Psycholinguistic Evidence for Laterality Preferences and Information Processing in Japanese*

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The human brain exhibits hemispheric differences in information processing functions, and this fact of laterality preferences is reflected in language processing functions which involve lexical access and written word recognition in Japanese. This paper evaluates the Japanese psycholinguistic literature in the areas of experimental psychology and clinical aphasiology in an attempt to ascertain whether Japanese is unique in its characteristic pattern of laterality preferences in information processing tasks which involve its syllabary (kana) and Chinese character (kanji) orthographic representations. This paper also addresses misperceptions regarding lateralization and hemispheric preferences in processing Japanese orthographic types, since purported differences in lateralization can be uncritically accepted as underlying factors in not only language processing, but can also find their way into *Nihonjinron* discussions of differences in mental attitude and philosophical outlook.

1. Introduction

The human brain exhibits hemispheric differences in information processing functions, and this fact of laterality preferences is reflected in language processing functions which involve lexical access and written word recognition in Japanese.

This paper evaluates the Japanese psycholinguistic literature in the areas of experimental psychology and clinical aphasiology in an attempt to ascertain whether Japanese is unique in its characteristic pattern of laterality

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preferences in information processing tasks which involve its syllabary (kana) and Chinese character (kanji) orthographic representations.[1]

The aim of this paper is to address misperceptions regarding lateralization and hemispheric preferences in processing Japanese orthographic types, since purported differences in lateralization can be uncritically accepted as underlying factors in not only language processing, but can also find their way into *Nihonjinron* discussions of differences in mental attitude and philosophical outlook.[2]

In this paper, we will evaluate the psycholinguistic evidence for laterality preferences in the language processing stages of lexical access and written word recognition in Japanese. The paper specifically focusses on the nature of information processing as it relates to the script types used in the Japanese writing system, and whether this is influenced by the features of the script types themselves or the cognitive functions applied to aspects of their decoding. Section Two reviews the classical view that kana is processed by

[1] As is well known, Japanese employs four orthographic types: the kanji, hiragana, katakana, and romaji scripts. Logographically-based kanji, derived historically from Chinese characters, is used for content words. The two kana syllabaries capitalize on the straightforward syllabic nature of Japanese phonotactics, and see somewhat specialized uses. Hiragana is typically used for morphological endings, as well for as function words and grammatical particles; katakana is used for loanwords from other languages, as well as to highlight or provide emphasis for native Japanese words, serving a function similar to italics and/or bold type in alphabetic typefonts. The romaji script type is a direct reflection of the Roman alphabet, and is used to transcribe loanwords in their original configurations.

[2] For example, oto-laryngologist Tadanobu Tsunoda published a series of best-selling popular books (1978, 1985a, 1985b), which appeared to offer scientific support for the unique nature of language processing by the Japanese brain. His original experimental framework (1972, 1974, 1975) initially examined Westerners' perceptual lateralization for vowel sounds by using a dichotic listening technique coupled with a finger-tapping task. Tsunoda suggested that native Japanese speakers showed left, linguistic hemispheric dominance for certain pure vowel sounds, while speakers of other languages were said to exhibit right, non-linguistic hemispheric dominance for both the vocalic and pure harmonic sounds. The implication is that the brain in Japanese speakers is highly lateralized, and processes both linguistic, logical input and natural, non-logical input through the single hemisphere, and is thus unique. Such claims can ultimately be rejected, because they can neither be duplicated in the laboratory nor be supported by relevant psycholinguistic or clinical literature (see Shimizu, 1975; Uyehara and Cooper, 1980).

the left hemisphere and kanji by the right hemisphere. Section Three summarizes experimental psychological studies which have addressed variables which might affect laterality preferences in processing kana and kanji. Section Four surveys clinical studies which call attention to the functional requirements which support laterality preferences in information processing of script types. Section Five offers our conclusions that laterality preferences are not affected by physical variables, although they can be influenced by qualitative variables. More importantly, they are influenced by the depth and type of processing involved in various aspects of decoding, as a direct result of the type of functional processing imposed by the cognitive requirements of the task.

