Subsyllabic units in reading

A difference between Korean and English

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Onset-rime structures appear to be important in learning to read English. They provide, in the spoken language, a subsyllabic structure that is accessible to children prior to their ability to reliably access phonemes (Goswami & Bryant, 1990; Treiman, 1992). This highly accessible rime structure then can play a role in the beginning stages of reading, as children learn to map written words onto spoken units. Goswami (1993), for example, found that presenting children with rime-based analogies facilitates learning a set of written words. This support for learning comes from the possibility that beginning readers recognize that the spoken word *plum* has (at least) two sounds, the onset /pl/ and the rime /um/ without necessarily being aware that each further contains two segments. Beginning readers take advantage of these accessible units, in particular allowing the child to recognize that the written words *plum, tum,* and *yum* all share a rime in their *um* spelling. Evidence for this process came from the fact that children, having learned to read one word, could best read words that shared rimes, rather than other syllable parts, with the learned word.

But is the value of onset-rime structure a universal feature of language (Fudge, 1969, 1987) or is it a linguistic-specific property? Correspondingly, is its value in supporting early reading a general property of how reading builds on spoken language or is a more specific property of reading certain languages written in certain orthographies?

Research on the development of phonological awareness and word recognition has led to a number of theories about influential features of both the spoken language and writing systems, and the process of mapping the latter onto the former. McBride-Chang, Wagner, and Chang (1997) demonstrate that speech perception is an important precursor to phonological awareness, and that its effects on word reading may be mediated by phonological processing skill. Cross-linguistic research and analyses have become a necessary methodology to isolate effects of each of these systems on the development of phonological awareness and word recognition ability (see for example Cossu, Shankweiler, Liberman, Katz & Tola, 1988; Wimmer & Goswami, 1994).

The Korean writing system provides an interesting comparison with studies done in English and European languages. In contrast to other writing systems, Hangul was more invented than developed, and its letter-phoneme correspondences are completely transparent. The main writing system of Korean, the Hangul, is alphabetic; however, unlike the Roman alphabetic system it is nonlinear. The composition of its letters follows a square structure, or Kulja, in which the letters are arranged left-to-right, top-to-bottom, as illustrated in Figure 1. Each square pattern contains up to 4 letters and corresponds to a single syllable.

Linguistically, there are a number of differences between Korean and English that could be important for the issues we raise here. For one, Korean has fewer phonemes than English, an inventory of 19 consonants, 10 vowels (19 including diphthongs), and 2 glides. Also in contrast to English and European languages, there is no voicing contrast in Korean. Thus /k/ and /g/ are not distinguished. However, Korean distinguishes among three manners of stop consonants in terms of vocal tract constriction (tenseness); for example, /p/, /pp/, and /p'/ are three different levels of the voiceless bilabial. A tendency toward open syllables and a lack of consonant clusters provide further contrast with English and European languages.

With these and other linguistic differences as potentially important for the issue we address, we can focus on the central question of whether this alphabetically written language, like English, awards some privilege in the use of onset-rime in reading. This question was addressed in a dissertation by H. K. Yoon (1997), who studied 4, 5, and 6-year-old Korean children's preference for subsyllabic units. In her grapheme substitution task, Yoon taught a child to read a 'clue word', e.g., 칼 (/kal/). Then, with the clue word still visible, the child heard other words that share some part of the syllable /kal/. Some shared the rime, e.g., /dal/, others shared the first and final consonant, e.g., /kul/, and others shared the initial consonant and the vowel, /kam/. The child's task was to select which part must be changed to produce a given target word from /kal/. For the /dal/ example, the child should select the first phoneme 'k', for the /kul/ example, the 'a', and for /kam/, the 'l'. Note that in the first case, going from *kal* to *dal*, the rime unit is preserved, and should be the easiest case if the onset-rime structure is salient. However, Yoon (1997) found that subjects performed more accurately in substituting the final consonant grapheme task (*kal* to *kam*) than the middle vowel (*kal* to *kul*) or initial consonant grapheme (*kal* to *dal*). Although the grapheme substitution task is not identical to Goswami's analogy task, there are enough similarities (e.g., a learned cue word to guide children's responses) to encourage the conclusion that Korean children, unlike English children, assign no privilege to the onset-rime structure. Instead, they seem more sensitive to the syllable body, the onset plus the vowel.

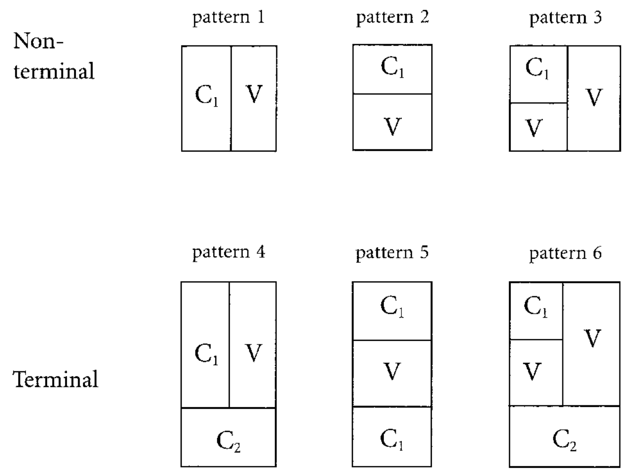

Figure 1. The 6 patterns of Kulja. Experiment 1 used patterns 4 and 5. Experiment 3 used 4, 5, and 6

Korean linguists Kim (1981) and Kwon (1987) first postulated the idea of the primacy of the body/coda structure in Korean. Similarly, evidence from word games and errors in speech and writing (Kim, 1981) have also lent support to the body/coda hypothesis. A number of empirical studies using adult Korean speakers further establish the use and preference for this pattern. In a Korean adapted replication of Fowler, Treiman, and Gross (1993), Yi (1998) asked subjects to perform a phoneme shift task. Subjects were presented with the pseudowords *pang* and *sep*, and then asked to substitute either the initial, middle, or final letter of the second syllable with the corresponding phoneme from the first syllable. Response time and error data suggested a preference for the body/coda structure in both visual and auditory presentation of the stimuli. Yi found similar effects in Korean using disyllabic (CVC-CVC) pseudowords, suggesting that this effect of syllable structure is not limited to word-level effects.

