*Studies in Language and Literature*, 1994, 13(2), 1—18

# A Review of Psychological Studies of Kana and Kanji Processing: A Single Phonological Route to a Multiple Interactive Activation*

Katsuo Tamaoka
Matsuyama University, Matsuyama, Japan**

**Abstract:**

In the present study on a review on Kana and Kanji processing, the historical background of psychological studies on Kana and Kanji is described to understand how the interactive activation models were developed as a universal explanation for language processing. The early studies on Kana and Kanji script in the 1960s are discussed in the framework of evolutional theories which focused only on the script capability of phonological representations. In the 1970s, studies of Japanese dyslexia found distinct phonological and orthographic routes to assess the mental lexicon by Kana and Kanji. In the early 1980s, neurological studies revealed that the nature of linguistic tasks resulted in a shift of hemispheric specification. In the late 1980s, psychological studies proposed the intricate model that Kana and Kanji processing interactively involve both phonological and orthographic processing. This further developed in the 1990s as the interactive activation (IA) theory and the parallel distributed processing (PDP) theory.

* This study was supported by a 1993 Institute Grant from Matsuyama University.
** Correspondence concerning this article should be addressed to Katsuo Tamaoka, Ph. D., Matsuyama University, 4-2 Bunkyo-cho, Matsuyama, #790 Japan.

## 1 Introduction

The generally-held notion that Kana is processed phonologically and Kanji is processed orthographically requires clarification (see Tamaoka, 1991 & 1993 for details of the phycholinguistic nature of Kana and Kanji). The early studies in Kana and Kanji script during the 1960s employed the single-sided perspective of evolutional theories which were based upon the script capability of phonological representations. In the 1970s, neurological studies of hemispheric specification in the human brain during Kana and Kanji processing supported distinct routes of phonological and orthographic recording to explain Kana and Kanji processing. In the early 1980s the nature of linguistic tasks, regardless of whether thay involved Kana and Kanji scripts, was revealed to result in the shift of hemispheric specification in the human brain. This finding terminated, at least among neuropsychologists, the case for two distinct routes for Kana and Kanji processing. In the late 1980s, psychological studies proposed the intricate model that Kana and Kanji processing interactively involve both phonological and orthographic processing. In the 1990s, this was further developed as the interactive activation (IA) theory and the parallel distributed processing (PDP) theory. In the present review, the historical background of these psychological studies of Kana and Kanji is described to understand how current models were developed as a universal explanation for language processing.

## 2 The Theory of Orthographic Evolution

The early studies of Kana and Kanji precessing existed within the framework of the extended theory of evolution. For example, Gelb (1964)

tried to classify all language within three categories: 'word-syllabic' for pictorial languages such as Chinese, Egyptian and Sumerian; 'syllabic' for languages in which syllables are described by logographic writing such as Elamite, Mesopotamian and Sino-Japanese; and 'alphabetic' for languages in which phonemes are presented by letters such as English, French, German, Greek and Latin. Based on Gelb's world-wide study of languages, evolutionary stages of languages were thought to delelop 'word-syllabic' via 'syllabic' to 'alphabetic' writing systems. This is an extension of the biological evolutionary theory into a 'theory of orthographic evolution'.

The Japanese language was also fitted into this evolutionary hierarchy. Seeley states "originally the Japanese had no writing system of their own" (1984, p. 214). The Japanese borrowed Chinese characters to represent their spoken language. Hughes (1962) believes that, after borrowing writing symbols from the Chisese language, Japanese evolved as far as syllabic writing but never went beyond it. Despite what Gelb and Hughes suggest, has the Japanese language really evolved from Chinese to a higher stage among writing systems ?

According to the theory of orthographic evolution, the Japanese language is a classified between the stage of 'word-syllabic' and 'syllabic', since Japanese contains two types of scripts: the mora script of Kana and the morphemic script of Kanji. Kana symbols have developed on the basis of Chinese characters to represent Japanese mora sounds, whereas Kanji characters have been adapted from Chinese characters with little change of ordinals so as to represent concepts of morphemes. The two different types of script can co-exist simultaneously within a single Japanese sentence. Since the sound system of the Japanese language is limited to only

101 syllables which have created a multitude of homophonic words, Kanji characters act to avoid confusion between them and to express complex concepts in a shortered form. Clearly, the characteristics of the Japanese language cannot be explained by the oversimplified framework used by Gelb (1964) and Hughes (1962).