2. Classical View

Results from early studies by experimental psychologists quickly gave rise to the assumption that phonologically-encoded kana are processed exclusively in the left linguistic hemisphere, while visuospatially-oriented kanji are processed in the right hemisphere. For example, some tachistoscopic studies of visual half-field recognition showed left visual field (and thus right hemisphere) superiority for kanji, while showing a right visual field (and thus left hemisphere) superiority for kana (e.g., Hatta, 1977a). These results were further supported by applications of the Stroop test, an experimental technique which tests an individual's ability to separate word and color stimuli.[3]

For instance, Hatta (1981) reports that Stroop test color stimuli produced greater interference in the left visual field when subjects were responding to kanji stimuli; such interference was not found for kana stimuli in the same visual field. Hatta interpreted these results as indicating that the right hemisphere is specialized for processing kanji, since color in-

[3] There are typically several conditions: for example, some color words are printed in black ink, some symbols are printed in colored inks, and some words are printed in colors which do not match the actual color named by the word. Subjects are typically found to more quickly name colors when the stimuli presented are color patches or symbols in the specific color than when colors are presented as words written in alphabetic symbols which are colored differently than the color to be named. Very simply, it is difficult to verbalize the name for the color red when the word is presented in blue print.

formation, which is processed by the right hemisphere (see Nagae, 1989), interfered with kanji processing.

Such experimental assumptions often seemed to be matched by early findings from the clinical literature which investigated language impairments in aphasics, and the way in which they could be seen to contrast with abilities in normal subjects. For example, in testing normal subjects by tachistoscopically presenting kana and kanji to both left and right visual fields, Sasanuma et al. (1977) found kana and kanji were differentially processed in the cerebral hemispheres. Performance on the kana task showed a significant right field superiority, while the kanji task elicited somewhat better performance in the left field. Along similar lines, tests on kanji and kana processing given to 10 Broca's aphasics, 10 simple aphasics, and 10 cerebrally damaged patients showing no aphasia, showed the Broca's group as exhibiting a clear asymmetry in processing kanji and kana (Sasanuma, 1977). Their success rate in kanji processing was roughly around the 50% mark, whereas with kana processing it was almost 0%. To account for this poor kana performance by Broca's patients, whose damage is found in the left inferior frontal lobe, Sasanuma posed a classical view of cerebral lateralization: the right hemisphere, dominant for gestalt pattern-matching, would be responsible for kanji processing, and the left hemisphere, dominant for sequential, analytical processing, would be responsible for kana processing. This simple dichotomy of function for the cerebral hemispheres was extremely attractive for its elegant simplicity.

3. Recent Evidence in Support of Diversity of Function

This classical view of lateralization is not, however, supported by results arising from the wide range of inquiry found in psychological and clinical literature since the late 1970's. A large number of studies have explored the dimensions of kana and kanji processing from a variety of perspectives, with the results reported by many of these studies calling for an expanded version of the classical view of lateralization. Because of their attention to experimental variables and the nature of the tasks posed to both normal and aphasic subjects, it is worth reviewing some of the more pertinent of these experimental and clinical studies.

3. 1. Experimental Studies

Experimental studies coming from the cognitive psychology tradition may be evaluated to examine the effect of two main experimental variables, the experimental stimuli involved and the specific tasks posed. One of the principal experimental paradigms has been the tachistoscopic presentation of kana and kanji stimuli to the left and right visual fields. When one examines those studies involving normal subjects, physical variables appear to show no decisive effects on laterality preferences. Such physical variables include factors like number of characters, number of strokes, size and rotation angles, and duration of exposure. In contrast, qualitative variables, such as the concreteness, frequency/familiarity, and part-of-speech classification of the stimulus item will influence laterality preferences. Importantly, there are also a number of studies which report that lateralization is not solely influenced by such qualitative variables, but by the depth of processing involved in a specific experimental task as well.

