCV= relative clause verb, SN= second noun, MCV=main clause verb, PL = plausible, IM= implausible, SRC = subject relative clause, ORC = object relative clause

implausible sentences than the plausible sentences, marginally at first noun region (*estimate*= -91.45, *SE*= 51.84, *t*= -1.764, *p*<0.1), significantly at relative clause verb (*estimate*= -349.33, *SE*= 61.315, *t*= -5.697, *p*<0.001) and second noun region (*estimate*= -285.43, *SE*= 60.16, *t*=-4.745, *p*<0.001). There was a significant main effect of structure on total reading time at main verb region (*estimate*= -133.11, *SE*= 37.31, *t*= -3.568, *p*<0.001). The participants took longer to read object relative structure than subject relative structure. In addition, there was an interaction between plausibility and structure on total reading time at second noun region (*estimate*= 251.12, *SE*= 120.66, *t*= 2.081, *p*<0.01), in which the implausible conditions seemed to lead to longer fixations in object relative clause (*estimate*= -410.99, *SE*= 86.29, *t*= -4.763) than in subject relative clause (*estimate*= -159.87, *SE*= 84.10, *t*= -1.901). From gaze duration to go-past time at this region, the control group read faster the object relative structures, particularly in the implausible conditions, but those trends were reversed on late measures.

As for APS group, total time differed across the plausibility at first noun region (*estimate*= -105.036, *SE*= 41.644, *t*= -2.522, *p*<0.05), relative clause region (*estimate*= -285.369, *SE*= 50.369, *t*= -5.666, *p*<0.001), second noun region (*estimate*= -265.73, *SE*= 43.59, *t*= -6.096, *p*<0.001) and main clause verb region (*estimate*= -88.23, *SE*= 30.00, *t*= -2.941, *p*<0.01). The participants spent more times reading in the implausible conditions than in the plausible conditions. Structure also had an effect on total reading time at relative clause region (*estimate*= -142.385, *SE*= 50.357, *t*= -2.828, *p*<0.01), second noun region (*estimate*= -107.26, *SE*= 43.54, *t*= -2.463, *p*<0.05) and main clause verb region (*estimate*= -59.46, *SE*= 30.08, *t*= -

1.977, $p<0.05$). The object relative structure was fixated longer than the subject relative structure at those regions. In addition, at first noun region, a marginal effect of rate (*estimate*= 67.683, *SE*= 42.889, *t*= 1.578, $p<0.1$) and a significant interaction between rate and plausibility (*estimate*= -208.958, *SE*= 85.418, *t*= -2.446, $p<0.05$) were found on total reading time. At this region, the participants read slower when simulating the slow speakers, and especially the reading times in the implausible conditions increased within the slow rate (*estimate*= -200.70, *SE*= 61.42, *t*= -3.268). There were also a marginal interaction between plausibility and structure (*estimate*= 151.977, *SE*= 83.448, *t*= 1.821, $p<0.1$) and an interaction among rate, plausibility and structure on total reading time (*estimate*= 410.064, *SE*= 171.384, *t*= 2.393, $p<0.05$) at this region. The reading times for implausible conditions appeared to increase more in object relative structure (*estimate*= -183.54, *SE*= 61.85, *t*= -2.968) and this tendency was notably larger when the participants imagined slow speaker (*estimate*= -386.86, *SE*= 86.56, *t*= -4.468). At second noun region, the model revealed an interaction between rate and plausibility (*estimate*= -206.53, *SE*= 88.66, *t*= -2.329, $p<0.05$), and interaction between rate and structure (*estimate*= 193.38, *SE*= 90.00, *t*= 2.149, $p<0.05$) on total reading time. Simulating slow speakers seemed to elicit longer fixation times in the implausible conditions (*estimate*= -343.86, *SE*= 61.86, *t*= -5.559) compared to fast speakers (*estimate*= -173.72, *SE*= 59.01, *t*= -2.944), whereas the structure effect was mainly accounted for by fast rate (*estimate*= -241.45, *SE*= 59.93, *t*= -4.029).

The group comparison of total reading time revealed that the participants read significantly slower in the implausible conditions than in the plausible

Table 7. Summary of statistical analysis for control group model and APS group model.

First Fixation Duration	Control				APS			
	FN	RCV	SN	MCV	FN	RCV	SN	MCV
Plausibility	-				-			
Structure	-				-			†
Plaus. x Struc.	-				-			
Gaze Duration	**Control**				**APS**			
	FN	RCV	SN	MCV	FN	RCV	SN	MCV
Plausibility	-			†	-			
Structure	-	†	†	***	-	†	**	
Plaus. x Struc.	-		**		-	*		
Go-past time	**Control**				**APS**			
	FN	RCV	SN	MCV	FN	RCV	SN	MCV
Plausibility	-	**			-		†	
Structure	-	*	***		-	***	***	**
Plaus. x Struc.	-		**		-			
Total Reading Time	**Control**				**APS**			
	FN	RCV	SN	MCV	FN	RCV	SN	MCV
Plausibility	†	***	***		*	***	***	**
Structure				***		**	*	*
Plaus. x Struc.			*		†			

Note : Plaus. x Struc.= an interaction between Plausibility and Structure, FN= first noun, RCV= relative clause verb, SN= second noun, MCV=main clause verb, † = p-value <0.1, * = p-value <0.05, **= p-value < 0.01, *** = p-value < 0.001

conditions at first noun region (*estimate*= -99.93, *SE*= 33.53, *t*= -2.989, *p*<0.01), relative clause region (*estimate*= -314.64, *SE*= 39.86, *t*= -7.894, *p*<0.001), second noun region (*estimate*= -271.56, *SE*= 37.33, *t*= -7.275, *p*<0.001), and main verb clause region (*estimate*= -73.294, *SE*= 23.89, *t*= -3.068, *p*<0.01) and total reading time significantly increased when the participants read object relative structure at relative clause verb region (*estimate*= -103.83, *SE*= 39.91, *t*= -2.602, *p*<0.05),

Table 8. Summary of statistical analysis for the model including both groups

	First Fixation Duration				Gaze Duration			
	FN	RCV	SN	MCV	FN	RCV	SN	MCV
Group	-				-			†
Plausibility	-				-			
Structure	-	†		*	-		***	*
Group x Plaus.	-				-			
Plaus. x Struc.	-				-		*	
Struc. x Group	-				-	**		
Group x Pl. x Str.	-				-	*		
	Go-past time				**Total Reading Time**			
	FN	RCV	SN	MCV	FN	RCV	SN	MCV
Group	-					*	*	
Plausibility	-	*		†	**	***	***	**
Structure	-	***	***	**		*	*	***
Group x Plaus.	-							
Plaus. x Struc.	-		*				*	
Struc. x Group	-	†						
Group x Pl. x Str.	-		*					

Note : Group x Plaus. = an interaction between Group and Plausibility, Plaus. x Struc.= an interaction between Plausibility and Structure, Struc. x Group = an interaction between Structure and Group, Group x Pl. x Str. = an interaction between Group, Plausibility and Structure, FN= first noun, RCV= relative clause verb, SN= second noun, MCV=main clause verb, † = p-value <0.1, * = p-value <0.05, **= p-value < 0.01, *** = p-value < 0.001

second noun region (*estimate*= -116.21, *SE*= 37.37, *t*= -3.109, $p<0.05$), and main clause verb region (*estimate*= -95.017, *SE*= 23.995, *t*= -3. 960, $p<0.001$). In addition, at second noun region there was an interaction between structure and plausibility on total reading time (*estimate*= 166.60, *SE*= 74.93, *t*= 2.223, $p<0.05$). The implausibility effect was larger on the object relative structure (*estimate*= -355.55, *SE*= 53.71, *t*= -6.620) than the subject relative structure (*estimate*= -187.44, *SE*= 52.04, *t*= -3.440). More importantly there were a main effect of group at relative clause verb region (*estimate*= 213.30, *SE*= 88.44, *t*= 2.412, $p<0.05$) and at second noun region (*estimate*= 209.99, *SE*= 80.14, *t*= 2.620, $p<0.05$) on total reading time.

At these regions, APS group showed significantly shorter fixations than the control group.

4.2.4. Survey

The participants in APS group overall responded positively on whether they were able to simulate the speaker's voice and utilize it while reading (Question 1 & 2). They also answered they could recognize the differences between APS reading and normal reading (Question 4). However, their answer rate was not distinguished from that of control group who did not in fact listen to any speaker's recordings but only saw the picture and then imagined the voice. Thus, only with this survey result, it would be difficult to conclude that the participants in fact successfully simulated the speaker's voice, even though it might indicate that listening to the actual speakers' voice was not necessary for APS reading, at least for one sentence reading.

