This paper aimed to identify factors that inhibit effective second language (L2) reading and to suggest technology-enhanced reading designed for providing L2 readers with bootstrapping resources. To this end, this paper also addresses the importance of syntactic and prosodic awareness in L2 reading, drawing on L2 reading theories and a number of empirical studies from a body of research related to L2 development. Syntactic and prosodic awareness contribute to L2 reading development as they are highly associated with fluent and accurate reading abilities. However, it is challenging for L2 learners to acquire syntactic and prosodic knowledge due to limited cognitive capacities related to L2 learning, limited prior linguistic knowledge that is usually gained from oral communication, and linguistic differences between native languages and a target language. Addressing these challenges, this paper reviews a potentially useful technological tool of text presentation technology that may help increase syntactic awareness. Although empirical studies that tested the usefulness of technology-enhanced reading tools produced mixed results, their findings imply a viable alternative way of reading and call for future research to validate it.

Keywords: bootstrapping, syntactic awareness, prosodic awareness, syntactic enhancement, second language, visual-syntactic text formatting.
other programs as you need. The first thing that happens on your computer is called bootstrapping, or booting in a shortened term. This is a self-starting process that needs no external input. Bootstrapping is also used in linguistics, referring to the idea that children are born innately equipped with a capacity that generate the basis of language (Höhle, 2009). When young readers have a difficulty learning new words due to lack of information about word meanings, they can use their innate knowledge of syntactic categories and their relations to semantic categories in order to make inferences, which is called syntactic bootstrapping (Gleiman, 1990). The development of children’s syntactic knowledge is supported by prosodic bootstrapping (Gervain, Nespor, Mazuka, Horie, & Mehler, 2008). Prosodic features, such as rhythm, pitch, stress, and other auditory aspects of a language provide cues to help children identify word and phrase boundaries (Christophe, Nespor, Teresa, & van Ooyen, 2003; Lust, 2006). Such bootstrapping processes occur when children develop their native languages.

We can easily imagine that bootstrapping efforts might fail when one’s startup resources are insufficient. This can happen when we are learning to read a second or foreign language. In particular, linguistic resources for bootstrapping can be hardly acquired if one attempts to learn a target language in a context where that language is not spoken in daily lives. This is a challenge that English-as-a-foreign-language (EFL) learners like those in many Asian countries commonly encounter. Attempting to address this issue, this paper aims to identify what causes EFL learners’ lack in bootstrapping resources and to seek for a way to compensate for their lack. The candidate for new bootstrapping resources should be something that leverages what language learners have into a more skillful and efficient language operations. I expect that those who have limited syntactic or prosodic awareness will benefit from such leveraging.

This paper essentially consists of two parts: the review of a comprehension theory and cognitive processes in order to identify any reason for bootstrapping failures, and the search for any bootstrapping resources for second language reading. As such, I will first review a theory of comprehension, which helps us understand how syntactic awareness assists reading comprehension. The second section will address how working memory affects reading comprehension processes. This review will be followed by an exploration of the relationship between syntactic awareness and oral language skills, which will naturally lead to an investigation of the role of reading speed in the process of comprehension and its relation with syntactic awareness. The next section will concern L2 reading processes and syntactic awareness within the framework established in the preceding sections. The final section will discuss the use of technology with the aim of facilitating L2 syntactic awareness during reading.

Reading Comprehension and Syntactic Awareness

The reader’s mental representation comprises various aspects, such as explicit information from the text, information associated to the text, and the inferences that readers make (McNamara & Magliano, 2009). The process of building a coherent mental representation entails an understanding of words, sentences, and their relations, for which lower-level processes (i.e., decoding, syntactic parsing) stand as prerequisites. Influential models of comprehension suppose that decoding and syntactic parsing contribute to comprehension (e.g., Construction-Integration, Structure-Building, Resonance, Causal Network, and Constructionist); yet, the impact of these lower-level processes has not been thoroughly explored in the models (McNamara & Magliano, 2009). Among the few models that have taken into account lower-level processes, the Structure-Building model proposed by Gernsbacher (1997) largely involves dimensions of syntactic processing and its contribution to comprehension. The following section reviews fundamental assumptions of the Structure-Building model.

Structure-Building Model

Gernsbacher (1990, 1997) has focused on cognitive abilities involved in comprehension processes. The three primary cognitive processes in her model are laying a foundation, mapping information onto the foundation, and shifting to build new substructures. There are two mechanisms involved that control these primary processes: suppression and enhancement.

Readers first engage in laying a foundation, which usually occurs at the beginning of stories, sections, or paragraphs. This initial process
demands more resources than the next comprehension processes, but plays a fundamental role as a structure on which subsequent information is mapped. Once the foundation is laid, readers map incoming information, which relates to previously processed information, from a new clause or sentence onto the existing structure or substructure. Mapping occurs when the incoming information is related to or overlaps with the existing information. Various types of cues signal overlap and likely lead readers to mapping: syntactic forms, conceptual repetition, causal coherence, and other cues for continuity. When incoming information is less coherent, readers lay another foundation or a new substructure. This is called shifting. Readers thus have mental representations that comprise multiple branching substructures.

Building structures and substructures as well as maintaining them is controlled by suppression and enhancement. Incoming information that coheres with the previous information can be enhanced and added for further structure building. In contrast, if new information is not deemed to be necessary for constructing the current structure, readers may suppress this incoherent information or shift to a new structure.

Differences in comprehension skills depend on differences in the efficiency of these primary processes and mechanisms. In particular, skilled and less skilled readers are distinguished by how they deal with irrelevant information. While skilled readers can inhibit irrelevant information and create fewer substructures, suppression is lacking for less skilled readers so that they may have multiple substructures during reading (Gernsbacher, 1990).