In considering the differences between Korean and English, however, it is also useful to keep in mind what these observations share — the observation that there are intermediate units between the syllable and the phoneme that may be functional in supporting early reading. It is clear that the rime is well established as one such unit. However, it may not be universal. Both the spoken language and the writing system might serve to influence which intermediate units will be most functional. In the case of a Korean-English comparison, the writing systems are both alphabetic. However, the unique spatial arrangement of the Hangul system, along with other features of the system[1], may encourage different processing strategies. Or it might be that because English is relatively unreliable in its grapheme-phoneme mappings, it encourages the onset-rime division in the interest of greater decoding reliability. Indeed, when rime units, rather than grapheme-phoneme pairings are the units of analysis, English turns out to be highly reliable (Treiman, Mullenix, Bijeljac-Babic & Richmond-Welty, 1995). Thus, it would be adaptive for children to focus on the more reliable rime units than on the less reliable grapheme-phoneme mappings. Korean is more reliable in its mappings than is English.

With these several possibilities in mind, we summarize below experiments aimed at learning more about the basis of this difference between English and Korean. We start by attempting to replicate H. K. Yoon's (1997) body-coda preference using a task which has reliably been used to establish the onset-rime unit, Goswami's analogy task. Experiment 1 seeks to establish that the differences between Korean (Yoon, 1997) and English (Goswami, 1993) children are not due solely to differences between word analogy and grapheme substitution tasks. Experiments 2 and 3 examine the possibility that script differences between the two writing systems influences the process of acquiring grapheme-phoneme correspondence rules. Experiment 2 examined the performance on the grapheme-substitution task of English-speaking adults learning Korean Hangul as an artificial orthography. Experiment 3 examined Korean children to learn whether their syllable body (C_1V_2) preference emerges also in an analogy task. Experiment 4 turned to spoken language, using a sound similarity judgement task to directly test whether differences in subsyllabic structure preferences are also present in perceptions of the spoken languages.

Experiment 1

Before we can address our primary research questions, we felt that it was necessary to establish the consistency of the body-coda preference in Korean children as shown in Yoon's (1997) Grapheme Substitution task. The findings of this study directly contradict those of Goswami's (1993) English-speaking children learning to read novel words in an Analogy task. While the findings from both studies appear reliable in their own right, task demands in either case may have contributed to the main effects. To be conclusive on this point, a cross-methodological design was developed to establish the psychological validity of the body-coda effect. Experiment 1 tested Korean-speaking children with the Analogy task used by Goswami (1993). Because many Korean 5-year olds can read words, we used monosyllabic CVC nonwords rather than real words. Table 1 illustrates the comparison between the Grapheme Substitution task used in the previous experiments and Goswami's Analogy task.

Table 1. Comparing Methodologies: The Grapheme Substitution Task and Reading by Analogy

Visual stimuli	**Auditory stimuli**	**Visual stimuli**	**Auditory stimuli**
CVC orthographic pattern	Corresponding pronunciation	CVC orthographic pattern	Corresponding pronunciation
mug ⟷ /mug/		mug ⟷ /mug/	
Grapheme Substitution Task (Yoon, 1997)		**Reading by Analogy** (Goswami, 1993)	
? ⟵ /dug/		dug ⟶ ?	

Table 2. Experiment 1: Analogy task Korean Hangul test stimuli and pronunciations

CVC Pattern	Clue Word	Shared Unit			
		C_1V	VC_2	V	C_1C_2
Pattern 4	쟐 /jyal/	쟙 /jyap/	샬 /syal/	샵 /syap/	졀 /jyul/
Pattern 5	뷱 /byuk/	뷴 /byun/	슉 /syuk/	슌 /syun/	뵥 /byok/
Pattern 6	괍 /guap/	괌 /guam/	솹 /suap/	솸 /suam/	궙 /guop/

Method

Participants

Twenty eight preschool children from the same kindergarten as Experiment 2 participated. Their mean age was 4 years and 5 months and all were native Korean speakers.

Materials

Korean CVC nonwords were developed to represent three of the basic six patterns of Kulja. These were Patterns 4, 5, and 6 illustrated in Figure 1. There were 3 clue words for each of the CVC Kulja forms. Each of the nine clue words was paired with 4 test nonwords. Each test word shared some part in common with the clue word; i.e. CV, VC, V, or CC. Table 2 shows examples of the nonwords used as tests for each type of clue word.

Procedure

An experimental session began with an explanation of the English word structure that included the idea that the initial consonant, the middle vowel, and the final

Table 3. Proportion of correct responses on each task condition

	Analogy condition (unit shared with CVC clue word)				
CVC Pattern	**CC**	**VC**	**CC**	**V**	**sum**
4 (□)	.494 (.3888)	.280 (.3982)	.238 (.3725)	.262 (.3887)	.3185
5 (□)	.512 (.4580)	.256 (.3941)	.274 (.4063)	.179 (.3040)	.3051
6 (□)	.345 (.3205)	.107 (.2877)	.155 (.3205)	.071 (.1839)	.1696
	.4504	.2143	.2222	.1706	

consonant part can be changed to make a new word. The experiment consisted of three phases. In the pre-reading phase, a child's ability to read was tested on 4 nonwords. If the child was able to read a particular test word, it was replaced by another word of the same condition to insure novel stimuli were used in the analogy phase. In the word learning phase, the child received the printed clue word along with its pronunciation (e.g., 걀 /jyal/) and encouraged to learn to read the clue word. Finally, in the analogy phase, the test words were given to the child with a request to use the clue word to help read any of the nonwords that he or she could not read. The order of the test words was randomized for each child.

Results

The main result concerns the comparison of analogy performance for rimes (shared VC) and bodies (shared CV). When clue words and test nonwords shared the CV, children correctly read the test nonwords on 45% of trials. This success rate was 21% when the clue word and test nonwords shared the VC, about the same as when they shared the CC, 22%. Nonwords that shared only the vowel produced a 17% success rate. Table 3 shows these data in proportion of correct responses.

Planned comparisons among the 4 Analogy Types verified that CV analogies produced a higher success rate than the VC analogies. There were no reliable differences among VC, CC, and V analogies.

The effect of Pattern was localized in the contrast between Pattern 6 and the other two types; the difference between Patterns 4 and the Pattern 5 condition was not reliable. The difficulty of Pattern 6 is arises either from a greater visual complexity (it presents 4 elements rather than 3) or a greater phonemic complexity (it contains two medial vowels) or both. The source of Kulja pattern differences is beyond our main purpose here. What is important is the generality of the CV > VC advantage over all 3 Kulja patterns.

Discussion

We now have a straightforward comparative result. Whereas English speaking children in the beginning stages of reading do better at reading rime-based analogies, Korean children at the beginning stages of reading do not; instead, Korean children do better at reading syllable body (CV) based analogies. This replicates the results of Yoon (1997) with the kind of task used by Goswami (1993). These results cast doubt on the idea that the rime as a functional orthographic unit is universal. The patterns found in Yoon's Grapheme Substitution results are not likely to be driven by task demands. Moving forward we are now able to ask questions about the influence of features of the written language in the development of functional rime or body units.

