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Recognition of Korean Ideographs and Phonographs in the Left and Right Visual Fields

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Visual field differences in reading Chinese ideographs(Hanja) and Korean phonographs (Hangul) were investigated in a sample of biscriptual Korean graduate students. The equivalence of the Chinese and Korean graphemic units and the non-sequential nature of Hangul syllable arrangement made it possible to separate the confoundings of phonetic with sequential representation and of ideographic with holistic patterns. Significant right visual field superiorities were found both for single Hangul syllables and two-syllable Hangul words. while there were no significant visual field differences either for single Hanja characters or two-character Hanja words. The results suggest that the phonographic nature of the stimuli, not sequencing, may suffice to produce a right visual field superiority.

The writing systems of the world can generally be classified as ideographic or phonographic. The most common form of ideographic script was invented in China and later adopted in Korea and Japan. Ideographs are symbols which have an iconic resemblance to the objects or concepts they represent, while phonographic symbols represent word sounds and are usually arrayed in a linear sequence. Studies of Chinese (Hardyck, Tzeng, & Wang, 1977; Luria, 1970; Tzeng, Hung, Cotton, & Wang, 1979) and Japanese (Hatta, 1977a, 1977b; Hatta, 1978; Sasanuma, Itoh, Mori, & Kobayashi, 1977; Yamadori, 1975) have supported the suggestion that phonographic symbols are primarily processed in the left hemisphere while ideographic symbols may be more likely to engage right hemisphere processing. Presumably such a division of labor would be a reflection of the left hemisphere's specialization for sequential, auditory processing, and the right hemisphere's facility with holistic, spatial thinking.

Luria (1970) reported that Russian patients with left temporal lobe injury had serious difficulty in distinguishing phonemes and in finding the contents of words in written tasks. Chinese patients with the same injury, however, had no such difficulty, purportedly because of the different quality of their orthographic system. In a study of a Japanese alexic patient with left hemisphere damage, Yamadori (1975) found that ideograph (Kanji) reading was better preserved than phonograph (Kana)

reading, suggesting that the left hemisphere was more important in processing phonographs than ideogrphs. Sasanuma (1975) classified 378 Japanese aphasic patients according to Kana versus Kanji impairment patterns and concluded that damage to classical speech areas such as Broca's and Wernicke's might be responsible for the phonological impairment underlying Kana errors, while impairment of Kanji processing might reflect non-phonological aspects of language involving lesions outside the speech areas.

When stimuli are rapidly presented to the right or left visual field via tachistoscope, stimuli presented to each visual hemifield are projected to the hemisphere contralateral to the field of presentation. McKeever (1971)demonstrated right visual field (left hemisphere) superiority for English words in both bilateral and unilateral tachistoscopic presentations. Hardyck, Tzeng, & Wang (1977) presented both English and Chinese word pairs in the right or left visual field and measured reaction time to identify the pair as same or different. They found no evidence of functional lateralization when a new decision had to be made on each trial. However, when a small number of pairs were presented repeatedly, reaction time decreased for English pairs in the right visual field presentations and for Chinese pairs in the left visual field presentations, suggesting an interhemispheric difference in organization for the two languages. However, because Hardyck et al. (1977)used English monolingual subjects in the repeated presentations experiment, it is possible that Chinese characters were perceived as random spatial patterns rather than as meaningful linguistic symbols.

Chinese differs from English both in orthography and in the demand characteristics of reading. Presumably reading in Chinese engages more of a gestalt, pattern-recognition capability while reading in English elicits a sequential, analytic sound-mapping process. In an effort to disentangle orthography from mode of processing, Tzeng, Hung, Cotton & Wang(1979) conducted a series of experiments. In their first two experiments Chinese graduate students at the University of California were asked to provide verbal identification of single-character and two-character ideographs presented to the right or left visual field. A significant left visual field advantage was reported for single character ideographs, while the reverse was found for two-character ideographs. In a third experiment, reaction times to identify two-character ideographs as meaningful versus meaningless were measured, and a right visual field advantage for correct positive identifications was found. In addition, a significant interaction between imagery level and visual field suggested to the authors that low imagery items were analyzed better by the left hemisphere, while high imagery items might invoke a simpler pattern-recognition analysis involving both left and right hemisphere processes. Tzeng et al.(1979) argued that the hemispheric differences between reading ideographic symbols and reading alphabetic symbols reflected a task-specific property of cerebral hemispheric processing rather than an orthograph-specific property. They proposed that ideographic symbol reading was related to pattern-recognition capabilities of the right hemisphere and that phonetic symbol reading was related to sequential and analytic faculties of the left hemisphere.