3. 1. 1. Physical Stimuli

Most experimental work that has manipulated various types of physical stimuli relating to kana and kanji, including the number of strokes, size and rotation angles, and duration of exposure, has not reported decisive effects on laterality preferences. For example, one might speculate that the number of strokes, or figural complexity in the orthographic presentation for kana or kanji, could be a factor which would induce a processing asymmetry in laterality preferences. But Bussing et al. (1987) tested 115 German subjects with kana, simple kanji, and complex kanji. The task consisted of indicating, as quickly as possible, whether two stimuli presented in sequence were the same or different. Visual field differences were not found for any of the script types, and the expected left field advantage for higher figural complexity in complex kanji was not found. The results suggest that figural complexity generally has no effect on the identification of kana and kanji.[4]

[4] Kaiho (1979), however, reports an interesting fact about complexity of kanji. For kanji of 13 strokes or less, difficulty in kanji processing increases proportionally to the number of strokes; however, after this point, increase in the number of strokes facilitates kanji processing. The author attributes this finding to 'chunking' in visual pattern recognition, whereby each kanji is treated as a unit, rather than as an unorganized clutter of strokes.

There is no experimental study which specifically focuses on the effect of font or letter size on kana and kanji processing (Nagae, 1992).[5] If Kanda's (1984) inferences about script size are correct, the size of kanji characters should not have any significant effect on the processing of orthographic symbols in respect to laterality preferences, though they may speed recognition.

Rotation angles may affect lateralization, and it is generally reported that inverted or rotated characters elicit a left visual field advantage. For example, Hayashi and Hatta (1978) probed laterality differences by posing several levels of cognitive processing in conjunction with a mental rotation task in which subjects matched kanji at various angles of rotation with normally presented kanji. They found that not all mental rotation invokes the right hemisphere, despite its pattern-matching nature; when the mental rotation task was supplemented by the use of verbal mediators, the left hemisphere appeared to be more centrally involved in performing the task than the right hemisphere. Thus, although the mental rotation task might incur lateralization effects, the effects are likely to be mediated by the degree of rotation and the interjection of verbal mediators. This conclusion is also supported by Nishikawa and Niina (1981), who in fact failed to find visual field differences due to rotation.

Duration of exposure is not in and of itself a decisive factor either. Many tachistocopic studies have employed exposure durations raging from 50 msec to 200 msec, suggesting that duration of exposure does not have a significant effect on lateralization. Once the duration of exposure exceeds 200 msec, however, visual field effect cannot be effectively measured because information has already begun to flow across the corpus callosum. If one excludes those experimental studies which have failed to control for this effect, one notes that duration of exposure does not have an effect on lateralization (Nagae, 1992).

3.1.2. Qualitative Stimuli

In contrast to the results arising from experimental manipulation of phys-

[5] Langman and Saito (1984) note, however, that Japanese subjects are sensitive to the calligraphy types for kanji presentation in print, although this relates to conscious, subjective judgments rather than processing strategies below the level of awareness.

ical stimuli, qualitative stimuli, such as the part-of-speech classification, familiarity, and concreteness of the kanji stimuli can have significant effects on lateralization. For example, Elman et al. (1981a) had subjects verbally report on the grammatical category each kanji word belonged to, while their reaction times to tachistoscopic presentation was taken as the response measure. The results suggest that laterality preferences in processing kanji are more complex than previously claimed, with the expected right hemisphere superiority obtained only for nouns, but not for adjectives and verbs. Adjectives and verbs were in fact processed more rapidly in the right visual field, thus suggesting left hemisphere superiority.[6] One reason why such part-of-speech classification shows differential lateralization effects may be because nouns tend to denote high imagery objects while adjectival and verbal items fail to provoke such imagery.[7]

