Children's Reading Development and Orthographic Theory

: Specific Focus on the Non-alphabetic Writing System - Korean

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Contents

Introduction

Reading is considered a behavior that requires a complex cognitive and neurological process, as multiple skills are involved when decoding the diverse components from the written scripts. Through reading, individuals are forced to decode sounds or meanings from a symbol or a compound symbol which take shape in the form of words. Improving such skills in a designated sequence is termed reading development, and such a development process tends to be diverse among individuals, while maintaining a certain universal stream. Such diversity among individuals does not randomly occur, but is based on the characteristics of the script they are facing, and the specific factors of those scripts they need to decode. In other words, different writing systems, with certain significant factors, will influence the readers' performance in reading development. The aspects of the reading process affected by different writing systems can be defined as language effect, or more specifically, the impact of orthography on reading development. Hence, based on the characteristics of the target script's writing system and orthography, readers need to adopt respective strategies to achieve a decent level of reading development.

The previous studies on reading development presents numerous accounts on the general process of reading development, and spotlight how different writing systems and their orthography have influenced the reading behavior of individuals. However, those studies mainly cover scripts from the alphabetic system, while the various other non-alphabetic scripts, specifically scripts in which two or more different types of writing systems co-exist are left behind. For this reason, the proposed research will investigate reading development in non-alphabetic writing systems, with a special focus on the Korean script.

To aid in a finer understanding of the topic, a theoretical account of how different writing systems and their respective orthographic characteristics will influence the reading development will be discussed in the first two chapters. Further, the chapters will continue to discuss orthographic influences on non-alphabetic scripts, with a specific scope on East-Asian Languages; Chinese, Japanese and Korean which is considered to have mutual interchanging aspects in terms of orthographic structure. Then, the Korean script will be focused on in depth, with an experimental analysis and respective discussion of the reading development process of Korean children at the end.

1. Impact of Writing System on Reading Development

1.1. Diversity in Writing System

Writing is a conventional means of representing language through visual form (Rodgers, 2005). The writing system consists of several essential elements; *signs and symbols*, which convey either unique sounds or meaning in the target languages; the final representation of these sets of signs and symbols are defined as a *script*.

Such a writing system can be categorized into several types based on the specific representation form of the script, in other words, *orthography*. Within a broad classification, Figure1 below shows the three different types of writing systems;

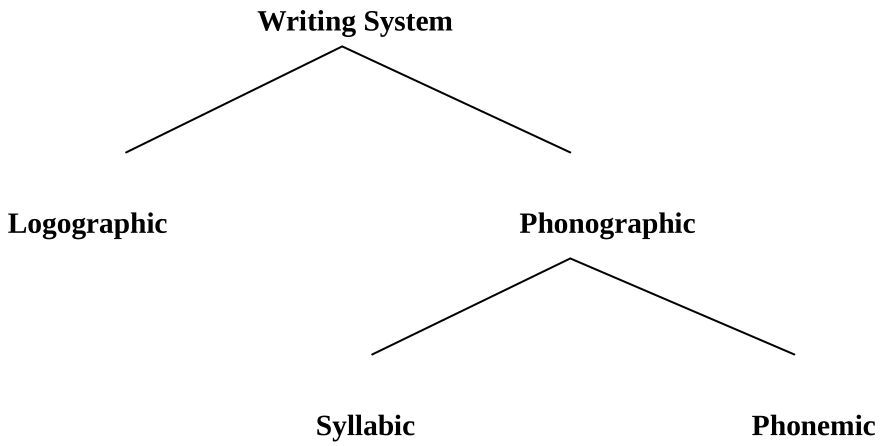

Figure1. Three types of Writing Systems

Writing systems can be divided into two big frameworks based on the association between meaning and symbols. If each symbol conveys meaning constituents such as a morpheme, then such a writing system can be defined as a *Logographic System*. On the other hand, if the symbol represents sounds as a phonetic or phonological constituent without any reference to meaning, the system can be defined as a *Phonographic System*. Among Phonographic systems, depending on which units a symbol represents, the system can further be divided into a *Syllabic System,* if the symbol represents a syllable, or a *Phonemic System,* if the phoneme is represented via symbol. The summarized distinction of writing systems is described in Table1 below:

Type		**Representation of Symbol**	**Respective Language**
Logographic System		Morpheme (Meaning)	Chinese Character Japanese Kanji
Phonographic System	Syllabic System	Syllable (Mora)	Japanese Hiragana
	Phonemic System (=Alphabetic)	Phoneme (Sound)	English and other European Language

Table1. Classification of Writing Types

1.2. Reading Process based on Writing System

1.2.1. *Connectionist Model*

Previous Literature defined the reading process based on the difference between writing systems in many ways. One of the theoretical frameworks that have provided the foundation for several implemented models of the reading process is the '*Connectionist Model'*, introduced by Seidenberg and McClelland (1989). As the writing system can be divided into three different types based on the constituents of symbols, according to the *Connectionist Model*, the reading process can be defined as three-triangular layers, described in Figure2 below:

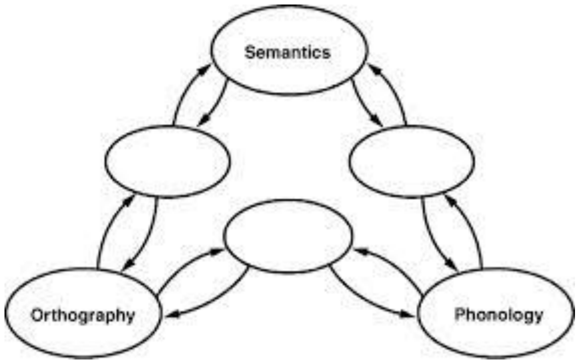

Figure2. Connectionist Model (Seidenberg and McClelland, 1989)

During the reading process, the three layers, *Orthography, Phonology* and *Semantics,* are all highly associated each other. From the orthographic level, the reading process goes through to the phonological level, which represents the step of decoding the sound from the symbol; this is a primary step in phoneme writing systems (or in other words, alphabetic writing systems) such as English and other European languages. Moreover, at the semantic level there are two manners of processing: directly from the orthographic units to the meaning, which is prominent in the *Logographic* writing systems such as Chinese Character or Japanese Kanji or, indirectly from the orthography layer to the phonology layer, then from the phonology layer to the semantic layer, which is common in the *Phonographic* systems, which can then further be divided into *Syllabic* and *Phonemic* (alphabetic) systems such as in Japanese hiragana and the English language, respectively. Therefore, based on how the symbols are represented, the order of the activation of the reading process can differ, leading to different strategies for reading development (Perfetti & Dunlap, 2008). Therefore, depending on the writing system, the required process in a target language can differ, and as a consequence, the required skills for the proper reading development in a target language are different.

1.2.2. *A Dual-Route Cascaded (DRC) Model*

The *Dual Route Cascaded (DRC) Model* (Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001) describes the reading process in more detail (see Figure 3). With a more specific description of how the process works, the DRC model explains the reading process with detailed routes consisting of the

Lexical Semantic Route, *Lexical Non-semantic Route,* and the *Grapheme to Phoneme Relation Route* (GPR).

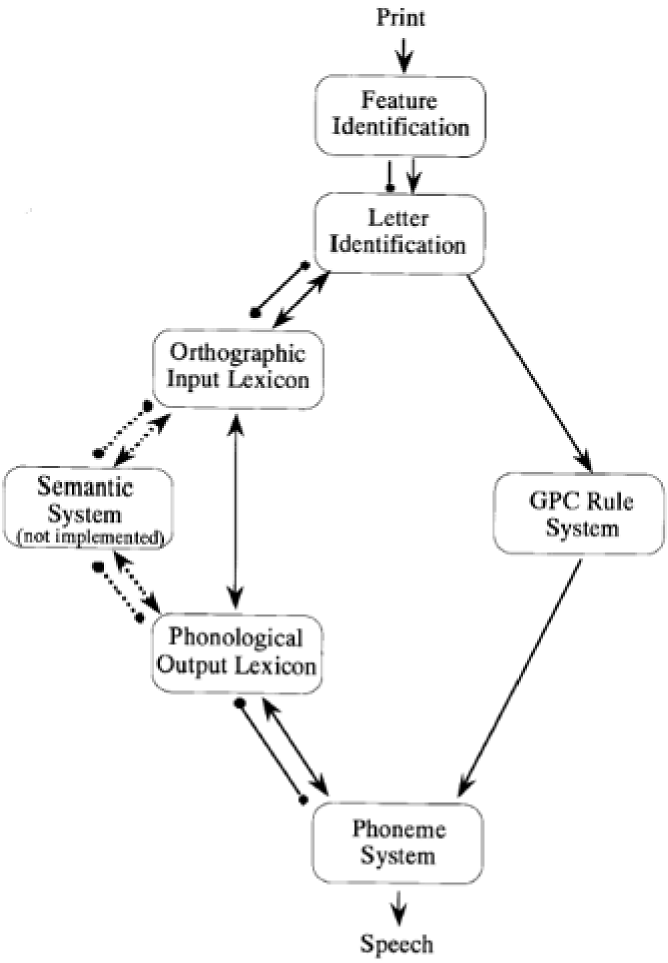

Figure3. The Dual Route Cascaded (DRC) Model (Coltheart et al, 2001)

The process of activation for each route is described as follows:

Lexical Non-semantic Route

The word or letter activates the word's letter units; these letters, then activate the word's entry in the orthographic lexicon, which then activates the corresponding word entry into a phonological lexicon which finally activates the word's phonemes.

Grapheme to Phoneme Correspondence Route

Instead of activation on the word or letter units as a whole, the GPC route starts from a letter string (from a symbol), then this letter string is converted into a phoneme string according to the grapheme-phoneme corresponding rules. In other words, letter units are activated through the lexical non-semantic route but based on the set of rules, the activation goes from the first letter to the last letter in sequence.

With three distinctive routes, the *DRC model* of reading mainly covers how the visual features, in the case of reading; symbols to words, go through the activation process and in which ways the corresponding sounds are generated. These routes can be separated into two general categories; a *Lexical Route*, in which the coarse grained mapping skill is needed; since reading a lexicon is processed in the beginning stage, not only are the sounds mapped (*Lexical non-semantic route*) but also the meaning (*Lexical Semantic Route*), and a *Sub-lexical route,* in which the initial process of reading involving decoding the sound of each phoneme and therefore decoding meaning is not necessary. Similar to the *Connectionist Model*, the *DRC model* also predicts the fact that the reading process can differ depending on which type or characteristics of letters the reader encounters. In other words, when individuals are required to read a target word, two routes are always available for grapheme-phoneme conversion and for word recognition, but based on the type of writing systems, or the types of orthography in the same writing system, different reading process can be triggered, thereby generating different strategies for reading.

1.3. Summary

Writing Systems vary across the many languages, and such differences are caused by the disparities of rules, features, and compositions. Since reading is processed via decoding letters from a target script, different writing systems trigger the different reading strategies. Although the diverse reading models, including the *Connectionist* and the *DRC models*, tend to have disparities in terms of methods and hypothesized assumptions, most of the reading models indicate the fact that because of the variations in the characteristics of writing – characteristics of rules (orthography), orders, and formation-, the strategies to achieve proper reading development also differ and this is assumed to be a universal effect on reading development. Based on the two reading models, correlating with the division of the three types of writing systems, reading routes can be divided into two general types; decoding the features of a word as a whole, or decoding the phonetic or phonological features of the target word. Decoding the phonetic or phonological features of the target word can be divided into two patterns, one with decoding through the syllables, and one through the phonemes by sequence. For each route, specific skills are required and those skills can be defined as '*orthographic awareness'*, '*syllable awareness',* and '*phonological awareness',* respectively.

2. Impact of Orthography on Reading Development

2.1. Orthography Theory

As stated in the previous chapter, various models of reading process indicate the implicit hypothesis that various stages of reading development are being affected by certain properties of written language, and as a broader concept, this has to be related with the decoding skills of words and symbols of written language. Furthermore, this assumption is predicted to be universal across all languages, specifically to all writing systems.

Previous literature (Wimmer et al, 1994; Hutzler & Wimmer, 2004; Thorstad, 1991; MacWhinney, 1999; Davies et al, 2013) has attempted to confirm this assumption through different experiments; one of the most acknowledged effects of orthography in reading the alphabetic writing systems is the *Orthographic Effect*.

2.2. Orthographic Effect

Orthography across all writing systems varies, as the rule of each writing system has not only similarities but also disparities. For example English, German and Spanish share the similar writing system defined as the alphabetic writing system, since a symbol represents a sound directly. However, the way in which those symbols are combined, or the characteristic of the orthographic components they have creates disparities among them, and such distinctions are described in the *Orthographic*

Impact Theory, which is based on two key elements of the orthography; the *Depth of the Orthography* and the *Complexity of Syllable*.

2.2.1. Depth of the Orthography

In an alphabetic writing system, decoding sounds from scripts precedes decoding meaning from words since a symbol represents a sound directly; thus, the skill of phonological decoding is imperative to reading development. Therefore, decoding the phonological code from the symbols is affected by the depth of the rule between symbols and sounds. In other words, since the alphabetic symbols only represent the sound and not the meaning, the relationship between target symbols and respected sounds has a significant effect on reading. Ziegler and Goswami (2005) identified this relationship as the '*Psycholinguistic Grain Size Hypothesis'* with three contributing factors; *availability*, *consistency*, and *granularity*.