Sasanuma, Itoh, Mori, & Kobayashi(1977) investigated hemispheric asymmetries for recognition of nonsense words in Japanese subjects and found a significant right visual field superiority for Kana(phonographic) but not for Kanji(ideographic) symbols. Although the proportion of Kanji symbols correctly identified was greater in the left than right visual field, the difference was not statistically significant. However, when the patterns of individual subjects were examined, it was found that all but five of the 24 subjects had a greater right visual field advantage for phonographs than for ideographs of the 18 subjects with a right visual field advantage for phono-

graphs, 12 also had a left visual field advantage for ideographs. Sasanuma et al's(1977) results suggest that individual subjects' phonographic processing was more sharply lateralized to the left hemisphere than ideographic processing, even in the absence of an overall left visual field advantage for ideographs.

In another study of Japanese subjects, Hatta(1978) used tachistoscopic presentation to investigate lateralization for ideographs and phonographs. Hatta(1978) analyzed his data in two ways, first by averaging across subjects to look mean differences between right and left visual fields, and then by examining patterns of visual field superiority within subjects. The analyses of visual field differences revealed a left visual field superiority for single ideographic character recognition, and right visual field superiority for phonograph recognition as well as for two-character ideographic word recognition. These results were confirmed in analyses of individual performance patterns. Hatta's (1978) interpretation of his findings was that visual processing predominated for recognition of single ideographic characters, but that the salience of phonological factors increased with the addition of second ideograph. He suggested that because ideographic characters have both visual and phonological components, each component may elicit task-specific processing capacities. Like Tzeng et al. (1979), Hatta (1978) emphasized mode of processing rather than orthography as the key to understanding hemispheric asymmetries in ideograph recognition.

Because ideographic and phonographic symbols are commonly intermingled in written Korean, the Korean language can be used to investigate hemispheric asymmetries. Korean phonographic script (Hangul) consists of 14 basic consonant smbols and 10 basic vowel symbols. Hangul symbols are arranged to form a single block, which is a syllable. That is, the graphemic unit of Hangul is the syllable, which usually contains one vowel and from one to three consonants (Taylor, 1980). A restricted number of Chinese characters (Hanja) are used in Korean in addition to the Hangul alphabet. Each Hanja (ideographic) character can be transcribed into a single Hangul syllable, and a two-character Hanja word can be written as a two-syllable Hangul word. That is, the graphemic units of Chinese ideographs (Hanja) and Korean phonographs (Hangul) are the same, although two writing systems are inherently different in nature.

Unlike English or Japanese phonetic scripts, Hangul syllables are not arranged sequentially, but have a pattern-like formation. Wang (1981) illustrated the similarities between the shapes of Hangul syllables and of Hanja characters. Therefore, Hangul syllables may be regarded as true phonographic counterparts to Hanja characters and make it possible to separate the confoundings of phonetic with sequential representation and of ideographic with holistic patterns.

In the present study, visual field differences between Korean ideographs (Hanja) and phonographs (Hangul) were investigated in biscriptual Korean subjects. Because of the equivalence of Hanja and Hangul graphemic units and the nonsequential nature of Hangul syllable arrangement, it was possible to ask whether lateralized differences between symbol systems was more closely tied to orthography or processing demands. The hypotheses were: 1. For Hangul, the right visual field advantage would be shown in both one-syllable and two-syllable conditions. 2. For Hanja, the right visual field superiority would be seen in two-character condition, while the left visual field superiority would be seen in one-character condition.

Methods

Subjects

The subjects were 18 male Korean graduate students at the University of Washington, and ranged in age from 23 to 35 years (mean age was 29.4 years). All subjects

were strongly right-handed(mean handedness score on Old-field's (1971) Edinburgh Handedness Inventory was 97. 43; range was 86. 7 to 100). Subjects were paid for their participation.