Many studies report the significance of familiarity and frequency on lateralization. For instance, Kawakami (1993) examines the effect of script familiarity on lexical decision tasks in an experiment which created familiar/unfamiliar words, three to five kana in length, by writing half of the stimulus words in the kana script they are not usually written in. Subjects judged whether these stimuli, some of which were misspelled, were real words. Reaction times increased in proportion to word length for unfamiliar script words, but this increase was not found with familiar script words. Kawakami concluded that visually familiar sequences of kana are treated as chunks in reading, but that visually unfamiliar sequences are not. In other words, familiar kana words have more left visual field (and hence right hemisphere) advantage than unfamiliar words due to their visual fa-

[6] There is, incidentally, no such study which duplicates the above findings with kana words, likely due to the fact that in Japanese content words are regularly transcibed in kanji and no study has specifically addressed this potential difference.

[7] Another reason may be that verbs and adjectives are predicates in propositional analysis terms, while nouns are arguments which revolve around the predicate. Predicates, in this respect, thus carry the logical relationships of the *dramatis personae* when framing language intentions, just as they carry the syntactic framework when intentions are translated into sentences with linguistic structure in a given language. Not surprisingly, then, kanji which represent verbs and adjectives show a left hemisphere supriority, since subjects are implicitly invoking linguistic concatenation possibilities even when processing a single such kanji.

miliarity.

The influence of familiarity by virtue of frequency has also been noted for kanji recognition. For example, in Minagawa et al. (1988) four different simplified kanji that were unfamiliar to subjects were exposed to either their right or left visual field. Overall reaction times revealed that the right visual field increased in superiority throughout the testing and that the visual half-field asymmetry shifted from left to right as the testing progressed. The above findings clearly indicate that during the early stages of testing, unfamiliar kanji characters were processed as meaningless patterns by the right hemisphere. However, as the stimuli became more familiar, they began to be processed by the left hemisphere.

The above familiarity effect can be duplicated even with other scripts. For example, Yoshizaki and Hatta (1987) found exactly this effect for the learning of Hebrew words by Japanese subjects. Four experimental groups learned pronunciation only for Hebrew words, the meaning only, both pronunciation and meaning, or nothing. Although there was no visual field advantage in testing prior to the learning experience, subjects who had learned pronunciation only or pronunciation plus meaning showed a right visual field advantage after learning the Hebrew words. The inference is that familiarity with the stimuli as linguistic objects is the crucial factor in producing a shift in visual field advantage, as it encourages left hemisphere engagement. There is, of course, no evidence that Hebrew in and of itself calls upon the right hemisphere in any unique way, insofar as Hebrew speakers are concerned. The characteristic Semitic configuration of skeletal roots largely consisting of consonants and word-patterns consisting of vowels is simply another way of presenting morphological features, but this structural feature does not invoke right hemisphere processing preferences (see Bentin and Frost, 1995).

The key consideration is whether such stimuli are treated as linguistic symbols or simply as unfamiliar, and thus unanalyzable, figures or patterns. A typical finding is that reported by Endo et al. (1981). This experiment tested for laterality differences in script processing for Japanese subjects without a knowledge of Korean *hangul* vs. Japanese-speaking Korean subjects resident in Japan with some knowledge of the hangul writing system. Five two-syllable nonsense kana words, five single-kanji words, and five hangul words with a CVC shape were tachistoscopically presented to all subjects, who were to classify them into one of two word groups. Reaction times revealed no laterality differences in processing kana and kanji; but Japanese subjects showed a right hemisphere superiority for hangul, while the Korean subjects showed a left hemisphere superiority. It would appear that Japanese subjects processed the hangul symbols as unfamiliar visual patterns, while the Korean subjects processed hangul as orthographic stimuli. Even increasing familiarity with novel patterns as potential linguistic symbols seems to have an effect. Hatta and Konda (1992) tested Japanese subjects for sequential changes in hemispheric advantage when there is an increase in familiarity for novel stimuli, by employing unfamiliar human faces, Korean *hangul* symbols, and alphabetic letters in the ornate Palace script as stimuli. The majority of subjects showed a continuing left visual field advantage for face recognition, irrespective of increasing familiarity, confirming that the right hemisphere is specialized for human face recognition. In contrast, the visual field advantage began to disappear with an increase in familiarity with the unknown script stimuli; although the data do not show a sudden and complete change to the opposite visual field, they do reveal a diminishing of visual field advantage as subjects accommodated to the unfamiliar orthographic symbols.