Meanwhile, for the questions on whether APS reading was helpful for reading English sentences (Question 3 & 5), the participants show no preference (2.32 out of 1-4 scale; mean scale is 2.5). Some participants thought that APS reading was actually harmful to their reading, since simulating interfered with focusing on comprehending the meaning and structure of sentences, decreasing reading rate. On the other hand, others who preferred APS reading believed that it helped memorize the information, or enabled them to read word by word or in an orderly way. (Appendix E for details)

Table 9. Survey questions and response scale (1 to 4 Likert scale, 4 as very positive.)

Survey questions	APS	Control
1. I was able to recall the voice of speaker in the picture.	3.16	3.24
2. I was able to read the sentence while recalling the speaker's voice.	3.16	3.06
3. The simulation helped me read the English sentence.	2.32	2.18
3-1. Why do you think that?	Appendix E	
4. I can notice differences between the simulating reading and normal reading.	3.16	3.00
4-1. Why do you think that?	Appendix E	
5. The simulation helped me read English sentences, compared to the normal reading	2.32	2.29
6. I usually use the inner speech to read English sentences.	2.63	2.71

Chapter 5 Discussion

This study examines whether auditory perceptual simulation can enhance second language learners' online sentence processing. The research questions were whether APS modulates the L2 sentence processing and it induces more detailed syntactic processing, and whether it increases comprehension accuracy and reading rate. From the results, we discuss the influence of APS, focusing on the research questions.

5.1. Faster and concrete syntactic processing in APS group

From regions of interest analysis, we found that the APS group detected the implausibility earlier and overcame the difficulties it caused faster. The results of early measures and go-past time revealed the tendency that the plausibility effect occurred earlier in the APS group than in the control group. The group comparison revealed that on gaze duration there was an interaction between plausibility and structure at second noun region. It means that both groups read slower in the implausible conditions than in the plausible conditions at the critical region in the subject relative structure. On the other hand, at the critical region in the object relative structure, only APS group showed plausibility effect, which was supported by an interaction between group, plausibility, and structure on gaze duration. In short, in the subject relative structure, both groups showed the plausibility effect on gaze duration, whereas in the object relative structure, relatively harder to parse the structure, only APS group noticed the implausibility. Meanwhile, the control group

also recognized the implausibility of the object relative structure, but they did at the later part. There was a marginal plausibility effect with no interaction at post region (MCV) on gaze duration in the control group analysis. Their gaze duration was longer in the implausible sentence than in the plausible sentence. On the other hand, the gaze duration at the post region did not differ across the plausibility conditions in the APS group analysis. In brief, the APS group constructed the structural relation relatively faster when parsing the object relative clause structure.

The analysis of go-past time and late measures suggested that the APS group overcame the difficulties produced by the implausibility faster than the control group. On go-past time, the plausibility effect was larger for the control group than the APS group at the critical region in the subject relative clause. If gaze duration does not show any difference but go-past time does at a region, it must be due to regressions that occurred from that region (Pickering et al., 2004). Since the gaze durations of two groups did not differ at this region, this difference on the go-past time reflected the regression to the previous word, namely, later efforts to overcome difficulties. Thus, the APS group needed shorter time to resolve difficulties of the implausibility at the critical region in the subject relative structure than the control group did. Meanwhile, at the relative clause region, the go-past time was longer in the object relative structure than in the subject relative structure, and the tendency was larger for the APS group. Yet, it did not indicate that the APS group had more difficulties in the object relative clause than the control group, since this trend continued from gaze duration, not reflecting later struggles. Rather, the control group seemed to require more times to overcome the implausibility of the object relative

structure than the APS group did, in that the implausibility had an influence on go-past time only for the control group whose gaze duration did not vary in the plausibility at this region. Hence, the control group was more effortful to understand the unlikelihood of the sentence at the critical region in the object relative clause. From these results, one might wonder why there was plausibility effect on go-past time but no plausibility effect at the critical region on early measures for the control group. If they failed to learn the implausibility at the critical region, they would have no need to regress out to the previous words, not inflating go-past time. Moreover, even if they noticed it at the post region and decided to go back to the earlier parts, it would not be reflected in the go-past time at the critical region either. Among several possibilities, the most reasonable interpretation for it seems to be that these results in fact consisted of two discrete patterns of eye-movements. Some readers identified the implausibility at the critical region and regressed to the previous words, increasing the go-past time, while others found it after they reached the post region, producing plausibility effect on gaze duration at the post region. For the former cases, the plausibility effect did not reach the significance level on gaze duration, which meant that only a few readers detected the implausibility of the sentence. Nonetheless, those fewer cases regressed long enough to make a difference in the plausibility on go-past time. Thus, plausibility effect on go-past time with no effect on early measures might imply that those fewer cases had a considerable amount of difficulty in resolving the implausibility.

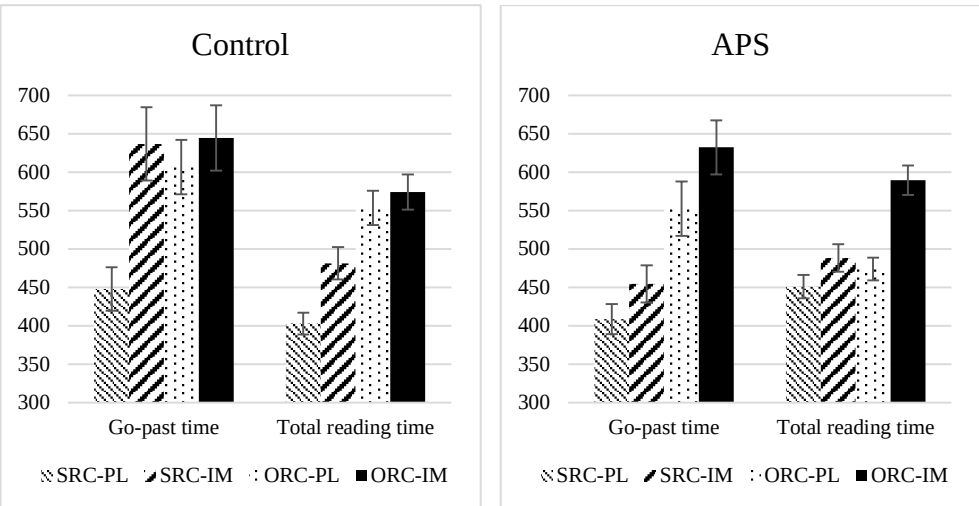
On total reading time, there was a main effect of group at relative clause verb and second noun region. The reading times of the APS group were significantly

shorter than those of the control group. Total reading time is known to reflect the readers' later struggle to overcome difficulties. What distinguishes total reading time from go-past time is that it includes all fixations re-entered to the region after readers once left that region. That is, it involves all the cases regressed more than once, and those regressed after readers have already progressed out of the region to the next region. Thus, compared to go-past time, it additionally indicates lasting difficulty that needs to be regressed many times. Given the control group's late plausibility effect found from early measures and more difficulty from go-past time analysis, their total reading time at relative clause verb and second noun regions would necessarily be longer than those of the APS group, which was confirmed by the results.

It is also notable that total reading time at second noun and relative clause verb region for the APS group was shorter than the control group, in all four conditions. Although the structure effect seemed to be larger for the control group on total reading time, both groups showed similar patterns in durations— longer for the implausible conditions than the plausible conditions and for the object relative structure than the subject relative structure, and the longest in implausible object relative structure. In other words, the group difference between two groups did not derive merely from a certain condition but equally from all conditions. Thus, it is not only the difficulty from the implausibility that led to longer total reading time for the control group, but the global difficulty in processing the relative structure. In particular, there was no group difference at main clause verb region where the main verb phrase starts. It suggested that parsing the relative structure was a main

difficulty that the control group had during processing. Moreover, it seemed that the control group experienced more difficulties when interpreting the object relative structure. Even though it is not statistically justified there was trend that the control group took longer in the plausible objective relative structure on go-past time and total reading time at the main verb region, compared to the APS group (Figure 5). While the APS group did not have much difficulty in this condition after they first regressed out, the control group continued to spend as much time as in the other implausible condition.

Figure 5. Mean of go-past time, second-pass time, and total reading time at the main verb region in APS and control group.



Note : SRC-PL = Subject relative clause - Plausible, SRC-IM = Subject relative clause - Implausible, ORC-PL = Object relative clause - Plausible, ORC-IM = Object relative clause - Implausible

To summarize, the APS group constructed the structural relation earlier than the control group, especially in the object relative structure. However, despite

the rapid processing, their syntactic processing was not clumsy, or the structure they built was shallower than that of the control group, in that they overcame the difficulties from the implausibility faster. In particular, the APS group had the advantage of parsing the relative structures compared to the control group who had difficulty to process the object relative structure.