In the Chinese language, although some Chinese characters are simple logograms, most contain both morphemic and phonetic components (Hung & Tzeng, 1981; Leong, 1973, 1986, 1987; Tzeng, Hung & Wang, 1977; Wang, 1973). In addition, Chinese characters can be used as a syllabary to write foreign names and placenames originally presented in alphabetic or syllabic languages (Leong, 1986). Hence, the Chinese language cannot simply be relegated to the primitive stage of a 'word-syllabic' language. In addition, its sophistication must be seen to equal that of Japanese despite the claims of Gelb and Hughes that Japanese had progressed somewhat further on the path to the syllabic level than Chinese. Singificantly, Gelb and Hughes failed to provide meaningful evidence to prove the evolution either from pictorial writing to syllables, or from syllables to alphabets (Mattingly, 1985). The borrowing of a character set, or the adaptation of a writing system seems to depend on the phonemic, syllabic, and morphemic structure of each language, on dialect variety and historical change, and on the cultural and political setting (Read, 1983). Furthermore, rejecting the vertical orthographic evolution and replacing it with the psycholinguistic horizontal continuum, Downing and Leong (1982) proposed that "idiographic and alphabetic systems of writing differ only in degree and not in kind" (p. 169). Then, the script capability of sounds is no longer an important factor in judging its orthographic development.

The theory of orthographic evolution posits a sequential development

of orthographies described from the perspective of sound-to-script representation. Those orthographies which could represent sounds most precisely are perceived as the most advanced languages; consequently, English and other alphabetic languages are placed on the top of the orthographic evolutionary ladder. However, an orthography has the active function of transcribing utterances of a language for the purpose of communicating with others and providing new knowledge. The evolutionary theory of orthographies, which is based upon the script capability of sound representation, fails to explain either a mechanism for information processing, or an intricate procedure for word recognition based on script symbols. Writing systems come to a popular target of psychological studies in order to understand their mechanism in terms of accessing the described meanings.

## 3 Neuropsychological Studies of Kana and Kanji Processing

The evolutionary theories do not deal with the mechanisms for information processing. With no discussion of script symbol recognition by humans, they only consider how well scripts can represent sounds. Thus, the review of Kana and Kanji processing studies moves to the area of neuropsychological studies which focus on identifying the language processing mechanism in the human brain.

Neuropsychological studies of Kana and Kanji processing began with the area of dyslexic patients. Depending on the nature of the neurological impairment (Sasanuma, 1974a, 1974b; Sasanuma & Fujimura, 1971 & 1972), there are two different tendencies among Japanese aphasic patients which could be classified as either Kana aphasia or Kanji aphasia. Kana aphasia is the impairment of Kana processing and is characterized by a

difficulty in phonetic discrimination, while the ability to process Kanji is relatively well preserved or almost intact. On the other hand, Kanji aphasia is the impairment of Kanji processing characterized by difficulty in visual or direct graphic-lexical processing in contrast to well-preserved phonological (Kana) processing. Based on the studies of Japanese aphasic patients, Sasanuma and Fujimura (1971) hypothesized that "Kanji processing and Kana processing are relatively independent from each other" (p. 15).

Using normal right-handed subjects, Sasanuma, Itoh, Mori and Kobayashi (1977) measured the accuracy of tachistoscopic recognition of nonsense Kana and Kanji words exposed in the left and right visual fields. This study suggested that Kana and Kanji are processed somewhat differently in the cerebral hemispheres: a right visual field superiority exists for Kana, and a nonsignificant trend toward right visual field superiority occurs for Kanji. Furthermore, Sasanuma (1980) found that in the phonetic task condition, both Kana and Kanji indicated significant right visual field superiority, while in the visual task condition, neither Kana nor Kanji showed visual field superiority. This indicated shift of laterality from right visual field superiority to no asymmetry. Sasanuma (1980) interpreted this result in combination with a previous experiment (Sasanuma et al., 1977), as indicating that a change in strategy caused the shift of laterality.