Experiment 2

One possibility for the Korean-English contrast lies in their scripts. Although both are alphabetic writing systems, the Korean script, in presenting a syllable unit in a recognizable spatial array, may promote a syllable parsing preference that favors the first and second graphemes. (Alternatively, one might say that the linear arrangement of letters in English discourages parsing the first two graphemes together.) An inspection of the 6 Kulja types in Figure 1 illustrates that possibility. Although most of the types cannot be said to group syllable bodies more than rimes, Pattern 4 for CVCs presents C1 and V on the same line, with C2 on the bottom line. Pattern 6 also separates the final consonant from the vowel. It is possible that the Korean preference for body + coda parsing arises from the script: C1 and V are more often grouped visual than are V and C2.

To examine this possibility, Experiment 2 presented Korean children with linear English script, using English CVC words and nonwords. If the children show the same results with English script as in Hangul, the Korean script, this would at least suggest that it is not the script by itself that is responsible for the contrast between Korean and English.

Method

Participants
Twenty seven preschool children (7 age-four and 20 age 5) with a mean age of 5 years, 5 months, participated. All were kindergarten students in a central South Korean elementary school. All were native Korean speakers.

Materials
English CVC words and nonwords were used in a Grapheme Substitution task. There were 12 CVC clue word (in English/Roman script) and 12 nonword clues and their corresponding 12 spoken syllables. None of the syllables were words in Korean, although all could be considered legal nonwords. Four problems were given for each substitution location (initial, middle, and final substitution). An example in each task condition is shown in Table 4.

Table 4. Experiment 2: Grapheme Substitution task stimuli in English orthography

Substitution condition	word	nonword
Initial consonant	bar/bar/ → /par/ bog/bog/ → /jog/ mug/mug/ → /dug/ sum/sum/ → /gum/	deg/deg/ → /jeg/ lum/lum/ → /hum/ sup/sup/ → /jup/ zep/zep/ → /lep/
Middle vowel	jig/jig/ → /jag/ sin/sin/ → /sun/ bar/bar/ → /bur/ gut/gut/ → /got/	bap/bap/ → /bip/ mol/mol/ → /mel/ dit/dit/ → /dat/ lod/lod/ → /led/
Final consonant	dog/dog/ → /dot/ sum/sum/ → /sun/ mug/mug/ → /mut/ zip/zip/ → /zig/	dit/dit/ → /dil/ min/min/ → /mig/ sup/sup/ → /sut/ jep/jep/ → /jeg/

Table 5. Grapheme Substitution procedure for CVC syllable in English orthography

	bun → initial consonant substitution ← sal
mun	min → middle vowel substitution ← dol dal
	mul → final consonant substitution ← dam

Procedure

Subjects were tested individually in the Grapheme Substitution task adapted from Yoon (1997) illustrated in Table 5. The first part of the experiment was an explanation of English writing. The explanation emphasized the location of the initial consonant, the middle vowel, and the final consonant part and was followed by an explanation of the substitution game. The experimenter then taught the child to read a clue word (e.g., mun ‡/mun/) on a card. While this card remained visible as a clue word, other words were presented. One shared a rime, and required the initial consonant to be substituted; e.g., /bun/. Another required vowel substitution /min/, an a third required final consonant substitution, e.g., /mul/.

In the test phase, children were presented with a clue word that was written on a card and simultaneously spoken. The card remained in front of them while the new target word was spoken. They were then asked which part of the clue word should be changed to produce the spoken target word.

Results

The main result is a confirmation of the syllable body-coda preference. On average, target words that required final consonant substitutions, the indicator of body-coda preferences, were correct 79% of trials. By contrast, words that required initial consonant substitution, the indicator of onset-rime preference, were correct on

Table 6. Experiment 2: Mean number of correct response on each substitution task

	Substitution Position			
Lexicality	Initial consonant	Middle vowel	Final consonant	sum
Word	1.222 (1.423)	0.370 (0.839)	2.482 (1.397)	1.358
Nonword	1.000 (1.468)	0.296 (0.869)	2.259 (1.678)	1.185
	1.111	0.333	2.370	

37% of trials. Poorest performance was for medial vowel substitution, which produced correct responses on only 11% of trials. Table 6 summarizes these data in terms of the mean number of correct responses.

Planned comparisons confirmed that there were two differences in the Substitution Location effect. Initial consonant and final consonant substitution were reliably different ($p < .05$) as was the difference between middle vowel and final consonant substitution ($p > .05$).

Discussion

These results further replicate those of Yoon (1997). Thus, whether in Korean with written Hangul or in English (unknown words for Korean children) with linear Roman letters, Korean children at the early stages of learning to read show a preference for the body-coda structure over the onset-rime structure. These results tend to cast doubt on the possibility that script differences as the source of the Korean-English contrast. It not only suggests that the Korean body-coda preference is not likely driven by the Hangul script, but it also suggests that the English script fails to drive an onset-rime preference in these speakers. To drive this point home, Experiment 3 asks if the reverse is true. That is, will Native-English speakers exhibit the onset-rime preference in the presence of the Korean script?

Experiment 3

Our first question was whether we would observe the rime preference in English speaking subjects using the Grapheme Substitution task. If so, then we would have increased reason to believe that the Korean-English contrast in subsyllabic structure is a genuine language or writing system difference rather than a result of task driven, methodological differences. The second question asked was whether these differences were driven from script rather than spoken language differences. If the onset-rime pattern persists in English subjects' performance on the Grapheme Substitution task, using the Korean Hangul script, we can infer that the body-coda preference exhibited by Korean speakers is not driven by the script. For practical reasons, this study was carried out using English-speaking adults. Comparing this task with the data from Yoon's (1997) Korean children may present some obvious differences with children learning to read. However, by utilizing Hangul as an artificial orthography, some general features of learning in an unfamiliar writing system can be mimicked. For instance, Artificial Orthographies use novel alphabet forms that confront adult learners with some of the challenges faced by a child learning to read (McCandliss, Schneider & Smith, 1997). Although the composition of artificial orthographies is arbitrary and any system can be used to study certain aspects of learning, the use of the Korean Hangul as an artificial orthography allows a comparison with Korean learners. When presented with a Grapheme Substitution task in an artificial orthography, would English adults show the Korean preference pattern (preference for onset + vowel) or the English (rime) pattern?