5.2. The influence of prosodic phrasing and more 'careful' reading strategy.

These syntactic advantages can be accounted by richer phonological information activated when the readers simulated other speakers' voice (Zhou & Christianson, 2016). In particular, the phonological information such as the prosodic phrasing, might help to organize a sentence into phrases and to specify syntactic segmentation of the sentence (Li & Yang, 2009). It seemed that, with richer phonological information, the APS group more properly phrased the structural units and more easily process the relative structure. We found wrap-up effects only from the APS group. The wrap-up effects, longer reading times around phrase boundaries, occur when a clause or a sentence end is signaled by prosodic cues during silent reading (Hirotani, Frazier, & Rayner, 2006). Luo, Yan, and Zhou (2013) showed that the readers who were signaled at a phrase boundary by the prosodic cue fixated longer on pre-boundary and post-boundary region, compared to those who were not cued. Thus, the presence of the wrap-up effects indicates that the readers are actively using prosodic cues and properly phrasing the structural units. In the target sentences of the experiment, the prosodic boundary is most likely to be present at the end of

the relative clause (e.g. *The cat that chased the mouse // was fast*)[1]. If the participants properly phrased a structural unit, fixation durations at the critical region (pre-boundary) and post region (post-boundary) would increase. APS group showed the structure effect on gaze duration both at the relative clause region and second noun region. They read *mouse* slower in the subject relative structure (*The cat that chased the mouse // was fast.*) than in the object relative structure (*The cat that the mouse chased // was fast.*), and *chased* in the object relative structure (*The mouse that the cat chased // was fast.*) than in the subject relative structure (*The cat that chased the mouse // was fast*.). On the other hand, although the control group also revealed the structure effect at both regions, the gaze duration at the relative clause was reversely longer for the subject relative clause than the object relative clause, which suggested that they did not or were not able to use the prosodic cue. Furthermore, there was a marginal group effect at the post region on gaze duration. It was only effect from all analysis that the APS had longer duration than the control group. As Luo et al. (2013) demonstrated that wrap-up processing also increases the reading time at post-boundary, APS group seemed to read longer at this region due to the wrap-up effect. With these results, we concluded that the APS group had a larger wrap-up effect and hence they were more involved in utilizing prosodic cues. During the wrap-up processing, they were able to settle the relative clause structure earlier and it seemed to help the APS group more easily resolve the structural difficulty for the rest of

[1] In Hirotani et al. (2006), native speakers tended to insert a pause at the end of the relative clause, when there was no prosodic cue such as comma.

processing. On the other hand, the control group who did not properly phrase the sentence, unable to take advantage of the wrap-up effect, was slower to learn the implausibility of the sentence and had more difficulty parsing the relative structure. Provided that the control group regressed more toward the second noun and relative clause region, yielding longer total reading time at the regions, this initial investment through the wrap-up processing brought about more efficient reading in the later processing for the APS group.

Another possible account is that the APS group might utilize more 'careful' reading strategy, parsing the sentence in orderly manner. In the survey, we found the contradicting preference from the APS group. Some preferred the APS reading, while the others did not. Those who preferred believed that it helped them to read word by word and in an orderly way. On the other hand, those who disliked thought it to slow reading rate and to hinder from focusing on the meaning and structure of sentences since they had to read word by word. These different opinions, in fact, pointed out the same issue in APS-reading— when they use APS-reading they had to read in an orderly manner which is the characteristic of speaking. When the readers "appropriately" simulate the speakers' voice, it would not allow them to regress to the previous words or skip some words. For some participants, this orderly manner of reading might be considered slower. They noted, comparing normal reading to APS reading, that the normal reading was faster because they were able to read the sentence concentrating only on the words that they think were important, they were able to scan through whole sentences and grasp the meaning faster, or they do not need to read the sentence word-by-word. However, these opinions were not

consistent with the actual result and human eye-movement mechanism. It is not possible for ordinary readers to scan through whole sentences because of the limited eye span (Rayner & Slattery, 2009) and APS reading was numerically faster than normal reading. In other words, their notes were rather likely to be how they felt about APS reading, in which they believed that they had to read in an orderly, word-by-word fashion. We assume that this orderly manner of reading helped the APS group to pay more attention to each word and structure, which facilitated faster and more concrete syntactic processing.

This manner of reading seems to be related with less 'risky' reading strategy. According to Rayner, Reichle, Stroud, Williams, and Pollatsek (2006), older readers adopted the 'riskier' reading strategy, the reading pattern where they guess the next word more often with the partial information, in order to compensate their overall slow reading. When adopting the riskier reading strategy, readers would show longer saccades and skip more words, but frequently regress to the previous words due to unreliable predictions (Rayner, Castelhano, & Yang, 2009). These characteristics of the riskier reading strategy are opposite to the orderly reading manner that the APS group experienced. In fact, they rarely skipped the content words, their forward saccade amplitudes (length) was relatively short[2], and they did not regress more than L1 readers in Zhou and Christianson (2016). Moreover, compared to the control group, there was a trend that the saccade amplitudes of the APS group (1.48 degree)

[2] The average saccade amplitude for silent reading is 2 degree for readers of English and other alphabetic writing systems (Rayner, 2009), while that of the APS group was 1.48 degree, which was comparable to the average saccade amplitude for oral reading, 1.5 degree.

were numerically shorter than those of the control group (1.82 degree) and they regressed less than the control group (regression- ratio : APS- 39.4% vs. control- 46.3%). Because both groups had average saccade length, rare skips of words, and average regression ratios, it is difficult to consider them to adopt a 'risky' reading strategy. Rather, they both applied a 'careful' reading strategy but the APS group seemed to be more 'careful' in reading process. We presume that simulating the voice required the APS group to adopt more 'careful' reading strategy, which may assist them in paying more attention to each word and syntactic structure.

5.3. Overall reading pattern difference between the APS and control group

The syntactic advantages the APS group had—establishing structural relation earlier and recovering from difficulties faster—led to overall distinct patterns in syntactic processing between the APS group and the control group. The group comparison analysis of sentence reading times revealed a marginal interaction between group and plausibility, which was mostly explained by a smaller or no plausibility effect of APS group. When two groups were separately analyzed, while control group showed a main effect of the plausibility, APS group did not show any effect on the sentence reading times. APS seemed to modulate the second language learners' processing patterns toward less fragile syntactic processing.

Nevertheless, this different patterns in syntactic processing did not induce overall shorter sentence reading times for the APS group. Although APS group read numerically faster than control group, the tendency was not statistically justified. It was inconsistent with Zhou and Christianson (2016), in which the APS group read

significantly faster than the control group. In addition, overall comprehension accuracies of both groups were not distinct from each other. The accuracies were too high across all conditions to reveal the group differences. It was unexpected because L2 Korean speakers in Lim and Christianson (2013b) showed lower accuracy on average, about 70%. The response accuracy in this study was even higher than that of the native speakers in Zhou and Christianson (2016). Because of the ceiling effect, we were not able to find the group differences in comprehension accuracy.

In fact, the target experimental items consisted of short sentences with a rather simple relative clause structure and controlled, easy words. Even for the control group, the sentences would not have been difficult to process fast and accurately. However, since there was a group difference on total reading times at the relative clause verb and second noun region and the sentence reading times for the APS group were numerically faster than for the control group, processing longer sentences with more complicated structures might have different effects on the results. In particular, the group difference occurred mainly from the regions where the control group had relatively more difficulties to parse the structure. Thus, it is possible that the APS group would have more benefit in reading rate and comprehension accuracy, if the target items includes more complex structure, or structures in which prosody plays a larger role, such as including more phrase boundaries.

Even so, the question still remains, why L1 participants in Zhou and Christianson (2016) showed a group difference between the APS and control group who read similar materials. It might indicate different underlying processing

mechanism between L1 and L2 readers. For several possible reasons—because they do not usually speak or listen to second language in an ESL environment, they are less knowledgeable about phonological information, or processing L2 sentence is cognitively too burdensome for them to read and simulate simultaneously— L2 learners might not fully take advantages of APS reading. As a result, the extent to which APS can facilitate the reading rate in L2 processing might be restricted to a certain degree. On the other hand, the participants in this study might not be typical of L2 learners, in that their comprehension accuracy was even higher than that of L1 participants. Because we randomly chose the participants, only requiring some experimental conditions necessary for controlling English proficiency, there is no reason to suppose that they were skewed participants. However, as they all were recruited from the same university, they might not be typical of L2 processors for any reason. Since we did not implement other cognitive measurements relevant with language processing such as working memory capacity, we are not able to confirm the representativeness of the participants at this point. Therefore, further studies are necessary in order to conclude where these different results between this study and L1 study are originated from.

