

**ACCESSING THE JAPANESE MENTAL  
DICTIONARY THROUGH THE JAPANESE  
WRITING SYSTEM**

Joseph F. Kess and Tadao Miyamoto  
Department of Linguistics  
University of Victoria  
Victoria, B.C.  
Canada V8W 2Y2

Occasional Paper #15  
November 1997

## Table of Contents

### Abstract

1.	Introduction .....	1
2.	<i>Kanji</i> .....	2
2.1	Phonological Activation .....	4
2.2	Semantic Radical .....	8
2.3	Compound <i>Kanji</i> .....	10
3.	<i>Kana</i> .....	13
4.	<i>Katakana</i> .....	17
4.1	Familiar <i>Katakana</i> Words .....	18
5.	<i>Hiragana</i> .....	19
5.1	The Issue of Script Familiarity for <i>Kana</i> .....	20
6.	<i>Kana</i> Script vs. <i>Kanji</i> Script Processing .....	21
7.	Mixed <i>Kana-Kanji</i> Texts .....	23
8.	<i>Romaji</i> .....	26
9.	Conclusion .....	28
	References .....	31

## Abstract

This Occasional Paper synthesizes conflicting models of Japanese lexical access and word recognition, and the way in which the four orthographic types (*katakana*, *hiragana*, *romaji*, and *kanji* characters) in the modern Japanese writing system access the mental lexicon in processing written Japanese words and text.<sup>1</sup> Japanese research into the processing requirements of a mixed orthography sheds light on the basic questions of word recognition and lexical access in psycholinguistics, and this paper reviews this rich paradigm of psycholinguistic research in an attempt to explain how lexical access becomes word recognition in processing written Japanese when presented in exclusively syllabary, Chinese *kanji* characters, or mixed scripts.

---

<sup>1</sup> This work has been supported by a continuing research grant on *Comprehensive Research on the Role of the Japanese Language in the International Community (Kokusai Shakai ni okeru Nihongo ni tsuite no Sogoteki Kenkyu; #07NP1001)* provided by the Ministry of Education, Science and Culture Grant-in-Aid for Creative Basic Research.

## ACCESSING THE JAPANESE MENTAL DIRECTORY THROUGH THE JAPANESE WRITING SYSTEM

### 1. Introduction

The history of the Japanese scripts evolves from early adaptations of Chinese characters through to the legislated literacy of recent times, with the end result being two *kana* syllabaries, which match the relatively simple syllabic structure of the language, and a large inventory of logographic *kanji* which can have varying pronunciations. The issues in lexical access for Japanese words are complicated by the very fact that Japanese does not have a single script type. Instead it has three script types,<sup>2</sup> two of them syllabaries and one of them a logographic system based on Chinese characters borrowed and adapted over the centuries. Even though Chinese characters (*hanji*) are employed in Japanese, the structuring of the mental dictionary for Japanese *kanji* is in many ways quite different from that for Chinese characters. Certainly the most vibrant areas of research for Japanese psycholinguistics have been tied to the architecture of its orthographic system. Japanese research has been keenly interested in the structure of the mental lexicon because of possible differences in syllabic *kana* vs. logographic *kanji* processing, as well as in possible differences in processing Japanese vs. non-Japanese orthographic layouts. The early literature entertained the notion that the two types of writing system, *kana* syllabary vs. *kanji* logographs, would employ different mechanisms and perhaps even different sides of the brain.<sup>3</sup>

---

<sup>2</sup> Actually, with the increasing use of the Latin alphabet-based *romaji*, it now has four script types. Where Japanese may or may not be the most complicated orthography among the world's languages, it now has the unique distinction of employing all three extant forms of transferring sound to written symbol, namely, the alphabetic, the syllabary, and logographic writing systems.