Stimuli

Four sets of 80 stimuli were prepared for presentation via slide projector. The stimulus categories were as follows:

1. Two-character Hanja words.
2. Single Hanja characters.
3. Two-syllable Hangul words.
4. Single Hangul syllables.

For the first stimulus condition 40 two-character Hanja words were selected from a Korean Junior high school textbook. Simple, commonly-used characters were chosen. A single Hanja character was then selected from each word, and these characters were used as stimuli in the second stimulus condition. Both the two-character and the single character Hanja stimuli were translated into their Hangul counterparts, providing Hangul stimuli for conditions 3 and 4. Examples of the stimuli are presented in Figure 1.

Procedure

The experiment was conducted in Korean, and each subject was exposed to all four stimulus sets. In each of the four conditions there were 80 trials, with all stimuli appearing once in each visual field. Hanja and Hangul presentations were counterbalanced such that half of the subjects started with Hanja and the other half starteh with Hangul. Stimuli within each condition were randomly ordered, and the ordering was reversed for half the subjects.

Stimuli were presented one at a time to the right or left visual field, using a set of three yoked Kodak Caroussel Projectors equipped with electric tachistoscopic shutters and timers. The duration of stimulus presentations was 70 msec for the single Hanja and single Hangul conditions (sets 2 and 4), and 100 msec for the

a. Two-character Hanja word(Ideographic)

b. Single Hanja character(Ideographic)

c. Two-syllable Hangul word (Phonographic)

d. Single Hangul syllable (Phonographic)

Figure 1. Examples of Korean Phonograghic and Ideographic Stimuli

two-character Hanja and two-syllable Hangul conditions (sets 1 and 3). Each stimulus slide was preceded by a one-second central fixation point and followed by a one-second mask. The stimuli subtended a visual angle of 4.5 degrees from the fixation point.

Subjects were asked to maintain central fixation and to identify the stimulus verbally as soon as it was presented. Four practice trials preceded the test sessions for each condition. Visual fixations of the subiects were monitored by the experimenter to verify that no eye movements occurred prior to stimulus onset.

Results

As in the Hatta (1978) and Sasanuma et al. (1977) studies, data were analyzed both for the group as a whole and by individual performance patterns. The number of correct identifications in each visual field was computed and averaged across subjects for each of the four conditions, and the pattern for each subject across conditions was determined.

The mean number of correct identifications for right and left visual fields in the four conditions are reported in Table 1. The maximum possible score for each visual field was 40, and the total possible score for each condition was 80.

Right visual field scores were significantly higher than left visual field scores for both single Hangul syllables ($t=2.514$, $df=17$, $p<.05$) and two-syllable Hangul words ($t=2.497$, $df=17$, $p<.05$). However, there were no visual -.557, $df=17$, $p=$n. s.) or two-character Hanja words ($t=$ .327, $df=17$, $p=$n.s.). Overall, Hangul stimuli were identified correctly more often than Hanja stimuli, both for single Hanja characters and their Hangul phonetic equivalents ($t=4.198$, $df=17$, $p<.01$) and for two-character Hanja words and their phonetic equivalents ($t=2.696$, $df=17$, $p<.01$).

The distributions of individual patterns of performance for the four conditions are displayed in Tables 2 and 3. For both single Hangul syllables and two-syllable Hangul words the results are consistent with the analyses of mean visual field scores. In both Hangul conditions at least two thirds of the subjects exhibited a right visual field superiority. For the single Hanja characters however, 10 of the 18 subjects were more accurate for stimuli that were presented to the left visual field, and 3 subjects showed no visual field advantage (see Table 2). The four subjects with a left visual field advantage for single Hangul syllables also had a left visual field advantage for single Hanja characters. For both Hangul and Hanja stimuli, right visual field advantages were greater for paired than single stimuli. In the paired stimulus conditions, 16 of the 18 subjects had a right visual field advantage for two-syllable Hangul words, and 9 subjects had a right visual field advantage for two-character Hanja words (see Table 3). One-half of the subjects in the sample showed right visual field advantages for both field differences for either single Hanja characters ($t=$

TABLE 1. Mean Number of Correct Ideograph and Phonograph Identifications(N=18)

Ideographs	Left Visual Field		Right Visual Field		Total	
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
Single Hanja characters	21.61	4.63	20.67	5.47	42.28	9.28
Two-character Hanja words	18.06	6.11	18.72	6.01	36.78	11.50
Phonographs						
Single Hangul syllables	25.28	5.19	29.39	4.60	54.67	8.41
Two-syllable Hangul words	21.06	6.19	26.17	6.09	47.23	11.76