Hatta (1981) further examined the hemispheric asymmetries at three different stages of Kanji processing: (1) the discrimination stage of the configuration of the letters; (2) the lexical decision processing stage; and (3) the semantic processing stage. Like Sasanuma (1980), the study found that the direction of hemispheric superiority might shift depending on the stage of information processing. More right hemisphere involvement was found at the discrimination stage, a bihemispheric involvement appeared at

the lexical decision processing stage, and more left hemispheric involvement was evident at the semantic processing stage. Hatta's study (1981) suggested that both hemispheres cooperate, and that their differences are differences of degree at each stage of processing, rather that of rigid functional specification.

Information processing in Kanji and Kana could require a different degree of hemispheric cooperation depending on the perceptual, lexical or semantic stage. As suggested by Hatta (1981), exclusive hemispheric specification is not enough to describe the complex mechanisms of Kanji processing. Using three different levels of single Kanji processing varying from orthographic to phonological to semantic, Leong, Wong, Wong and Hiscock (1985) found that visual laterality effects are dependent on the Kanji processing level demanded by the different tasks. Therefore, separate cerebral processing from alphabetic to morphemic (Kanji) script is not supported. Leong (1986) emphasized the interplay of phonological, morphological, syntactic and semantic processing for Kanji processing. According to these neuropsychological studies, Kana and Kanji processing appear to involve multi-path routes as indicated by the shifts of laterality which occur depending on the required level of information processing.

## 4 Vocal Interference Paradigm in Processing Kana and Kanji

Although neurological studies of hemispheric specification provided the overall Kana and Kanji processing in the brain, actual Kana and Kanji processing mechanisms need to be clarified by the experimental approach to language processing. Japanese orthography contains both phonological (Kana) and morphemic (Kanji) scripts. In addition, Kana has two sets of phonological representation, Hiragana and Katakana, which exisit at the

'mora' level ('mora' is derived from a Latin word meaning delay of space of time). Hiragana is mostly used for grammatical inflections (e. g., verbs and adjectives) and function words (e. g., adverbs and conjunctions), and Katakana is employed for writing loan-words from alphabetic languages.

In order to demonstrate a difference in Kana and Kanji processing mechanisms, Kimura (1984) created word pairs written in Hiragana and Kanji, which provide two different conditions for accessing meaning. The tasks (i. e., lexical decision) reguired subjects to decide whether the words were related in meaning. In addition, Kimura treated the same tasks written in Kana and Kanji with or without concurrent vocal interference, requiring subjects to say aloud the numbers from one to five in Japanese over and over without stopping until the task was completed. Hence, there were four conditions: (1) the task written in Hiragana without vocal interference, (2) the task written in Hiragana with vocal interference, (3) the task written in Kanji without vocal interference, and (4) the task written in Kanji with vocal interference.

The results of Kimura's study confirmed that vocal interference affected processing of words presented in Hiragana script more than those in Kanji script. Kimura stated that she had proven two hypotheses: (1) Hiragana was more affected by vocal interference than Kanji, and (2) the process of prelexical phonetic recording in Hiragana is influenced by vocal interference. However, Kimura's study contains three additional factors which influenced the script condition of Hiragana and which should be taken into account when assessing her findings. First, most of the words Kimura used are usually written in Kanji, so the subjects were not accustomed to seeing them written in Hiragana (i. e., script unfamiliarity effect).

The script unfamiliarity effect has been studied by Hirose (1984), who

compared Kanji words written in Katakana which should be written in Kanji and to alphabetic loan-words which should be written in Katakana. He found a difference in vocalization latency between the conditions of familiar script and unfamiliar script. Besner and Hildebrandt (1987) conducted a similar experiment using alphabetic loan-words presented in Katakana and Kanji words presented in Katakana. They found that Kanji words presented in Katakana were named more slowly than alphabetic loan-words in Katakana. Since alphabetic loan-words are almost always written in Katakana, Besner and Hildebrandt demonstrated that the Kana (Katakana in their study) script also show holistic and orthographic recording which was previously claimed as the mechanisms of Kanji processing (Kimura, 1984 ; Sasanuma, 1974a, 1974b, 1975 ; Sasanuma & Fujimura, 1971 & 1972 ; Sasanuma, Itoh, Mori & Kobayashi, 1977). Therefore, the script unfamiliarity of Kanji-written words presented in Hiragana used in Kimura's study may have resulted in longer naming times for Hiragana processing.