Concreteness of the kanji also appears to have an effect. For instance, Ohnishi and Hatta (1980) observe that when high concrete kanji are presented to the left visual field and low concrete kanji to the right visual field simultaneously, high concrete kanji are processed better than low concrete kanji, suggesting that concrete kanji have a left visual field (and hence right hemisphere) advantage. Hatta (1977b) also examined whether there are processing differences for kanji with highly concrete meanings and those with highly abstract meanings. His findings show that concrete kanji are more correctly recognized in the left visual field than are abstract kanji, and he therefore argues that, since the right hemisphere facilitates pattern recognition, and since concrete kanji are high in imagery, the factor of concreteness/abstractness affects efficiency of visual information processing for orthographic symbols like kanji. The corollary of this position is that the process of pattern recognition for verbal stimuli which are processed in the right hemisphere is facilitated by imagery. The above finding was also replicated by Elman et al. (1981b) who report that there was a right hemisphere advantage for concrete kanji nouns, but that the left hemisphere was superior in identifying abstract kanji. Furthermore, Nagae (1994) tested normal subjects by having them judge whether tachistoscopically presented concrete/abstract kana and kanji words were congruous with the meaning of a sentence presented beforehand. Subjects processed the concrete words written in kanji, as well as in kana, significantly faster than abstract words when these stimulus words were presented in the left visual field. These results demonstrate that, regardless of script type, concrete words have a significant left visual field (and thus right hemisphere) advantage.

In sum, when one considers the nature of the experimental stimuli that have been used in controlled approaches to laterality preferences, it would appear that physical variables have no significant effect on lateralization. Qualitative stimuli, on the other hand, do indeed appear to have significant effects on lateralization, although this may arise from their ability to evoke imagery.

3.1.3. Experimental Tasks

Having now examined the effects of the actual experimental stimuli used to elicit lateralization in the majority of studies, we will next turn our attention to the possible effects arising from the various types of experimental tasks asked of subjects. That is, do the cognitive functions posed by the differing requirements of the various graphemic, phonemic, and semantic tasks employed with subjects have any effects on lateralization when it comes to kana and kanji processing?

Firstly, experimental studies which employ graphemic processing tasks generally have a pair of letters presented simultaneously to just one visual field for graphemic identification, to avoid any involvement of memory. Many previous studies (see Kess and Miyamoto, 1994, Chapter 10) show that when there is an advantage, it is usually a left visual field (and hence right hemisphere) advantage. This generalization is hardly surprising, given that the right hemisphere is dominant for gestalt pattern-matching, and hence responsible for processing of the configurational aspects of kanji.

This generalization works for kana as well, as demonstrated by Kawakami (1993) and Besner and Hildebrandt (1987). Familiar kana words can be treated as visual chunks and can be processed without intervention by phonemic decoding procedures. When kana words are employed for such graphemic processing tasks, they show this left visual field (and hence right hemisphere) advantage.

Secondly, phonemic tasks typically involve presentation of stimuli in sequence or in parallel, to one of the visual fields for phonological identification. A prime example of this is the naming task, in which the subject must say the word, first activating and then realizing the phonological identity of the stimulus item. Not surprisingly, much previous work (see Kess and Miyamoto, 1994, Chapter 10) in this paradigm demonstrates a right visual field advantage for both kana and kanji. For example, Sasanuma et al. (1980) presented kana and kanji to the left and right visual fields, with subjects required to make decisions about phonological identity. The results revealed a significant right visual field superiority not only for kana, but for kanji as well. This finding supports the interpretation that the left hemisphere is dominant in phonemic processing, that is, whenever kana and kanji are processed for their phonological properties.