TABLE 2. Distribution of Individual Performance Patterns by Visual Field Advantage : Single Stimuli

Phonographs (Hangul)

		LVF>RVF	RVF=LVF	RVF>LVF	TOTAL
Ideographs (Hanja)	LVF>RVF	4	0	6	10
	RVF=LVF	0	0	3	3
	RVF>LVF	0	2	3	5
	TOTAL	4	2	12	18

LVF=Left Visual Field
RVF=Right Visual Field

TABLE 3. Distributions of Individual Performance Patterns by Visual Field Advantage : Paired Stimuli

Phonographs (Hangul)

		LVF>RVF	RVF=LVF	RVF>LVF	TOTAL
Ideographs (Hanja)	LVF>RVF	2	0	5	7
	RVF=LVF	0	0	2	2
	RVF>LVF	0	0	9	9
	TOTAL	2	0	19	18

LVF=Left Visual Field
RVF=Right Visual Field

paired-stimulus conditions. Five of the remaining 9 subjects showed a right visual field advantage for Hangul and a left visual field advantage for Hanja. As with the single syllable and single character conditions, the few subjects (N=2) with a left visual field advantage for Hangul pairs also showed a left visual field advantage for Hanja pairs.

Figures 2 and 3 show the magnitudes of asymmetries for Hangul (phonological)and Hanja (ideographic) stimuli for individual subjects. In both figures the difference between percent correct in the right visual field and percent correct in the left visual field (R-L) is on the ordinate for Hangul and on the abscissa for Hanja. The data for single character/syllable stimuli are in Figure 2 and those for paired stimuli in Figure 3. Data points below the diagonal represent subjects who had a greater right visual field advantage for phonographs than ideographs ; those above the diagonal showed a greater right visual field advantage for ideographs than phonographs ; and those on the diagonal had an equal degree of visual field asymmetry for both phonographs and ideographs. If phonographs are more likely to engage left hemisphere processing than ideographs, most subjects would be expected to fall below the diagonal. For the single character/syllable stimuli, 15 of the 18 subjects are below the diagonal (Figure 2), and for the paired stimuli, 16 subjects are below the diagonal (Figure 3). When the sign test for matched pairs (Siegel, 1956) was applied to these data a significant excess ($p<.001$) of subjects below the diagonal was confirmed for both the single-and the paired-stimulus conditions.

Individual subject data are also presented in Figures 4 and 5, this time contrasting subject's performance on single-versus paired-stimulus conditions within each orthography. For Hangul phonographs (Figure 4) 11 of 18 subjects were below the diagonal, and for Hanja

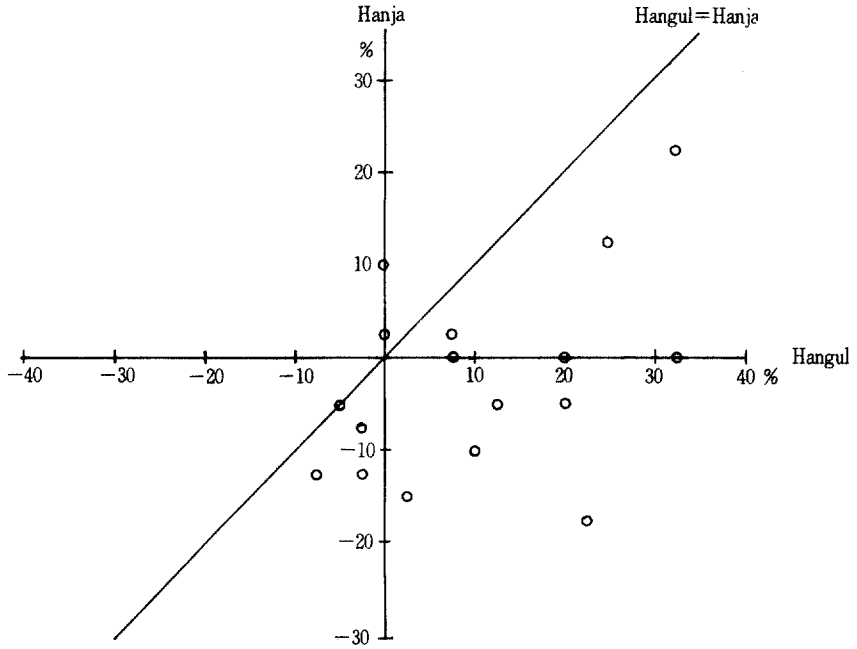

Figure 2. Distribution of Subjects' Right-Left(% Correct) Values for Single Hangul Syllables and Single Hanja Characters