The use of syntactic cues for building cohesive structures. One of the differences between skilled and less skilled readers is whether they are able to construct a hierarchical representation of text. As described earlier with Gernsbacher’s (1997) model, less skilled readers tend to shift and create too many substructures that are hard to assemble into a whole structure, leading to these readers’ slow processing and inaccurate comprehension. In other words, less skilled readers focus their attention on local levels and build a linear structure rather than a hierarchical structure. Such individual differences in comprehension skills have to do with how to utilize syntactic information as it signals coherence relations in text and guides the mapping process. Those who have inefficient enhancement and suppression mechanisms may have difficulty utilizing linguistic cues. For example, Gernsbacher and her colleagues found the facilitative effect of a syntactic form of preceding sentences (e.g., parallel form) on the comprehension of following sentences (1997). In this case, syntactic information served as a cue for mapping, facilitating the enhancement mechanism. Syntactic sources of information also help suppression mechanisms modulate the activation of potential meanings that a word or phrase might have. When reading homonyms such as bear or work, readers may often activate multiple meanings of these ambiguous words. An ability to use the syntactic context (She glanced at the bear versus He could not bear to see her grief) helps readers suppress inappropriate meanings.

In the same vein as Gernsbacher’s model, Givón (1995, 2009) and Kintsch and Mangalath (2011) have detailed syntactic cues as basic and continuous resources for the construction of structures and meaning. In particular, Givón provided support for syntactic cues being used for the enhancement mechanism in Gernsbacher’s model. According to Givón, overt grammatical signals, including syntactic constructions, instruct readers in establishing a coherent mental representation of a text through anaphoric (backward) processing and cataphoric (anticipatory) grounding. Processing anaphoric elements refers to the connection of incoming new chunks of text to some existing mental representation. Grounding cataphoric elements involves the opening of forthcoming associations in not yet completed structure. Linguistic elements that provide coherence across text include referents, temporality, aspectuality, modality/mood, location, and action/script. Both vocabulary and syntactic knowledge can guide readers through the processing of these elements. Givón argued that, while vocabulary knowledge is fundamental for fine-grained text comprehension, syntactic cues can expedite the processing of text coherence elements and thereby comprehension.

Kintsch and his colleague (1995, 2011) also stressed the important role of syntax in forming a coherent mental representation of text as it guides parsing processes. He stated that parsed chunks are easy to analyze and retain in the working memory buffer (cognitive perspective will be discussed in more detail in the following section), assisting readers make
connections between the previous information (either of text or of world) and the current input. In this process, a large amount of readers’ knowledge can be activated or inhibited, but does not necessarily remain activated. Some portions of the information become deactivated unless they relevantly fit into the current context. In other words, syntax-cued comprehension processing enables readers to make causal inferences by selecting coherent and relevant ideas from multiple information. This understanding of Kintsch reminds us of the suppression mechanism in Gernsbacher’s model.

Going back to the disparity between skill and less-skilled readers, some studies other than those dealing with comprehension theories have also attended to the use of syntactic cues (e.g., reading strategy and eye movement studies). One of the strategies that skilled readers commonly employ when reading challenging texts is to grasp words in clausal or phrasal units (LeVasseur et al., 2006). This is a process that helps them understand how words, phrases, and clauses fit together in sentences to convey meaning, anticipate what comes next, and thus avoid confusion. In contrast, poor readers read one word at a time (Cromer, 1970) and rarely parse words into phrases or clauses (Fuchs, Fuchs, Hosp, & Jenkins, 2001). This tendency is consistent with what has been observed in eye movement studies where poor readers tend to have a higher number of fixations, longer fixation durations, and more regressions (Hutzler, Kronbichler, Jacobs, & Wimmer, 2006; Rayner, Chace, Slattery, & Ashby, 2009). This value of understanding phrase and clausal structure of sentences helps explain why students’ syntactic awareness is significantly related to both fluency and comprehension (Gaux & Gombert, 1999; Ravid & Mashraki, 2007; Mokhtari & Thompson, 2006).

**Working memory and reading comprehension**

Reading comprehension is subject to various inherent constraints on human cognitive capacity, for example, working memory, which is the capacity to store and manipulate information online (Carretti, Borella, Cornoldi, & De Beni, 2009). A number of complex span tasks have been developed to measure this ability to simultaneously process and store information (Unsworth, Heitz, Schrock, & Engle, 2005). Task types vary depending on items to be processed and remembered (e.g., verbal, numerical, or spatial). Studies have found that the processes of processing and storage in complex span tasks are highly related to higher-order cognition (e.g., Unsworth, Redick, Heitz, Broadway, & Engle, 2009). Other studies have shown that an individual’s working memory capacity reflects a domain-general factor such that various complex span tasks, not just verbal tasks, account for variance in verbal ability tests (e.g., Li, Christ, & Cowan, 2014). In fact, it is well documented that skilled readers tend to have higher working memory capacity than do less skilled readers (Cain, Oakhill, & Bryant, 2004; Sesma, Mahone, Levein, Eason, & Cutting, 2009; Swanson & O’Connor, 2009). The following paragraphs further detail the relationship between working memory and syntactic awareness in the process of reading comprehension, mainly drawing on Gernsbacher’s (1997) comprehension model.