Psycholinguistic Grain Size Hypothesis **(Ziegler & Goswami, 2005)**:

Reading development is effected from the abstraction of optimal mappings between orthographic units and the sounds of the language via three contributing factors

a. Availability

The factor of availability concerns the degree of availability of the sound units in the conscious entry of a target language prior to the reading. For example, in the sound entry of the English orthographic system, the sound unit /d^h*/ is not available while it is available in the Korean orthographic system. Therefore, if Korean children learn to read a word including /*d^h*/ sound units, it is easier for them to learn the sound from the target word than for children of English speaking countries.*

b. Consistency

Consistency is the factor of consistent associations between the sounds and the symbols of a target language. For example, in Japanese Hiragana, one sound is available from one symbol, a perfect one to one system, therefore there is a high level of consistency between the *sounds and the symbols; 'あ' in Hiragana represents the sound /a/ across all the positions. However in English, one symbol can have two or more different sounds based on the position and the composition of the symbols; 'a' in the word 'radical' has two different sounds as the first 'a' represents /æ/ sound while second 'a' represents /ə/. Therefore, English is a language with a low level of consistency while Japanese Hiragana is a language with a high level of consistency.*

c. Granularity

Granularity is the factor of whether the units of orthography are smaller or larger in size. Such size can vary across three types of levels: the grapheme-phoneme level (the single letters or double letters that correspond to phonemes, such as 'b' from 'bee' or 'ph' from 'phone'), the rime level ('eet' in street), and the lexical level (mappings between the representations of the complete letter string, spelling a word, and the complete phonology of its pronunciation, such as a Chinese letter in which one letter itself represents one or two sounds). If the grain size of a target word is small, then the children learn that word easier than a word with a bigger grain size, since the greater the grain size of a word, the more orthographic units there are to learn.

Thus, if the sound units in the target language are highly available in the reader's daily routine, the correspondences between the sounds and symbols are highly consistent, and the grain size of the orthography is smaller, it is easier for children to learn a target language. Although this theory contains its own limitations in the sense that not all the factors fit into the exact categories, accounts of consistency of mapping between the sounds and symbols are a good way of predicting the orthographic effect on reading, specifically for languages in the alphabetic writing systems. Based on the degree of consistency, the characteristics of orthography can be divided into two types; *Transparent* (or shallow) and *Opaque* (or deep) orthography. *Transparent orthography* indicates a highly predictable relationship between the sounds and the symbols due to a highly regular and consistent mapping. Forst, Katz, and Bentin (1987) described this property of transparent orthography as the phonemes of the spoken word being represented by the graphemes in a direct and unequivocal way. Such examples are found in various cases on transparent language in alphabetic writing systems; for example in the cross-linguistic longitude studies of children of German (Wimmer & Hummer, 1990), Greek (Goswami, Porpodas, & Wheelwright, 1997), Italian (Thorstad, 1991), Spanish (Suarez-Coalla & Cuetos, 2013), Welsh (Ellis, & Hooper, 2001), English, and French (Goswami et al., 1998; Landerl, Wimmer & Frith., 1997). The reading development process with more accurate and fast reading fluency has been found in children of Transparent orthographies (Spanish, Italian, Welsh), as compared to the children of Opaque orthographies. This is due to the irregular relation between sounds and symbols in the Opaque languages, such as the English language, which has 26 letters, including 24 consonants and 5 vowels, which in turn, represent more than 40 phonemes. Moreover, the vowels are very ambiguous in terms of their mappings since there are 12 digraphs and 6 different pronunciations depending on their position. Consonants, such as ‘g’ read differently based on their position; the first ‘g’ in the word ‘gorgeous’ sounds / g/, while the second ‘g’ sounds / dʒ/. Further, when consonants can change sound when presented in combination with other vowels and consonants. Some consonants, such as ‘l’ sometimes become silent; ‘l’ in the word ‘lux’ sounds / l/, while ‘l’ in the word ‘salmon’ is silent. Therefore, it takes much more effort and time for English speaking children to learn to read due to the amount of possible sounds they need to achieve in their orthographic systems (Goswami, 2005). On the other hand, in Spanish, which contains a relatively one to one correspondence between the sounds and the symbols with small amount of diagraph, children tend to achieve an adult-like reading performance earlier (Goswami, 2005). The depth of orthography has thus a significant effect on reading development in alphabetic languages, and this assumption is assumed to be cross-linguistically predictable.

2.2.2. Complexity of the Syllable

Another contributing factor of orthographic effects on reading development is indicated as the complexity of syllable. Complexity can be measured by the number of syllables per words: The more syllables per word, the higher the complexity of syllables (Menzareth, 1954). For example, in English, four or more possible syllables exist such as V, CV, VC, and CVC, while many other languages tend to have only simple V, CV and CVC syllables, resulting in a difference in the time and effort required to learn to read.

2.3. Orthographic Effect on Alphabetic Writing System

Based on the two contributing factors explained above; *Depth of Orthography* and *Complexity of the Syllable*, the language of alphabetic writing systems can be classified as shown in Table2 below:

Syllabic	Orthographic Depth				
	Shallow ---Deep				
Simple	Finnish	Greek Spanish Italian	Portugese	French	
Complex		German Norwegian Icelandic	Dutch Swedish	Danish	English

Table2. Hypothetical Classification of Participating Languages Relative to the Dimensions of Syllabic Complexity (Simple to Complex) and Orthographic Depth (Shallow to Deep), (Seymour et al., 2003)

Considering the orthographic effect on alphabetic systems, reading development in languages begins from the awareness of phonology in the written script, thereby achieving a proper accuracy and speed of reading. Since the transparent orthographies contain the frequently occurring words in consistent ways, children with these orthographic languages read non-words faster and more accurately when such words consist of the frequent morpheme constituents (Burani et al, 2002). However, the non-word reading in opaque orthographies is relatively slow since the children are initially more adaptive to using direct lexical access strategies, memorizing the specific spelling orders to establish units for word recognition.

In summary, reading acquisition in languages with alphabetic writing systems necessitate the skills in mapping between orthographies and phonologies (Shares et al, 1984), and depending on the characteristics of a given orthography, the strategies vary but ultimately establish the larger grain size mappings to facilitate more rapid phonological decoding.

2.4. Summary

To summarize, the orthographic impact on an individual's reading development is significant, and this effect is cross-linguistically eminent. Once the readers start to learn how to read, depending on the target written system, they have to excel at the proper strategies, among which are orthography, phonology, and syllable awareness. Although the skill of decoding the orthography, syllable, and phonology is required in all kinds of reading development, based on the type of written script, a certain type of awareness becomes more predominant in the beginning stage of reading development. When decoding the script with a grapheme to phoneme relation, the strategy is defined as a sub-lexical scheme while the other strategy is a lexical scheme, which requires decoding from the lexicon/morpheme to the sounds or meaning. Then, once a strategy is chosen, the reader's developmental pace is influenced by two or more contributing factors, and in the case of alphabetic systems, such factors are *depth of orthography* and *complexity of syllables*, since the symbol itself represents a sound from the base level.

3. Impact of Orthography on Non-alphabetic Writing

The transparency of symbols and sounds correspondence is the key feature in defining alphabetic writing systems (Lieberman et al, 1980). However, although many accounts on the reading process based on the orthographic impact have been made; most of the studies are focused on alphabetic writing systems, and are more than likely to remain silent about writing system outside the alphabetic writing system. One of the features of non-alphabetic languages is that the representation of the relationship between meaning and sound is different from that of alphabetic languages. Specifically, in certain languages such as Chinese, a symbol represents a meaning directly, whereas in alphabetic languages, a symbol instead corresponds to a sound. This can be explained through the *Connectionist model*, as the chain between the semantic level and the orthographic level is more dominant than the chain between the phonology level and the orthographic level, which is more likely to appear in alphabetic writing systems. Three East Asian languages, Chinese, Japanese and Korean share this feature despite some disparities in their writing systems. Therefore it is plausible to speculate that these three languages show both similarities and disparities in the reading process. The crucial feature among these three languages is that all of their writing systems share the meaning root from the Chinese character. In other words, although the writing systems in those languages differ; a logographic system for Chinese and Japanese Kanji, a logographic and syllabic system for Japanese Kana, and a mono-phonemic and syllabic system for Korean respectively, the access of meaning, either in lexical or symbol units, is directly related to Chinese logograms.

3.1. Orthographic Impact on Chinese Character

Chinese is one of the most predominant languages used in Asia. The Chinese writing system is much more complex than that of the alphabetic writing system since it is composed of numerous logographic characters with thousands of diverse word forms. Furthermore, within each character, the distinctive square-combined configurations are marked with radicals, and in general, there is no obvious letter to sound correspondence (Chen, 1992; Chen & Juola, 1982). In other words, each Chinese character has a semantic meaning with an inconsistent coding of phonological information, and a low level of correspondence between the phoneme and letters (Perfetti et al., 2005). In addition, Chinese characters are not only arranged linearly but also in a vertical top to bottom arrangement with phonetic and semantic radicals: these phonetic and semantic radicals are further divided into strokes or stroke patterns which generate various components of characters (Zhou, 1978). Chinese Characters consist of a semantic radical and a phonetic radical (Li, 1993; Yin & Rohsenhow, 1994), with phonetic radicals indicating the pronunciation of whole character and semantic radicals being directly connected to character meaning (Wang, 1997). For example, the character '湖' (meaning: lake, pronunciation: hú) is a compound of a semantic radical '水' (water), and a phonetic radical '胡' (hú). However, about 62 % of phonetic radicals are unreliable cues for pronunciation, due to irregular complex characters which have different pronunciations from their phonetic radicals (Zhou, 1980). For example, the phonetic radical '青' (pronunciation: qing) signals the sound as 'qing' in a regular compound character, but in irregular characters, the sound changes on a case by case basis, such as in the word '猜', where the phonetic radical '青' sounds like 'cai' instead of 'qing' (Wu et al., 1999). Therefore, reading in Chinese is more likely meaning-based (Weekes et al., 1998; Zhou & Marslen-Wilson, 1996), which predominantly requires the ability of recognizing the shape of the symbols, defined as *Orthographic awareness,* along with *Phonological awareness* to decode respected sounds. Based on the *DRC* model, the lexical route is dominant in Chinese reading as the readers need apply Orthographic awareness as a whole in order to produce a proper sound from the script. Such evidence can be found from the comparative studies between English and Chinese (Cheng & Harris, 2010), where the depth of orthography itself is defined as highly opaque. From the Semantic and Phoneme substitution tasks, although both languages require two categories of awareness in general, readers in English tend to show higher phonological related activation, while readers in Chinese show higher semantic based activation in their reading. Therefore, as the Orthographic Depth Hypothesis has revealed from the studies on the alphabetic writing system - the transparently and consistently encoded information in orthography is more strongly activated during reading in alphabetic languages. In Chinese reading, semantic information is strongly activated, while phonological information is weakly activated since the orthography itself requires *Orthographic awareness* to precede *Phonological awareness* at the beginning.

3.2. Orthographic Impact on Japanese

Japanese is considered a *mixed writing system* consisting of two different types of orthographies, one with logographic Kanji that shares similar radicals with Chinese and the other with syllabic Kana (Wydell et al., 1993). Kanji characters are used for nouns and for the root morphemes of inflected verbs, adjectives, and adverbs, while Kana characters are used for function words and the inflections of verbs, adjectives, and adverbs (Wydell & Butterworth, 1999).

In Japanese Kanji, the Kanji character always represents one particular syllable or mora of the language, which is similar to Chinese symbols, as there is no consistency between sound and symbol. However, unlike Chinese characters, Japanese Kanji do not have tone, and have a fixed manner of extracting sounds from symbols: On-reading (original pronunciations taken from spoken Chinese) and Kun-reading (conveys the meaning of Chinese character). Since the two ways of reading have a strict division between access to meaning (Kun-reading) and to phonetic sounds (On-reading), some findings (Wydell, Butterworth, & Patterson, 1995; Wydell, Patterson, & Humphreys, 1993) suggest that the reading of Kanji characters involves access to semantics from Kun-reading and to phonology from On-reading. Therefore, although it is still a controversial issue, unlike Chinese reading, Japanese Kanji reading might not necessitate a predominant orthographic awareness in reading. However, decoding a sound from a symbol is essential for generating meaning from Kanji, just as it is with Kana, since the Kanji words are subtracted at the word level rather than the character level.

The writing system of Japanese, Kana, is mainly characterized as a Syllabic system. Kana has a low complexity in its structure of syllable – 40 unvoiced CV combinations, 5 vowels, and one nasal coda (Akita & Hatano, 1999). In addition, the consistency between sound and meaning is almost completely regular. Hence, the grapheme to phoneme relationships in Japanese Kana can be interpreted as a perfect one to one mapping, which corresponds with other clear transparent orthographies. The highly consistent relationship between sounds and symbols in Kana makes for a faster acquisition for Japanese readers (Shimamura & Mikami, 1994; Wydell et al., 1995), similar to the pattern from transparent alphabetic writing systems. Therefore, with clear support from the Orthographic Impact Theory, reading Kana requires a strong activation of phonological coding skills, thereby causing a faster reading speed in general.