Experiment 1 used the materials of Yoon (1997) with only minor modification in a Grapheme Substitution task. Three possible outcomes for these data arise when compared with the original results from Korean speakers. American adults could produce (1) a different pattern than Korean speakers consistent with English onset-rime syllable structure (Kessler & Treiman, 1997); (2) a pattern similar to the Korean subjects, implying that the demands of the task discourage an onset-rime preference; (3) a pattern of equally high performance across all units, reflecting the fact that the English adults' high level of literacy and related phonological sensitivity allows easy access to all units, phonemes included.

Method

Participants

Thirty native English speakers, ages 18–24, participated for partial satisfaction of an undergraduate course requirement at the University of Pittsburgh.

Material

An artificial orthography was created from the Korean Hangul system. In the full Hangul system, there are 6 different syllable patterns (configurations of letters) that can represent the two basic Korean syllable types: consonant + vowel (C_1V_1) and consonant + vowel + consonant ($C_1V_1C_2$). A syllable is encoded in a Kulja (visual syllabic unit) that contains 2–4 letters. The six patterns of Kulja vary according to the placements of consonant and vowel (see Figure 2.) In this experiment, only two Kulja patterns representing a $C_1V_1C_2$ type syllable were used, pattern 4 (ex. 강) and 5 (ex. 공).

For the experiment, there were 12 visually presented clue Kuljas and their corresponding 12 spoken syllables. The clue stimuli were equally divided into the two Kulja patterns, half used pattern 4 and half used pattern 5. For each grapheme position in the $C_1V_1C_2$ Kulja, three grapheme substitution problems were created: initial substitution, middle substitution, and final substitution. As illustrated in Figure 1, a Pattern 4 Kulja is a left-right and bottom form (for example, 강); Pattern 5 is top-middle-bottom form (for example, 공). The following examples in Table 7

Table 7. Grapheme Substitution procedure for $C_1V_1C_2$ syllable in Hangul as an Artificial Orthography

	돔	→ initial consonant substitution	←	잘	
곰	굼	→ middle vowel substitution	←	덜	달
	골	→ final consonant substitution	←	당	

Table 8. Experiment 3: Graphem Substitution task procedure in Korean Hangul

Task	$C_1V_1C_2$ Kulja	Example
Initial-consonant substitution	명	We read it /myung/. To become / 경/(/gyung/), which part is substituted or deleted? (with pointing to the initial, middle and final part)
Middle-vowel substitution	귤	We read it /gyul/. To become / 굘/(/gyol/), which part is substituted or deleted? (with pointing to the initial, middle and final part)
Final-consonant substitution	종	We read it /johng/. To become / 좁(/johp/),which part is substituted or deleted? (with pointing to the initial, middle and final part)

illustrate how the Grapheme Substitution task employed the Kulja. In each case, the Kulja on the left (the clue Kulja) is converted to the Kulja on the right (the target Kulja) by the substitution of a single letter.

Procedure

Subjects were tested individually, beginning with an explanation of the artificial orthography. The experimenter explained that in the Kulja word structure, the initial consonant, the middle vowel, and the final consonant part can be substituted to create a new word. The participant was then taught to read a clue word, e.g., 강 (/kang/), which remained available on a card as a clue. In an experimental trial, presentation of the clue word was paired with the corresponding spoken syllable and then followed by a spoken syllable that shared segments with the clue word. For example, the clue word /kang/, could be followed by the spoken syllables /dang/ (initial consonant substitution), /kung/ (middle vowel substitution) and /kal/ (final consonant substitution). The participant was asked to indicate which part of the visual clue word would need to be changed in order to produce the new spoken syllable.

For each of the three substitution patterns, there were four problems (2 in Pattern 4, 2 in Pattern 5). An example in each task condition is shown in Table 8. All twelve problems were presented in random order.

Table 9. Experiment 3: Mean number of correct responses in each substitution task

	Substitution Position					
	Initial con(C1)		Middle vow(V)		Final con(C2)	
kulja pattern	4	5	4	5	4	5
M	1.62**	1.76	1.10	1.31	1.24	1.14
SD	(.622)	(.511)	(.817)	(.850)	(.831)	(.875)
Sum	1.69		1.21		1.19	

** Maximum in each category = 2

Table 10. Experiment 3: Number of subjects who showed above 3 of 4 correct responses in each condition

	Substitution Position	
initial con.(C1)	middle vow.(V)	final con(C2)
26*	14	15

* Maximum in each category = 29

Results

The important result is that when the target Kulja was produced from the Clue word by the substitution of the initial consonant, performance was superior to the other two substitution conditions. Thus, when the written syllable and the spoken syllable shared a rime, the task was easier. The average percent correct was 84.5% for initial consonant substitution, but only 60.5% and 59.5% for middle vowel and final consonant substitution, respectively. Planned comparisons reveal that this was a reliable effect. The mean number of correct responses on the substitution task are summarized in Table 9.

Because there is 1/3 chance of guessing correctly, we also examined the results from a criterion perspective. If we take 3 out 4 problems correctly solved a criterion for individual success, we can ask how many individuals were successful for each substation type. Of 29 participants, these numbers were 26 for initial consonant, 14 for medial vowel, and 15 for final consonant as shown in Table 10. From both overall means and individual participants, the results support the conclusion that the rime is a privileged unit for English adults in the grapheme substitution artificial orthography task.

Discussion

The results demonstrate that the Grapheme Substitution task is sensitive to more than one kind of subsyllabic structure. For Korean children, the task produces a

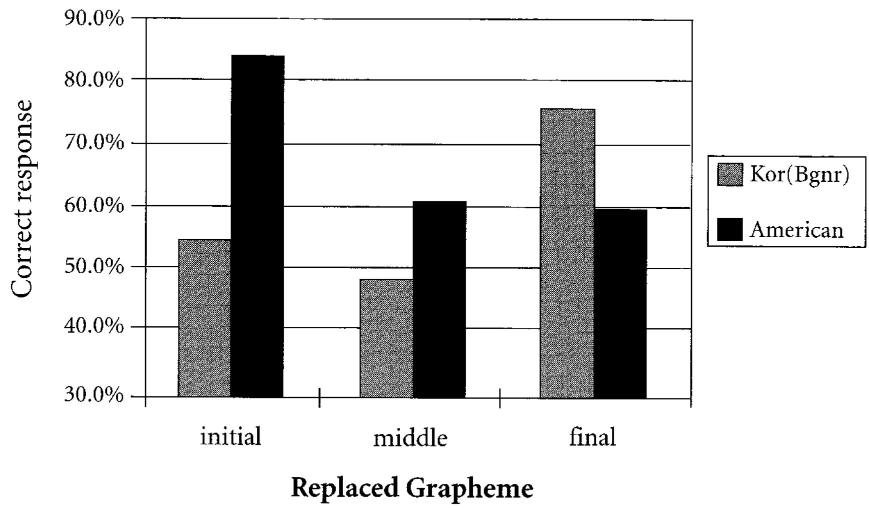

Figure 2. Experiment 1. The Grapheme Substitution Task Comparing English Speaking
Note. Adults and Korean Speaking Children (Yoon, 1997)

preference for body-coda structures; for English speaking adults, the task produces a preference for an onset-rime structure. This contrast can be seen in Figure 2, which shows Yoon's (1997) Korean data and the results of Experiment 3.