Second, the Japanese sound system is limited to 101 mora (see Tamaoka, 1991 & 1993 for details of the Japanese sound system and homophonic words), a fact which has created many homophonic words. If Kanji words are written in Hiragana, it is difficult to identify the correct word among possible homophonic words. For instance, in Kimura's study, the sound of /kyoukai/ which occurred in Hiragana actually presents three commonly-used homophonic words : 'church', 'association' and 'border'. Kimura seems to have assumed subjects would imagine 'church' for the task, but that requires some guessing in the script situation of hiragana. This homophonic effect can be observed in seven other of Kimura's stimulus items, which comprise 26.7% of the total stimulus items in her list (Kimura,

1984, p. 128).

These words are of homophonic lexical ambiguity, containing two meanings in a single word. Hoppe and Kess (1980) conducted a study concerning the detection of ambiguity in Japanese and they reported that of the four different types of ambiguity in Japanese, homophonic lexical ambiguity was the secound most difficult form to detect. An alternative explanation for the results of Kimura's study is that the mean difference of 8.65 seconds between Kana and Kanji tasks without vocal interference may have been partly created by the delay in identifying a proper meaning for some homophones.

Third, the task of using paired words which are related in meaning is rather ambiguous. The word pairs of 'spirit' and 'body', 'train' and 'commute', and 'history' and 'modern times' were used as lexically-related words in Kimura's study. However, differences in individual experience and personal knowledge can change these lexical relations between words. Also, the seemingly unrelated pairs of 'judgement' and 'telephone', 'education' and 'seaside', 'crash' and 'teacher' may be related in the personal life of some subjects. Thus, Kimura's experimental tasks are questionable due to their ambiguity.

Kimura did not take into account these three factors influencing the tasks she used. The script-unfamiliarity condition requires phonological recording for lexical access. Some words printed in Hiragana take longer to access to the lexicon due to the existence of homophonic words. In addition, identifying the relationship between words may be ambiguous for some subjects. Although Kimura's study provide some evidence to support phonetic involvement in processing Kana, futher research should be conducted in which the three factors affecting reaction times of Kana lexical

access are controlled. This will more precisely confirm the difference of the similarity in processing mechanisms between Kana and Kanji.

## 5 Phonological Recording of Kanji : On- and Kun-Reading

Most Kanji have more than one possible pronunciation : typically one "Kun" pronunciation and one "On" pronunciation (see details in Tamaoka, 1991). Kun pronunciations are normally used when the Kanji character stands on its own, but can be used in combination with other characters as well. Conversely, the On pronunciation is typically used for two-Kanji compound words, and is seldom used for a single Kanji. How is this On/Kun phonological structure of Kanji lexically represented ?

Nomura (1978) computed an On-reading dependency ratio in each kanji (On-reading frequency divided of a total On- and Kun-readings). Comparing the reaction times for reading a single Kanji of high or low On-reading dependency ratios, Nomura found that the lower the On-reading ratio, the faster the reaction time becomes. Moreover, when On-reading or Kun-reading was specified in vocalizing a single Kanji, the Kanji of high On-reading dependency ratio did not indicate differences in reaction time between On-reading and Kun-reading specification. However, for the Kanji of low On-reading dependency ratio, reaction time in vocalizing Kun-readings was faster than reaction time in vocalizing On-readings.

Kaiho and Nomura (1983) interpreted this result by speculating that Kun-readings have a stronger relation to a Kanji meaning that do On-readings. For Kanji with a high On-reading dependency ratio, since Kun-readings are not used frequently as On-readings, the relation to the meaning of Kanji in equalized between On-readings and Kun-readings. This results in no significant difference between the reaction for On-readings and

Kun-readings. For Kanji with a low On-reading dependency ratio or high Kun-reading dependency ratio, Kun-readings have a much closer relation to the Kanji meaning. Thus, Kun-readings are vocalized faster than On-readings for Kanji with a low On-reading dependency ratio or Kun-reading with a high dependency ratio.