5.4. The effect of speaker's rate on APS group processing

In this study, the APS group showed no difference in speaker's rate, while in Zhou and Christianson (2016), the participants read faster when they simulated a fast speaker than a slow one. Rate difference is important evidence demonstrating that the participants indeed simulated the voice during silent reading. Thus, no rate

effect might suggest that the participants were not able to or did not simulate the voice properly. However, considering different syntactic patterns in sentence processing between the APS and control group, the presence of wrap-up effect in the APS group, and the survey reporting the differences between two readings, it is unreasonable to assume that the APS group did not appropriately perform APS reading.

One of reasons for no rate effect seems to be procedure difference. In Zhou and Christianson (2016), one of the speakers' photographs was randomly presented as a cue before the participants read each sentence. Thus, they had to identify the speaker's characteristics, comparing to the other. On the other hand, this study gave only one speaker in each block, and so the participants did not need to distinguish one speaker to the other. We believed recalling the same speaker within a block to reduce their cognitive load and assist their auditory imagery perception. It might facilitate simulating process, but because they were not required to identify the speakers, it was not necessary for them to apply distinct characteristics of each voice to simulation. As a result, we did not find rate effect for the APS group.

Alternatively, there was no rate effect, because it was hard for some readers to simulate the fast rate speaking. Although two speakers were separately presented in each block, the APS group were able to distinguish two speakers' rates to some degree, provided that some participants reported that simulating a slow speaker was easier. However, some of them might not be able to follow the fast rate speaking, due to their limited phonological skills or poor reading fluency, resulting in rather harmful effect on the processing in terms of reading rate. The results of the sentence

reading times showed large individual variations in the rate effect. Some readers read faster in the fast rate conditions, while the others read slower. Whether simulating the fast rate speaker accelerates or decelerates reading processing might depend on individual simulating skills. Because of those individual variations the rate effects seem to offset each other. However, neither reading fluency nor proficiency predicted the direction of the rate effect. If limited phonological skills were a main reason for the reverse rate effect, those regarded as less fluent should read slower in the fast rate conditions, but that was not the case. Therefore, the first interpretation for no rate effect is more probable, but since there are other factors such as musical ability and experience (Hubbard, 2010) than phonological skills that influence auditory simulation, more research should be further conducted to resolve this issue.

5.5. The limitations of the study and pedagogical implications.

The results demonstrated that APS reading induced faster and more solid syntactic processing in L2 sentence processing. APS as a reading strategy, however, should be further researched before applying to the L2 reading instruction because of several limitations of the study. Above all, there was no group difference in the sentence reading time and comprehension accuracy, despite distinct syntactic processing patterns. It might derive from the idiosyncrasy of the participants in this study. Although the participants were randomly recruited, all of them were the students of the same university, Seoul National University. Since the students in Seoul National University, one of the top universities in South Korea, are known for their high academic achievements, it can be argued that they outperformed typical

L2 learners in working memory capacities, analytical competence, or information processing capacity. These factors might have counteracted the effect of APS, yielding similar, high accuracy of comprehension questions in both the APS reading and control group. Thus, further research will be required to discuss the exact influence of APS reading on L2 reading processing.

Additionally, this study examined the influence of APS only in the sentence base. Using APS in a longer text may reveal different patterns of syntactic processing. Since the APS reading elicited shorter total reading time within the relative clause in which the control group had more difficulties, parsing a longer text with more complex structures that would be possibly assisted by APS may have a larger effect on reading rate and comprehension accuracy. Meanwhile, as the survey showed, a few participants thought APS reading obstructed paying attention to meaning and structure, because the act of simulation gave them an additional cognitive burden. Those loads may become even larger in a longer text, rather hindering L2 learners from efficiently processing it. Therefore, to apply APS as a reading strategy or pedagogical method, there needs to be more research on it in a larger text base.

Furthermore, in this study, there was only one instruction session for APS reading. According to the survey, the participants were able to perform APS during their reading task. However, it was uncertain that they were sufficiently accustomed to utilizing it as their reading strategy with one training session. Several more training sessions may even facilitate APS effect and have a different outcome.

Despite the limitations of this study, APS reading has some pedagogical implications with respect to the importance of phonological processing during silent

reading. It has long been known that the phonological representations play a large role in L2 reading, but the research on it has been mainly conducted to investigate the relationship between phonological representations and syntactic processing, or their role in silent reading. On the other hand, this study focused on how to enhance those phonological representations with a simple method, and whether that information is able to assist in syntactic processing. As a result, we found that the phonological processing can be possibly improved by APS, which positively influenced the interrelated syntactic processing.

In second language educational situations, silent reading necessarily functions as the primary mode of reading and reading instruction, because of classroom settings where a number of students simultaneously participated in reading practice. Regardless of whether educators are aware that reading processing is strongly related with phonological representations such as prosodic phrasing even during silent reading or not, the significance of phonological information in reading processing is often disregarded due to the circumstances or for the convenience and they only focus on the structure and meaning. However, if educators recognize that a small amount of exposure to the educators' or another fluent English speaker's voice and a simple instruction that learners actively simulate the voice can improve their reading processing, they would not necessarily give up all the benefits that the phonological representations offer because of the environmental restrictions.

When APS is applied in instruction, it can be considered as an imaginary version of assisted reading, or reading-while-listening approach, which is an oral reading of a text while simultaneously listening to a fluent rendering of the same text

by a reading partner, by a group reading, or from a recording (Rasinski & Hoffman, 2003). Heckelman (1969) assumed that through simultaneously seeing a text and hearing the words spoken by a more able reader, neurological memory trace would be established in the mind of the less able reader. Several studies showed that assisted reading improves L2 readers' comprehension and reading fluency (Kim, 2012; Taguchi, Takayasu-Maass, & Gorsuch, 2004). APS, perceived 'hearing' simulation, obviously will not have exactly the same effects with real listening practice in assisted reading, since it lacks simultaneous modelling from more fluent readers. APS is, however, more efficient and practical in classroom settings where silent reading is a primary mode of instruction and a number of students are simultaneously engaged in the class, and particularly in foreign language instructional situations where fluent readers are less available. Additionally, APS has its own advantages in that readers can actively choose extensive reading materials they prefer regardless of resources, and they can read them in their own comprehension pace. To summarize, APS may function as an assisted reading instruction of silent reading, which is simpler and less influenced by the class-room setting.

Chapter 6 Conclusion

This thesis investigated the influence of APS reading on L2 sentence processing and its role as a reading strategy. The results showed that the APS group processed the syntactic representation faster than the control group. The early measures of eye-tracking revealed that the APS group detected the implausibility of the sentence at the critical region in the object relative clause structure while the control group did it at the post region, indicating that APS reading group established a proper structural relation earlier than the control group did. Moreover, despite the rapid syntactic processing, the syntactic structures APS group constructed were not shallower nor weaker than those of the control group. The APS reading group fixated significantly shorter at the relative clause verb and second noun region on the total reading time, the late measure. They required less time to overcome difficulties from the implausibility and structural processing, compared to the control group. The differences in syntactic processing of each region eventually led to the pattern difference in sentence reading times between two groups. The APS group showed no plausibility effect in sentence reading times, whereas the control group read significantly slower in the implausible sentences than in the plausible sentences. It demonstrated that APS reading helped L2 learners become less dependent on the world knowledge and pay more attention to the syntactic structure.

These syntactic advantages seemed to be derived from two possible factors. First, the simulation of other speakers' voice during silent reading induced the richer phonological representations to the participants. During APS reading, L2 learners

can utilize more salient prosodic information such as prosodic phrasing and it enables them to parse the relative clause structure more easily. The presence of prosodic phrasing was evidenced by the wrap-up effect which was found only from APS group. Secondly, the APS reading group seemed to adopt more ‘careful’ reading strategy than the control group, due to its characteristics of ‘listening’. With more ‘careful’ reading strategy, APS group skipped less and regressed less, which allowed them to pay more attention to the syntactic structure.

Although the results partially supported the positive effect of APS reading on L2 syntactic processing, future research will be necessary before it can be applied in L2 educational settings, because of several limitations of the study. Above all, inconsistent with L1 study, there was no difference in response accuracy and sentence reading times between two groups. It might suggest the limitation of APS effect in L2 reading, or the idiosyncrasy of the participants in this study. Moreover, since this study focused on single sentence processing, it is difficult to directly extend the results to a larger text which is mainly used in learning context. Therefore, further studies need to be conducted to investigate the effect of APS on a larger context and a variety of L2 readers.