<sup>3</sup> Of course, what such early studies concluded was that the nature of the cognitive task is what predicts laterality preferences, not the stimulus types itself. Kess and Miyamoto's (in press) overview of the Japanese experimental literature on kanji processing shows a clear interaction between the experimental stimuli involved vs. the specific tasks posed. The stimulus type is not what drives the particular cognitive demands arising from the various types of experimental tasks asked of subjects when dealing with kanji. Although the stimulus type *per se* makes its own specific processing demands, it is the cognitive task type that is the crucial consideration in evaluating laterality preferences when subjects deal with logographic hanji or kanji. For example, experimental studies which employ graphemic processing tasks in which a pair of symbols are presented simultaneously to just one visual field for graphemic identification often find 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 and hanji. Even here, depth of processing encouraged by exposure times has an effect. For example, in reviewing previous work on laterality preferences and kanji/hanji processing tasks, Hasuike, Tzeng, and Hung (1986) observe that previous studies which found superiority for the non-linguistic, or pattern-matching gestaltic, right hemisphere in hanji processing did so when there were very short exposure durations

The expectation was that *kana* syllabaries would be processed through phonological decoding, whereas *kanji* would allow direct access to meaning. In this respect, the two writing system types, one based on a phonological principle and the other based on the same morphological principle as Chinese *hanji*, would ostensibly rely on different processing principles. The expectation was, furthermore, that the morphologically-based *kanji* would allow direct whole-word access to meaning direct from the orthography, while the phonologically-based *kana* would have to go through the step of phonological decoding to get at meaning. This expectation was further enhanced by the fact of extreme regularity in the relationship of the *hiragana* and *katakana* syllabaries to their respective syllables. The facts are, as we shall see, otherwise, and in some ways reminiscent of research findings for other languages while in other ways quite different. Modern psycholinguistic concerns with the role of 'top-down' processing mechanisms vs. 'bottom-up' processing mechanisms are complemented by these Japanese inquiries which assess the contribution of, as well as possible interaction between, graphemic, phonemic, and semantic information in *kana* vs. *kanji* reading. And so, we attempt in this paper to present an overview and synthesis of Japanese psycholinguistic research into how these aspects of written Japanese affect word recognition in that language. We also attempt to relate these findings to the cognitive processes that underlie lexical access for visual word recognition and reading for languages in general. Very simply, we attempt to ascertain whether the four orthographic types (*katakana*, *hiragana*, *romaji*, and *kanji* characters) in the modern Japanese writing system differ significantly in the way they access the mental lexicon.

## 2. *Kanji*

As is well-known, Japanese employs *kanji* characters borrowed from the morphemically-based logographic system developed for Chinese orthography. Beginning in the seventh

---

for hanji stimuli. Such stimuli must have elicited this right hemispheric superiority because they were essentially treated as non-linguistic stimuli. When stimulus exposure durations exceeded 50 msec, these right hemisphere superiority effects did not appear. Conversely, one must admit that the non-analytic, non-phonological, right hemisphere, has some input at the earlier stage of hanji processing, and that graphemic information is being registered in some way by the cognitive mechanisms allied to interpretative procedures.

century, *kanji* were imported and transduced into Japanese orthography from Chinese *hanji* in four separate and distinct historical periods. Massive borrowing transformed the vocabulary and established new patterns for the creation of lexical items. In Chinese, their use constitutes the only writing system, but in Japanese, the use of Chinese characters is complemented by two other sets of orthographic symbols, both of which are syllabic in origin and themselves ultimately derived from *kanji* simplifications.