Taft and Tamaoka (1992, unpublished data) conducted an experiment on On/Kun sensitivities in naming a single Kanji. Two Kanji lists (64 Kanji each for a total of 128 Kanji as a control Kanji group) of high (100%) and low (lower than 30%) On-reading ratios were prepared on the basis of the On-reading ratio which indicates the frequency of a singe Kanji read in On-reading. In these two Kanji lists, a target group of 32 Kanji with a 45% to 55% range of On-reading ratio and which could possibly be read in both On- or Kun-reading were embedded in a random order. When Japanese university students read the target Kanji within the Kanji list of the high On-reading, they tended to use On-reading. Kun-reading was preferred in the Kanji list of the low On-reading (the higher Kun-reading). Thus, Kanji readers must be sensitive to the On/Kun-reading of Kanji at the single Kanji level.

Furthermore, Tamaoka and Taft (1992) examined the On/Kun-reading sensitivity at the word level using phonologically consistent and inconsistently structured pseudohomophones. The study suggested that, when reading two-Kanji combinations, readers are sensitive to the On/Kun structure of words in the sense that they favour pure pronunciations (i. e., consistently structured pseudohomophones) over mixed ones (i. e., inconsistently structured pseudohomophones). This may not be surprising because most Japanese two-Kanji words have a pure rather than a mixed structure. Additionally, when the combination of the articulatory codes for each of

the two characters already exists in the lexicon, readers prefer it rather than those which have never been combined before. However, it remains to be seen how the combination of articulatory codes is represented in the lexicon as opposed to an individual articulatory code associated with each Kanji.

## 6 New Perspectives for Kana and Kanji Processing

One of the main phonological characteristics in the Japanese language is portrayed by the simple sound system limited to 101 mora sounds. Both the Chinese language and the English language contain relatively sophisticated sound systems compared to Japanese. The co-existence of two types of orthography in the Japanese language may result from the language's simple sound system. Therefore, the function of Kanji in Japanese texts could be to act as a visual variation in a sentence for accessing the mental lexicon. Furthermore, the involvement of two different Kana, Hiragana and Katakana (see Tamaoka, 1991 & 1993), is also required to avoid phonepic confusion when accessing the lexicon. These three scripts can be distinguished from each other according to the figure-ground theory.

Since Japanese children easily transcribe any Japanese speech sequence into either type of Kana without difficulty, Morton and Sasanuma (1984) assumed that "Kana symbols are initially translated directly into some phonological equivalent" (p. 38). However, they did not deny the possibility of direct access by orthographic recording to access the lexicon when processing Kana. In fact, Hatta and Hirose (1984) conducted an experiment measuring reading time of Katakana words and those printed in Hiragana. The results indicated that there was a Stroop effect among native Japanese speakers in reading Katakana words printed in Hiragana,

but no Stroop effect was found among Australian students who had learned the Japanese language. Some questions remain regarding whether the Australian students did know all the Katakana words (then, non-lexical guess), or whether they were exposed enough to Japanese written materials to show a script difference in reaction time between the words printed in Hiragana and Katakana. Nonetheless, the study of Hatta and Hirose can suggest that Katakana can be processed directly as an holistic orthographic approach by native Japanese speakers since they found a Stroop effect in reading Katakana words printed in Hiragana.

Besner and Hildebrandt (1987) also found that Katakana can be accessed directly without reference to phonological recording. They compared reaction times for vocalizing words normally written in Katakana and Kanji words printed in Katakana. Thus, processing Katakana could involve a direct route as well as an indirect route to access the Japanese mental lexicon.

Downing and Leong (1982) argued that "ideographic and alphabetic systems of writing differ only in degree and not in kind"(p. 169). According to this argument, differences in orthographies are rather a matter of how much direct and indirect access to the lexicon involved in information processing at different linguistic stages. Kanji, adopted from Chinese orthography, seems to show similar characteristics to the original orthography, while Kana can be understood as a simple version of phonetic script with the smallest unit being the mora. Therefore, it might be logical to withdraw the assumption that the processing route of Kana and Kanji may change depending on a number of linguistic factors such as homophonic effects, word printed frequency (Tamaoka, 1989, Experiment 3; Tamaoka, 1992), script familiarity (Takahashi & Tamaoka, 1992), semantic con-

text (Tamaoka & Takahashi, 1992; Tamaoka & Takahashi, in preparation), and even readers' reading abilities (Tamaoka, Leong & Hatta, 1991 & 1992).