Despite of several limitations, the study presented some pedagogical implications for fast and accurate reading processing in L2 reading instruction. First, it highlights the importance of phonological representations during silent reading, which has been disregarded due to L2 instruction environment. Secondly, it demonstrated that the phonological representation and its interrelated syntactic processing can be improved by a simple instruction such as APS reading. In

conclusion, this study provides basic directions for future research and a possibility that APS reading can be utilized as an efficient reading strategy for L2 learners whose syntactic processing is weak and slow.

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Appendices

Appendix A

1	(a)	The chef that ruined the food was in the kitchen.
	(b)	The food that ruined the chef was in the kitchen.
	(c)	The food that the chef ruined was in the kitchen.
	(d)	The chef that the food ruined was in the kitchen.
2	(a)	The cop that pursued the thief was driving a car.
	(b)	The thief that pursued the cop was driving a car.
	(c)	The thief that the cop pursued was driving a car.
	(d)	The cop that the thief pursued was driving a car.
3	(a)	The cat that chased the mouse was fast.
	(b)	The mouse that chased the cat was fast.
	(c)	The mouse that the cat chased was fast.
	(d)	The cat that the mouse chased was fast.
4	(a)	The ghost that scared the boy was hiding behind a curtain.
	(b)	The boy that scared the ghost was hiding behind a curtain.
	(c)	The boy that the ghost scared was hiding behind a curtain.
	(d)	The ghost that the boy scared was hiding behind a curtain.
5	(a)	The bird that ate the worm was small.
	(b)	The worm that ate the bird was small.
	(c)	The worm that the bird ate was small.
	(d)	The bird that the worm ate was small.
6	(a)	The hunter that shot the deer was in the Rocky Mountains.
	(b)	The deer that shot the hunter was in the Rocky Mountains.
	(c)	The deer that the hunter shot was in the Rocky Mountains.
	(d)	The hunter that the deer shot was in the Rocky Mountains.
7	(a)	The lawyer that sued the doctor was smart.
	(b)	The doctor that sued the lawyer was smart.
	(c)	The doctor that the lawyer sued was smart.
	(d)	The lawyer that the doctor sued was smart.
8	(a)	The coach that scolded the player won the championship twice.
	(b)	The player that scolded the coach won the championship twice.
	(c)	The player that the coach scolded won the championship twice.
	(d)	The coach that the player scolded won the championship twice.
9	(a)	The owner that fed the cat was sitting on a sofa.
	(b)	The cat that fed the owner was sitting on a sofa.
	(c)	The cat that the owner fed was sitting on a sofa.
	(d)	The owner that the cat fed was sitting on a sofa.

10	(a)	The man that walked the dog was in the park.
	(b)	The dog that walked the man was in the park.
	(c)	The dog that the man walked was in the park.
	(d)	The man that the dog walked was in the park.
11	(a)	The father that scolded the teenager was in the living room.
	(b)	The teenager that scolded the father was in the living room.
	(c)	The teenager that the father scolded was in the living room.
	(d)	The father that the teenager scolded was in the living room.
12	(a)	The guide that led the tourist liked Europe a lot.
	(b)	The tourist that led the guide liked Europe a lot.
	(c)	The tourist that the guide led liked Europe a lot.
	(d)	The guide that the tourist led liked Europe a lot.
13	(a)	The waiter that served the guest was tall.
	(b)	The guest that served the waiter was tall.
	(c)	The guest that the waiter served was tall.
	(d)	The waiter that the guest served was tall.
14	(a)	The soldier that protected the villager was brave.
	(b)	The villager that protected the soldier was brave.
	(c)	The villager that the soldier protected was brave.
	(d)	The soldier that the villager protected was brave.
15	(a)	The fly that ate the frog was green.
	(b)	The frog that ate the fly was green.
	(c)	The frog that the fly ate was green.
	(d)	The fly that the frog ate was green.
16	(a)	The doctor that treated the patient was female.
	(b)	The patient that treated the doctor was female.
	(c)	The patient that the doctor treated was female.
	(d)	The doctor that the patient treated was female.
17	(a)	The detective that investigated the suspect was very tired.
	(b)	The suspect that investigated the detective was very tired.
	(c)	The suspect that the detective investigated was very tired.
	(d)	The detective that the suspect investigated was very tired.
18	(a)	The dog that bit the man was in the yard.
	(b)	The man that bit the dog was in the yard.
	(c)	The man that the dog bit was in the yard.
	(d)	The dog that the man bit was in the yard.
19	(a)	The golfer that hit the ball was in the shade.
	(b)	The ball that hit the golfer was in the shade.
	(c)	The ball that the golfer hit was in the shade.
	(d)	The golfer that the ball hit was in the shade.
20	(a)	The mother that bathed the child smelled nice.
	(b)	The child that bathed the mother smelled nice.

	(c)	The child that the mother bathed smelled nice.
	(d)	The mother that the child bathed smelled nice.
21	(a)	The bird that protected the chick was in the big tree.
	(b)	The chick that protected the bird was in the big tree.
	(c)	The chick that the bird protected was in the big tree.
	(d)	The bird that the chick protected was in the big tree.
22	(a)	The reporter that interviewed the actress was at the coffee shop.
	(b)	The actress that interviewed the reporter was at the coffee shop.
	(c)	The actress that the reporter interviewed was at the coffee shop.
	(d)	The reporter that the actress interviewed was at the coffee shop.
23	(a)	The grandmother that dressed the child had a beautiful smile.
	(b)	The child that dressed the grandmother had a beautiful smile.
	(c)	The child that the grandmother dressed had a beautiful smile.
	(d)	The grandmother that the child dressed had a beautiful smile.
24	(a)	The tutor that taught the student solved the math problem.
	(b)	The student that taught the tutor solved the math problem.
	(c)	The student that the tutor taught solved the math problem.
	(d)	The tutor that the student taught solved the math problem.
25	(a)	The consultant that advised the client was very clever.
	(b)	The client that advised the consultant was very clever.
	(c)	The client that the consultant advised was very clever.
	(d)	The consultant that the client advised was very clever.
26	(a)	The kids that obeyed the teacher enjoyed the summer break.
	(b)	The teacher that obeyed the kids enjoyed the summer break.
	(c)	The teacher that the kids obeyed enjoyed the summer break.
	(d)	The kids that the teacher obeyed enjoyed the summer break.
27	(a)	The criminal that kidnapped the girl was on CNN news.
	(b)	The girl that kidnapped the criminal was on CNN news.
	(c)	The girl that the criminal kidnapped was on CNN news.
	(d)	The criminal that the girl kidnapped was on CNN news.
28	(a)	The boss that fired the worker was unhappy.
	(b)	The worker that fired the boss was unhappy.
	(c)	The worker that the boss fired was unhappy.
	(d)	The boss that the worker fired was unhappy.
29	(a)	The volunteer that helped the blind was very handsome.
	(b)	The blind that helped the volunteer was very handsome.
	(c)	The blind that the volunteer helped was very handsome.
	(d)	The volunteer that the blind helped was very handsome.
30	(a)	The parent that raised the twins lived in New York.
	(b)	The twins that raised the parent lived in New York.
	(c)	The twins that the parent raised lived in New York.
	(d)	The parent that the twins raised lived in New York.

31 (a) The lawyer that defended the client was worried about the result.
(b) The client that defended the lawyer was worried about the result.
(c) The client that the lawyer defended was worried about the result.
(d) The lawyer that the client defended was worried about the result.

32 (a) The conductor that led the orchestra was pleased with the performance.
(b) The orchestra that led the conductor was pleased with the performance.
(c) The orchestra that the conductor led was pleased with the performance.
(d) The conductor that the orchestra led was pleased with the performance.

Appendix B

Script 1

Good morning, students. In today's class, we're going to talk about how to slow down aging. But before we discuss it, let's think about what influences how fast people age. First of all, genes play a major role. They affect how much hair we lose and how easily we gain weight. A second influence is our lifestyle. Older looking skin and wrinkles can be caused by too much sun exposure in our youth, especially if we have active, outdoor lifestyles. Social relationships are a third factor. Older people who feel isolated or lonely often age faster than those who don't have those feelings. But older people who are more socially active age slower and live longer than those who aren't. Lastly, poor nutrition is another important factor that speeds aging. It significantly increases the risk of developing systemic diseases such as diabetes, cancer and heart disease. Now I'm going to show you some video clips related to today's topic.