To sum up, although Japanese reading consists of two different reading types and writing systems, Kanji and Kana, readers have to activate syllable awareness in both systems, in terms of developing the ability to segment spoken words into syllables, with Kana being primarily processed phonologically and Kanji being combined with decoding the visual pattern of characters and extracting phonological code based on the context.

3.3. Summary

Even in the languages in which the writing systems differ from that of alphabetic languages, it is certain that the orthographic impact is strongly significant in reading development. Both Chinese and Japanese orthography were affected from the orthographic depth and the syllable complexity, both in reading speed and reading accuracy. Furthermore, such different reading paces and rates of development have been generated via different requirements of language awareness. Strong requirements of certain language skills trigger a strong activation of the respected components of the script. The following table is the description of Chinese and Japanese reading development:

<table>
<tr><th colspan="2">Orthography</th><th>Writing system</th><th>Most Required skills</th><th>Key feature</th></tr>
<tr><td colspan="2">Alphabetic Language</td><td>Phonographic</td><td>Phonological awareness</td><td>Transparency</td></tr>
<tr><td colspan="2">Chinese Character</td><td>Logographic</td><td>Orthographic awareness</td><td>Visual pattern</td></tr>
<tr><td rowspan="2">Japanese</td><td>Kanji</td><td>Logographic</td><td>Orthographic awareness
and
Syllabic awareness</td><td>Syllabic segmenting
Visual pattern</td></tr>
<tr><td>Kana</td><td>Syllabic</td><td>Phonological awareness</td><td>Transparency</td></tr>
</table>

Table3. Description of Orthographic Information and Effect in Languages with Three Types of Writing Systems

While the alphabetic writing system is strongly associated with sound from the symbol level, the non-alphabetic writing system varies: Japanese Kanji and Chinese Characters, are connected to a certain degree to the meaning from the word level, and Japanese Kana, although possessing a highly syllable based composition, its transparent orthography leads readers to a more phonological process in the beginning.

To conclude, there are many different orthographic systems which exist in other languages that do not completely resemble an alphabetic orthographic system. Therefore, identifying the reading development in non-alphabetic languages has to begin with defining the characteristics of the target orthography to generate, not only proper understanding of the reading process, but also the correct strategies for readers.

4. Research

Thus far, the current research has discussed the core components of reading development and how such components apply cross-linguistically to various writing systems. It has focused on how these features, specifically orthographic frameworks, affect an individual's reading development, thereby identifying the importance of focusing on these differences in order to understand an individual's reading development more properly. The following chapters will now examine one particular script, Korean, a language spoken in both South and North Korea. Although the Korean orthography has been previously studied and presented in many pieces of literature, there are no direct studies done based on reading models, and it is unclear which factor is most crucial in affecting reading development in Korean. Therefore, revealing which writing system Korean possesses, and which orthographic factors will influence reading development in it must be examined in order to understand proper reading development in Korean children.

Since Korean belongs to the non-alphabetic writing system category along with the Chinese and Japanese languages, it is assumed to have a different reading process than that of the alphabetic writing system, but at the same time, considering the uniqueness of the 'Hangeul' script, it is predicted to show some disparity from the Chinese and Japanese reading processes as well. This aspect allows for a good examining case for current theories of reading development in certain aspects. To investigate such factors within the framework of the reading development process, the proposed research will describe the Korean writing system sequence by sequence: Taking the *Dual Route Model* as a framework, the processes involved in learning about the sounds and symbols in Korean writing system are first specified by highlighting the relationship between Korean symbols and the underpinned Chinese characters to define which reading route Korean possesses: the Lexical Semantic Route or the Lexical non-semantic Route. Next, an examination of the precise predictors of individual differences in reading attainment will be conducted in a framework of the Orthographic impact. Further, considering the unique composition of Korean script, the contributing factors in Korean reading between syllabic factors and phonemic factors will be defined. Before going on to experiments, in order to provide an accurate understanding of Korean script, a general description of the Korean writing system will be given.

4.1. General Description of Korean Writing System

4.1.1. Derivation of Korean Script

Korean has a unique writing system called ' Hangul' (한글), formulated in 1446 by King Sejong.

Before the invention of 'Hangul, Classical Chinese was used for reading and writing, for more than 2000 years. The Discordance between daily speech and written script caused tremendous trouble, such that it led the monarchy to create its own script based on diverse written scripts from all over the world. To create a fine-tuned writing system, Korean borrowed many of its underlying principles, such as the combination of syllable representation and sound representation, from the Indian model 'Sanskrit' (c.f. National Institute of Korean Language). Although they have no similarities in symbols. Korean script has one symbol which represents one sound, and the combination of each symbol has strict rules, causing newly formulated sounds based on the composition (c.f. Figure 4)

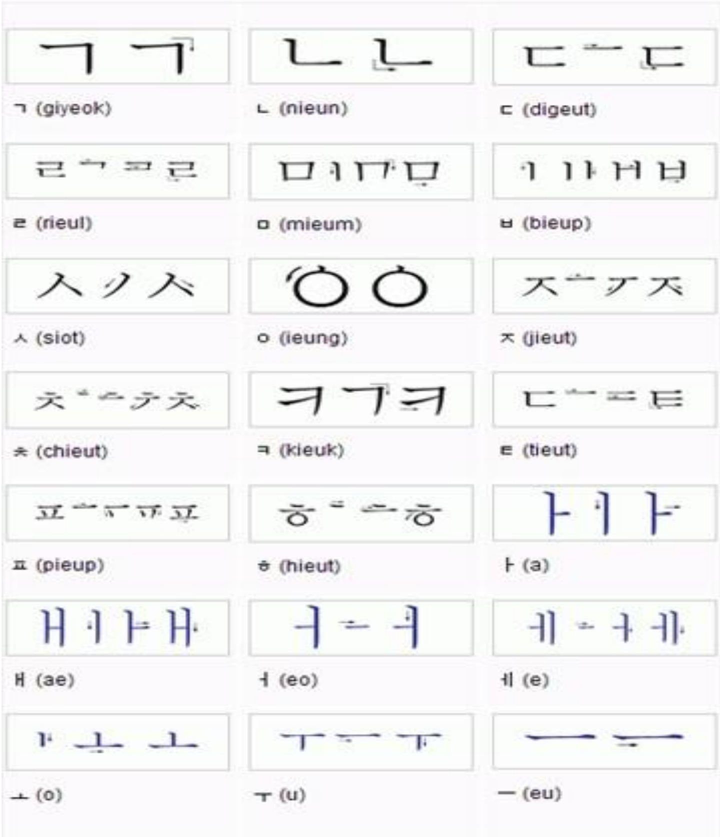

Figure4. Korean Symbols: Consonants and Vowels

Furthermore, along the formation of the script, Korean has a direct meaning route derived from the Original Chinese Character (Different from Current Modern Chinese 'Mandarin'); almost 70% of Korean words have a directly corresponding Chinese character behind them. However, Chinese characters are only used for indicating the meaning of Korean symbols or words, but are not directly connected to the sound of Korean symbols or words. Korean possesses diverse roots for their word meaning, not only Chinese: Chinese words (approximately 70% of Korean words), 2-3% from different languages, such as German, Japanese, and English (for recently invented words), and the remaining 27% are pure Korean words (Kim, & Na, 2000). Such examples can be found below:

Example1.

Hanguel

제목 (je-mok): symbol1 - 제(je), symbol2: 목(mok)

Definition: title

Meaning: title (symbol1) and object (symbol2)

Corresponding Chinese character: 題目 (ti-mu) – symbol1: 題 (ti), symbol2: 目 (mu)

Meaning**:** title (symbol1) and object (symbol2)

In example1, the word 'friend' in Korean is created by combining two square shaped syllables, 'je' and 'mok' with their respective meanings, 'title' and 'object', with the corresponding Chinese character sharing the same meaning. However, the sound from each symbol in Korean and the matching Chinese character show disparity, in other words, the adopted logographic symbols in Korean are there in order to represent a meaningful morpheme, not a pronunciation.

4.1.2. Composition of Korean Language

Although Korean is derived from many different roots, causing it to have a diverse and unique writing system, it is unlike the Japanese writing system, which consists of two different writing systems including *Kanji*, which is similar to the Chinese logogram system; Korean does not follow the logogram, but more likely resembles English writing as a form of phonemic structure. However, unlike English or languages of the Alphabetic writing system, each symbol or phoneme is not spread in a linear order, but formulated in a unique composition in the shape of a square box (c.f. Figure5). Each symbol can be placed in four different locations of a square box: upper left, upper right, bottom left, and bottom right. The locations follow strict rules: consonants are required to be placed in the upper left, and optionally placed in the bottom left and bottom right: vowels are always placed in the upper right location, and such vowels can form a diphthong. Therefore, one syllable can be composed in four different ways: CV, V, CVC, and CVCC.

(C)	V
(C)	(C)

Figure5. Composition of a Korean Syllable

For example, the formation of the word ‘밥’ (definition: rice, gloss; bap) can be analyzed as follows:

ㅂ	ㅏ
ㅂ	

Example2

In example 2, the word has been constructed from a consonant ‘ㅂ’ (/b/) placed in the upper consonant position, a vowel ‘ㅏ’ (/a/) in the upper right position, and ‘ㅂ’ /b/ for the left bottom consonant. With this unique composition, the Korean writing system has 14 consonants and 24 vowels in total.

4.2. Research Question

The major aim of this research is to define the relationship between the writing system and reading process in Korean, and its orthographic impact on Korean reading development. As mentioned above, the experiment and analysis were conducted in three parts.

1) Orthographic impact on Korean reading

First of all, to define which factors of Korean orthography affect the reading development of individuals, the relation between reading level and orthographic components, depth between symbols and sounds, and complexity of syllable, were examined. The Korean script ‘Hangeul’ is considered to be a transparent orthography (Frost et al, 2005), since the sounds of its symbols are relatively consistent, except in some cases in the bottom consonants when the composition of words forces the original sounds of the symbols to change. Within the Orthographic depth framework, Korean features a transparent orthography, consistent with other research Consistency between symbols and sounds aids in the process of learning to read. However, the uniqueness of the composition of symbols to words and the rule of generating respected sounds from the compounds is quite complex in comparison to Chinese in which a simple morpheme represents a meaning, and Japanese, in which only a few syllable forms exist. Therefore, based on the reading level, the hypothesis will be as follows:

Hypothesis1

As followed by universal claim, reading speed becomes a factor to distinguish the fluency in the reading development of Korean reading since the orthographic consistency in Korean is considered to be transparent. Therefore, the consistency of Korean symbols will have a significant effect on the reading speed of Korean children. Furthermore, the complexity of the syllable which generates complex sound units will have a significant effect on the reading development process.

2) Cross-modal mapping in Korean reading development

Based on the description of Korean script above, Korean script has a unique writing structure which is not a common feature in any other languages. In Korean, two types of syllables exist, the syllable based on one square box which represents one morpheme, and a word based syllable which occurs when one square box combines with another square box to create a morpho-syllabic block. Therefore, even though the Korean writing system can be defined as a mono-phonemic writing system, it is unclear whether Korean reading can be predicted solely based on the findings from the alphabetic writing system. Therefore, the research will examine the significance of the effect of the orthographic factor on the reading development of Korean children; syllable awareness or phonological awareness.

Phonological awareness is one of the main skills which is needed to process the reading in alphabetic text, and since the Korean script, particularly the characteristics of the symbol itself, is highly phonemic as in that of alphabetic script, such phonological skills will be required during the Korean reading process. Further, considering the unique syllabic structure of Korean script, syllable awareness might play a significant role in Korean reading as well. This will give great implications for further studies since Korean has both phonemic and syllabic components in its writing system, thereby creating an unclear approach. The respected hypothesis is as below:

Hypothesis2

The influence of syllable awareness will be observed in the reading development of Korean children, since Korean reading requires processing sound units from the morpheme level instead of processing sounds based on the symbol level. Also, the performance will be modulated by the position of the phonological unit if the composition of words becomes complex.

3) Writing System of Korean

Lastly, to define which writing system Korean possesses within the framework of the DRC model, theoretical accounts related to the categorization of writing systems will be examined. Further, to define the reading strategies of the Korean writing system between the Lexical Semantic Route and Lexical Non-semantic Route, and between grapheme to phoneme mapping and coarse grained mapping, it is crucial to investigate the effect of Chinese Characters in the Korean reading process both in terms of accuracy and speed, as 70% of Korean scripts are directly connected to Chinese logograms in terms of meaning access. The hypothesis of the first experiment is given below:

Hypothesis3

Although the Chinese Character will be different in correlation with the reading fluency, the actual reading speed and accuracy will not be strongly affected by the degree of knowledge of Chinese character, since Korean symbols are related to Chinese logogram in meaning but not sound.

The answer to this question, along with a theoretical account, will allow the category of the Korean writing system to be determined.