**Working memory in structure building.** Taking into account the aforementioned individual differences of using syntactic cues, it is fruitful to speculate how varying working memory capacities affect the enhancement and suppression mechanisms within Gernsbacher’s (1997) model. One key question is whether the high working memory capacity entails maintaining more information to be used for enhancement or less information as a result of suppression. Considering that chunking (i.e., grouping of several single units into a meaningful compound element) is a common learning strategy to increase the efficiency of working memory (Cowan, 2012), it seems reasonable to conjecture that high capacity readers store large amounts of inputs effectively by chunking them. This is empirically evidenced by a number of studies suggesting that individuals with greater working memory capacity tend to hold more information relevant to a current task (Swanson & O’Connor, 2009; van Leeuwen, van den Berg, Hoekstra, & Boomsma, 2007). The pieces of information retained in one’s consciousness can help one with anaphora or cataphora resolution. For example, when reading a pronoun, a reader with high working memory capacity tends to recall the noun to which the pronoun refers. This is how the new information that is related to the current structure becomes enhanced in the mental structure according to Gernsbacher’s model.

The existing literature, however, yields support for suppression as well as enhancement. Another line of research has shown that high capacity readers inhibit irrelevant information such that they store less information...
than low capacity readers (Kane, Conway, Hmabrick, & Engle, 2007; St Clair-Thompson & Gathercole, 2006). This implies that readers with high working memory are more likely to suppress the new irrelevant information and to shift to a new substructure. In either case, enhancement or suppression, the result can be the efficient construction of structures in readers’ mental representation, accordingly leading to resourceful memory storage for readers.

Given the limited working memory involving a combination of storage and processing, another question concerns whether this efficient mental structure building affects higher level processing such as inference generation. An inference can be defined as information that is implicit in the text but that can be made by connecting two or more pieces of information (Elbro & Buch-Iversen, 2013). Inference can be as simple as solving anaphora resolutions or as complex as drawing on world knowledge.

Research supports that high capacity readers can generate more inferences while reading than low capacity readers (Estevez & Calvo, 2000; Cain et al., 2004). I conjecture that this association between cognitive capacity and high-level comprehension ability should be reviewed within the frame of enhancement and suppression mechanisms. For instance, high capacity readers simultaneously retain multiple cohesive information blocks in working memory, serving as resources that allow them to construct more inferential relationships of a given story, such as identifying (in) consistencies in a text (e.g., Carretti, Cornoldi, De Beni, & Romano, 2005). The suppression mechanism may be helpful in this higher order cognitive process as well. High capacity readers have less irrelevant information in memory than low capacity readers, information which would otherwise compete for working memory resources and disrupt inference making processes (McNamara & O’Reilly, 2009).

**Syntactic cues as a facilitator for inference generation.** Although an inference-making ability in large part depends on varying degrees of one’s knowledge structure (Elbro & Buch-Iversen, 2013), syntactic cues in text can also play a role in this higher level of information processing. According to Givón (2009), surface information of text, including syntactic cues, does not survive beyond one’s working memory; however, this information assists readers in placing chunks, with which the information is associated, in a coherent structure—a hierarchical and sequenced representation of text. This associatively structured network of text can make information be more readily available for later retrieval. Givón added that a current context cues the retrieval of stored information. Although he did not directly address the role of syntactic information of current text in the old information retrieval, one may take this and his previous explanation as an implication that syntactic sources in the given context can make it easy to access and recollect the stored information for making inferences.

Kintsch (1995) agreed with Givón that syntax plays a role of mental process instruction in comprehension processes. He argued that due to limited working memory capacity, all of the information cannot always remain activated; instead, readers experience recurring processes of analyzing, storing, and connecting pieces of chunks from text. Syntactic cues usher readers through this processing, telling them specifically where to search for what in a specific text (e.g., subject-verb-object construction, cues for topicality, etc.). It is in this way that although sophisticated levels of comprehension cannot be completed without full knowledge (e.g., vocabulary, prior knowledge, etc.) about a given text, syntactic cues can expedite the readers’ processing toward high levels of comprehension, such as inferences (Kintsch, 1995).

**Word knowledge and syntactic awareness**

One clue to understanding the role of syntactic awareness in reading may also lie in its association with vocabulary development. Word knowledge is the principal source that learners refer to when they try to make sense of L2 input (VanPatten, 2004). Research on the relationship between vocabulary and reading comprehension shows that readers need to be familiar with 95 percent or more of the words in a text if they are able to comprehend the text and to infer the meanings of new words (Horst, 2009). In fact, a number of theorists have placed word knowledge at the center of their reading models, such as the Reading Systems Framework (Perfetti & Stafura, 2014). Perfetti and Stafura maintained that readers’ word knowledge plays a fundamental role in local comprehension processes that necessitate the integration of word level and text level comprehension systems. They added that adequate syntactic processing can make this
Empirical studies have supported the positive influence of syntactic awareness on vocabulary skills. Training to read for context has resulted in increased abilities to learn words (Kuhn et al., 2006), not by increasing short-term phonological memory, but by increasing metalinguistic and metacognitive awareness (e.g., syntactic awareness). In another training study (Snellings, van Gelderen, & De Glopper, 2002), lexical access speed improved for students who received computerized training that required them to make decisions about target words (e.g., whether an item was used appropriately in a sentence).

Oral Language Skills and Syntactic Awareness

A significant association between oral competence and reading has been well documented in studies that examined and developed Hoover and Gough's Simple View of Reading (1990). In the literature surrounding this reading model, there is a consensus that reading comprehension requires two independent components: automatic word decoding and effective linguistic comprehension skills (Catts, Adlof, & Weismer, 2006; Hoover & Gough, 1990; Joshi & Aaron, 2000; Scarborough, 2001; Vellutino, Tunmer, Jaccard, & Chen, 2007). Decoding refers to the process of translating a printed word into a sound. Linguistic comprehension includes parsing, bridging, or discourse building. The linguistic comprehension skills in the simple view of reading model was measured by listening comprehension. In fact, listening comprehension skill is highly related to written language comprehension (Berninger & Abbott, 2010).