(a) The effect of too much sun exposure
(b) How to prevent heart disease
(c) Important factors that speeds aging
(d) How to slow down aging

Script 2

Hello, everyone. As you know, eating after 8 p.m. has a bad reputation. But, in reality, eating certain foods at night can actually have some surprising health benefits. For example, eating high-protein peanut butter at night can help you build muscle while you sleep. Also, eating tomato soup at night can help control your blood sugar the next day, and even help you regulate your appetite. Some nighttime snacks even help you relax and get ready for bed, such as roasted pumpkin seeds. Pumpkin seeds are high in magnesium, which relaxes the body. Magnesium is an essential mineral that is used in more than 300 reactions in your body. In addition, the cold sweetness of frozen blueberries is very refreshing at the end of the day, since nutrients in blueberries can help improve brain function and heart health. Remember, food is fuel! As long as you eat the right things, it's absolutely fine to eat before bed.

(a) The negative effect of eating frozen blueberries
(b) How to improve brain function and heart health
(c) The health benefits of eating at night

(d) How to regulate one's appetite

Script 3

Good morning, everyone. Spring's here and more people are interested in getting into shape. But it's not easy to find time to go to the gym. There are some good ways to exercise in your daily life. At the office, set your alarm so that you can stand up every hour. Do simple exercises before sitting back down. When you commute, walk, walk, and walk. Get off the bus a few stops ahead and walk. At the subway station, walk around the platform while waiting for a train. In the shopping mall, make it a rule to go around the whole mall at least twice before you make a decision. Two hours of shopping burns as much as 300 calories. At home, dance or do some stretching exercises while you're watching TV in your living room. Remember: The more you move your body, the healthier and happier you get!

(a) The safety guidelines for exercise
(b) The ways to exercise in everyday life
(c) The advantages of working out at a gym
(d) The roles of exercise in dealing with stress

Script 4

Good afternoon. Last time we talked about how to choose a topic for your speech. Even if your topic sounds really interesting, you cannot make a successful speech if the opening is not attractive. So, today let me tell you some powerful ways to begin a speech effectively. First, you can ask a question. It can make the audience curious, leading them to engage in what you are saying. Second, you can use visual aids such as a video clip or a photograph to make your speech more entertaining. If your speech topic is related to the environment or science, you can use a map or a graph. Finally, you can tell a personal story, if it's clearly connected to the topic of your speech. It'll make your speech more memorable. These techniques can help you make a good start in your speech. Now it's time for you to practice.

(a) The necessities for analyzing an audience
(b) The importance of a good topic in a speech
(c) The various reasons for sharing personal stories
(d) The effective ways to start a speech

Appendix C

[실험 내용 및 영어학습 경험에 대한 설문조사]

ㅁ APS 읽기방식에 대한 설문

본 실험에 대한 간략한 설문을 진행하오니 지금까지의 실험에 대해서 떠올리며 물음에 답하여 주세요. 먼저 본 실험에서와 같은 방식으로 문장 읽기를 진행하도록 하겠습니다.

[실험과 동일하게 사진제시 후 문장제시]

1. 나는 사진을 보았을 때 사진 속 인물의 목소리가 잘 떠올랐다.

(전혀 그렇지 않다.) 1 2 3 4 (매우 그렇다)

2. 나는 사진 속 인물의 목소리를 떠올리며 사진 속의 인물이 읽는 것처럼 주어진 문장을 읽는 것이 가능하였다.

(전혀 그렇지 않다.) 1 2 3 4 (매우 그렇다)

3. 본 실험과 같은 방식으로 영어를 읽는 것이 독해를 하는 데에 도움이 되었다.

(전혀 그렇지 않다.) 1 2 3 4 (매우 그렇다)

3-1. 위와 같이 답한 이유를 간략히 서술해주세요.

( )

다음으로는 위와 같은 방식이 아닌 일반적인 읽기 방식 (평소 읽는 방식)으로 문장 읽기를 진행하도록 하겠습니다.

[사진 없이 문장만 제시]

4. 나는 지금과 같이 일반적인 방식으로 읽었을 때와 인물의 목소리를 떠올리면서 읽는 방식 간에 차이가 느껴진다.

(전혀 그렇지 않다.) 1 2 3 4 (매우 그렇다)

4-1. 위와 같이 답한 이유를 간략히 서술해주세요.(차이가 있다면 어떤 점에서 차이가 있다고 생각되는지)

(   )

5. 일반적인 방식과 비교하였을 때 본 실험과 같은 방식으로 영어를 읽는 것이 독해를 하는 것에 도움이 되었다.

(전혀 그렇지 않다.) 1　　2　　3　　4 (매우 그렇다)

6. 나는 평소에 영어읽기를 할 때 속으로 소리를 내어 읽는다.

(전혀 그렇지 않다.) 1　　2　　3　　4 (매우 그렇다)

ㅁ 영어실력에 대한 자가평가.

다음의 제시된 기준을 보고 개인에게 해당되는 기준을 선택하여 주세요.

말하기 (1　　2　　3　　4　　5　　6)

읽기 (1　　2　　3　　4　　5　　6)

듣기 (1　　2　　3　　4　　5　　6)

	말하기	읽기	듣기
1	일반 생활에서 자주 사용되는 간단한 언어적 표현을 구사할 수 있다. (자기 및 타인 소개, 그에 관한 기초적인 질문 및 대답)	일반 생활에서 자주 사용되는 간단한 언어적 표현을 이해할 수 있다.	
2	자주 사용되는 직접적으로 연계되는 언어적 표현을 구사할 수 있다. (사람, 직장, 주변환경 등과 관련되는 사항 묘사)	자주 사용되는 직접적으로 연계되는 언어적 표현을 이해할 수 있다.	
3	말하기 간에 발생될 수 있는 상황을 간단한 언어를 사용해 극복할 수 있다. (주제에 관련된 간단한 표현, 희망, 목적, 의도 등의 묘사)	명확한 표준어에 대한 요점을 이해할 수 있다.	
4	일부 분야에 대해서는 전문적인 토론이 가능하고 대화에서 큰 불편 없이 의사소통이 가능하다.	세부적이고, 추상적인 보다 복잡한 내용을 이해할 수 있다.	
5	명확하고 체계적으로 복잡한 상황을 표현하고, 적합하고 다양한 문장연결표현을 사용한다.	광범위한 분야의 긴문장과 내재된 의미를 이해할 수 있다.	
6	복잡한 상황에서 즉흥적으로 매우 유창하고 정확하게 표현할 수 있다.	실질적인 모든 읽기, 듣기에서 노력없이 이해할 수 있다.	

Appendix D

Script for oral reading fluency evaluation

Spider was a hungry one, he always wanted to eat. Everybody in Ashanti knew about his appetite. He was greedy, too, and always wanted more than his share of things. So people steered clear of Spider.

But one day a stranger came to Spider's habitation out in the back country. His name was Turtle. Turtle was a long way from his home. He had been walking all day in the hot sun, and he was tired and hungry. So Spider had to invite Turtle into his house and offer him something to eat. He hated to do it, but if he didn't extend hospitality to a tired traveler it would get around the countryside and people would soon be talking about Spider behind his back.

Oral reading fluency scale

Level 4 – Reads primarily in larger, meaningful phrase groups. Although some regressions, repetitions, and deviations from text may be present, these do not appear to detract from the overall structure of the text. Preservation of the author's syntax is consistent. *Variations in pitch (intonation) and stress patterns exhibit the rhythmic aspect of oral language.*

Level 3 – Reads primarily in three- or four-word phrase groups. Some smaller groups may be present. However, the majority of phrasing seems appropriate and preserves the syntax of the author. *There are variations in pitch (intonation) and stress patterns and the majority of these patterns sound appropriate*.