Current findings on Kana and Kanji processing require a new perspective to form an alternative theory. Elements constructing Kanji may be processed via the direct route of orthographic recoding as well as via the indirect route of phonological recording. Kana symbols could also be accessed directly in the lexicon without phonological recording. Then, direct and indirect processing could be a matter of degree depending on the nature of tasks and words.

The flexible version of dual lexical access theory, which proposes interaction of direct and indirect recording for Kana and Kanji processing depending on the nature of tasks and words, appears to be a more likely lexical access procedure than two exclusive distinct accessing routes of Kana and Kanji processing. The interactive activation theory which puts its emphasis on the intricate interactions of two types of phonological and orthographic recording to access the mental lexicon may be an even stronger theoretical candidate to apply to Kana and Kanji processing. As reviewed in this study, the new model of interactive activation at a multiple linguistic level is constructed by disproving the distinct model of phonological and orthographic recording.

## REFERENCES

Besner, D., & Hildebrandt, N. (1987). Orthographic and phonological codes in the oral reading of Japanese Kana. *Journal of Experimental Psychology, 13,* 335-343.

Downing, J., & Leong, C. K. (1982). *Psychology of reading.* New York: Macmillan Publishing.

Gelb, I. J. (1964). *A study of writing.* Chicago & London: The University of Chicago

Press.

Hatta, T. (1981). Different stages of Kanji processing and their relations to functional hemisphere asymmetries. *Japanese Psychological Research, 23,* 27-36.

Hatta, T. & Hirose, T. (1984). Gairaigo, hi-gairaigo no ninchi shori ni kansuru kenkyu: Nihongin daigakusei to gaikokujin daigakusei no yomijikan no kekka kara [Reading Japanese and foreign loan words by Japanese and Australian students]. *Dokusho Kagaku* [*The Science of Reading*], *28,* 121-129.

Hirose, T. (1984). Kanji oyobi kana tango no imiteki shori ni oyobosu hyoki hindo no kouka [The effect of script frequency on semantic processing of Kanji and Kana words]. *The Japanese Journal of Psychology, 55,* 173-176.

Hoppe, R. A., & Kess, F. K. (1980). Differential detection of ambiguity in Japanese. *Journal of Psycholinguistic Research, 9,* 303-318.

Hughes, J. P. (1962). *The science of language: An introduction to linguistics.* New York: Random House.

Hung, D. L., & Tzeng, O. J. L. (1981). Orthographic variations and visual information processing. *Psychological Bulletin, 90,* 377-414.

Kaiho, H., & Nomura, Y. (1983). *Kanji joho shori no shinrigaku* [*Psychology of kanji information processing*]. Tokyo: Kyouiku Shuppan.

Kimura, Y. (1984). Concurrent vocal interference: Its effects on kana and kanji. *Quarterly Journal of Experimental Psychology, 36A,* 117-131.

Leong, C. K. (1973). Hong Kong. In J. Downing (Ed.), *Comparative reading: Cross-national studies of behavior and process in reading and writing* (pp. 383-402). New York: The Macmillan Company.

Leong, C. K. (1986). What does accessing a morphemic script tell us about reading and reading disorders in an alphabetic script? *Annals of Dyslexia, 36,* 82-102.

Leong, C. K. (1987). *Children with specific reading disabilities.* Amsterdam: Swets & Zeitlinger.

Leong, C. K., Cheng, P. W., & Mulcahy, R. (1987). Automatic proccessing of morphemic orthography by mature readers. *Language and Speech, 30,* 181-197.

Leong, C. K., Wong, S., Wong, A., & Hiscock, M. (1985). Differential cerebral involvement in perceiving Chinese characters: Levels of processing approach. *Brain and Language, 26,* 131-145.

Mattingly, I. G. (1985). Did orthographics evolve? *RASE, 6,* 18-23.