According to recent statistical analyses of *kanji* in daily usage, just over 3000 of the possible 50,000 *kanji* are typically used in contemporary magazines and newspapers. In fact, less than 200 *kanji* account for 50% of daily usage, while 1000 *kanji* account for 90% of daily usage. An inventory of 2000 *kanji* account for 99%, suggesting that the actual number of discrete but frequently-used *kanji* is considerably less than one expects (see Nomura, 1984). Statistical data even point to a decline in the use of *kanji*; for example, novels written in 1900 employed text which was 39.3% *kanji*, while those written in 1950 employed only 27.5% (Nomura, 1984). The same is true when one charts the decline in *kanji* usage in major Japanese newspapers published during the Meiji (1868-1911), Taisho (1912-1925), and Showa (1926-1989) eras. The use of *kanji* in the 'big newspapers' aimed at bureaucrats and intellectuals was at first extremely high, with an occurrence rate of *kanji* close to 65%. Government notices cited in such papers exhibited a *kanji* occurrence rate which went as high as 95%. High frequencies for *kanji* were at first observed even with the 'small newspapers' aimed at the common people; here the occurrence rate was reported at around 55%. Throughout the last century of Japanese newspapers, however, the occurrence rate for *kanji* has decreased steadily, spurred on by governmental decrees reducing the number of officially approved *kanji* and the attempt to make newspapers available to a larger readership (see Kajiwara, 1982).

But reading written Japanese is not as simple as processing a limited number of single characters which represent single words with single readings. A number of orthography-specific requirements interact to make *kanji* processing a many-faceted cognitive task in Japanese. For example, Japanese *kanji* characters have varying pronunciations (or 'readings'), and this fact arises from the history of their implementation.

There are two possible types of reading for a given *kanji*: a given *kanji* can have a native Japanese reading, known as its *kun*-reading, or it can have an imported Chinese, or *on*-, reading. Furthermore, the Chinese *on*-readings can also vary; a given *kanji* can have *on*-readings which correspond to the four periods of historical borrowing from China they arrived in.

One of the key processing questions for *kanji* recognition involves the role of phonological vs. semantic factors, and their possible application in a parallel mode vs. a sequential mode. Similar to the debate in Chinese lexical access, can meanings of words written in *kanji* be understood even when their phonetic codes are not retrieved from the written transcriptions? The problem of phonological activation in Japanese, however, is complicated by the problem alluded to above, namely, that there is usually more than one reading for a given *kanji*. A second question is whether the much-lauded semantic quality of the component radicals in individual *kanji* characters actually have much to do with lexical access, that is, whether they are employed during the semantic interpretation of the character. The third important question has to do with the fact that many common and technical Japanese words are typically compounds, and not words represented by single *kanji*. The question here is whether compound *kanji* are recognized and processed as integrated units, or whether their successful recognition is contingent upon the recognition and processing of their *kanji* individual components.

We will attempt to survey some of the experimental answers to these basic questions below, largely focussing on Japanese research reports, in an attempt to elucidate what we have learned about the architecture of the mental lexicon for that language.

## 2.1 Phonological Activation

Chinese orthography, the source from whence Japanese *kanji* are derived, is morphemically-based. Yet Chinese allows, and may even sometimes require, phonological information to be accessed during its word recognition procedures. The majority of Chinese logographs are phonographs (Wang, 1981), and it is this type of logograph which has typically drawn our attention in questions of automatic phonological activation in Chinese lexical access and word recognition. Phonographs exhibit two possible constituent

parts traditionally, there is a radical or signific, usually on the left side of the character, which refers to meaning; on the right side of the character, there is often a phonetic which refers to pronunciation (see Chen and Yuen, 1991).<sup>4</sup> And it was this system which, in principle at least, was borrowed into Japanese. Although the characters imported from China into Japanese often retain these phonetic radicals, these are nowhere as reliable or useful in reading Japanese *kanji* as they are in Chinese. In fact, the percentage of phonetic radicals with reliably correct readings for a given *kanji* are very limited in Japanese. This basic difference in and of itself makes the discussion of phonological activation inherently different for character recognition in Japanese discussions of lexical access.

A central issue in Chinese *hanji* processing has been related to this dichotomy between phonological and semantic properties of characters, and attempts have made to examine whether the phonological properties of a given *hanji* character must be invoked before its meaning can be accessed. The issue of phonological activation is, of course, worthy of interest whether or not there are so-called phonetic radicals within the logographic symbols for either language. It is just that their presence in Chinese has been more closely tied to such inquiry in Chinese psycholinguistics, in Japanese considerably less so. Nevertheless, the same psycholinguistic question arises in respect to Japanese *kanji* processing, namely, whether phonological and semantic processing interact in parallel or sequential modes when the mental dictionary is consulted. One view, the speech recoding view, claims that character processing in lexical access automatically proceeds from the written form of the word *through the speech coding for the word*.