Level 2 – Reads primarily in two-word phrases with some three- or four-word groupings. Some word-by-word reading may be present. Word groups may seem awkward and unrelated to larger context of sentence or passage. *There are few variations in pitch (intonation) and stress patterns or the variations often sound inappropriate and awkward.*

Level 1 – Reads primarily word-by-word. Occasional two-word or three-word phrases may occur – but these are infrequent and/or they do not preserve meaningful syntax. *Reads in a monotone without variations in pitch or stress patterns.*

Appendix E

Group	3-1. The reason why APS reading was beneficial / harmful	4-1. Comparison between APS reading and ordinary reading
APS	단어별로 끊어읽기가 가능했다.	일반적인 읽기방식은 문장을 더 빨리 읽게 된다. 중요하다고 생각되는 서술어 위주로 읽는다.
	목소리를 떠올리는 것과 문장을 이해하는 것을 동시에 하는 것이 어려웠다.	평소에 속읽기를 하는 스타일이어서 그런 것 같다.
	평소에 읽을 때 목소리를 생각하지 않기 때문에 새로운 방식으로 읽는 것이 익숙하지 않았다.	목소리를 떠올리지 않고 읽는 것이 더 편합니다. 평소에 그렇게 읽기 때문인 것 같습니다.
	목소리 상상이 영어 독해 속도를 저하한다.	속도가 차이가 난다.
	차근차근 읽는 데에는 도움이 된 것 같으나, 다른 것에 집중하느라 문장의 내용과 구조에 집중하기 힘들었다.	일반적인 방식으로는 앞 단어부터 완전히 차례대로 읽는 것이 아니라 문장 전체를 보고 내용을 빠르게 파악할 수 있으나 목소리를 떠올리면서 읽으면 천천히 차례대로 읽게 된다.
	말하는 속도가 느렸고 단어를 끊으면서 말하는 화자였기 때문에 떠올리며 따라할 때 독해하기 더 쉬웠다.	원래 읽는 방식이 더욱 빨랐기 때문에 차이를 느꼈다.
	읽는 속도가 느려지고, 헷갈리는 내용일 경우 암기력이 떨어지는듯 싶다.	목소리를 떠올리며 읽을 때에는 실제로 목소리를 내서 읽는 것 마냥 시간이 더 걸린다.
	머릿속에서 소리 내어 읽는 것이 잘 된다.	속으로 소리 내어 읽는 크기나 속도가 제시되지 않아서.
	사진과 목소리 사이의 간극이 꽤 있었다. 아이 목소리에 성인 여자 사진이 매칭되는 것이 이상했다.	원어민의 목소리 대로 읽으니까 더 매끄럽고 빠르게 읽어졌다.
	읽어주는느낌이 처음에는 들었는데 갈수록 목소리가 잊혀졌다.	목소리를떠올리면 읽는게 아니고 듣는느낌이다.
	목소리를 떠올리며 글을 읽는 것이 원래 글을 읽는 속도를 방해하는 느낌이었다.	눈으로 문장을 쭉 읽는 방식은 목소리를 떠올리며 단어를 하나씩 읽을 필요가 없어서 속도가 더 빨랐다.

	실험과 같은 방식으로 읽을 때 평소보다 더 신경을 쓰면서 읽게 되어서 오히려 시간도 오래 걸리고 헷갈렸다.	더 빨리 정확히 읽을 수 있다.
	음성을 인식하면서 문장을 읽는 경우 음성정보에 대한 추가적 인식으로 인해 독해가 지연됨.	타인의 목소리와 무관하게 해석에만 집중 가능.
	빠르게 읽을 수 있었음.	평소에도 사진 속 사람의 말하기처럼 머릿속에서 빨리 읽기 때문에 큰 차이가 느껴지지 않음.
	목소리를 생각하면서 읽는게 쉽지 않았다.	좀 더 잘 읽히는 것 같다.
	본 실험과 같은 방식으로 영어를 읽다 보니 더 기억에 잘 남는 느낌이 들었다.	인물의 목소리를 떠올릴 때 그 사람이 마치 말하고 있는 것 같아 기억에 더 잘 남는다.
	인물의 목소리를 떠올리는 것에 집중하느라 평소보다 독해 속도가 늦어졌다.	일반적으로 읽을 때 문장에 더 집중되고 이해가 잘 된다.
	평소 모든 문장을 다 머릿속으로 읽으면서 독해하지는 않아서.	목소리를 떠올리면서 읽었을 때 상황이 더 구체적으로 그려졌다.
Control	제인이 경찰관으로 잘 대입해서 읽히지 않았다.	문장을 읽어가면서 그 상황에 대한 상을 그릴 수 있었기 때문이다.
	사진 속에 있는 사람의 이미지와 문장의 내용이 어울리는 것 같았다.	전에 본 그림의 영향으로 차이가 없다.
	인물의 목소리를 상상하는 것은 문장을 기억하는 데에는 도움이 되는 것 같은데 독해와는 큰 관련이 없다고 느껴졌다.	인물의 목소리를 떠올리면서 읽는 방식은 문장이 읽혀졌을 법한 상황을 생각하면서 문장을 기억하는 데 도움이 되었던 것 같지만 일반적인 방식으로 읽었을 때에는 문장이 독해만 되고 기억에 잘 남지는 않는 것 같다.
	도움이된다.	아니다
	실제 그 장면 속에 내가 있다고 생각하니 더 몰입이 잘 되었다.	누군가의 말이라기 보다는 단순 정보로써 다가와진다.

	내용 자체를 이해하는 데 크게 영향을 미치는 것 같지는 않았다. 그런데 만약 내용이 해당 사진 인물의 이미지와 일치하는 부분이 있었다면 더 내용이해가 잘되었을 것 같다. 예를 들어서 로맨틱한 내용의 문장인데 그 화자에 대응되는 성별과 이미지의 사진이 나오면 아마 내용이 더욱 생생하게 이해될 것이다.	내용이 다른 컨텍스트를 요구하지 않는 평범한 내용이라서 그냥 무미건조하게 와닿았기 때문이다.
	상상하면서 읽는 데 시간이 더 걸리는 것 같아서.	더 빨리 읽히고 문장이 강조하는 지점이 없게 느껴진다.
	원어민의 억양, 강세를 생각하며 읽는 것이 영어 문장의 어감과 의미를 잘 전달하는 것 같다.	평소에 한글로 된 책을 읽을 때 누군가의 목소리를 머리 속에 떠올리면서 읽지 않지만 앞의 단계에서는 그랬고 현재 단계에서는 영어 문장이긴 하지만 짧기 때문에 굳이 누군가의 목소리를 떠올리지 않고 한글로 된 책을 읽듯이 읽었다.
	독해에 도움이 되는 지는 잘 모르겠습니다.	인물의 목소리를 떠올리면서 읽으면 억양과 호흡에 차이가 생긴다.
	목소리를 떠올리는 것과 문장을 이해하는 것 간에 큰 관계가 있다고 생각되지는 않았다.	약간의 차이가 느껴지기는 한다. 목소리를 떠올렸을 때 좀 더 특정 맥락 하에서 읽는 것 같았다.
	인물의 목소리가 어떨지에 집중하게 되어서.	인물의 목소리를 떠올리는 것에 비해 문장 자체에 집중할 수 있었다.
	의식적으로 생각하려하다보니 집중이 조금 떨어짐.	조금더 편한 마음으로 읽어서 더 집중할 수 있었음.
	문장의 악센트가 상상되었다. 중요한 부분에 집중이 더 잘되었다.	혼자 읽을 때는 중요한 부분에 더 집중이 되지 않는다.
	그사람의 외형을 보고 목소리를 예측할 수 있었지만 그걸로 문장을 이해하는데 도움이 되었다고는 생각하지 않는다. 오히려 그사람이 어떤 억양으로 이야기했을지 상상하느라 독해에 방해가 되는 느낌도 있었다.	분명 억양을 상상하면서 읽는건 실제 그사람과 대화하고 있다는 기분을 어느정도 느낄 수 있는 방식인듯 하다.

	딱히 특정 인물의 목소리를 떠올리며 읽는 것만으로는 독해력 향상에 도움이 된다고 생각하지 않는다.	앞서 인물의 목소리를 상상하면서 읽기 보다는 평소 습관대로 읽다보니까 읽는 속도가 더 빠르다.
	외국 경험이 별로 없어서 얼굴을 보았을 때 목소리가 잘 상상되지 않습니다.	특별히 지인 중에 누가 자주 사용하던 표현이어서 딱 그 사람의 목소리가 생각나는 것이 아니라면 목소리가 잘 떠오르지도 않고 별 도움이 되지 않는 것 같습니다.
	연설을 할 때는 중요한 부분을 강조하며 말을 하는데 이러한 방법은 독해를 할 때도 통용될 수 있을 것 같습니다.	일반적인 방식으로 읽었을 때는 그냥 훑는다는 식으로 읽었는데 앞에서 인물의 목소릴 떠올리며 읽었을 때는 좀 더 문장 자체에 집중하는 느낌이었습니다.
	목소리를 상상하고 읽는 두 번의 과정을 거쳐야해서 독해에 더 오랜 시간이 걸린다.	문장에만 더 집중하게 된다. 어떤 인물이 문장을 말하는지는 독해에 중요하지 않다.