The relationship between decoding and linguistic comprehension in the reading process is graphically depicted by Scarborough (2001), where decoding skills and linguistic comprehension represent two major strands that are woven together to form a rope of skilled reading. As a strong rope is built with relatively equally balanced individual strands, it seems ideal to develop both decoding skills and linguistic comprehension in a proportionate manner to prevent rope kinks.

What is interesting is that the two major strands of reading are thought to develop and operate to some extent separately in reading acquisition and the reading process (Hoover & Gough, 1990). It is evidenced by some empirical studies that poor decoders have deficits in phonological processing but...
The role of using syntactic cues in reading can be understood in its relationship to rapid reading as well as accurate reading. Although the reading rate is not always interchangeable with reading fluency, this section considers fluency as a broader umbrella term and reading rate is its key factor. According to the National Reading Panel (2000), reading fluency is a set of skills that allows readers to rapidly decode text while maintaining a high level of comprehension. This may include readers’ ability to make logical connections within and between sentences to make sense of a text as a whole and to review their prior knowledge in order to construct new knowledge based on reading (Fuchs et al., 2001). Therefore, automatic syntactic processing (Grabe, 2009) and recognition of phrasing (Kuhn & Stahl, 2003) are among the skill components needed for reading fluency.

Given the complex and dynamic series of tasks related to reading, faster speeds of syntactic processing may indicate that fewer cognitive resources are needed to make meaningful connections among sentences (Jenkins, Fuchs, van den Broek, Espin, & Deno, 2003). This in turn makes more cognitive resources available for other comprehension-related activities, such as making inferences or retrieving background knowledge.

Further elaboration on the correlation between reading fluency and comprehension is needed. In fact, fluency development is often neglected by teachers and learners who feel that they should always be learning something new, as Nation stated (2009). Yet, considering successful reading necessitates accurate and rapid reading (Kame’enui & Simmons, 2001), fluency, which involves making the best use of what is already known (Nation, 2009), requires proper attention. The studies reviewed below provide empirical evidence indicating that reading fluency is an important factor in comprehension and that syntactic awareness is closely engaged in the relationship between fluency and comprehension.

In particular, Klauda and Guthrie (2008) found that various levels of fluency and reading comprehension had a strong positive bidirectional relationship. Their study of 278 fifth graders examined fluency at three levels—word, sentence, and passage—and the relationship of each level to reading comprehension. Word-level fluency means the correct and effortless recognition of individual words, and sentence-level fluency...
concerns the readers’ capacity to parse text into meaningful phrases. Fluency at the passage level refers to the processing of passage-level features, such as the macrostructure of the text. At the beginning of the school year, a series of tests were administered, including a comprehension test, background knowledge test, and inference-making test as well as three different levels of fluency tests. Twelve weeks later, all participants again completed the comprehension test and the sentence-level fluency test at the same level as the original test point. Reading fluency at the beginning of the study predicted growth in comprehension 12 weeks later. Likewise, comprehension at the beginning of the study predicted growth in fluency 12 weeks later.

In addition to rapid recognition of words, phrases, and sentences, reading fluency involves reading with appropriate prosodic components, that is, the rhythmical features of speech that include stress, pitch, and duration (Kuhn et al., 2006; National Reading Panel, 2000). Prosodic features play an especially significant role in oral communication (Speer & Ito, 2009), but they are also useful in the reading process (Miller & Schwanenflugel, 2006). Prosody again is highly associated with syntactic awareness, as prosodic features suggest syntactic information that cannot be easily conveyed in a linear manner. When phrase boundaries are not explicitly marked in written texts, prosodic cues can aid readers in constructing meaning by segmenting or chunking text into syntactically appropriate and meaningful phrases. A number of studies have found that skilled readers capitalize on prosodic knowledge during both oral reading and silent reading (Ashby, 2006; Benjamin & Schwanenflugel, 2010; Miller & Schwanenflugel, 2006).

The role of prosodic knowledge in reading comprehension provides convincing evidence regarding how significant syntactic awareness is linked to effective reading. A correlation study conducted by Whalley and Hansen (2006) examined the relationship between word- and phrase-level prosodic sensitivity and reading ability. A total of 84 fourth graders were tested on reading ability, phonological awareness, word-level prosodic sensitivity, phrase-level prosodic sensitivity, and rhythmic sensitivity. For the phrase-level prosody test, students were asked to match a spoken phrase with a phrase that substituted the words with nonsense syllables but retained the prosodic features of the spoken phrase. After controlling for phonological awareness and general rhythmic sensitivity, students’ prosodic word and phrase sensitivity predicted unique variances in word-reading accuracy and reading comprehension. Phrase-level prosodic sensitivity predicted unique variation in reading comprehension after additionally controlling for word reading accuracy. Whalley and Hansen interpreted their findings as evidence that prosodic sensitivity helped students recognize syntactic structure, thereby facilitating text comprehension.

L2 Reading Comprehension as Structure Building and Syntactic Awareness

Simply speaking, L2 readers process information more slowly, use fewer metacognitive strategies, and monitor comprehension more slowly (Goldenberg, 2011). It is challenging to move beyond this stage and achieve competence in L2 reading. The framework set forth in the previous sections helps us identify various factors that often limit the use of syntactic and prosodic cues while comprehending L2 texts. Figure 1 illustrates these dynamics of L2 reading.