Of course, we must keep in mind that children and literate adults may differ in learning to read. It is likely that literacy supported the adult performance in Experiment 1. Although the spoken syllables were Korean, hence unfamiliar to our American participants, the Grapheme Substitution problems could have been solved by mapping the letters of the novel alphabet onto English alphabetic representations, which would serve as a basis for the decision. Also, the Korean speech sounds used in this experiment are represented much differently in the English orthography than in Korean. For example the word /myung/ is represented with 5 graphemes in English and the onset 'my' violates phonotactic regularities in English. However the task was performed in detail, there is no obvious explanation for the onset-rime preference. A letter strategy would make all letters available (subject to perhaps serial order effects) and a phonetic "segment" strategy leaves open the question to be addressed: Is some subsyllabic unit larger than the phoneme privileged in this processing task? Thus, whatever the processing details for this task, it appears that they entail a preference for the onset-rime structure, as suggested for other English language studies (Treiman, 1992; Goswami, 1993). An explanation for why Korean and English are different in this respect was the goal of the remaining experiments.

We now have three results for reading that point to a genuine language related difference. Experiment 1 found that Korean children replicated the Korean body-coda pattern using the Analogy task, previously demonstrated to produce the onset-rime pattern in English speaking children. Experiment 2 found that Korean children showed what we will now call the "Korean pattern" even when presented with English words in the linear Romanized format. Experiment 3 found that the English-speaking adults showed what we will now call the "English pattern" in a Grapheme Substitution Task using the spatially organized Korean Hangul. Given the results of Experiment 1–3, the Korean-English differences appear not to lie in the script. This result leads to the hypothesis that the differences originate in linguistic factors within the two spoken languages. Experiment 4 examines this hypothesis.

Experiment 4

The question turns now from the writing system to the language system. Evidence from various speech-related tasks is at least consistent with the assumption that spoken English syllables are perceived as having onset/rime (C-VC) structures (Fowler, 1987; Kessler & Treiman, 1977; Treiman, 1983, 1986). More recently, evidence similarly points to the possibility that Korean syllable structure is CV-C in spoken language tasks rather than C-VC (Yoon, 1995; Yoon & Derwing, 1994; Yi, 1998). If so, this fact would be sufficient to account for our observed contrasts in reading tasks. Thus, the Linguistic Hypothesis is that differences observed between Korean and English arise not in script differences but in differences between the two languages.

The possible sources for phonological differences between Korean and English are numerous. To consider two that are especially relevant for differences in subsyllabic structures, we note (1) that Korean has a smaller inventory of syllable types, essentially only CV and CVC (V and VC also occur with less frequency), compared with English, (2) that Korean and English differ in the degree to which syllable boundaries are clear and unambiguous. The first of these facts means that Koreans do not encounter complex consonants in onsets. Accordingly, the distinction between onset and initial phoneme collapses — onsets are phonemes. Also, Korean rimes tend to end in simple codas. To the extent that onset-rime structures are especially useful only in syllables with complex onsets (or complex codas), Korean gains no value. However, because there is no reason to think that the onset-rime structure in English is restricted to its complex consonants, the role of syllable type would have to be mediated by some other factor. For example, the existence of complex consonants might make phoneme segmentation more difficult and allow syllable nuclei (vowel peaks) plus syllable closings to be perceived as more coherent. With generalization across syllable types, this would result in a highly general functional value for rime units in English.

The second fact may be more important. English, but not Korean, is a syllable stressed language. In general, syllable-stress languages have greater variation in syllable "weight" than non-stress languages; a strong syllable is more perceptible than a weak syllable. This may serve to weaken syllable boundaries, as internal stressed vowel nuclei become perceptually salient in strong syllables, while weak syllables, and their boundaries, become perceptually invisible. Like other languages without syllable stress alternation, Korean has very clear syllable boundaries. With clear boundaries and even weighting on all syllables may come a stronger functioning of the syllable unit. Subsyllabic structures would be less salient.[2]

These differences illustrate the potential for speech-based perceptual differences between the two languages. The present study was designed not to localize the exact source of any such difference, but rather to discover whether the differences we observed in reading have a parallel in the spoken languages. Would Korean and English listeners, confronted with identical syllables, show differences in how they perceive these syllables? In particular, in judging the extent to which two spoken syllables are similar, would their judgments follow on rime preference or a syllable body preference? The Linguistic Hypothesis is that Korean speakers should show a syllable body preference and English speakers, a rime preference.

Method

Participants

Korean and American undergraduates students participated. Forty-nine students at the University of Pittsburgh (all native speakers of English) and 49 from the Inje University (all native speakers of Korean) served in partial fulfillment of introductory psychology requirements at their respective universities.

Materials

Pairs of monosyllabic CVC words and nonwords of were constructed such that a given CVC was a word in both Korean and English, or else was a nonword in both Korean and English. Pairs of disyllabic CVCVC nonword stimuli were similarly constructed. Forty-eight word or nonword pairs were constructed for each condition. As shown in Table 11, the stimulus pairs varied in the number of phonemes shared by the two members of the pair: CVCVC pairs shared 0-phonemes, 1 phoneme matched, 2-phonemes or all 3 phonemes. Members of a CVCVC pair shared 0, 1, 2, 3 or all 5 phonemes. CVCs were the main focus, because CVCs had been used in the other experiments. Thus CVC pairs could share CV (syllable bodies) or VC (rimes).

Procedure

Stimulus pairs were tape-recorded in a single random order and played to participants in individual experimental sessions. As shown in Figure 3, the words within a stimulus pair had an ISI of one second, and each pair was repeated once with an ISI of two seconds. After the pair was repeated, participants rated the sound similarity of the pair on a 7-point scale.