국문 초록

제 2 언어 읽기처리과정에서 청각시뮬레이션이 미치는 영향 : 안구운동추적 연구

본 논문의 목적은 청각시뮬레이션를 활용한 읽기 (APS 읽기)가 제 2 언어 학습자의 읽기처리과정에서 좀 더 정확하고 빠른 통사처리과정을 유도할 수 있는지를 연구하는 것이다. 독자들은 묵독 (silent reading)을 할 때 그들 자신의 목소리('inner voice')를 머릿 속에서 들을 수 있는 것처럼, 다른 사람의 목소리도 상상을 통해서 들을 수 있는데, 이러한 현상은 '청각 시뮬레이션' (auditory perceptual simulation)이라고 불린다. APS 읽기는 이러한 '청각 시뮬레이션'을 활용한 읽기 방법이다 (Zhou & Christianson, 2016). APS 읽기에서, 독자들은, 단순히 속으로 읽는 것이 아니라, 보다 의식적으로 다른 화자가 글을 읽어 주고 있다고 머릿 속으로 상상하면서 읽게 된다. Zhou and Christianson (2016) 은 이 과정을 통해서 영어 원어민들이 그것을 활용하지 않는 독자에 비해서 더 빠르고 정확하게 읽기를 할 수 있다는 것을 발견하였다. 그들은 APS 읽기에 의해서 운율(prosodic) 정보가 좀 더 명확히 처리되고 이와 밀접하게 연결된 통사적 재현이 함께 증진되어서, 독자들이 더 정확하고 빠르게 통사적 처리를 하게 된다고 주장하였다.

비록 제 2 언어 학습자의 통사적 처리는 원어민에 비해서 덜 정확하다고 알려져있지만, 많은 연구들은 제2언어 학습자들도 특정 상황 하에서 통사적 처리를 보완하고 더 정확한 통사적 재현을 구축할 수 있다는 것을 보여주었다 (Leeser, Brandl, & Weissglass, 2011; Lim & Ahn, 2015; Lim & Christianson, 2013a, 2013b, 2015; Williams, 2006). 가령, 제 2 언어 학습자들은 번역과제와 같은 특정 과제를 수행할 때에 보다 정밀한 통사적 처리를 할 수 있게 된다 (Lim & Ahn, 2015; Lim & Christianson, 2013a, 2013b, 2015). 번역과제를 진행하면서, 제 2 언어 학습자들은 통사적 구조에 더 주목하게 되고, 이는 더 정확한 통사적 처리를 가능하게 하였다.

하지만 번역과제와 같은 과제들은, 더 정확한 통사적 처리에만 초점을 두어, 속도와 효율성이라는 중요한 의사소통의 목표를 놓치고 있다. 번역과제는, 번역을 하는 과정때문에, 비록 제 2 언어 학습자들의 통사처리과정을 개선하였을지라도, 학습자들이 문장을 이해하는데에는 결과적으로 더 많은 시간을 걸리게 한다. 대조적으로 APS 읽기는 통사적으로 더 정확한 읽기를 가능하게할 뿐만 아니라, 동시에 Zhou and Christianson (2016)의 원어민 화자의 실험결과에서 나타난 것처럼 읽기의 속도도 증진시킨다. 만약에 제 2 언어학습자들이 묵독의 과정에서 APS 를 활용할 수 있고 APS 읽기가 주는 이점을 얻게 된다면, APS 읽기는 통사적 처리가 부족한 제2언어학습자들에게 더 효율적인 읽기방법이 될 것이다. 이러한 관점에서 본 연구는 비슷한 실험방법을 제 2 언어 학습자에게 적용하여, Zhou and Christianson (2016)의 연구에서 APS 읽기가 원어민

화자의 읽기과정에 영향을 주었던 것처럼, 제 2 언어학습자의 읽기처리를 증진시킬 수 있을지를 탐구하고자 한다.

이를 위해서, 두 안구운동추적(eye-tracking) 실험이 진행되었다. 첫번째 실험에서, 통제집단의 실험참여자들은 (1)과 같은 문장을 읽고 (2)와 같은 확인 문장에 답을 하였다.

(1) a. The cat that chased the mouse was fast. (Subject relative clause -Plausible)
b. The mouse that chased the cat was fast. (Subject relative clause -Implausible)
c. The mouse that the cat chased was fast. (Object relative clause -Plausible)
d. The cat that the mouse chased was fast. (Object relative clause -Implausible)

(2) a. The cat chased the mouse. The cat was fast. (The verification for 1a and 1c)
b. The mouse chased the cat. The cat was fast. (The verification for 1b and 1d)

위의 실험문장들은 개연성효과(plausibility effect)를 활용하기 위하여 설계되었다. 개연성 효과는 독자들이 자신들의 세상에 대한 지식에 비추어 개연성이 떨어지는 문장을 읽었을 때, 그렇지 않은 문장을 읽었을 때에 비해서 더 많은 시간이 걸리는 것을 의미한다. 증가된 시간은 구체적으로 두 가지의 읽기 처리과정을 나타낸다. 첫번째로 이것은, 독자들이 문장을 올바르게 해석한 후에야 (“쥐가 고양이를 쫓는다”) 문장의 개연성이 부족하다는 것을 인지할 수 있기 때문에, 독자가 올바르게 문장관계를 정립하였다는 것을 보여준다. 두번째로, 독자들은 그들이 정립한 문장의 구조가 튼튼하지 못하고 믿을만하지 못할 때 어려움을 극복하는 데에 더 많은 시간이 필요할 것이므로, 독자들의 통사적 재현이 불완전하다는 것을 의미한다. 전자는

안구운동추적의 초기측정치(early measures)에 반영될 것이고, 후자는 후기측정치(late measures)에 반영될 것이다.

두번째 실험에서, 참여자들은 APS 읽기를 활용하여 읽기과제를 수행하였다. 그들은 APS 읽기방식에 따라 먼저 녹음된 원어민화자의 음성을 들었고, 그 다음에 그 화자가 자신들에게 문장을 읽어주고 있다고 상상을 하면서 문장을 읽었다. 만약에 APS 읽기가 제 2 언어 학습자의 통사적 처리를 증진시켰다면, 개연성효과는 APS 읽기집단에서 통제집단에 비해 더 빠르게 나타날 것이고 더 빠르게 사라질 것이다. 더욱이 만약에 그러한 통사적 이점이 전반적인 읽기과정에 영향을 미친다면, APS 읽기집단은 통제집단에 비해서 문장을 더 빠르고 더 정확하게 읽게 될 것이다.

실험의 결과는 APS집단이 문장의 비개연성을 통제집단에서 더 빠르게 감지하였고, 더 빨리 비개연성으로 부터 발생된 어려움을 극복하였다는 것을 보여준다. 초기 측정지 분석에 따르면, 통제집단은 (1d)와 같이 상대적으로 해석이 어려운 목적격 관계대명사절의 핵심영역(critical regions)에서 문장의 비개연성을 알아차리지 못했지만, APS 읽기 집단은 목적격 관계대명사절에서도 문장의 비개연성을 핵심영역(critical regions)에서 알아차렸다. 이것은 APS읽기 집단이 통제집단에 비해서 더 빠르게 문장의 구조를 정립하였다는 것을 의미한다. 한편, 후기측정치 분석은 APS읽기 집단이 (1a)에서 (1d)까지 모든 조건에서 통제그룹에 비해 더 짧게 핵심영역을 응시하였다는 것을 보여주었다. 이런 결과는 APS 읽기 집단이 문장의 비개연성을 해석하는 데 뿐만 아니라 관계대명사절을 해석하는 전반에 있어서 더 빠르게 어려움을

극복하였음을 나타낸다. 요약하면, APS읽기는 제2언어학습자가 통사적 처리에 더 주의를 기울이게 돕고, 보다 정확한 통사구조를 정립하는 것에 도움을 주었다.

이러한 각 문장 영역에서의 통사적 처리의 차이는 두 집단 사이의 읽기 양상의 차이로 이어졌다. APS 읽기 집단은 문장전체읽기시간에서 개연성 효과가 나타나지 않았지만, 통제집단은 개연성이 부족한 문장을 읽을 때 더 오랜 시간이 걸렸다. 이러한 양상에서의 차이가 읽기 속도의 증가와 정답률의 증가로 이어지지는 않았다. 두 집단 모두 동등하게 높은 문장에 대한 이해도를 보였으며, APS읽기 집단의 문장읽기시간은 통제집단에 비해서 길지 않았다.

결론적으로, APS 읽기는 제2언어학습자가 더 튼튼한 통사적 구조를 더 빠르게 정립하는 데에 도움을 줌으로써 그들의 통사적 처리과정을 증진시켰다. 하지만 이러한 통사적 증진이 그들의 읽기 속도를 느리게 하거나 문장 전체의 이해도를 떨어뜨리지는 않았다. 그러므로, 비록 이를 제2언어 학습자의 교육방법으로 적용하기 전에 많은 후속연구가 필요하겠지만, APS읽기는 제2언어학습자의 더 빠르고 더 정확한 읽기를 위한 효율적 읽기방식으로 고려될 수 있을 것이다.

주요어 : 제2언어 습득, 제2언어 읽기, 안구운동추적 실험, 청각 시뮬레이션, 제2언어 통사처리, 내포 운율감

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