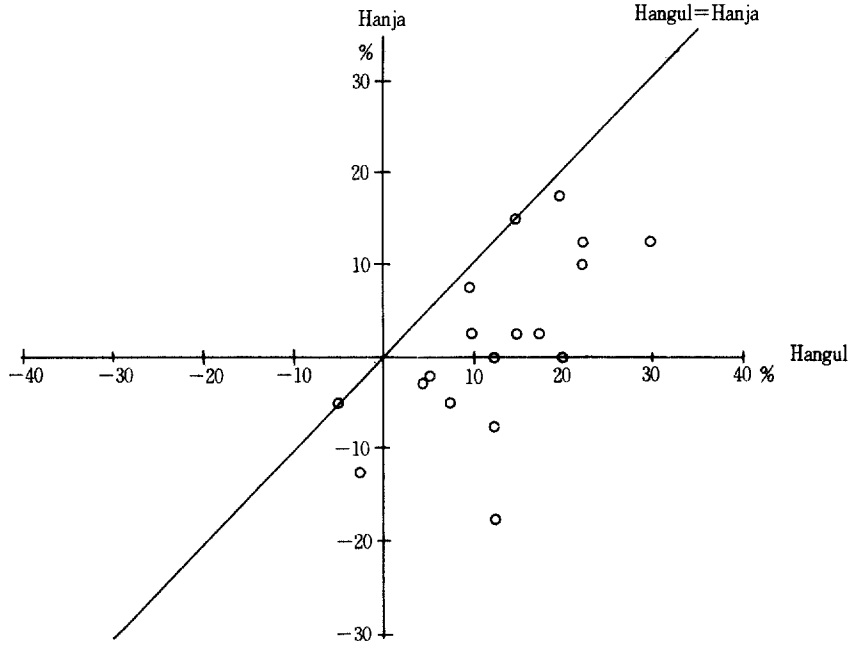

Figure 3. Distribution of Subjects' Right-Left(% Correct) Values for Two-Syllable Hangul Words and Two-Character Hanja Words

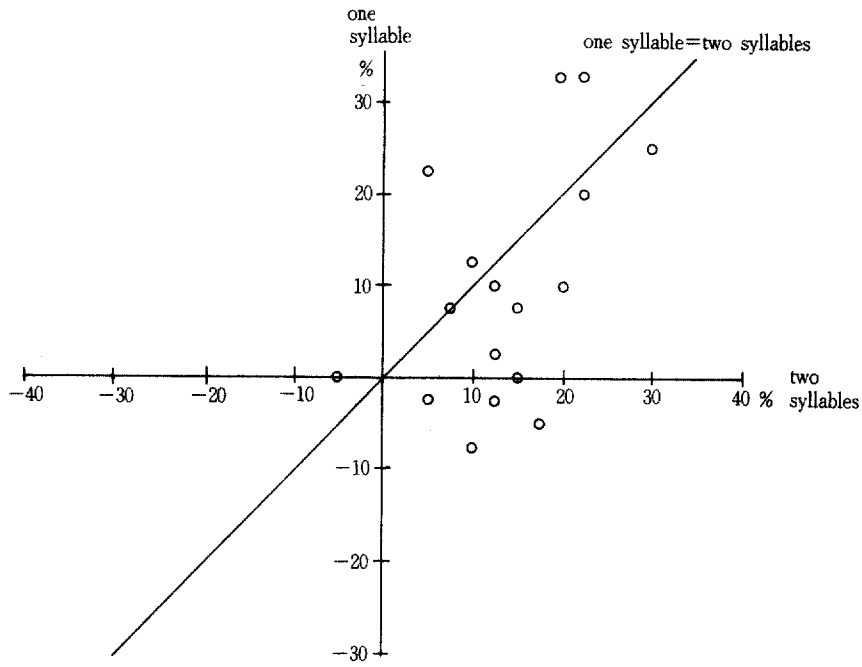

Figure 4. Distribution of Subjects' Right-Left(% Correct) Values for Single and Paired Hangul Syllables