The following paragraphs discuss factors underlying this challenge and also suggest what it takes to become proficient L2 readers.
L2 oral language skills
A significant association between oral competence and reading has been already discussed in the previous section within the frame of the simple view of reading (see Hoover & Gough, 1990). L2 sentence comprehension is also strongly correlated with L2 oral competence (Lefrancois & Armand, 2003). When learning a mother language, children can extract and remember linguistic knowledge (e.g., sound sequences and syntactic structure) that is learned from oral communication when they encounter new vocabulary and syntax while reading. However, this is less likely to happen for L2 learners, because they can be, and often are, taught reading before reaching a certain level of oral English proficiency (Goldenberg, 2011). The learning seems even harder in contexts where there is little exposure to oral communication, such as EFL contexts. With insufficient spoken language data available for processing, EFL readers have far fewer chances than L1 speakers or ESL readers to transfer linguistic knowledge that is learned from oral communication to written texts. This implies that it is very challenging for EFL readers to develop knowledge related to language forms on their own.

Working memory overload
Like in reading in general, both storage and processing abilities contribute to L2 reading processing. This is evidenced by research findings that L2 reading scores were explained by test-takers’ working memory span but not by their simple storage-only memory (Juffs & Harrington, 2011). Yet, L2 readers are possibly faced with an extra load on working memory during L2 processing, as L2 language process exerts a greater demand on the processing and storing capacity of working memory than L1 processing (VanPatten, 2004). The reason for this particular challenge involved in L2 reading can be found in information processing theories.

According to information processing models that explain how information is stored and processed in the human mind, learners can attend to and process only a limited amount of information at a time, due to limited working memory (Baddeley, 2003). Sometimes learners do not need to pay much attention or make much effort to process information, whereas other times, they are consciously aware of other processes that require a substantial number of resources. Depending on the amount of attention and effort that a process requires, the process can be controlled or automatic. Controlled processes make considerable demands on cognitive capacity and require more resources, while automatic processes are unintentional and relatively effortless with little need for processing energy. From this information processing view of language, L2 researchers asserted that L2 acquisition requires more controlled processes that exert a greater demand on the processing capacity of working memory, because L2 learners may have little proceduralized linguistic knowledge (Loewen, 2005).

Linguistic distance between L1 and L2
Another factor that may discourage L2 readers from using syntactic cues is the linguistic distance between L1 and L2. van Hell and Tokowicz (2010) assert that the more dissimilar L2 syntactic structure is from L1, the less likely L2 readers are to catch syntactic cues. They further note that L2 readers’ inefficiency in processing syntactic information would prevent them from automatic structure building out of text. Bernhardt (2000, 2011) acknowledges a disproportionate contribution of L1 literacy to L2 reading development and proposes a compensatory model of L2 reading. She argues that readers’ L1 knowledge, which accounts for 20 percent of L2 reading processing, can compensate for deficiencies in L2. In this process of compensation, the contribution of L1 literacy to L2 reading development varies depending on the similarity between the L1 and L2. She stresses that we need to distinguish reading languages that share cognate words and syntactic similarity from reading languages that do not. This is also why L2 reading for those with high linguistic dissimilarity with a target language entails significantly more parsing errors than those without (Frenck-Mestre, 2005).

In fact, a number of studies have examined linguistic distances between native languages and a target language and how the distance between the two influences the efficiency of learning L2. Chiswick and Miller (1995) have studied the relationship between English acquisition of immigrants and their income-level with focus on the linguistic distances between English and their native languages. In this and their subsequent studies (e.g,
Chiswick, Lee, & Miller, 2005), immigrants whose native languages were more distant from English in terms of language family had less likelihood of gaining high proficiency in English compared to those whose native languages were more linguistically similar to English. A similar result was found in another study, where the linguistic distance between German and other languages was measured and its effects on the proficiency of learning German were examined (Ispphording & Otten, 2013). Greater linguistic distance decreases the probability of being proficient in the host country’s language, which is more apparent in the case of older learners’ language acquisition.

Enhancing syntactic awareness for structure building

Through the repeated exposure to and experience of language, linguistic knowledge becomes proceduralized (Lyster & Sato, 2013). Among other critical components of linguistic knowledge, increasing syntactic awareness is a prospective contributor toward proceduralizing linguistic knowledge based on the preceding discussion. However, it seems exceptionally challenging for L2 readers to achieve the proceduralization of syntactic skills as compared to other language skills until they develop strong knowledge of the syntax to the extent that they can perform syntactic parsing nearly as effortlessly as L1 readers do (Bernhardt, 2000).

In fact, L2 readers are significantly less likely to utilize syntactic cues than other linguistic information while reading. VanPatten (2004) theorizes that once meaning is taken into account as default for information processing, L2 learners’ attention can then be directed to less important structures in the input. Due to the limited attentional resources of L2 learners, they selectively process input for meaning before form, lexical items before grammatical form, and meaningful grammatical forms before non-meaningful grammatical forms. This processing pattern has been reported in a number of empirical studies. For example, L2 readers relied more on non-syntactic information than syntactic information (Felser, Roberts, Gross & Marinis, 2003; Lee & VanPatten, 1995; Papadopoulou & Clahsen, 2003). Adult L2 readers were able to use lexical semantic cues in the same way as L1 readers but this was not the case in terms of syntactic information (Clahsen & Felser, 2006; van Hell & Tokowicz, 2010). L2 readers were also less efficient in integrating prosodic cues in reading tasks than L1 readers (Akker & Cutler, 2003). Therefore, it is not surprising that L2 readers, especially those with low proficiency, tend to have weak syntactic processing skills.