Prior to the experimental sequence, participants received four practice CVC

Time: 1s 1s 2s 1s 4s

Tape: "Number 1"–/mug/–/mut—/mug/–/mut/——"Number 2"

Subject: ———————————— (Response) ——

Figure 3. Presentation rate of Sound Similarity Judgement stimulus pairs

Table 11. Examples of CVC stimulus pairs used in Experiment 4

	Example pairs (C1VC2–C1VC2)		
Number of matched phonemes	**Units matched**	**Word**	**nonword**
0	none	/bag/-/sun/	/nig/-/wom/
1	C1	/tug/-/tar/	/dit/-/dag/
1	C2	/bam/-/sum/	/mol/-/pel/
1	V	/tug/-/bud/	/min/-/nig/
2	C1V	/mug/-/mut/	/jeb/-/jec/
2	VC2	/sum/-/gum/	/dep/-/zep/
2	C1C2	/bum/-/bam/	/dit/-/dat/
3	all	/jip/-/jip/	/nig/-/nig/

Table 12. Examples of CVCVC stimulus pairs used in Experiment 4

Number of matched phonemes	**Mismatched units**	**Example /CVCVC/-/CVCVC/**	**Num. of matched unit CV**	**VC**
5	none	/sodak/-/sodak/		
4	C1	/tosam/-/posam/	1	2
4	C2	/sodak/-/somak/	1	1
4	C3	/cokam/-/cokan/	2	1
3	C1V1	/kopak/-/tupak/	1	1
3	V1C2	/mupak/-/mokak/	0	1
3	C2V2	/tomik/-/tosak/	1	0
3	V2C3	/konok/-/kokun/	1	1
2	C1V1C2	/sutam/-/cokam/	0	1
2	V1C2V2	/tocin/-/tusan/	0	0
2	C2V2C3	/konok/-/kokun/	1	0
0	all	/kopak/-/tusin/		

pairs with 0 to 3-phoneme overlap and five practice CVCVC pairs representing 0 to 5-phoneme overlap. Subjects were instructed to focus on the global impression of sound only and to rate the similarity in sound on a 7-point scale ranging from 0 (completely different) to 6 (exactly the same). The stimuli were presented in blocks with CVC word pairs first followed by CVC nonword pairs and then CVCVC nonword pairs.

Table 13. Mean Sound Similarity rating on CVC Word/nonword

Number of shared phoneme	Word		Nonword		
	Korean	English	Korean	English	sum
0	0.429	0.187	0.361	0.228	0.301
1	1.382	1.186	1.720	1.139	1.357
2	3.100	3.351	3.127	3.329	3.227
3	5.830	5.912	5.765	5.803	5.827
sum	2.685	2.659	2.743	2.678	

Results

Because our main purpose is to test the Linguistic Hypothesis on CVC syllables, we report here only those results. An important result is that both Korean and English speakers were sensitive to the number of shared phonemes. As can be seen in Table 13, as the number of shared phonemes between members of a pair increased, the mean similarity rating did also. The reliability of this effect was confirmed in a 2 (Word vs. Nonword) × 2 (Language) × 4 (Number of Shared Phonemes) Analysis of Variance (not reported here).

With the general meaningfulness of the similarity ratings established, we can turn to the key question about subsyllabic structures. The data were then analyzed according to shared subsyllabic unit. These results for the critical rime comparison can be seen in Figure 4. For both words and nonwords, English speakers rated pairs that shared rimes as the most similar. Korean speakers rated words that shared syllable bodies as most similar.

Consider first the VC (rime) results. Korean speakers gave a mean rating of 2.8 for word and 2.4 for nonwords (6 maximum) that shared VC; English speakers produced a mean rating of 3.9 and 3.7 for pairs sharing VC. The opposite pattern is seen for CV. Korean speakers produced a mean similarity rating of 4.1 and 4.0 for words and nonwords (respectively) sharing CV. English speakers produced mean similarity ratings of 3.23 and 3.08 for CV sharing word and nonword pairs, respectively. Thus, English speakers judged more similarity for pairs sharing a rime than pairs sharing a syllable body. Korean speakers judged more similarity for pairs sharing a syllable body than for pairs sharing a rime. Pairs that shared C_C were the lowest rated for words, but not for nonwords. Korean speakers rated nonwords with shared C_C higher than nonwords with shared VC. And English speakers rated C_C pairs no lower than CV pairs.

A 2 (Word vs. Nonword) × 2 (Language) × 3 (subunit type) Analysis of Variance confirmed the reliability of the mean differences seen in Table 8. The effect of the subunit that shared phonemes (CV, VC, C_C) was reliable ($p < .001$) and the interaction between the subunit and the language user was also significant ($p < .001$). Lexicality, whether a stimulus pair was a word or nonword, had no main effect.

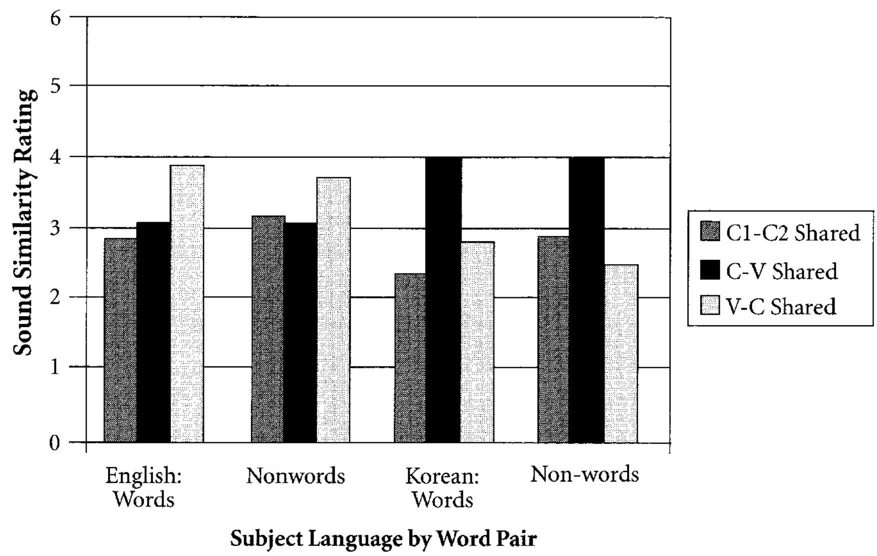

Figure 4. Experiment 4: Mean similarity ratings for CVCs that shared two phonemes (CV) (VC) (C_C) for Korean speakers and English speakers

However, Lexicality did reliably interact with subunit, ($p < .001$). This interaction is due not to the rime and body ratings, which were general over words and non-words, but to the C_C ratings, which were affected by whether the stimulus pair was a word. Planned comparisons found the expected differences between shared subunits and language user (English speakers: VC > CV, VC > C_C, CV = C_C; Korean speakers: CV > VC, CV > C_C, VC = C_C) to be reliable.