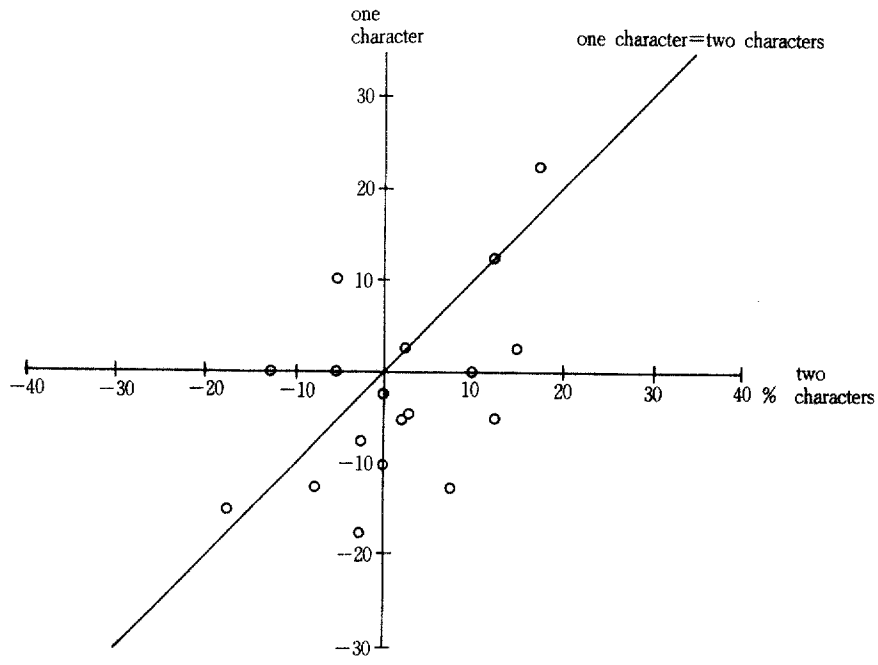

Figure 5. Distribution of Subjects' Right-Left(% Correct) Values for Single and Paired Hanja Characters

ideographs (Figure 5) 11 subjects were below the diagonal. That is, slightly more than half the subjects in the study had a stronger right visual field effect for paired stimuli than single stimuli. However, sign tests revealed that the distributional differences did not reach an acceptable significance level for either orthography.

Comparison of Figures 4 and 5 shows that subjects were much more likely to have a mixed pattern of responses to the ideographs than to the phonographs. Four subjects had a left visual field superiority for both single and paired ideographs, but no one showed consistent left visual field advantage in the phonograph conditions. Six subjects had a left visual field advantage for single ideographs and either no advantage or a right visual field advantage for ideograph pairs.

Discussion

The finding of an overall right visual field superiority in the identification of both single and two-syllable Hangul stimuli suggests a left-hemisphere processing superiority in a phonetic language that had not previously been investigated--Korean Hangul. This adds to the existing data from other phonetic representational systems: Japanese Kana (Hink, Kaga, & Suzuki, 1980; Imura, Nogami, & Asakawa, 1971; Sasanuma & Fujimura, 1971), English (Bryden, 1965; McKeever & Huling, 1971), French (Hamers & Lambert, 1977), and Russian (Luria, 1970). In addition, the finding of a right visual field advantage in single, nonsequentially arranged phonetic syllables argues against Tzeng et al's (1979) interpretation that hemispheric differences between ideographs and phonographs simply reflect task-specific differences in the sequential nature of the two orthographic systems. The results of the present study suggest that the phonographic property alone may suffice to produce a left hemisphere superiority. No evidence was found for increased asymmetry in the two-syllable phonographic condition. In previous studies these two factors, phonographic and sequential presentation, have been confounded.

The lack of overall visual field differences for ideographs is contrary to what would be expected from the Tzeng et al. (1979) and Hatta (1978) findings, although the trend of the individual response patterns is in the expected direction of left visual field superiority for single character ideographs and right visual field superiority for two-character ideographic words. Sasanuma et al. (1977) reported the same nonsignificant trend for Japanese Kanji characters.

Analyses of individual performance patterns confirmed the significantly greater right visual field effect for phonographs and indicated a possible but nonsignificant contribution of sequencing to the right visual field advantage. The magnitude of the right visual field effect was significantly greater for phonographs than ideographs in both the single- and the paired- stimulus conditions, while the difference between single- and paired-stimulus conditions within orthographies was not significant.