Despite aforementioned adverse factors, syntactic awareness needs to be meticulously developed for effective L2 structure building processes. In this sense, VanPatten (2004) early on suggested that L2 reading instruction should be designed in a manner that discourages readers from solely relying on meaning-based cues and from ignoring syntactic cues. Teaching how to chunk isolated pieces of words into meaningful phrases can be a useful instructional strategy, as a way to reduce working memory load and to facilitate the reading mechanisms. In fact, studies on the cognitive process have demonstrated that meaningful unit-based chunking of information has beneficial effects on learning, either by reducing repeated attention-switching between old and new information (Barrouillet & Camos, 2007) or by reducing the cognitive load that learners need to identify salient boundaries between information units (Schwan, Garsoffky, & Hesse, 2000; Wouters, Paas, & van Merriënboer, 2008). However, chunking as a reading strategy is insufficient in providing learners with abilities to capture hierarchical syntactic structure. From an instructional perspective, it is time consuming and uneconomical to teach how to parse sentences while students are reading. The following section turns its attention to the use of technology to address such issues.

Technology-Enhanced Reading

Technology is adaptive and facilitates repetitive practice, thereby allowing for learning in and outside of classrooms. This is especially helpful in EFL settings, where students learn mainly through interaction of non-native English teachers and textbooks. Regardless of individual learning or instructional context, there are a number of technological applications that help improve reading English. For instance, those who want to improve their basic grammatical knowledge of English can easily access many cell phone applications, including those that work on grammar, punctuation, and test-specific grammar skills. On the other hand, there
are also many software programs for those who want to enhance or teach comprehension skills. This software that provides comprehension strategies helps individuals learn discipline-specific knowledge (Computer Assisted Strategy Teaching and Learning; Sung, Chang, & Huang, 2008). Animated instructional agents in an e-reading program facilitate development of metacognitive awareness and learning comprehension strategies (e.g., Rose & Dalton, 2002). When students have limited background knowledge relevant to the reading materials, teachers can use online multimedia resources (e.g., PBS or National Geographic).

I suggest that researchers seek a technological way to provide bootstrapping resources that assist L2 readers in utilizing syntactic and prosodic cues, as shown in Figure 2. There are a relatively small number of technology applications, though these involved only minimal use of technology, which emerged within the framework of focusing on syntactic awareness while enabling reading for meaning. Such technology-enhanced reading modes were designed based on the assumption that natural exposure alone is insufficient to enable struggling readers to acquire the knowledge of English grammatical forms. The following section will evaluate candidates for bootstrapping resources.

**Input Enhancement**

These kinds of input modification aim to change the way input (i.e., grammatical features) is perceived by EFL readers by transforming input that may otherwise unnoticed. For example, the frequently used input modification mode is visual input enhancement, which emphasizes a target grammatical form in a given text, as shown in Figure 3. For visual input enhancement, prosodic cues in oral communication are substituted with orthographic conventions in reading, which include italicizing, underlining, boldfacing, and capitalizing. This text modification mode may help EFL learners saturated by input flooding, leading them to notice a target form while maintaining a communicative focus. However, the limitation of this method is to isolate one grammatical form (e.g., passive form) at a given time. This text presentation type does not seem to help increase overall syntactic awareness, an ability to phrase text into syntactically meaningful multi-word units.

**Syntactic Enhancement**

Another way of input modification is text reformatting, making it possible to increase the quantity and quality of targeted input. There has been an attempt to draw readers’ attention to overall syntactic structure. Traditional
block text format, which all readers are familiar with, is dense, packing a considerable amount of text content into a limited space. Avoiding the linear sequence in block text, text-reformatting studies have used varying degrees of technology to divide texts into smaller units (hereafter syntactic enhancement). However, only a few studies have investigated the effect of syntactic enhancement on reading skills in either L1 or L2 contexts. Though different studies used different terms to indicate syntactic enhancement, including meaningful phrases condition (Cromer, 1970), phrase spacing (Jandreau & Bever, 1992; Jandreau et al., 1986), phrase cued text (LeVasseur et al., 2006), and visual text formatting (Walker, U.S. Patent No. 6,279,017, 2001), the concept that underlies these studies is segmenting phrases (chunks or clusters) based on meaning. By using phrase-segmented as a common term to represent syntactic enhancement conditions, the following paragraphs review how each study implemented its conditions and how the phrase-segmented format affected reading performance.

As early as in 1970 Cromer found that additional space between major phrase boundaries in printed text supported those who poorly parse sentences to read as well as normal readers. In his study, a total of 64 college students read five stories and answered 20 comprehension questions under four conditions—regular sentences, single words, phrase-segmented, and fragmented word groupings. The single words condition had each word typed separately on a roll of paper. In the phrase-segmented condition, words were presented in groups, which were determined by a criterion of syntactic structures, punctuation, and semantics. In order to establish this condition, two researchers made the phrasings independently and then deliberated to come to an agreement on phrasings in each sentence. In contrast, the fragmented groupings condition presented words in relatively meaningless groups with the same length. None of the groupings in this condition was the same as phrases used in the phrase-segmented condition. Cromer found that poor readers performed as well in the phrase-segmented condition as good readers did in either the regular or the phrase-segmented conditions. These two groups had the comparable intelligence and vocabulary knowledge, but the average reading level of the poor readers were three years behind the good readers. The scores of the poor readers in the phrase-segmented condition were even higher than those of the good readers in the single words or fragmented conditions. Cromer employed this as the evidence that the phrase-segmented format facilitated the readers who did not otherwise use syntactic cues (i.e., reading word by word or fragments) due to their low syntactic awareness.