5. Method

5.1. Participants

Participants were recruited from pre-elementary and elementary schools in Daegue, Korea. There were a total of 60 participants, ranging in age from 4 to 11 years old, with a mean age of 8.32. The rationale behind the target age of participants was constructed based on the critical age of Korean reading in Korean children. Korean children learn to read the symbols between ages 3 and 5, and are able to read the symbol as a word starting from ages 5 to 7, before entering primary school. From the elementary level, the reading education starts from the basic level and goes to the advanced level, and by the end of 6th grade (age 13 to 14), students are able to process all the scripts of Korean. Before the experiment, the experimenter verified with the participants or, in the case of very young participants, their parents that they did not have a history of language disorders, or genetic mental disorders to prevent the experiment from having misleading results caused by behavioral or mental problems.

5.2. Designs and Materials

All of the stimuli which had been used as experimental items were assessed from the Korean word frequency lists by the National Institution of Korean Language (2005). This corpus is adequate for the current research since not only the size of the corpus is reliable, but also because the content of the text is diverse. The description of the content can be seen in Table 4 below:

Usage	Number of Syllables	Rate	Character of content		Number of files	Subordinate usage number of syllables	Rate of Usage	
01	274,662	9.10	01	Pure words	42	190,501	69.36%	
01	274,662	9.10	02	Adopted words	19	84,161	30.64%	
02	781,045	25.88	01	Children’s story book	17	73,589	9.45%	

02	781,045	25.88	02	Novel	112	552,933	70.71%	
02	781,045	25.88	03	Play/scripts	36	154,523	19.84%	
03	594,444	19.70	01	Discourse/Interview	8	36,058	6.28%	
03	594,444	19.70	02	Media/Science article	26	118,431	20.84%	
03	594,444	19.70	03	Newspaper	22	116,973	19.00%	
03	594,444	19.70	04	Magazine	20	93,512	16.29%	
03	594,444	19.70	05	Politics/Diplomacy	48	229,470	37.59%	
04	289,560	9.60	00	Journals	58	289,560	100.00%	
05	1,078,054	35.72	01	Educational books	22	97,381	9.41%	
05	1,078,054	35.72	02	Appellative texts	34	147,019	15.04%	
05	1,078,054	35.72	03	Social scripts	32	162,985	15.21%	
05	1,078,054	35.72	04	Arts	33	164,857	23.46%	
05	1,078,054	35.72	05	Humanity journals	50	254,168	12.45%	
05	1,078,054	35.72	06	Environmental Journals	27	133,866	13.56%	
05	1,078,054	35.72	07	Military science	24	117,778	10.87%	
Total	3,017,765	100.00			630	3,017,765		

Table4. Corpus of 3,000,000 Korean Syllables (2005)

In the previous experiment on word processing, it was concluded that words that occur more frequently are processed more accurately and faster than words that occur less frequently (Duyck et al., 2004), and this effect is observed consistently in various linguistic tasks including tachistoscopic recognition, lexical decision and word naming. (Howes & Solomon, 1951; Whaley, 1978; Forster & Chambers, 1973).

The test items were sorted to contain a complete set of nouns. The noun was selected as the experimental item because most Korean verbs consist of roots and tenses concurrently, and such tenses are orthographically identical in most cases (see Table 5 for example). If the items were selected from verbs, then the root could not solely exist without the attachment of tense, therefore incomplete items will cause trouble when investigating the proper reading process. Even if the complete form of the verbs was used, familiar forms would be in a row since tense was limited to three forms; *past, present, and future*. Therefore, it becomes a problem to investigate a fair reading process. Similar problems arise for the adjective. There is a fixed marker for the adjective in Korean words, which serves as a suffix, and those markers are orthographically identical (see Table 6 for example).

Root	Tense	Tense marker	Gloss
가 (go) Ga	Present	+ -다 (da)	Ga+da
	Past	+ -ㅆ다 (-tda)	Ga+t+da
	Future	+ -ㄴ다 (nda)	Ga+n+da

Table5. Three Verb Formats in the Korean Language

Root	Marker	Adjective form	Gloss
빨가 (red) Ppalga-	-ㄴ (n)	빨간 (adj: red)	Ppalga+n
희 (white) Heui-	-ㄴ (n)	흰 (adj:white)	Heui+n

Table6. Adjective Forms in the Korean Language

Therefore, noun words are ideal experimental items to investigate an individual's actual reading speed, better than the verb, adjective, or other functional words since the word itself serves as a root without an identical attachment. The length of the selected nouns was 1 to 3 syllables. All the nouns were matched on frequency. The items were further divided into three groups based on the complexity of their compositions; the first group was comprised of words at a simple level which were composed of an upper consonant and vowel; CV, the second group as a middle level in which one or more of the square blocks is composed of an upper consonant, vowel, and one bottom left consonant; CVC, and a high level in which one or more of the square blocks is composed of an upper consonant, vowel, and both left and right bottom consonants; CVCC or composed with a diphthong. An example of selected words is described in Table 7.

Level	Word	Syllable composition	Gloss
Simple	아가	CV-CV	A-ga (baby)
Middle	문학	CVC-CVC	Mun-hak (literature)
High	삶	CVCC	Salb (life)

Table7. Classification of Complexity Level in Korean Words

5.3. Apparatus and Procedure

The experiment consisted of three different sessions of 45 minutes to 1 hour total running time, depending on the speed of the individuals'. The general components of the experiments were a reading aloud task, a lexical decision task, and self-paced reading tasks. Participants were situated in a designated room together with an experimenter, and given a break of 5 minutes between each session. For the reading aloud and lexical decision tasks, the stimuli were presented and the responses recorded via DMDX (Forster & Forster, 2003) on a Windows XP laptop. Stimuli were presented in 'Times New Roman' 11-point type. Participants were seated 30 cm from the display monitor. All the items were randomized through the software. Every session had 2 practice trials to help participants get familiarized with the experiment. Details and the order of the experiments are listed below:

Session 1: Reading fluency level

The first session of the experiment was a reading aloud task consisting of test items selected from the noun word list. Participants were divided into three levels of reading fluency based on their accuracy and speed. A total of 60 items were presented to the participants. Participants were asked to read the items aloud one by one and then the experimenter measured the speed and accuracy of the reading upon completion of the task. Responses made during the task were recorded digitally to a hard disk. Along with words, 60 nonsense words were created from the frequency list, by randomizing the initial and final words one by one, until all the words were meaningless but grammatically correct. Reading speed and accuracy were measured using the same procedure as with the 60 word items above.

Session 2: Knowledge of Chinese character

The second session was designed to investigate a cross-modal mapping between Chinese characters and Korean symbols in Korean reading. Since, 70 % of Korean symbols or words are derived from Chinese characters (Kim & Na, 2000), it is necessary to investigate the effect of Chinese characters on Korean reading. Therefore, 50 sets of Chinese characters were collected from the most frequently occurring Chinese characters in Korean symbols or words (National Institution of Korean Language). The task was performed as a reading aloud tasks. Participants were asked to read aloud the character one by one, with the full meaning and the respected sounds. Responses made during the task were recorded digitally to a hard disk.

Session 3: Syllable awareness and Phonological awareness

The next session examined the factors that influence the growth of syllable and phoneme level processing which serve as a correlating factor with the reading level and knowledge of Chinese characters. To investigate the effect of orthography on Korean reading, the session was divided into 4 sub-parts with 16 items each, therefore, 64 stimuli will be presented in total. Participants were asked to write down the answer as quickly and accurately as possible. The experimenter then examined the speed and the accuracy of every task.

Session 3-1: Syllable processing

Part 1: syllable substitution

The 16 pairs of words matched with frequency and length were presented to the participants. Participants were asked to substitute the initial or final syllable of each pair.

Part2: Syllable deletion

The 16 words were presented to the participants. Participants were asked to delete the initial or final syllable of the target word. The length of the words for the task varied from 2 to 4 square boxes.

Session 3-2: Phoneme processing

Part3: phoneme substitution

16 pairs of words were presented to the participants. Participants were asked to substitute the initial or final phoneme of words. In the case of Korean words, the initial phoneme represents the upper first consonant and the final phoneme represents the bottom left or right consonant.

Part4: phoneme deletion

16 words were presented to the participants. Participants were asked to delete the initial or final phoneme of words. The length of the words for the task varied from 1 to 4 square boxes.

6. Results

As the research question was to investigate the reading development process of Korean reading among children, related analyses were conducted based on the results of the proposed experiments. One participant's result was excluded from the analysis since the participant quit the session due to personal circumstances; therefore an incomplete performance was found. Based on the hypothesis, the results and related analysis were divided into three categories: Orthographic Depth Impact on Korean reading, Syllable and Phoneme processing on Korean reading and Correlation between Chinese knowledge and Korean reading.

6.1. Orthographic Impact on Korean Reading

6.1.1. Effect of Orthographic Depth on Korean Reading Development

The results of frequency matched Korean word and non-word reading are described in Tables 8 and 9 below as group statistics. The speed has been calculated as .ms and the accuracy has been scored for a correct answer, and 0 for an incorrect answer.

Reading level	N	Speed (M & SD)	Accuracy (M & SD)
1	18	1789 (102)	53,40 (2,9)
2	13	1469 (208)	55,15 (2,2)
3	28	1144 (55,98)	55.07 (1,92)
Total	59	1412 (304)	54,59 (2,42)

Table8. Group Statistics of Word Processing by Reading Level

Reading level	N	Speed (M & SD)	Accuracy (M & SD)
1°	18	2120 (35,6)	53,40 (2,9)
2°	13	1818 (24,42)	55,15 (2,2)
3°	28	1171 (24,35)	55.07 (1,92)
Total	59	1603 (429)	54,59 (2,42)

Table9. Group Statistics on Non-word Processing by Reading Level

While the differences of means in accuracy were not large between groups, the mean differences in speed were big, both in word and non-word stimuli. The Standard deviation between groups in speed was higher in word processing than non-word processing in total. The deviation was also higher for the individual differences within each level in word processing. For word reading, a statistical analysis was conducted between each level, showing that accuracy was not significantly different between reading levels 1 and 2 ($F(1, 28) = 1.37$, $p=.87$), or reading levels 2 and 3, ($F(1, 28) = 1.02$, $p=.90$), based on an Independent T-sample Test (see Appendix, Tables 10, 11). However, for the speed of reading words, the difference between reading levels 1 and 2 (F (1, 28) = 18.44) and reading levels 2, and 3 (F (1, 28) = 70.72) were highly significant (p=.00), respectively. Similar aspects were observed in non-word processing as well (see Appendix, Tables 12, 13). For the accuracy, the difference between groups, reading levels 1 and 2 (F (1, 28) = 0.01, p=.09) and, reading levels 2 and 3 (F (1, 38) = 1, 97, p=.87) was not large as in the word reading process; while the significant differences were observed for the speed of reading non-word stimuli, between reading levels 1 and 2 (F (1, 28) = 1.26, p=.00), and reading levels 2 and 3 (F (1, 38) = .00, p=.00). Therefore, both the results from Korean word reading and non-word reading show that the difference between groups divided by reading level are measured in the speed of Korean non-word reading, while no significant difference was measured in accuracy. The specific results for each age group are described in figures 6 and 7 for both accuracy and speed.

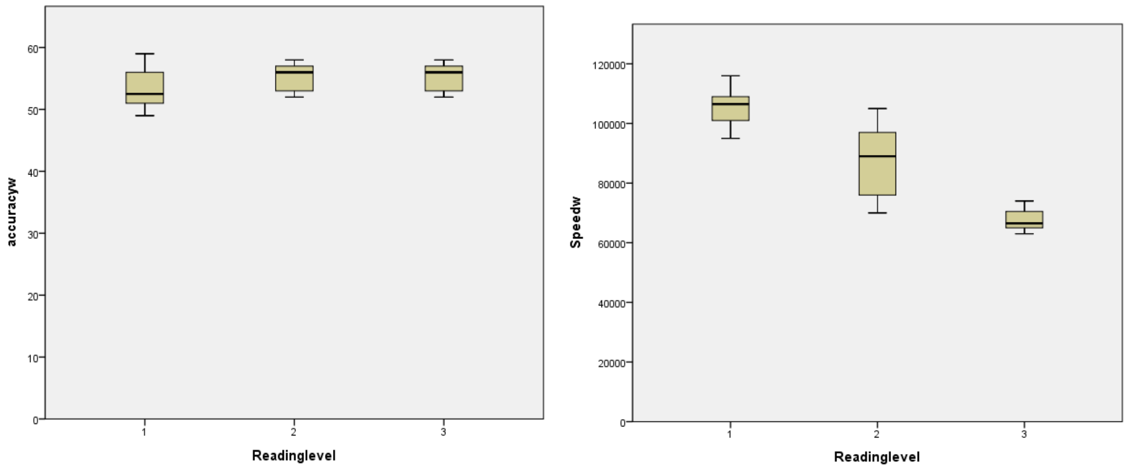

Figure6. The Mean Difference of Word Reading Accuracy and Speed among Reading Levels

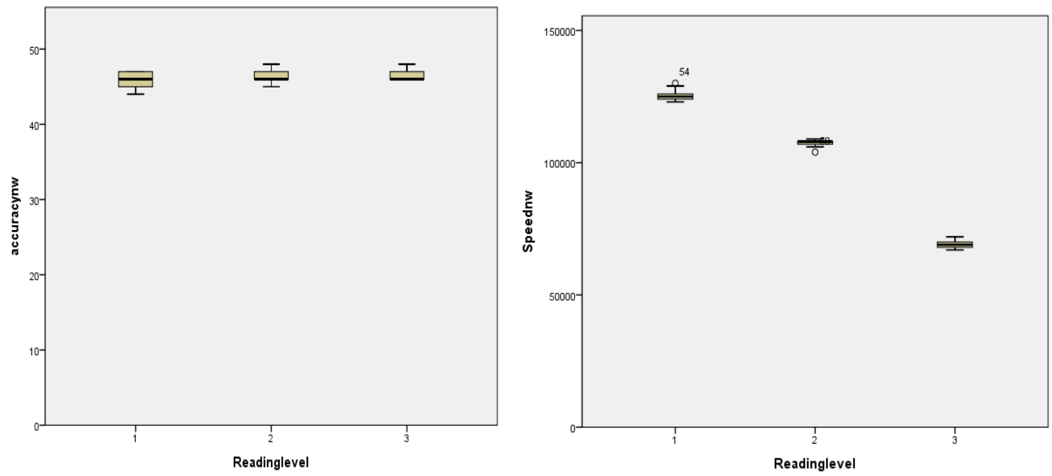

Figure7. The Mean Difference of Non-word Reading Accuracy and Speed among Reading Levels

While the differences in accuracy do not show a broad disparity among age groups in word or non-word reading, the differences in speed show that it prominently decreases as the participants' ages increase. As seen in the group statistical analysis, figures 6 and 7 show the individual deviation by reading level; the reading accuracy and speed were broader in word reading, especially in the speed of reading level 2. In other words, when comparing the performances in terms of accuracy and speed by reading level, significant differences were found in the speed of reading between each group while the accuracy was not influenced by level.