Thirdly, experimental tasks which have been designated as semantic tasks in the literature usually employ some kind of categorical identification task. Most experimental studies based on these semantic tasks report a right visual field (and hence left hemisphere) advantage when processing kanji for their semantic affiliations. For example, Hayashi and Hatta (1982) examine the relationship between semantic processing and cerebral laterality effects by measuring response times in a categorial classification task with kanji. The results demonstrate right visual field superiority, regardless of response hand, for both concrete and abstract kanji, suggesting superiority for the left hemisphere in the semantic processing required for kanji categorization.[8]

Finally, there are also several studies which examine the interactive effects of all three types of experimental task, that is, the interactive effect of graphemic, phonemic, and semantic tasks on lateralization. A study which illustrates this approach is found in Sekiguchi and Abe (1992), which examines hemispheric differences in kanji processing by employing an apparatus for brain-wave measurement. Event-Related Brain Potentials were measured at several points in the brain, monitoring brain-wave

[8] We are not aware of any study which duplicates the above findings with kana words.

activity in processing graphemic, phonemic, and semantic aspects of kanji compounds. Experimental stimuli were constructed in order to ask subjects whether the same kanji was found in a pair of compounds (a graphemic or pattern-matching task), whether a given pair of kanji compounds was pronounced the same (a phonemic or phonological decoding task), and whether a pair of kanji compounds belonged to a specific semantic category (a semantic decoding task). The authors then measured brain-waves corresponding to the subjects' activation of a micro-switch in responding to these questions. Brain wave activity was significant in the right hemisphere when graphemic aspects of kanji were being processed; brain wave activity was significant in the left hemisphere when phonemic and semantic aspects of kanji compounds were being processed. Despite the controversial nature of Event-Related Brain Potentials as valid measurements of cognitive activity, these results parallel other findings in suggesting that lateralization effects are directly tied to the functional requirements of the task before the subject, and not simply to the fact that the task involves kanji processing. Such findings, when taken as a whole, further suggest that the processing requirements of previous studies should be re-evaluated with this criterion in mind, and that simple generalizations about kanji vs. kana processing must be re-interpreted in this light.

3.2. Conclusion

In sum, if one examines the experimental literature in an attempt to weigh the contribution of the two main experimental variables, the experimental stimuli involved and the specific tasks posed, it is clear that the interaction between task type and stimuli type must be taken into account for a realistic explanation of cognitive processing. However, it is also clear that the cognitive demands arising from the various types of experimental tasks asked of subjects is the crucial consideration in evaluating laterality preferences. At the very least, it is clear that we cannot maintain the classical view that kana is processed by the left hemisphere and kanji by the right hemisphere. Our examination of the effect of experimental variables on lateralization shows that, regardless of script type, the configurational, pattern-matching aspects of both kana and kanji are predominantly processed by the right hemisphere. In contrast, the phonemic and semantic aspects of kana and kanji processing are predominantly handled by the left hemisphere. Thus, any cerebral shifts in respect to laterality preferences are very much affected by the functional requirements of the processing task, rather than by the simple feature of script type.[9]

4. Clinical Studies

Clinical studies of patients with unilateral brain damage or split-brain surgery provide even more convincing evidence that a simplistic view of kana and kanji processing cannot be maintained (see Kess and Miyamoto, 1994, Chapter 14). Their performance in dichotic listening and tachistoscopic tests certainly show that kana processing is more lateralized than kanji processing, but also suggest that certain aspects of kana and kanji processing may engage the left or right hemispheres, depending upon the nature and depth of the processing task. Thus, there is little question that the left