The idea is that activation of the phonological properties of a word is an automatic and integral component in the path of accessing the word's identity in the mental lexicon. Now this has not been as crucial an issue in Japanese psycholinguistic research into lexical access as it has been in Chinese research, largely because Chinese only has the one system

---

<sup>4</sup> Even so, the pronunciation of many of these phonetic compounds are not identical to their phonetic radicals in Chinese. In Chinese psycholinguistic research, it has been the set of phonographs which have pronunciations which are identical to their phonetic radicals that has served as the focal point of experimentation into lexical access and word recognition.

of logographic orthography. Japanese has complementary, if not alternative, orthographic systems based on the *kana* representation of syllable shapes, and therefore this issue has simply never assumed the major proportions in Japanese work that it has in Chinese.

Nevertheless, there has been some work on this issue, and it is useful to report the findings on phonological activation in Japanese. First of all, there has been some work on the small number of Japanese *kanji* which do have reliable phonetic radicals. Hirose (1992), for example, presented subjects with *kanji* stimuli, differing in the combinations of left- and right-hand radicals, and had them judge as quickly as possible whether sequentially-presented *kanji* had the same pronunciation or not. Right-hand radicals played a significant role in phonological processing of *kanji*, in that *kanji* pairs which shared the same right-hand radicals exhibited the fastest reaction times. A second experiment employed pairs of *kanji* which had the same radicals on the left- and right-hand side of the *kanji* characters, respectively. The left-hand radicals had no facilitating effect on the phonemic processing of *kanji*, suggesting that the information carried by the right-hand radicals does play some role in the phonological processing of *kanji* for Japanese readers.

The primacy and number of readings for *kanji* is obviously a consideration for fluent Japanese readers. Saito and Tsuzuki (1989) investigated retrieval for homophonic bisyllabic *kanji* in order to establish norms of retrieval variability for *kanji* readings. Subjects were presented with words transcribed in *hiragana* and then asked to write as many *kanji* words as they could think of for that pronunciation within 60 seconds. Correct *kanji* words tended to be recalled within the first 30 seconds, with a large number of widely differing incorrect *kanji* words emerging in the last 30 seconds. In the cases of incomplete retrieval, *kanji* for the first syllable were retrieved three times more often than *kanji* for the second syllable, reminding one very much of the classic tip-of-the-tongue experiments (see Brown and McNeill, 1966, and Kohn, Wingfield, Menn, Goodglass, Gleason and Hyde, 1987).<sup>5</sup>

---

<sup>5</sup> But the tip-of-the-tongue phenomenon in Japanese, because of the nature of the mixed script system, reflects different strategies for storage of lexical items written in *kana* and *kanji*. In two experimental probes, Murakami (1980) presented subjects with ten relatively rare, katakana loanwords, and then with ten *kanji* compounds. Subjects had to recall the words, recording those segments which they could recall. Retrieval of katakana loanwords was phonologically guided by the syllabic units found in the

However, the use of phonological information may not be as much at issue as is the temporal time frame for interaction between phonological and semantic information in processing *kanji*. When Wang (1988) asked subjects to find a target *kanji* word from each of three lists of homographs, homophones, and homonyms, respectively, processing of homographs was the quickest. Processing the other two lists took exactly the same time. A second experiment repeated the same test, using *kanji* compounds which consisted of four-syllables instead of two, and showed exactly the same results. These results were taken to suggest that phonological and semantic information about *kanji* are available in a parallel mode rather than a sequential mode.