Morton, J., & Sasanuma, S. (1984). Lexical access in Japanese. In L. Hendlum (Ed.) *Orthographics and reading,* Hillsdale, NJ: Erlbaum.

Nomura, M. (1978). Kanji no jouhou shori : On-yomi, kun-yomi to imi no fuyo [Kanji information processing : On-reading, kun-reading and lexical coding]. *Shinrigaku Kenkyu* [*The Study of Psychology*], *49,* 190-197.

Read, C. (1983). Orthology. In M. Martlew (Ed.), *The Psychology of written language : Developmental and educational perspectives* (pp. 143-162). New York : John Wiley & Sons.

Sasanuma, S. (1974a). Kanji versus kana processing in alexia with transient agraphia : A case report. *Cortex, 10,* 89-97.

Sasanuma, S. (1974b). Impairment of written language in Japanese aphasics : Kana versus kanji processing. *Journal of Chinese Linguistics, 2,* 141-157.

Sasanuma, S. (1975). Kana and kanji processing in Japanese aphasics. *Brain and Language, 2,* 369-383.

Sasanuma, S. (1980). The nature of the task-stimulus interaction in the techistoscopic recognition of kana and kanji words. *Brain and Language, 9,* 298-306.

Sasanuma, S., & Fujimura, O. (1971). Selective impairment of phonetic and non-phonetic transcription of words in Japanese aphasic patients : Kana vs. kanji in visual recognition and writing. *Cortex, 7,* 1-18.

Sasanuma, S., & Fujimura, O. (1972). An analysis of writing errors in Japanese aphasic patients : Kanji versus kana words. *Cortex, 8,* 265-282.

Sasanuma, S., Itoh, M., Mori, K., & Kobayashi, Y. (1977). Tachistoscopic recognition of kana and kanji words. *Neuropsychologia, 15,* 547-553.

Seeley, C. (1984). Aspects of the Japanese language writing system. *Visible Language, 18,* 213-218.

Taft, M., & Tamaoka, K. (1992, unpublished data). On and Kun pronunciations in Kanji characters.

Takahashi, T., & Tamaoka, K. (1991). Script familiarity effects on the efficiency of processing numerals by Japanese university students with high and low English proficiency. *Studies in language and literature, 11*(1), 33-48.

Tamaoke, K. (1991). Psycholinguistic nature of the Japanese orthography. *Studies in Language and Literature, 11*(1), 49-82.

Tamaoka, K. (1992). The word processing efficiency of English-speaking learners of the Japanese language. *Intercultural/transcultural education, 6,* 99-113 (in Japanese).

Tamaoka, K. (1993). Weniger lese- und rechtschreibschwache Kinder im Land der aufgehenden Sonne ? : Zum Mythos der japanischen Schrift. In H. Balhorn and H. Brügelmann (Eds.), *Bedeutungen erfinden — im Kopf, mit Schrift und miteinander.*

Hamburg : Faude.

Tamaoka, K., & Taft, M. (1992). Inhibitory effects in pronouncing Japanese characters. Paper presented at the 25th International Congress of Psychology, Brussels, 19-24 July, 1992.

Tamaoka, K., & Takahashi, T. (1992). Can efficiency of English word decoding be a good predictor of English ability for Japanese students ? *ARELE, 3,* 43-52.

Tamaoka, K., & Takahashi, T. (in preparation). Understanding humour from another culture : Comprehension of parental brain twisters by Japanese university students learning English as a second language.

Tamaoka, K., Leong, C. K., & Hatta, T. (1991). Processing numerals in Arabic, Kanji, Hiragana and Katakana by skilled and less skilled Japanese readers in grades 4-6. *Psychologia, 34,* 200-206.

Tamaoka, K., Leong, C. K., & Hatta, T. (1992). Effects of vocal interference on identifying Kanji, Hiragana and Katakana words by skilled and less skilled Japanese readers in grades 4-6. *Psychologia, 35,* 33-41.

Tzeng, O. J. L., Hung, D. L., & Wang, W. S.-Y. (1977). Speech recording in reading Chinese characters. *Journal of Experimental Psychology : Human Learning and Memory, 3,* 621-630.

Wang, W. S.-Y. (1973). The Chinese language. *Scientific American, 228,* 50-60.