Drawing on Cromer’s (1970) research, Jandreau and his colleagues (1986) developed an algorithm that determined varying degrees of space between words depending on syntactic structure and investigated the effect of converted texts using this algorithm. Unlike Cromer’s study in which spaces indicating phrase boundaries were assigned by hand, Jandreau and his colleagues used an algorithm for automatically converting texts. This algorithm first identified whether each word was a function word or a content word. Then the words were checked for which pattern they were categorized into (e.g., modal verbs and determiners). Once a pattern was determined, the algorithm inserted a break into phrase boundaries. The size of the breaks varied. As a result, different sizes of spaces between words indicated a hierarchical syntactic structure within each sentence (e.g., <<<Mary> <was sitting>> <<<on> <the seashore>>> <<<one hot day> <in June>>). College students (n = 44) read passages both in normally spaced or phrase-segmented condition. The findings indicated that reading speed (i.e., the total number of words read) was 16% faster in the phrase-segmented than the normal condition. Jandreau at al conducted a similar experiment with more finely segmented texts, in which college students (n = 36) read 20% faster in the phrase-segmented than in the normal condition.

A few years later, Jandreau and Bever (1992) explored the effect of syntactically cued text on a comprehension task. They used an algorithm for recognizing word class and patterns, then isolating minimal length phrases, and finally indicating phrase breaks. Extra spaces were added at the end of each within-sentence phrase group. This phrase-segmented condition was compared to both normal-spaced and even-spaced conditions. In the latter text condition, extra space was simply added between each word. A total of 134 L1 college students participated, among whom there were 65 average and 69 high proficiency students based on their verbal SAT scores. The participants read ninth- and tenth-grade level science texts in normal-spaced and even- and phrase-segmented format. While no effect of text format was found on reading speed for both proficiency groups, the phrase-segmented
format was effective for comprehension, for average proficiency students.

LeVasseur et al. (2006) examined the effect of phrase-segmented text on L1 reading fluency and comprehension in their repeated reading training study supported by a computer-based reading training program. English L1 students (ages 7 to 9 years) participated in three conditions of training: word list, standard text, and phrase-segmented text. In particular, phrase-segmented text had salient phrase boundaries that were indicated by extra spaces between them. Clausal structures were also preserved at line breaks. For example, noun phrases, verb groups, and predicative adjective phrases, which were identified as a syntactic chunk, were spaced and preserved. These boundaries were adjusted to associate complementizers, prepositions, and connective devices. The findings of this study suggest that all three training conditions positively affected reading comprehension. Repeated reading training regardless of text format positively affected reading fluency as compared to reading training with word lists. Phrase-segmented text reading especially resulted in greater gains in fluent reading with natural prosody than the other two reading conditions.

Walker (2001) developed another phrase-segmented format which is relatively more sophisticated than those in the previous studies: visual-syntactic text formatting (VSTF). In addition to the idea of making clausal boundaries salient as syntactic enhancement, Walker attempted to visualize the hierarchical syntactic structure by displaying no more than a couple of phrases per line as well as including varying degrees of indentations. Figure 4 shows an example of a linear text (at the top) and how some of its clauses are nested within larger ones (in the middle). In order to present this complex structure in VSTF (on the bottom), computer calculations are performed for each sentence in the text (Walker, 2001). The procedure ordering algorithm which is simplified from that in Walker (2001) is as follows:

1. Tokenize each sentence into words and punctuation
2. Identify characteristics of each word: possible parts of speech, numbers of syllables, educational levels, and pronunciation time
3. Investigate further the features of a word (e.g., reader- or text-specific lexicon) and disambiguate multiple parts of speech
4. Apply folding point rules using punctuation and parts of speech
5. Create text segments based on folding points and minimum/maximum line lengths (minimum and maximum line lengths were determined based on the range readers wish to see on a separate line, resulting in a range of 10 to 35 characters per line)
VSTF: Findings and limitations from previous studies

Some studies conducted by VSTF developers and others explored the effectiveness of segmented phrases across multiple rows out of one sentence, though few studies were published in refereed journals. Unlike the aforementioned syntactic enhancement studies, most of VSTF studies included not only L1 students but also L2 students as participants.

Walker and his colleagues tested the hypothesis that phrase-segmented format would help overcome the physical limit of human eye spans, leading to efficient reading (Walker et al., 2005). In this within-subjects study, 48 college students wore eye-tracking equipment to measure the amount of total eye fixation time per word while reading three passages in block format and three in phrase-segmented format supported by VSTF on computer screens. Walker et al. found that readers had shorter fixation durations and fewer regressive eye movements per word in the phrase-segmented condition, resulting in a 20 percent faster reading rate. Participants answered comprehension questions with 40 percent greater accuracy for the phrase-segmented passages than those in the block format. Thus, this study concluded that the phrase-segmented format led to gains in both reading speed and comprehension for college students.

Another hypothesis that Walker and his colleague attempted to test was that the phrase-segmented format would free up cognitive resources (i.e., working memory) which could then be employed in making sense of texts (Walker & Vogel, 2005). They found that the participating high school students (both L1 and L2) improved their reading retention in social studies and history. For example, tenth grade students (n = 40) who read their history texts in the phrase-segmented format showed greater improvement in a number of exams throughout the school year as compared to their control peers (n = 44) who read block-formatted texts. It is important to note that the text format effect became larger with a longer intervention as the effect size was larger in exams run in the second semester (.55) than in those in the first semester (.38). This implies that students may need time to familiarize themselves to the new text format. L2 students (n = 12) especially needed more reading sessions than their L1 peers until they grew accustomed to the format and outperformed their L2 control peers (n = 17).

These L2 students in the phrase-segmented condition had closed one-half to almost the full gap between themselves and L1 students in the control group by the end of the year. Although these results show that the phrase-segmented reading may contribute to the retention of content knowledge, this study did not provide direct evidence for whether the phrase-segmented reading supported limited working memory capacity.