The absence of stronger congruence among studies could be due to differences in the languages and cultures studied. Korean subjects may differ significantly from either Japanese or Chinese subjects in the extent to which right hemisphere strategies are engaged in processing ideographs. Although ideographs elicted less of a right visual field effect than phonographs, substantial left hemisphere involvement was still evident. This finding may relate to differences in ideograph frequency across the three languages, with Korean using far fewer ideographs than either Japanese or Chinese. Reading a newspaper requires mastery of 4000 to 7000 ideographic symbols in Chinese (Wang, 1973); about 3000 ideographic symbols in Japanese (Sasanuma et al., 1977); and only 2000 to 2700 in Korean (Nam, 1977). Another possibly important difference may be the age at which

formal instruction in ideograph learning begins. In China it begins in grade one (Lehmann, 1975), in Japan in grade one or two (Sasanuma et al., 1977), and in Korea not until grade four or seven. If lateralization changes during development, then the age at which a symbol system is first learned may affect the relative asymmetry of processing in that orthography.

Procedural differences across studies might also account for discrepant results. Although most of the studies reviewed here looked at mean performance differences as a function of visual field, in two experiments reaction time was the main dependent measure. The present study used masks, while none of the others did. Our subjects often complained that the images "went away" too quickly, although our somewhat longer exposure times may have allowed an accuracy compensation for the reportedly high effectiveness of masks in interrupting after-images.

There are at least three possible explanations for the finding that phonographs were more accurately identified than their ideographic equivalents. There are fewer average brush strokes in Korean phonographs than in ideographs. In this experiment the mean number of brush strokes for the single syllable phonographs was 5.4, while it was 7.0 for the ideographic equivalents. For the two-syllable phonographs there were an average of 11.0 brush strokes per word, and the ideographic equivalents took 14.8 strokes. It could be that phonographs appear simpler than ideographs and are therefore easier to recognize. A second possibility is that phonographs are easy to read because they are written exactly as they are pronounced, and this may facilitate recognition via some form of redundant coding. Finally, the subjects may simply have been more familiar with phonographic stimuli.

It appears from this study that Korean phonographs, like those of several other languages that have been investigated, engage cerebral processing mechanisms asymmetrically, with more left than right hemisphere involvement. The absence of a visual field superiority for ideographs in Korean subjects may be due to differences among Oriental languages. If this is so one might expect to find, within and across language cultures, differences related to the level of mastery and/or the age at which children begin to learn an ideographic symbol system.

It is also possible that while recognition of phonographs is dependent on asymmetrically distributed cerebral capacity, ideograph processing is not. A careful review of previously published research reveals robust lateralization effects only for phonetic languages. The most common finding for ideographic languages is an absence of asymmetry or a slight left visual field advantage.

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좌시야와 우시야에 제시된 한자와 한글인식

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여러 표음문자들에 관한 연구들에서 자극어를 좌시야와 우시야에 각각 순간노출기로 제시했을 때 피험자들은 우시야(좌반구)에 제시된 것을 일관성있게 더 잘 읽는 경향이 있었다. 이러한 결과들은 좌반구의 언어능력과 결부되어 해석되었다. 그러나, 표의문자인 한자를 자극어로 사용했을 때는 연구결과들이 일관성이 없었다. 여기에는 한자 특유의 공간적 배열이 영향을 미치는 것으로 보였다. 본 연구는 한자와 비슷한 공간적 배열을 가지며 표음문자인 한글을 한자와 함께 사용하여, 시야선호가 표음문자와 표의문자의 차이에 의해 나타나는지 아니면 문자의 배열상태의 차이에 의한 것인지를 밝혀보기 위한 것이었다. 실험조건은 한글과 한자 각각 한글자조건과 두글자로된 단어조건으로 이루어져서 각 피험자는 모두 4가지 조건을 수행하였다. 연구결과 한글은 한글자조건과 두글자조건 모두에서 우시야에 제시되었을 때 더 정확히 읽혀졌으나 한자는 시야에 따른 차이를 나타내지 않았다. 개인별 수행점수의 분석결과, 한글과 한자 모두 한글자조건보다 두글자조건에서 우시야선호성의 경향이 약간 나타났으나 통계적으로 의의는 없었고, 한글자조건과 두글자조건 모두에서 한글이 한자보다 의의있게 우시야 선호성을 보여주었다.