6.1.2. Effect of Complexity of Syllable

As the Complexity of the syllable affects the path or pattern of reading development in alphabetic languages (Ziegler et al., 2010), stimuli has been sorted based on the complexity of syllable to investigate whether the complexity has an effect on Korean reading as well. The analysis was done between simple syllables – syllables with one or more square boxes consisting of the CV format, and complex syllables – syllables with one or more square boxes consisting of the CVC or CVCV format. The group statistics of non-word and word syllable processing, both on simple and complex syllables, by reading level are described below.

Reading level	N	Simple syllable word (M & SD)	Complex syllable word (M & SD)	Simple Syllable Non-word (M & SD)	Complex Syllable Non-word (M & SD)
1	18	12,94 (0,72)	5,89 (0,68)	13,67 (0,49)	5,61 (0,61)
2	13	13,08(0,49)	9,54(0,52)	13,54(0,52)	8,15(0,69)
3	28	13,86(0,89)	13,18 (0,61)	14,07(0,60)	12,54(0,58)
Total	50	13,41(0,87)	10,15(3,24)	13,83(0,59)	9,46(3,15)

Table14. *Mean Proportion of Correct Responses on Simple Syllable and Complex Syllable Based on the Type of Tasks by Reading Levels*

Overall results indicate that participants of all reading levels scored lower in complex syllables than in simple syllables, both in word and non-word stimuli. In general, participants did better on simple tasks both in word and non-words, but for the complex syllables, performances in different levels tend to have significant differences. The standard deviations among individuals were significantly larger in complex syllables for non-word stimuli, while the distributions of scores were not consistent in word processing. For a more specific analysis, the *One-Way Anova* analysis was conducted (see Appendix, Table 15). The difference between groups was significant on both word ($F(1, 1) = 780.3$, $p=.00$) and non-word complex syllables ($F(1, 1) = 740.6$, $p=.00$), while not significant on both word ($F(1, 1) = 1.1$, $p=.32$) and non-word ($F(1, 1) = .87$, $p=.42$) simple syllables. The *Bonferroni* comparison between groups of reading levels indicated the same results (see Appendix, table 16); between reading levels 1 and 2, 2 and 3, and 1 and 3, the significant difference was measured on both word and non-word complex syllables ($p=.00$), while for the word and non-word simple syllables, there were no significant differences between each group ($p=1.0$). More specific differences between individuals in each group are formulated in figures 8 and 9 below:

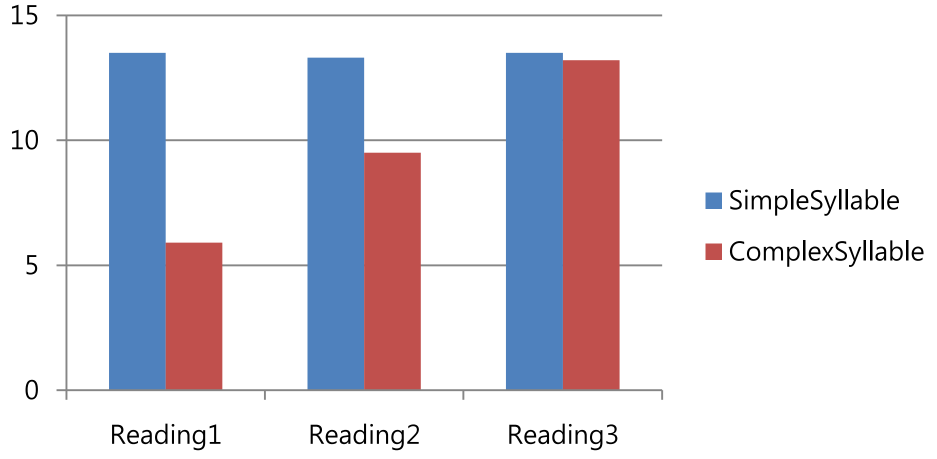

Figure8. Mean Proportion of Correct Responses on Simple and Complex Syllables based on the Type of Task in Word Reading

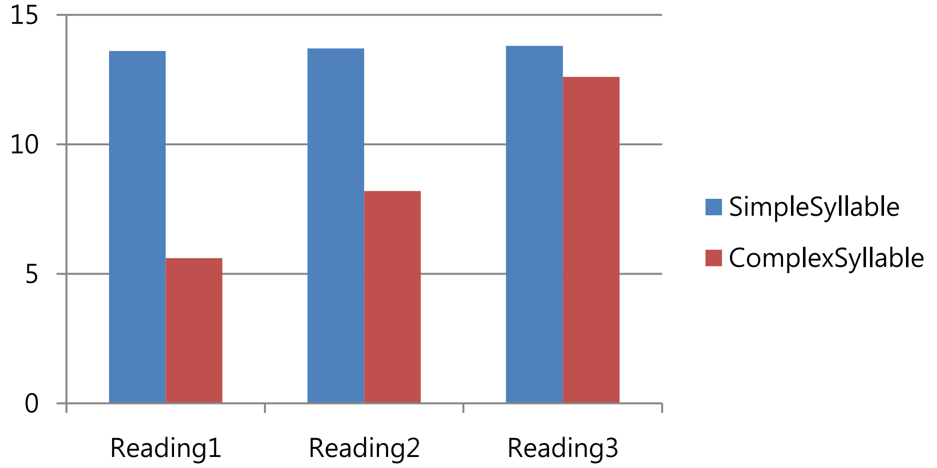

Figure9. Mean Proportion of Correct Responses on Simple and Complex Syllables based on the type of Task in Non-word Reading

The differences in performance were higher among individuals in reading levels 1 in simple and complex syllables, both for word and non-word processing. As the reading level improves, the differences in performance tend to decrease, albeit decreasing slightly more in word processing. Regarding the differences between reading levels, the performance on simple syllables does not have any significant influence, while the significant influence was found on the complex syllables between groups. Therefore, as stated in *the Orthographic Impact Theory*, the complexity of syllable does affect the reading path of participants, as the more complex the syllables are, the more difficult the reading process is.

6.2. Syllable and Phoneme Processing in Sound Learning in Korean

The third analysis was done to investigate the effect of orthographic skills; syllable awareness and phonological awareness. As noted in the previous chapter, Korean script is categorized as a mono-phonemic script, but with a specific type of syllable unit. Since Korean has a unique type of script, such that the symbol itself represents the sound through a mono-phonemic structure, but has a unique syllable composition based on the combination of consonant symbol and vowel symbol in one square box, it lacks a strict division regarding whether the syllable or phoneme process has a more significant influence on children's' phonological development. Therefore, an analysis was done to examine such factors when children are first faced with reading the script, and to determine which distinctive patterns are present during the developmental process.

For the analysis, frequency matched word based stimuli were presented to the participants. Since the task itself consisted of self-paced reading tasks, the stimuli were constructed of words. The correct response of each task, syllable processing (substitution and deletion of target syllable) and phoneme processing was calculated as 1 point when the participants gave the correct answer, and 0 for an incorrect answer. First, the results from the total syllable processing and phoneme processing among participants of all reading levels were summarized, shown in table 17 below:

Reading level	N	Syllable (M & SD)	Phoneme (M & SD)
1	18	29,78 (0,81)	13,67 (0,84)
2	13	30,15 (1,07)	17 (1,15)
3	28	30,21 (1,07)	24,43 (1,29)
Total	50	39,07 (0,99)	19,51 (4,99)

Table17. *Summary of Group Statistics on Word Syllable and Phoneme Processing*

In general, higher standard deviations were observed in phoneme processing than syllable processing, and for each group, such deviations gets higher as the reading level increases. For participants of all the reading levels, scores were better for the syllable tasks than the phoneme tasks. From the One Way Anova Test among reading levels (see Appendix, table 18), the difference in performance between groups was significantly higher for the phoneme tasks (F (1, 1) = 528, p=.00), while not for the syllable tasks (F (1, 1) = 1.1, p=.33). In specific, from the *Bonferroni* analysis (see Appendix, table 19), between each level, 1 and 2 (p=.91), 2 and 3 (p=1.0), and 1 and 3 (p=.45), the differences were not significant for the syllable tasks, while for the phoneme process the difference in performance was highly significant for all levels. Due to the bigger distribution in phoneme processing, the mean of correct responses was significantly different among age groups, and the distribution of the scores was highly scattered, while it was relatively centralized and regular for the syllable tasks. For the relation between syllable and phoneme processing among participants, the *Pearson Coefficient Correlation* test (see Appendix, table 20) was conducted and the correlation was very low (r=.22, p=.08) and not significant. The distribution of the score sheet also indicates that the performance on syllable tasks has no correlation with the phoneme tasks rather it is more related to the reading levels. Better reading levels showed overall better performances, but results were significantly different among levels on phoneme processing.

In summary, the results from the syllable and phoneme processes show that between groups the syllable processing was much easier than the phoneme processing, and that among participants of different reading levels, significant differences were found in phoneme processing with a stronger distribution across levels. A more specific analysis was conducted comparing each performance on syllable and phoneme processing based on the position of the target syllable and phoneme (see table 21 for the group statistic results).

Reading level		Initial syllable substitution	Final syllable substitution	Initial syllable deletion	Final syllable deletion	Initial phoneme substitution	Final phoneme substitution	Initial phoneme deletion	Final phoneme deletion
1	Mean	13.61	13.56	13.56	13.56	9.22	6.22	9.06	6.00
	N	18	18	18	18	18	18	18	18
	Std. Deviation	.608	.511	.511	.511	.808	.808	.802	.767
2	Mean	13.92	13.92	14.00	13.77	10.31	8.23	10.31	8.23
	N	13	13	13	13	13	13	13	13
	Std. Deviation	.641	.641	.577	.439	.480	.599	.751	.832
3	Mean	14.18	14.07	14.04	14.04	11.18	9.86	11.18	9.93
	N	28	28	28	28	28	28	28	28
	Std. Deviation	.548	.604	.693	.693	.548	.651	.670	.716
Total	Mean	13.95	13.88	13.88	13.83	10.39	8.39	10.34	8.36
	N	59	59	59	59	59	59	59	59
	Std. Deviation	.628	.618	.646	.620	1.051	1.722	1.169	1.864

Table21. *Group Statistic Results of* C*orrect Responses across the Position of Syllable and Phoneme*

As stated above, the mean proportion of correct responses was relatively higher in syllable substitution and deletion tasks, than in phoneme substitution and deletion tasks, across all the positions of the syllables. When comparing the standard deviation of each position in all the tasks, in the phoneme task, the final phoneme substitution and deletion had a higher distribution than the initial phoneme across all the levels. For the syllable task, the distribution does not have a specific pattern, rather it was different per level, but the size difference of the distribution was lower than that of the phoneme tasks. The One Way Anova Test for the syllable task (see Appendix, table 22), showed that across the position of target syllable and type of tasks, significant differences between groups were observed; initial syllable substitution ($F (1, 1) = 5.1$, $p=.01$), final syllable substitution ($F (1, 1) = 4.3$, $p=.02$), initial syllable deletion ($F (1, 1) = 3.6$, $p=.03$), and final syllable deletion ($F (1, 1) = 3.7$, p=.03). The *Bonferroni* Analysis was used to see the differences between levels more specifically (see Appendix, table 23), the significant differences were observed only between levels 1 and 3.