[9] Our basic claim that Japanese does not possess orthography-dependent processing mechanism is supported for instance by studies on Chinese *hanji* processing. One position, the Orthography-dependent Processing Hypothesis, claims that, unlike alphabetic and syllabary symbols, hanji can access meaning without the mediating step of phonological encoding (Biederman and Tsao, 1979; Chen, Flores d'Arcais, and Cheung, 1995; Keung and Hoosain, 1989; Tsao and Wu, 1981). An opposing view is offered by the Orthography-dependent Processing Hypothesis, which maintains that hanji, like alphabetic and syllabary symbols, cannot access their meanings without first invoking their phonological properties (Lam, Perfetti, and Bell, 1991; Tan, Hoosain, and Peng, 1995; Tzeng, Hung, and Wang, 1977; Tzeng and Wang, 1983). For example, convincing support for the Orthography-independent hypothesis is offered by Perfetti and Zhang's (1995) recent report of an experiment in which subjects judged whether a given pair of hanji was synonymous or homophonic. The results indicated that phonological interference took place within 90 msec of stimulus onset, but that semantic interference took place at 140 msec. In other words, phonological processing would appear to be activated before semantic processing, suggesting that the meaning of a given hanji is not accessed without the prior mediating step of phonological activation. It is quite likely that in the initial stage of hanji processing the rich visual properties of Chinese calligraphy may play a role which is significantly different from that of alphabetic and syllabary symbols. This factor, which may be manifested as right hemisphere superiority, may be predominate only at the initial stage of hanji processing; but the later stages of hanji processing are still highly orthography-independent (Hung and Tzeng, 1981) and may show right visual field (hence left hemisphere superiority).

hemisphere is largely responsible for processing the phonemic and semantic information required for the central aspects of kana and kanji interpretation, and that the right hemisphere is largely responsible for processing the visuo-spatial, pattern-matching information that is inherent in graphemic decoding. But even this dichotomy may not be that simple, for the two hemispheres can deal with certain types of information that might seem the exclusive domain of the other, depending upon the availability of functionally defining features such as familiarity and simplicity. For instance, Nagae (1989) claims that geometric figures can be processed by the left hemisphere, if these are not too complex; by implication, orthographic figures might also processed, if they are not too complex. Conversely, Nagae's (1994) examination of how normal subjects processed semantic information in kana and kanji words offers some support for the notion that even the right hemisphere exhibits some small semantic processing capability. Nevertheless, in general, the processing ability of the right hemisphere is both limited and different from that of the left when it comes to processing linguistic information.

Clinical studies in the vast medical literature offer two opposing views as to the exact role of the right hemisphere in language processing. One school argues that the right hemisphere is divorced from processing any aspect of kana and kanji. The opposing view admits that the contribution of the right hemisphere is limited, but argues that it does make a contribution, although that contribution has yet to be specified in any detailed fashion.

In reviewing previous studies of split-brain (commissurotomy) patients' abilities to manipulate visual and tactile stimuli, Sugishita (1980) offers the following conclusions regarding cerebral lateralization. First, the left hemisphere is specialized for language processing. Second, given split-brain patients' performance in copying figures such as Necker cubes and tetrahedrons, the right hemisphere is superior to the left in visuo-spatial processing. Thirdly, the claim that the right hemisphere is involved in some types of *language* processing (e.g., object-naming, picture-word matching, copying) must be accepted with reservation. Studies which drew such conclusions often employed split-brain subjects who had undergone a commissurotomy several years prior to actual tests. Lastly, results with split-brain patients confirm that the left hemisphere processes both kana and kanji; while the right hemisphere is involved with certain aspects of kana and kanji processing, such abilities are limited and are only observed a few years after commissurotomy. In sum, Sugishita questions the view that both left and right hemispheres are involved in language processing, and sees these functions as resident in the intact left hemisphere.