Discussion

The results provide clear support for the Linguistic Hypothesis, that subsyllabic pattern preferences observed in reading arise from language differences, rather than script differences or other factors. Korean speakers and English speakers heard the same spoken syllables — and the syllables had the same lexical status in each language — but produced different similarity patterns. English language subjects rated syllables more similar if they shared a rime (VC); Korean language subjects rated syllables more similar if they shared a syllable body (CV). This pattern is the same as observed in the reading experiments.

Of course, there is a big qualification that must be added to the interpretation of these results. The language-specific preferences observed in the experiment may arise from the structure of the spoken languages, the straightforward interpretation consistent with the Linguistic Hypothesis. Alternatively, they may arise because written representations influence performance of literate adult speakers,

Table 14. Mean similarity scores for the eight types of CVC test pairs

	C1VC2 word		C1VC2 nonword	
Matched unit	Korean	English	Korean	English
none	0.429 (0.566)	0.187 (0.415)	0.361 (0.499)	0.228 (0.508)
C1	1.449 (0.902)	1.463 (0.775)	2.197 (0.739)	1.520 (0.697)
C2	0.922 (0.635)	1.112 (0.746)	0.840 (0.787)	1.037 (0.744)
V	1.776 (0.844)	0.983 (0.687)	2.122 (0.865)	0.861 (0.754)
C1V	4.088 (0.834)	3.323 (0.813)	4.017 (0.924)	3.082 (0.804)
VC2	2.843 (1.043)	3.901 (0.832)	2.412 (0.889)	3.742 (0.873)
C1C2	2.371 (1.113)	2.830 (0.982)	2.952 (1,132)	3.163 (1.186)
all	5.830 (0.317)	5.912 (0.415)	5.765 (0.412)	5.803 (0.608)

even when the task involves spoken language. In short, we cannot rule out the possibility that the fundamental difference between Korean and English comes from different reading strategies that have some other origin than the spoken language. We will take up this point again in the general discussion. So, until we learn about the performance of pre-literate speakers in spoken language tasks, the allowable conclusion is that subsyllabic preferences observed in reading are also observed in speech judgments.

General discussion

Our goal was to investigate the characteristics of spoken and written language that lead to the development of subsyllabic units (onset-rime or body-coda) in reading. We began by asking if subsyllabic units in early reading, namely the onset and rime, were universal or language-specific. Secondly, we asked whether these units are indicative of a general early mapping process of orthography onto the spoken language or a property of particular orthographies in particular writing systems. The results of our experiments directly suggest that while the sensitivity to subsyllabic units may be universal, the form of preferred linguistic units may be language specific. Whereas native English speakers develop a preference for onset-rime units, native Korean speakers show a preference for a body-coda structure.

Just as studies of English children find support for an onset-rime structure that emerges prior to acquiring literacy (see Goswami, 1993), evidence exists of Korean children's use of the body-coda structure prior to acquiring reading skill (Yoon, 1997). In Experiment 1, we found further support for Korean children's use of the body-coda pattern in Goswami's Analogy task. Thus, we could no longer assume our findings were due to secondary, task-driven differences. A similar study conducted by Lee and Yi (1999) investigated Korean children's body/coda preferences at different points in reading acquisition. Lee and Yi presented the aural version of Phoneme Shift task to three groups of children: kindergartners with no reading ability, kindergartners with some reading proficiency, and first graders with proficient reading and writing skill. The results of this study suggest that the body-coda preference is somewhat diminished as children acquire proficiency in reading. However, similar to the onset-rime in English, the body-coda pattern is present at a very early stage of reading development.

Now that we have well established the differences between Korean and English patterns of performance, we turn our attention to the origination of these preferences. Both Goswami's (1993) Analogy task and Yoon's (1997) Grapheme Substitution task require subjects to utilize some knowledge of the orthographic system in the child's native language. Similarly, Lee and Yi's (1999) study seems to suggest that orthographic knowledge and reading skill may play a role in the body-coda pattern preference. The uniqueness of the kulja pattern of the Korean Hangul led us to question whether the script may be driving the effects seen in Korean children. In Experiment 2, we asked Korean children to perform the Grapheme Substitution task in a foreign script (Roman/English alphabet) where orthographic knowledge would not play a direct role in performance. Again, the body preference persisted. While it is possible that children may have mapped the English orthography onto their knowledge of Korean orthography, it is highly doubtful that this would occur given such little experience with their native script. Thus, our Korean pattern is seemingly not driven by experience with Hangul, or the Kulja pattern within the writing system. We speculate that the Roman-English orthography fails to drive the onset-rime pattern — since it had not for these children. The results of Experiment 3 confirm, at least for adult speakers of English, that the onset-rime preference persists in the presence of a novel orthography. This result also rules out the influence of the spatial arrangement of the Kulja driving body-coda preferences.

In light of these findings, there is great cause to doubt the hypothesis that the rime structure is universal (Fudge, 1987). Since the Korean-English difference in Experiments 1–3 are not driven by the particular scripts of each language, we assume that differences must be driven by experience with spoken language. In Experiment 4, adult native language users of both Korean and English were asked to perform a speech perception task. In our Sound Similarity Judgment task, Korean subjects reliably rated item pairs according to a body-coda preference and American subjects according to an onset-rime structure regardless of the stimuli voice (Korean vs. English speaker). These results suggest that subsyllabic patterns are fairly well established phonological representations in adult language users. Because the voice of the speaker had little effect on similarity ratings, we conclude that subsyllabic units emerge as linguistic elements of speech perception in a speaker's native language. Although we cannot entirely rule-out the possibility of an effect of literacy on speech judgements, we believe that such an effect would be greatly minimized. Thus, we assert a *Linguistic Hypothesis* that the emergence of subsyllabic units as functional elements in reading are language-specific and are derived from features of the spoken language system mapping onto the writing system. To further understand how these linguistic differences arise, we look at how these subsyllabic units emerge in reading performance.

One general explanation for the use of sub-syllabic units in reading is that larger orthographic units of recognition develop in response to children's experience with the writing system. In particular, Orthographic Rime units are argued to arise (1) because of the lack of transparency in the English orthography, (2) because of the frequency of the occurrence and use of these units from the child's instructional/cultural background. According to the orthographic depth hypothesis, the fact that the English orthography lack transparency, i.e. one grapheme maps to multiple phonemes, encourages the use of larger and more reliable units in order to read proficiently. Treiman et al. (1995) analyzed the predictability of phonology from orthography and found greater regularity among rime units in the English language then in the body (CV) or vowel unit (V) alone. The second argument for Orthographic Rime units is that these units emerge from mere frequency of exposure (Treiman, Goswami & Bruck, 1990; Bowey, 1996; Bowey & Hansen, 1994). According to this view, children necessarily acquire grapheme-phoneme correspondences at the early stages of reading development, but as they become proficient at decoding, children utilize these larger units. This idea is supported by the orthographic rime frequency effect (Treiman, Goswami & Bruck, 1990; Bowey & Underwood, 1996), i.e. the fact that children read words like *tain* (high frequency rime) more accurately than *taich* (low frequency rime). What is important to note about these theories is that the emergence of subsyllabic orthographic units occurs as a function of experience with a particular orthography in a particular writing system.