For the phoneme tasks, the substitution and deletion tasks show significant differences across all the positions (see Appendix, table 24), with a higher significant difference on the final position of the target phoneme (final phoneme substitution; F (1, 1) = 151.4, p=.00, and final phoneme deletion; F (1, 1) = 147.4, p=.00). From the *Bonferroni* analysis (see Appendix, table 25), it can be seen that while the differences across all the levels were significant, the biggest differences were observed between levels 1 and 3 on final phoneme substitution and deletion (mean difference, 3.6 and 3.9, respectively) and between levels 1 and 2, there were also big differences on final phoneme substitution and deletion tasks (mean difference, 2.0 and 2.2, respectively). Although the difference was significant on initial phoneme tasks, the gap between levels was relatively lower than that of final phonemes. When comparing the performance only on the phoneme tasks, through the use of *Pearson Coefficient Correlation* test (see Appendix, table 26),the correlation between initial and final phoneme tasks were highly related (substitution; r=.91, p=.00, deletion; r=.77, p=.00). In other words, if the participants scored better in the initial phoneme task of the substitution and deletion tasks, the results from the final phoneme tasks would be higher as well. Using the total sum of the correct responses on each position and task, the following graphs, figures 10 and 11, represent the deviation between positions and types of tasks:

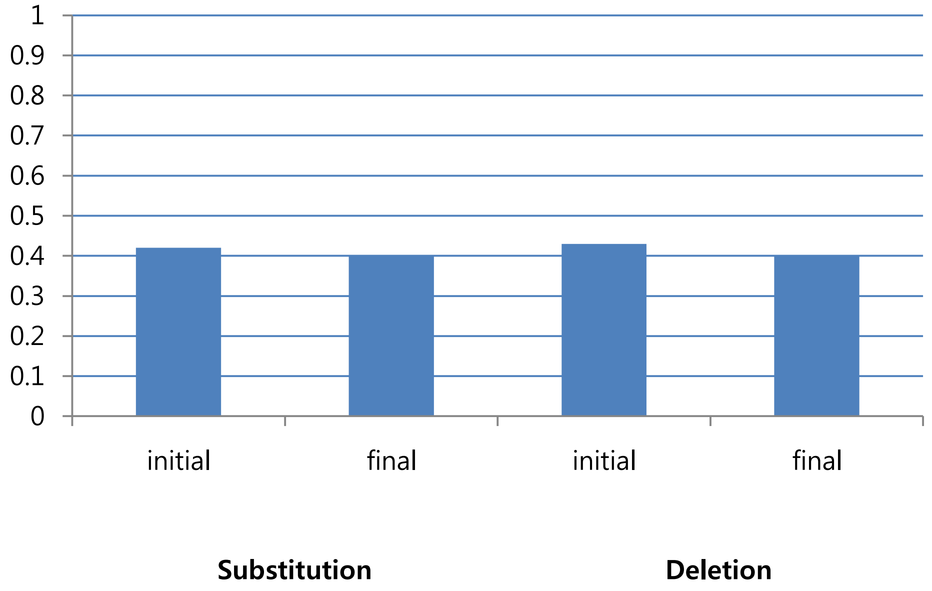

Figure10. Summary of Performance on Substitution and Deletion Tasks with Different Positions of Syllables

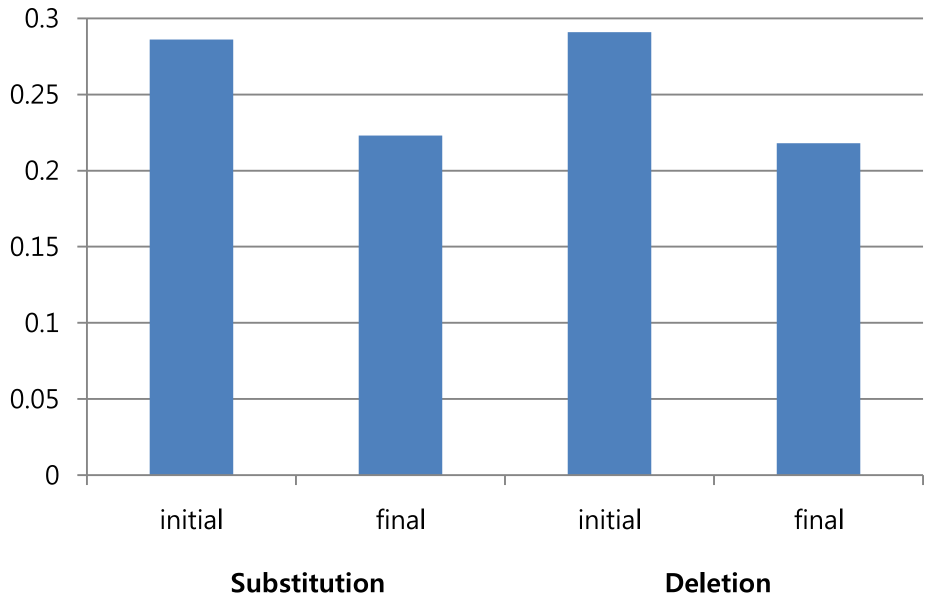

Figure11. Summary of Performance on Substitution and Deletion Tasks with Different Positions of Phoneme

When the total sum of correct responses has been calculated, the results become more straightforward. As seen in figures 9 and 10, no matter what task the participants performed, substitution or deletion, when conducting the syllable task, there are not many differences between the initial and final syllable. On the other hand, when participants were performing the phoneme task, there were certain disparities between the initial and final phoneme substitution and deletion tasks. Such disparities were not significant between the type of task; substitution or deletion. The *Pearson Coefficient Correlation* Test (see Appendix, table 27) indicates that no significant relationship was found between substitution and deletion tasks (r=.19, p=.16), with no effect of the task itself to the performance in general.

To sum up, between syllable and phoneme processing in general, children have better performance in syllable tasks than phoneme tasks with a significant difference across the levels. On the other hand, children tend to show highly significant difficulties when conducting the phoneme tasks and these differences were quite regular between all the levels. Specifically, the position of the target stimuli showed influence on the performance in general, especially for the phoneme tasks with the final phoneme being the most difficult task for the children.

6.3. Correlation between Chinese Knowledge and Korean Reading

The responses from the Chinese knowledge task have been calculated, and the level of Chinese knowledge has been categorized based on the criterion; level 1 (0-15 correct responses), level 2 (16-30 correct responses) and level 3 (31 correct responses). The re-categorized results of the Chinese knowledge level have been analyzed along with the reading level of the participants with a group statistical analysis, shown below:

Chinese level

Reading level	Mean	N	Std. Deviation
1	1.00	18	.00
2	1.08	13	.28
3	1.11	28	.42
Total	1.07	59	.31

Table28. Summary of Correct Responses of Frequency Matched with the Chinese Character among each Reading Level

From the statistical analysis, it can be seen that participants from reading levels 1, 2, and 3 received relatively similar scores with similar means, with a slight difference in deviations. Children with better reading levels tended to have a slightly larger distribution of correct responses, but the differences between individuals were not very significant. In other words, the number of correct responses of Chinese characters does not correlate with the reading fluency of the children. Based on the One-Way Anova Test, the relationship between groups in Chinese Character level is described in table 29.

Chinese level

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.13	2	.06	.64	.53
Within Groups	5.60	56	.10		
Total	5.73	58			

Table29. *One-Way Anova Test between Chinese Character Level and Reading Level*

As shown in table 31, the significant influence between groups in Chinese character level are not observed (F (1, 1) =.64, p=.53). In other words, the results of the correct responses for the Chinese characters do not differ much. Such correlation between knowledge of Chinese characters and reading level can be revealed through the *Pearson Coefficient of Correlation* test in table 30.

		Chinese level	Reading level
Chinese level	Pearson Coefficient	1	.147
	Sig. (2-tailed)		.27
	N	59	59
Reading level	Pearson Coefficient	.147	1
	Sig. (2-tailed)	.27	
	N	59	59

Table30. Coefficient of Correlation between Chinese Level and Reading Level

As shown in Table 30, the Chinese level does not have any significant influence on the reading level of children (p=.27) and the reading level does not have a significant influence on the Chinese level (p=.27). The linear relationship between the Chinese level and the reading level of participants indicates a low linear relationship (r=.2). A more specific analysis was conducted, highlighting the relation between the Chinese level on reading speed and accuracy separately (see Appendix, table 31). The reading aloud task on the matched word list of Korean was calculated both in terms of speed and accuracy. When comparing the results of Chinese level with speed and accuracy on the Korean word reading task, accuracy has a very weak linear relationship (r=.15) and speed a negative linear relationship (r=-.19), which represents a weak connection. No significant relationships were found for speed (p=.15) or accuracy (p=.25). Such results were shown in the graph between reading levels and the Chinese level as shown in figure12 below:

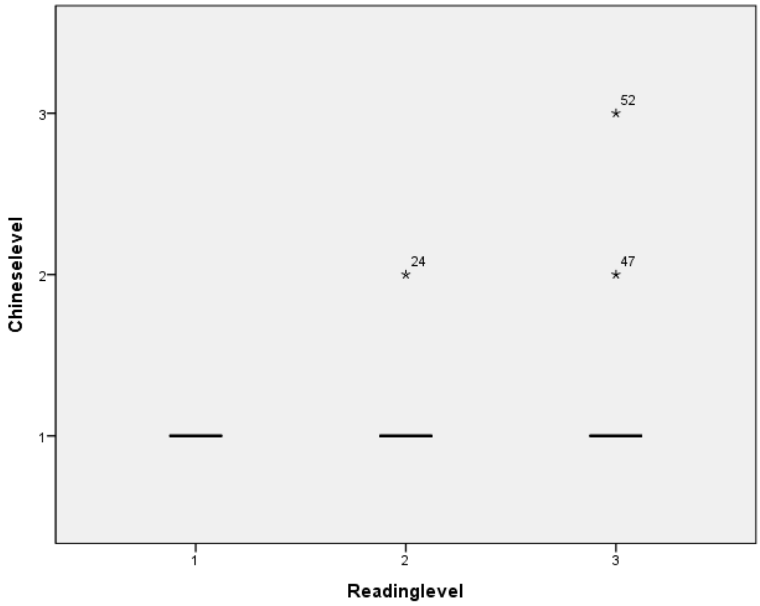

Figure12. Mean (and 95% between Subject Confidence Interval) for the Proportion of Chinese Level among Age Groups

As shown in figure 12, with the exception of a few outliers, no significant differences were found in the general proportion of the Chinese level among each reading level. Therefore, it is plausible to conclude that the degree of Chinese knowledge has no significant influence on Korean word reading; both in terms of speed and accuracy, and that there is not a big difference between participants with different reading levels.

6.4. Cross-modal Analysis of Korean Reading, Chinese Knowledge and Phonological Processing

From the individual analysis, the results point out that; 1) Among the participants, speed is the key factor in determining the reading fluency in Korean reading, 2) Complexity of the syllable has an influence on Korean reading, 3) Children show high levels of syllable awareness, but the pattern of phonemic skills is relatively low, and 4) The degree of recognizing Chinese characters does not have any correlation or effect on Korean word and non-word reading. A more comprehensive analysis is given (table 32) in the form of a simple linear regression analysis to see the direct relationship between all the variables from the individual analysis.

Model Summary

Model	R	R Squares	R adjusted	Std. Error of the Estimate
1	.96[a]	.92	.91	.70

a. Predictor: (Constant), Chinese level, syllable, phoneme

Anova[a]

		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	311.12	3	103.71	210.31	.00[b]
	Residual	27.12	55	.49		
	Total	338.24	58			

a. dependent variable: accuracy

b. predictor: (Constant), Chinese level, syllable, phoneme

Coefficients[a]

		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	32.57	2.95		11.05	.00
	Syllable	-.24	.09	-.09	-2.51	.02
	Phoneme	1.00	.04	.97	24.88	.00
	Chinese level	-.24	.29	-.03	-.82	.43

a. Dependent variable: accuracy

Table32. *Simple Linear Regression Analysis of Reading and Chinese level, Syllable Processing and Phoneme Processing*

Regarding the relationship between accuracy as a dependent variable and Chinese level (level of Chinese character knowledge), syllable processing, and phoneme processing as independent variables (r^2=.92, p=.00), the effect of phoneme processing was significant on the accuracy in Korean reading of children (p=.00), while the syllable processing and Chinese level were not.

Model	R	R Squares	R adjusted	Std. Error of the Estimate
1	.914[a]	.836	.827	126.612

a. Predictor: (Constant), Chinese level, syllable, phoneme

Anova[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4484625.434	3	1494875.145	93.252	.000[b]
	Residual	881679.413	55	16030.535		
	Total	5366304.847	58			

a. Dependent variable: Speed

b. Predictor: (Constant), Chinese level, syllable, phoneme

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		

1	(Constant)	-210.823	155.745		-1.354	.181
	Syllable	-5.868	54.153	-.006	-.108	.914
	Phoneme	66.296	4.108	.903	16.139	.000
	Chinese level	-6.073	3.483	-.095	-1.743	.087

a. Dependent variable: Speed

Table33. *Simple Linear Regression Analysis of Reading and Chinese Level, Syllable Processing, and Phoneme Processing 2*

As for the relationship between the speed of reading in Korean children and other variables (r^2=.84, p=.00 <0.05), it is even clearer that the Chinese level does not have any significant effect on the speed of reading in Korean children (p=.09), while the phoneme processing still has a significant effect (p=.00) and syllable processing is not significant but slightly related (p=.91).