Vogel (2011) reported his successful use of phrase-segmented text in a standardized test preparation program at a high school in Colorado, in which two-thirds of participants were L2 students. In the 4-week test preparation sessions, the participating students, who were at an unsatisfactory or partially proficient level, read sample test passages in VSTF for 20 minutes on a daily basis. As a result, 81% of the students met the state standard for acceptable growth and 62% met the school goal of reading at a proficient level by the end of the school year. This result should, however, be carefully interpreted given that this study was not in a refereed publication.

A more extended study conducted by Park et al. (2013) investigated which components of language (e.g., vocabulary, comprehension, literary analysis, written conventions, and writing strategies) were most affected by phrase-segmented reading. In this two-group pre- and post-test experimental study in California, 347 sixth grade students read a digital textbook generated by VSTF technology in their English language arts (ELA) class for one school year, while a control group (n = 222) read a traditional paper textbook (block format) with the same content. The ELA subtest results from the California Standards Tests (CST) for two consecutive years, one before and one after the treatment, served as the pre- and post-tests. The treatment group outperformed the control group in the subtest of vocabulary, written conventions, and writing strategies. The authors speculated from these findings that phrase-segmented text reading could draw students’ attention to syntactic structures that might have otherwise been ignored. Performance on the written conventions is closely and directly related to syntactic knowledge, as this subtest requires knowledge of sentence structure, grammar, punctuation, capitalization, and spelling. In addition, performance on the writing strategies subtest represents knowledge of vocabulary analysis and language structures rather than writing abilities, as this subtest does not require the ability to write an essay, but rather the ability to choose...
the best option when revising a flawed text.

A couple of small classroom studies reported in Park et al. (2013) examined the use of phrase-segmented text reading in South Korea, which is an EFL context. One study used phrase-segmented text in twelfth grade English classrooms and assessed reading performance of treatment (n = 71) and control (n = 96) group students using pre- and post-tests. On the post reading comprehension test conducted three months after the treatment started, the treatment students outperformed their control peers by .45 standard deviations. The teacher who conducted this study observed that her students preferred reading in the phrase-segmented format to block format because they felt the former less overwhelming and faster than the latter.

Another study presented in Park et al. (2013) used VSTF technology to reformat listening test scripts, as well as reading materials, in eighth grade English classrooms. Due to the great linguistic difference between L1 and L2 in an EFL context such as South Korea, listening instructions are often accompanied by reading scripts. This practice aimed at students’ better understanding of vocabulary, expressions, prosodic features, structures, and content found in listening materials, and ultimately better listening comprehension. The treatment group (n = 36), who studied reading and listening materials over three months, outperformed the control group (n = 18) on the researcher-developed reading post-test by .70 standard deviations after controlling for pretest scores. The treatment group also gained higher scores than the control group on the listening post-test, but the effect size was not statistically significant. The teacher reported that the treatment condition was especially useful to demonstrate the role of prosodic cues in communication. Despite their promising findings, these two studies are vulnerable to experimental bias; that is, the classroom teachers who conducted the experiment might have unconsciously behaved differently to members of control and experimental groups.

Yu and Miller (2010) recently provided an interesting study that compared three different text formats: block, phrase-segmented (VSTF), and sentence-segmented format (see Figure 5). The last format was invented by the authors and named after the game Jenga. According to the inventors, the shape of interlocking sentences in this text format resembles the way in which blocks of Jenga are stacked after some blocks are moved out. A click on a given paragraph of a web page converts the paragraph into this sentence-segmented format with unaligned sentences that each connect to a previous one with a space. Another click can return this sentence-segmented format to the original format at readers’ discretion. In this within-subjects study, 30 adult L2 readers with high proficiency in English (proved by their TOEFL or SAT test scores) read in three text formats and were assessed in terms of speed and comprehension. The participants also answered survey questions on their perceptions on the formats. It was found that the participants read fastest in block format and comprehended better in sentence-segmented format than in the other two. Survey results indicated that the participants felt that reading was easier in either phrase- or sentence-segmented formats than in block format, whereas they reported that text format did not affect how well they comprehended text. Yu and Miller concluded that segmented formats might be more comfortable to eyes and brain as compared to dense block format, but also that frequent segmentation in VSTF might hinder the participants’ reading performance. The interpretation of these findings needs to take into account proficiency levels or ages of participants. High proficiency adult L2 readers in this study might have sufficient syntactic skills and not been responsive to phrase-segmented format.
Future Research

This paper explored to identify factors that inhibit EFL students from developing their reading skills in terms of human cognitive capacities and information processing. Understanding that EFL students often lack in bootstrapping resources that can leverage their skills and knowledge into reading comprehension, I suggested syntactic enhancement that can compensate for the lack. The use of syntactic enhancement as scaffolding of L2 reading is drawn from the idea of input enhancement that has been commonly used in L2 research and instruction. Input enhancement manipulates texts in a way to make target L2 input salient, which otherwise learners are likely to neglect, in order to make learning of this particular input take place. A number of L1 research, but a very few L2 studies, have examined the idea of manipulating text to make phrase boundaries noticeable.

Therefore, future research is called upon to examine whether EFL students comprehend English texts more quickly and accurately when provided with syntactic enhancement. In addition, it will be interesting to inspect whether and how readers’ working memory capacity mediates the relationship between syntactic enhancement and EFL reading performance. Drawing on the theoretical literature on the use of syntactic cues for efficient working memory function as well as enhanced comprehension, it is hypothesized that phrase-segmented format serves as bootstrapping resources and facilitates rapid and accurate L2 reading. As a tool to convert standard block text to phrase-segmented text, VSTF technology, which reformats text into hierarchically organized segmentation based on linguistic rules and human perceptual tendency, can be used.

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