Others are less prone to actively deny that the right hemisphere may have some part in processing kana and kanji. For example, Iwata (1977) has shown that, in a kanji and picture matching task which required semantic processing, split brain patients did indeed exhibit 100% performance with their left hemisphere. But they also exhibited a 56% success rate when using the right hemisphere, suggesting that the right hemisphere does play some part in processing such minimal semantic features for kanji. Otsuka and Shimada (1988) similarly found that 36 unilaterally brain-damaged patients showed left hemisphere dominance for both kana and kanji processing, but that the right hemisphere did exhibit some semantic processing abilities, despite its inability to make graphemic-phonemic linkages. Furthermore, Yamadori et al. (1983) report a case of agraphia coupled with alexia, caused by lesions destroying the posterior half of the corpus callosum and the left medial occipital lobe. The result was a dissociated agraphia of the disconnection type for kana and kanji, suggesting that the neural substrate necessary for writing both kana and kanji is stored bilaterally, while the neural substrate for ordering these graphemes into a meaningful sequence is confined to the left hemisphere. Yamadori (1980) elsewhere discusses two case studies of right-handed Broca's patients whose symptoms support the above hypothesis. Both patients were able to copy kanji and some kana with their left hands, which is under the control of the right hemisphere. The author suggests that the right hemisphere is associated with 'motor engrams' for kanji and kana, explaining how patients with symptoms paralleling those of total aphasics can nevertheless copy kanji and kana. Importantly, although these patients could write single kana and kanji, they could not sequence kana and kanji into words and phrases, suggesting that the right hemisphere critically lacks the ability to sequence phoneme-dependent linguistic units.

If this school of thought is correct, we cannot say that the right hemisphere is completely uninvolved in processing kana and kanji. What is not clear is just how which aspects of kana and kanji processing are contributed to by the right hemisphere, and the extent of this involvement. So far as we know at this point, the phonemic and semantic processing capabilities of the right hemisphere appear to be extremely limited when compared to the left hemisphere, but so far no one has clearly demonstrated the extent of its involvement in kana and kanji processing.

5. Concluding Remarks

It is clear that we cannot maintain the simplistic view that the cognitive considerations in processing Japanese orthography are unique, with kana processed by the left hemisphere and kanji processed by the right hemisphere. The issue has more to do with the types of processing tasks involved, and the cognitive requirements they impose. Although it is safe to assume that the configurational, or graphemic, aspects of kana and kanji identification and interpretation are predominantly handled by the right hemisphere, and the phonemic and semantic aspects of kana and kanji processing are handled by the left hemisphere, there may be more of an interactive relationship between the two hemispheres which awaits elucidation. Although the evidence is as yet equivocal, it is likely that both left and right hemispheres collaborate in processing certain aspects of the graphemic, phonemic, and semantic information necessary for decoding words written in kana and kanji. It is clear that more research is needed to ascertain the exact contribution of the two hemispheres when differing cognitive tasks are posed. Most importantly, we are severely limited in knowing how the left and right hemispheres integrate these informational modules during lexical access and word recognition procedures in language processing (see Hoptman and Davidson, 1994), and this will obviously be the challenge for future studies in psycholinguistics, neuropsychology, and clinical aphasiology.

In conclusion, however, it should be noted that the popular view that kanji is processed in the right hemisphere and kana in the left is simply incorrect. A more accurate view reflects the fact that both left and right hemispheres are variously involved in processing different aspects of kanji and kana. Their participation in lexical access and word recognition procedures inevitably reflects different steps in accessing the mental lexicon, as cognitive mechanisms respond to varying functional requirements posed by the task at hand. Moreover, any suggestion that the Japanese brain is unique by virtue of the way in which the orthographic resources of written Japanese are deployed is clearly unsupportable, and the psychological and clinical literature in kana and kanji processing clearly shows this. The claim that laterality preferences in Japanese simply matches the cleavage between the two orthographic types of kana and kanji overlooks the universalistic, function-based nature of information processing by the human brain.

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