6.5. Discussion

Based on the results from the experiment and the respective analysis, the proposed hypotheses will be thoroughly examined once again for better understanding.

A. *Hypothesis1.*

As followed by universal claim, reading speed becomes a factor to distinguish the fluency in the reading development of Korean reading since the orthographic consistency in Korean is considered to be transparent (Frost, 2005). Therefore, consistency of Korean symbols will have a significant effect on reading speed of Korean children. Furthermore, the complexity of the syllable which generates complex sound units will have a significant effect on reading development process.

In testing the frequency matched word and non-word stimuli, the accuracy had a lower standard deviation difference between participants of different reading levels, while the difference from the phoneme processing was higher. In other words, the distribution of scores on accuracy were not extremely spread out among participants, while the reading speed decreased significantly across the reading levels, especially in word processing.

Such slight differences on the steep of decreasing between word and non-word reading are caused by the relationship between reading levels and word frequency. The more fluent children's reading levels are, the faster the reading process and familiarity of a word. Such familiarity of a word at reading level 3 can be explained as the beginning of an elementary school education providing more exposure to the reading environment. Considering most of the participants of reading level 3 were engaged or about to engage in the elementary school level, this aspect coincides with one of the factors, '*availability'*, in the reading model, the *Psycholinguistic Grain Size Theory (*Ziegler & Goswami, 2005**)***;* which states that as the availability of the target sound units in daily life increases, the fluency of reading improves. Therefore, the readers tend to perform better, with a significant degree of reading development, as the input of sound units and the target languages are significantly amplified. Therefore, the higher consistency between symbols and sounds of Korean script makes children's reading development easier in terms of learning a sound, especially on the speed of reading; this effect becomes most noticeable when the '*availability'* is enhanced through the environment.

Furthermore, the effect of complexity was also measured. As the syllable becomes more complex, inside of the square box (in the form of CVCC or CVC), children tend to have more difficulty producing a correct response than with the simple CV square form without any bottom consonants. This aspect becomes worse; when the children face the two word-syllable target containing two full bottom consonants; few children answered correctly, or they hesitated or did not answer. For those who gave the correct response, it took more time than with the other stimuli. Since the structure of the Korean syllable system is unique, when the bottom consonant's combination becomes complex, for example compound consonants on the bottom with a strict disparity such as 'ㄹ' (/l/; liquid sound) and 'ㄱ'(/k/; a velar sound), children were inclined to have more difficulties. Also, as the size of the syllable grew, similar patterns were observed. Children did better on the one to two square syllable words than the 3 to 4 syllable words.

Such difficulties on complex syllables were significantly dominant in the children with a low level of reading, and this also indicates that the complexity of syllables affects the reading development of Korean children. Therefore, in Korean, a transparent orthography in which speed acts as a significant factor in the reading process, complexity is also shown to affect the overall performance, which supports the *Orthographic Theory (*Wimmer et al., 1994; Hutzler & Wimmer, 2004; Thorstad, 1991; MacWhinney, 1999; Davies et al., 2013) cross-linguistically.

B. *Hypothesis2*.

The influence of syllable awareness will be observed in the reading development of Korean children, since Korean reading requires processing sound units from the morpheme level instead of processing sounds based on the symbol level. Also, the performance will be modulated by the position of the phonological unit if the composition of words becomes complex.

The results indicate that the children performed significantly better on all syllable tasks than phoneme tasks across all positions of the target stimuli. The performance in substituting or deleting the initial syllable was slightly better than with the final syllable, but in general, there was not a significant difference between the initial and final syllable tasks. Children are aware of the division of a syllable, which is due to the strict division of a syllable in the square-box shape in Korean script. When it comes to the more complex syllables, children showed slight hesitation, especially for the initial position, but some of the participants solved this issue by drawing a line between the square box and an adjacent square box to make sure the distinction of syllable was clearer. This aspect was surprising, since even the youngest and least fluent groups of children, who have just started to learn or are not familiar with the serially composed symbols, were able to complete this action, while taking only a little more time than participants of better reading levels.

On the other hand, the results from the phoneme task indicate a different feature of the children's behavior; overall, the children have more difficulties processing the phoneme tasks as compared to the syllable tasks. Specifically, when analyzing the score sheet, children had more difficulties substituting or deleting the final phoneme, especially when the phoneme was placed in the bottom position. Initial phonemes mostly consist of one consonant or vowel type consonant ‘ㅇ’ (/ng/), but the options for the final phonemes are much more diverse, such as C, or CC. When the children needed to substitute or delete the initial phoneme ‘ㅇ’ (/ng), more errors were found than in the simple consonant C. The majority of errors observed included the inclination to perceive the final phoneme as a whole square box syllable instead of substituting or deleting the final bottom phoneme, and certain incorrect answers were generated by mixing up the sound unit from a whole square box with a phoneme. When children were asked to replace or delete the ‘phoneme’, the first step they made was cognizing the sound units, and this awareness was focused on a big chunk of the sound, thus the sound unit from an entire square box syllable.

Another type of error the children made occurred when replacing the final bottom phoneme for the composition of a double consonant – CC type; instead of targeting the second consonant, children made an answer from the sound units of a combination of consonants or they confused the first consonant with an entire phoneme unit from the bottom. For example, when the word ‘젊’ (jul-rm) was given, and the target phoneme was ‘ㅁ’ (/m/), instead of correctly responding, children answered ‘ㄹ’(/l/), which serves as a first consonant, or the sound units of a combination of the two consonants ‘ㄹ(/l/)’+’ㅁ(/m/)=’ㄹ’(/l/); they also perceived the ‘ㄹ’(/l/) sound unit as an entire phoneme unit, instead of distinguishing each phoneme. In other words, during Korean phonological development, children are likely to perceive a relation between symbols and sounds based on the sound units from the syllable, instead of recognizing the sound unit through phoneme to phoneme serially. This process can be explained through a DRC modal (Coltheart et al., 2001); such a process can be interpreted as the findings from the Lexical route:

“Phonemes are activated in parallel across all phoneme positions by the lexical route, but are

activated serially, left-to-right, phoneme-by-phoneme, by the sub-lexical route." (Coltheart et al, 2001)

Although Korean script is constructed through a mono-phonemic symbol in which symbols represent a respected sound, the reading process in Korean children does not completely follow the GPC route. Instead, children take a lexical route, in which the whole-grained process is applied, and a word or letter activates a word's letter unit in Korean, it is a one square box syllable that activates a phonological unit 'phoneme' in the end. When children of Korean reading encounter the letter units from the script, the first thing they do is to recognize the word in the lexical entry in the orthographic units, in the case of Korean, this means finding a lexical square box shape in the orthographic units, then the corresponding sound which is generated from the whole square box syllable is activated, in the form of a phoneme combination inside of the square box syllable. These coarse grained mappings between sounds and words require syllable awareness for the Korean speaking children to distinguish or activate the syllable units into proper sound units.

The phoneme awareness had less influence than the syllable awareness, at least in the beginning stages. This is due to the fact that the process of coarse grained mapping makes a combination of phonemes works as one sound unit instead of working one by one, serially. Therefore, in the phonological awareness of Korean children, syllable awareness has more influence than phoneme awareness, and this feature is caused by the uniqueness of the orthographic characteristics of Korean script, in which the two types of syllables become a significant factor in the reading process.

C. *Hypothesis 3.*

Although the Chinese Character will be different in correlation with the reading fluency, the actual reading speed and accuracy will not strongly be affected by the degree of knowledge of Chinese character, since Korean symbols are related to Chinese logogram in meaning but not sound.

Although the more aged groups performed slightly better on the Chinese level tasks, this does not necessarily correlate with their reading level, but can more likely be interpreted as more exposure to the characters in their individual environments. Participant environments are not identical, thereby causing the irregular pattern of Chinese level across age groups. In the Coefficient of correlation analysis, although some of the participants from the more advanced reading level performed slightly better on Chinese level, it was not significant enough to conclude that one at a better reading level tends to know more related Chinese Characters or vice versa.

The comparison of participants' reading fluency with the factors of Chinese knowledge, syllable processing, and phoneme processing can be summarized as shown in Figure 13 below:

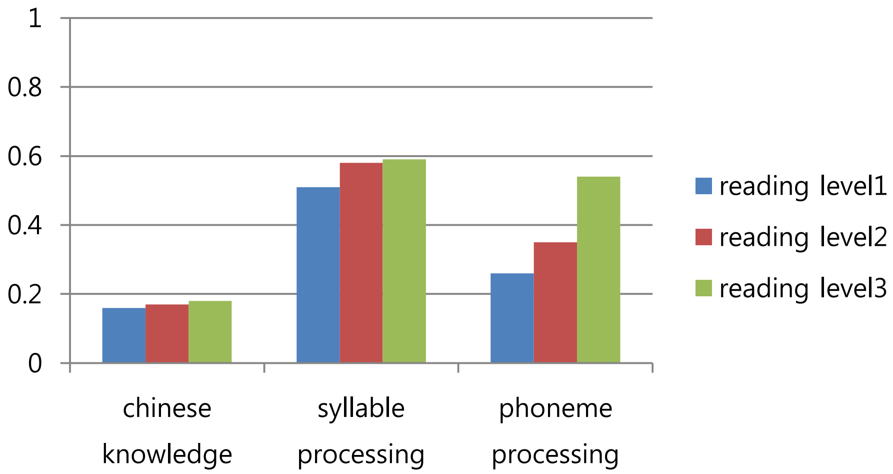

Figure13. Three Dimensional Comparisons between Reading Level and Chinese Knowledge Level, Syllable Processing, and Phoneme Processing

The stimuli applied in the experiments were matched with the meaning, for instance, a Chinese character was matched with a Korean symbol or word(s) s (one square box – one syllable). Therefore, although the list was random, the speed and accuracy of reading sorted Korean words was still shown to have an indirect correlation with the Chinese character stimuli in the Chinese level experiment. As stated in the analysis, based on Pearson's Coefficient results, no significant relationships between speed and Chinese knowledge or, accuracy and Chinese knowledge were found. In other words, the degree of knowledge of the matched Chinese characters does not have much influence on the fast and accurate reading of Korean words.

Although the meaning components of Korean words or symbols consists mostly of Chinese characters, the relationship between these two morphemes is quite limited since the Chinese character itself works as an image to represent the meaning, without having any significant influence on building the sound structure or the composition of the Korean symbols. Chinese characters are only there to aid in a finer understanding of the words through context. Therefore, the general reading aloud task, used to investigate the phonological aspects and visual accuracy, does not have any correlation with the knowledge of Chinese symbols even though the listed words are matched. In the general process in the early stages of reading development, children gradually build knowledge of symbols which correlate to respective sounds or meanings based on the categorization of the orthographic characteristics.

In the case of Korean reading, a symbol itself represents a sound from the first place, instead of a semantic representation which requires the semantic related route. Therefore, for the Korean speaking children, the beginning stage of reading development is mainly associated with decoding the sound from the scripts, instead of decoding the internal shape of the symbols to decode an attached meaning. Therefore, the degree of knowledge of Chinese characters does not have a significant influence on Korean reading for children, since the role of Chinese characters in Korean script is merely to aids in a more thorough meaning distinction. Consequently, the hypothesis on the Correlation between Chinese knowledge and the Korean reading process has been confirmed through the experiments, as the degree of Chinese knowledge has no significant influence on Korean symbol or word reading in children.

Conclusion and Implications

So far, the research has argued language-universal cognitive features of learning to read; the orthographic impact states that the features of orthography influence the reading process of the target script cross-linguistically and that language specific requirements necessitate specific strategies for readers. From the overall assessment of Korean reading development, the specific features of the script, from the symbol to the structure or composition of the symbols, play a key role for the strategies, as Korean itself follows neither the alphabetic system nor the adjacent language group, Chinese and Japanese. It is the unique features of Korean script itself that influence the reading process in the end, thereby posing the question for further studies, that among non-alphabetic systems, which factors of the script play a key role in reading.

Furthermore, two key issues remain understudied from the proposed research, the correlation between the Chinese knowledge level and the semantic access of Korean reading. Also, in order to observe the variations in reading development, direct and indirect comparisons between children and adults of Korean readers might be a good method to determine the significant differences and the specific stages of the development in general. Such further studies will bring about a thorough understanding of the reading process in non-alphabetic languages, which remain understudied. Also, to aid in building a concrete starting point and respected strategies for practice in the area of reading and its disorders, the proposed research will develops a good starting point for the Korean script. Therefore, the proposed research, although with some limitations on the method, will shed light on the fundamental features of the Korean script, thereby giving good implications for further studies.