A second general explanation for the acquisition of subsyllabic units is that they develop as phonological structures in the process of gaining phonological awareness (Goswami & Bryant, 1990; Treiman, 1992). According to Goswami's (1993) model, children at the early stages of reading instruction come equipped with phonological knowledge of onsets and rimes onto which orthographic recognition units are then mapped. This idea is supported by a number of findings identifying the onset-rime preference in spoken language tasks in adults and preliterate children (see Bradley & Bryant, 1983; Treiman, 1983, 1986; Treiman, Goswami & Bruck, 1990). Goswami's theory thus assumes that subsyllabic phonological units arise prior to reading instruction, and that the phonological onset-rimes are the bootstrapping units for acquiring subsequent orthographic knowledge. The phonological structure hypothesis is consistent with our *Linguistic Hypothesis* of the Korean body-coda preference. As we stated earlier, speech perception is an important precursor to phonological awareness, and that its effects on word reading may be mediated by phonological processing skill (McBride-Chang, Wagner & Chang, 1997).

The majority of studies on subsyllabic units have focussed on the onset-rime hypothesis in English and European languages. Because English orthography lacks transparency, we cannot rule out an orthographic factor in the emergence of these units, nor can we discriminate between phonological and orthographic accounts.

However, studies in relatively transparent writing systems (e.g., Dutch, Turkish, German, and Korean) may allow for stronger conclusions. A series of experiments in Dutch reported in this volume, Geudens and Sandra (1999, this volume) investigated the occurrence of orthographic rime units in a relatively transparent orthography, in which the grapheme-phoneme mapping is nearly one-to-one. They argue, based on previous results, that the transparent Dutch writing system does not require onset-rime orthographic units, but that preferences for such units might arise as a function of frequency of exposure to onset-rime orthographic patterns in instructional materials and word games. The results of their experiments, however, suggest that at least low-skilled Dutch readers (Grade 1) benefit from viewing words segmented into onset-rime units (see Geudens & Sandra, this volume, Experiment 1, Figure 1: Mean latencies by fluency).

While seemingly contradictory to a hypothesis that asserts the existence of functional subsyllabic units in reading, the Geudens and Sandra findings may prove consistent with our Linguistic Hypothesis. In McBride-Chang et al. (1997), the effects of speech perception on phonological awareness and word reading seem to occur relatively early in the acquisition of word recognition skill. As a child gains fluency in their decoding skill, the impact of spoken language on phonological skill is minimized as the influence of the writing system acts to finely tune phonological awareness. The fact that the low skilled Dutch readers did show evidence of onset-rime orthographic structures but high skilled readers did not, suggests a developmental difference in the salience of these units. Similarly, the Yi and Lee findings seem to lend further evidence to this developmental shift in phonological skill in Korean children. Furthermore, the functionality of these subsyllabic units as fluency is achieved may be relegated to processes of production and manipulation in reading rather than identification/recognition processes. For instance, Booth and Perfetti (in press) found no evidence for the use of the onset-rime structure in early word identification processes after Grade 2, but did so in a masked-prime word-naming task.

Summary

So, what have we learned? Aspects of the spoken language have a strong effect on the shape and development of phonological awareness. As spoken languages, English and Korean have highly contrasting features. As opposed to English, Korean has a much simpler syllable structure and vowel harmony. Korean has definite syllable boundaries and lacks stress in multisyllabic words. English has complex syllables with consonant clusters at syllable onsets and codas. English is a stress language with unclear syllable boundaries. Importantly, English has relatively more flexibility between onsets and vowels than between vowels and codas (Chomsky & Halle, 1968). Thus, the development of a rime as a phonological unit in English and the body in Korean are likely tied to the linguistic structure of the spoken language. Children gain the ability to manipulate these phonological features (gain 'awareness') prior to encountering instruction with the writing system. Kindergarten children in both English and Korean show an appropriate knowledge of subsyllabic units.

How do these units persist into orthographic representations? While we assume that phonological subsyllabic units are functional prior to reading skill, we have not ruled out a possible interaction with the writing system. The evidence from English, Dutch, and Korean suggests that as children gain fluency in reading performance, reliance on onset-rime units may diminish. As children become more skilled at reading they appear to rely less on these units. Somewhat contradictory to this is the orthographic rime frequency effect in English, where subsyllabic units play a strong role in word recognition skill after fluency is achieved (see Bowey, Vaughan & Hansen, 1998). However, the effects of rime frequency after fluency is achieved may be task dependent (see Booth & Perfetti, in press).

The orthographic depth hypothesis fails to capture why subsyllabic units appear in Korean reading performance (a transparent orthography) or in perception of speech. Similarly, this hypothesis fails to account for onset-rime effects in low-skilled Dutch readers (Geudens & Sandra, this volume) and German normals and dyslexics (Landerl & Wimmer, 2000), both languages having transparent orthographies as well. Mere exposure-based accounts of the development of orthographic recognition units do not account for Korean children's performance in the English writing system or English adults performance using Hangul as an artificial orthography. Also, this hypothesis fails to explain Geudens and Sandra (this volume) onset-rime persistence in the unbiased curriculum.

In summary, the appearance of subsyllabic units in reading according to the data in Korean and English is most likely due to the early mapping of orthography onto salient phonological units that exist in the spoken language system. Such a conclusion not only accounts for onset-rime units, but similarly may account for morpho-syntactic features as well (e.g., the relative ease of recognizing and manipulating "d/ed" and "s/es" as final phonemes/graphemes). We conclude that our Linguistic Hypothesis identifies orthographic units such as onsets and rimes, or bodies and codas, as properties of a mapping system of salient visual features to phonological features that reflect the deep linguistic structures of the spoken language.

Notes

1. For example, consonants and vowels are systematically different in their visual appearance and consonant letters often include visual information relating to place of articulation.

2. It is important to keep in mind that subsyllabic structures can co-exist with other units. To raise the possibility that two languages contrast in sub-syllabic structures is not to suggest that speech perception uses different mechanisms or even different units in the two languages. Phonemes, for example, can function as perceptual units, even if syllables or unites intermediate to phonemes and syllables are also functional in some sense.

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Precursors of Functional Literacy

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