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Appendix

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Accuracy (w)	Equal variances assumed	1.372	.251	-1.770	29	.087	-1.709	.966	-3.684	.266
	Equal variances not assumed			-1.849	28.863	.075	-1.709	.924	-3.601	.182
Speed (w)	Equal variances assumed	18.435	.000	5.675	29	.000	320.423	56.462	204.943	435.904
	Equal variances not assumed			5.122	16.208	.000	320.423	62.563	187.934	452.912

Table10. *Results of Independent Sample T-test of Frequency Matched Korean Word Reading, on both the Accuracy and the Speed between Reading Levels 1 and 2*

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig	t	df	Sig(2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
accuracy	Equal variances assumed	1.022	.318	.121	39	.904	.082	.679	-1.291	1.455
	Equal variances not assumed			.115	20.622	.910	.082	.717	-1.411	1.576
Speed	Equal variances assumed	70.724	.000	7.763	39	.000	324.363	41.782	239.850	408.875

	F	Sig	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Equal variances not assumed			5.527	12.813	.000	324.363	58.687	197.389	4510.336

Table11. *Results of Independent Sample T-test of Frequency Matched Korean Word Reading, on both the Accuracy and the Speed between Reading Levels 2 and 3*

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Accuracy non-word	Equal variances assumed	.007	.935	-1.703	29	.099	-.517	.304	-1.138	.104
	Equal variances not assumed			-1.737	27.645	.094	-.517	.298	-1.127	.093
Speed non-word	Equal variances assumed	1.261	.271	26.433	29	.000	302.603	11.448	279.189	326.016
	Equal variances not assumed			28.066	28.957	.000	302.603	10.782	280.550	324.655

Table12. *Results of Independent Sample T-test of Frequency Matched Korean Non-word Reading, on both the Accuracy and the Speed between Reading Levels 1 and 2*

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig.(2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper

Accuracy Non-word	Equal variances assumed	1.967	.169	.153	39	.879	.033	.216	-.403	.469
	Equal variances not assumed			.137	18.313	.893	.033	.241	-.473	.539
Speed Non-word	Equal variances assumed	.002	.969	79.056	39	.000	646.802	8.182	630.253	663.351
	Equal variances not assumed			78.975	23.422	.000	646.802	8.190	629.877	663.728

Table13. *Results of Independent Sample T-test of Frequency Matched Korean Non-word Reading, on both the Accuracy and the Speed between Reading Levels 2 and 3*

		Sum of Squares	df	Mean Square	F	Sig.
Simple Syllable word	Between Groups	.734	2	.36	1.14	.32
	Within Groups	18.01	56	.32		
	Total	18.74	58			
Complex Syllable word	Between Groups	588.51	2	294.25	780.38	.00
	Within Groups	21.11	56	.37		
	Total	609.62	58			
Simple Syllable Non-word	Between Groups	.56	2	.28	.87	.42
	Within Groups	17.94	56	.32		
	Total	18.50	58			
Complex Syllable Non-word	Between Groups	553.71	2	276.85	740.59	.00
	Within Groups	20.93	56	.37		
	Total	574.64	58			

Table15. *One Way Anova Test on Performance Differences between Simple and Complex Syllables,*

based on the Reading Level

Bonferroni

Dependent Variables	(I) Reading level	(J) Reading level	Mean Difference(I-J)	Std. Error	Sig.	95% Confidence Interval for Difference	
						Lower	Upper
Simple Syllable word	1	2	.11	.20	1.00	-.40	.63
		3	-.07	.17	1.00	-.50	.36
	2	1	-.11	.20	1.00	-.63	.40
		3	-.18	.19	1.00	-.66	.29
	3	1	.07	.17	1.00	-.36	.50
		2	.18	.19	1.00	-.29	.66
Complex Syllable word	1	2	-3.65*	.22	.00	-4.20	-3.10
		3	-7.29*	.18	.00	-7.75	-6.83
	2	1	3.65*	.22	.00	3.10	4.20
		3	-3.64*	.20	.00	-4.15	-3.13
	3	1	7.20*	.18	.00	6.83	7.75
		2	3.64*	.20	.00	3.13	4.15
Simple Syllable non-word	1	2	-.08	.20	1.00	-.59	.43
		3	-.13	.17	1.00	-.57	.29
	2	1	.08	.20	1.00	-.43	.59
		3	-.05	.19	1.00	-.53	.42
	3	1	.13	.17	1.00	-.29	.57
		2	.05	.19	1.00	-.42	.53
Complex Syllable non-word	1	2	-2.54*	.22	.00	-3.09	-1.99
		3	-6.92*	.18	.00	-7.38	-6.47
	2	1	2.54*	.22	.00	1.99	3.09
		3	-4.38*	.20	.00	-4.89	-3.88
	3	1	6.92*	.18	.00	6.47	7.38
		2	4.38*	.20	.00	3.88	4.89

*. Mean differences are significant at 0.05.

Table16. *Bonferroni Analysis of Differences between Simple and Complex Word, and Non-word Syllables by Reading Level*

		Sum of Squares	df	Mean Square	F	Sig.
Syllable	Between Groups	2.21	2	1.10	1.11	.33
	Within Groups	55.51	56	.99		
	Total	57.72	58			
phoneme	Between Groups	1373.88	2	686.94	528.00	.00
	Within Groups	72.85	56	1.30		
	Total	1446.74	58			

Table18. *One Way Anova Test on Performance Differences between Syllable and Phoneme Processing, based on the Reading Level*

Bonferroni

Dependent variables	(I) Reading level	(J) Reading level	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference	
						Lower	Upper
Syllable	1	2	-.37	.36	.91	-1.27	.52
		3	-.43	.30	.45	-1.18	.31
	2	1	.37	.36	.91	-.52	1.27
		3	-.06	.33	1.00	-.89	.76
	3	1	.43	.30	.45	-.31	1.18
		2	.06	.33	1.00	-.76	.89
phoneme	1	2	-3.33*	.41	.00	-4.36	-2.31
		3	-10.76*	.34	.00	-11.61	-9.91
	2	1	3.33*	.41	.00	2.31	4.36
		3	-7.42*	.38	.00	-8.37	-6.48
	3	1	10.76*	.34	.00	9.91	11.61
		2	7.42*	.38	.00	6.48	8.37

*. Mean Differences are significant at 0.05.

Table19. *Bonferroni Analysis of Difference between Syllable and Phoneme Processing by Reading Level*

		Syllable processing	Phoneme processing
syllable	Pearson Coefficient	1	.22
	Sig. (2-tailed)		.08
	N	59	59
phoneme	Pearson Coefficient	.22	1
	Sig. (2-tailed)	.08	
	N	59	59

Table20. *Pearson Coefficient Correlation Test between Syllable and Phoneme Processing*

		Sum of Squares	df	Mean Square	F	Sig.
Initial Syllable Substitution	Between Groups	3.53	2	1.77	5.13	.009
	Within Groups	19.30	56	.34		
	Total	22.84	58			
Final syllable Substitutes	Between Groups	2.94	2	1.47	4.28	.018
	Within Groups	19.22	56	.34		
	Total	22.16	58			
Initial Syllable Deletion	Between Groups	2.76	2	1.38	3.61	.034
	Within Groups	21.40	56	.38		
	Total	24.16	58			
Final Syllable deletion	Between Groups	2.58	2	1.29	3.67	.032
	Within Groups	19.71	56	.35		
	Total	22.30	58			

Table22. *One Way Anova Test on Correct Responses*

across the Positions of the Syllable

Bonferroni

Dependent Variable	(I) Reading level	(J) Reading level	Mean Difference(I-J)	Std. Error	Sig.	95% Confidence Interval for Difference	
						Lower	Upper
Initial Syllable substitution	1	2	-.31	.21	.45	-.84	.22
		3	-.56*	.17	.00	-1.01	-.13
	2	1	.31	.21	.45	-.22	.84
		3	-.25	.19	.60	-.74	.23
	3	1	.56*	.17	.00	.13	1.01
		2	.25	.19	.60	-.23	.74
Final Syllable substitution	1	2	-.36	.21	.27	-.89	.16
		3	-.51*	.17	.01	-.95	-.08
	2	1	.36	.21	.27	-.16	.89
		3	-.14	.19	1.00	-.63	.34
	3	1	.51*	.17	.015	.08	.95
		2	.14	.19	1.00	-.34	.63
Initial Syllable deletion	1	2	-.44	.22	.16	-1.00	.11
		3	-.48*	.18	.03	-.94	-.02
	2	1	.44	.22	.16	-.11	1.00
		3	-.03	.20	1.00	-.55	.48
	3	1	.48*	.18	.039	.02	.94
		2	.03	.20	1.00	-.48	.55
Final Syllable deletion	1	2	-.21	.21	.98	-.75	.32
		3	-.48*	.17	.02	-.92	-.04
	2	1	.21	.21	.98	-.32	.75
		3	-.26	.19	.55	-.76	.23
	3	1	.48*	.17	.02	.04	.92
		2	.26	.19	.55	-.23	.76

*. Mean differences are significant at 0.05..

Table23. *Bonferroni Analysis on Performance Differences on Syllable Tasks based on the Position of the Target Syllable by Reading Level*

	Sum of Squares	df	Mean Square	F	Sig.

Initial phoneme substitution	Between Groups	42.046	2	21.02	53.54	.00
	Within Groups	21.987	56	.39		
	Total	64.034	58			
Final phoneme substitution	Between Groups	145.187	2	72.59	151.42	.00
	Within Groups	26.847	56	.47		
	Total	172.034	58			
Initial phoneme deletion	Between Groups	49.400	2	24.70	46.38	.00
	Within Groups	29.821	56	.53		
	Total	79.220	58			
Final phoneme deletion	Between Groups	169.361	2	84.68	147.43	.00
	Within Groups	32.165	56	.57		
	Total	201.525	58			

Table24. *One Way Anova Test on Correct Responses across the Positions of the Phoneme*

Bonferroni

Dependent variable	(I) Readinglevel	(J) Readinglevel	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference	
						Lower	Upper
Initial Phoneme substitution	1	2	-1.08*	.22	.00	-1.65	-.52
		3	-1.95*	.18	.00	-2.42	-1.49
	2	1	1.08*	.22	.00	.52	1.65
		3	-.87*	.21	.00	-1.39	-.35
	3	1	1.95*	.18	.00	1.49	2.42
		2	.87*	.21	.00	.35	1.39
Final Phoneme Substitution	1	2	-2.00*	.25	.00	-2.63	-1.39
		3	-3.63*	.20	.00	-4.15	-3.12
	2	1	2.00*	.25	.00	1.39	2.63

		3	-1.62*	.23	.00	-2.20	-1.05
	3	1	3.63*	.20	.00	3.12	4.15
		2	1.62*	.23	.00	1.05	2.20
Initial Phoneme Deletion	1	2	-1.25*	.26	.00	-1.91	-.60
		3	-2.12*	.22	.00	-2.67	-1.58
	2	1	1.25*	.26	.00	.60	1.91
		3	-.87*	.24	.00	-1.48	-.27
	3	1	2.12*	.22	.00	1.58	2.67
		2	.87*	.24	.00	.27	1.48
Final Phoneme Deletion	1	2	-2.23*	.27	.00	-2.91	-1.55
		3	-3.92*	.22	.00	-4.49	-3.36
	2	1	2.23*	.27	.00	1.55	2.91
		3	-1.69*	.25	.00	-2.33	-1.07
	3	1	3.92*	.22	.00	3.36	4.49
		2	1.69*	.25	.00	1.07	2.33

*. Mean differences are significant at 0.05.

Table25.*Bonferroni Analysis on Different Performances on Phoneme Tasks based on the Position of the Target Phoneme by Reading Level*

		Initial phoneme substitution	Final phoneme substitution
Initial Phoneme substitution	Pearson Coefficient	1	.91**
	Sig. (2-tailed)		.00
	N	59	59
Final phoneme Substitution	Pearson Coefficient	.91**	1
	Sig. (2-tailed)	.00	
	N	59	59

**. Coefficient Correlation is significant at 0.01 (2-tailed).

		Initial phoneme deletion	Final phoneme deletion
Initial phoneme deletion	Pearson Coefficient	1	.77**
	Sig. (2-tailed)		.00
	N	59	59
Final Phoneme deletion	Pearson Coefficient	.77**	1
	Sig. (2-tailed)	.00	
	N	59	59

**. Coefficient Correlation is significant at 0.01 (2-tailed).

Table26. *Pearson Coefficient Correlation Test between Initial and Final Phonemes, both Substitution and Deletion Tasks.*

		substitution	Deletion
substitution	Pearson Coefficient	1	.19
	Sig. (2-tailed)		.16
	N	59	59
deletion	Pearson Coefficient	.19	1
	Sig. (2-tailed)	.16	
	N	59	59

Table27. *Pearson Coefficient Correlation Test between Type of Tasks; Substitution and Deletion Tasks*

		Chinese level	accuracy	speed
Chinese level	Pearson Coefficient	1	.15	-.19
	Sig. (2-tailed)		.25	.15
	N	59	59	59
Accuracy	Pearson Coefficient	.15	1	
	Sig. (2-tailed)	.25		
	N	59	59	
Speed	Pearson Coefficient	-.19		1
	Sig. (2-tailed)	.15		
	N	59		59

Table31. Coefficient of Correlation between Chinese Level and