The effect of homophonic overlap between words is a fairly reliable finding, and that interference effect from homophonic words has been used alone, or in conjunction with various semantic categorization tasks, to test the time course of phonological activation. An early study by Erickson, Mattingly, and Turvey (1977) tested whether silent reading of *kanji* requires short-term phonetic storage. Four sets of *kanji* words were prepared as stimuli, with sets phonetically similar, semantically similar, orthographically similar, or neutral, respectively. When subjects were required to write the *kanji* word which appeared on the screen one second before a probe word, recall of the phonetically similar *kanji* words was worst among the four stimuli sets, suggesting interference from phonological overlap.

When a semantic categorization task is added to the variable of phonological overlap, the results for Japanese bear considerable similarity to the results that are reported for English. Let us review the results for English first. Van Orden (1987) and Van Orden, Johnston, and Hale (1988) gave English-speaking subjects a category name like *flower*, and then had them decide whether a later target word was a member of that category. But they manipulated target words to include targets like *rows*, which is a homophone with a word like *rose*. *Rose* is obviously a real member of the category of *flower*. Both experiments

---

words, but retrieval processes for *kanji* compounds suggested that the individual *kanji* were the units that were being accessed.

found that subjects made more categorization errors with, and spent more time on, the homophone foils than they did on the spelling controls. What this means is that when the category was *flower*, and the target word was *rows*, the existence of homophone foils like *rose* gave more problems than target words which were spelling controls (like *snobs*).

In fact, such homophonic overlap gave rise to problems, even when the target words were non-words. Van Orden, Johnston, and Hale (1988) introduced as targets non-words that were homophones. For example, *brane*, was to be matched for possible category inclusion in a category entitled *a part of the human body*. The reasoning is that since non-words such as *brane* are obviously not entries in the mental lexicon, there must be a mandatory phonological activation of such words if categorization errors occur. And indeed, this is just what happens with *brane*, a homophone with *brain*; it does not happen with *blane*, however, a non-word spelling control. What we infer from such results is that there is automatic activation of phonological information in lexical access for English words.

Are there similar results in Japanese *kanji* processing? Three experiments reported by Wydell, Patterson, and Humphreys (1993) also found a significant homophone effect for Japanese, wherein homophonic target words elicited longer reaction times and more errors than their controls. But Wydell, Patterson, and Humphreys also found a significant effect which arose from orthographic similarity. That is, incorrect target words that were visually similar to correct exemplars, and which fit the semantic category, were also responsible for longer reaction times and higher error rates, although not to the same extent as the results obtained from phonological overlap in homophones. The effects were strongest when both factors intersected, that is, when homophonic targets were also visually similar in orthographic shape to correct exemplars of the semantic category specified. We may infer that, in Japanese, lexical access for *kanji* invokes both orthographic and phonological representations for the appropriate information.

## 2.2 Semantic Radical

The traditional belief is that *kanji* need not invoke phonemic recoding in accessing semantic features, due to the fact that logographs represent words, and not sounds. A single *kanji*

may be complex in that it may include a segment that signals some aspect of meaning or pronunciation, or both. At the left-hand side of the complex character, for example, there may be an additional component that suggests meaning, the radical *hen*. At the right-hand side of the complex character, there may be an additional component which suggests pronunciation, the radical *tsukuri*. Although the positions of these radicals can vary, they generally appear at the left and right sides, respectively. There are some interesting findings for single *kanji* characters which include more than one of these single components.

There is little question that Japanese readers can often, but do not always, use the cues provided by the component parts of *kanji* in order to ascertain their meaning. Certainly, *kanji* components can help readers of Japanese to infer the meaning of unfamiliar technical words in a way that meanings of words transcribed in *kana* cannot. For example, one experiment matched 30 unfamiliar, technical terms with their definitions; the inferability of the *kanji* compounds was almost perfect, much like Latin- or Greek-derived technical terms operate for English readers (Hatano, Kuhara, Akiyama, 1981). When subjects were given the 30 definitions and corresponding *kana* words, and asked to change these into *kanji*, the correct matchings were also statistically significant; when subjects made correct *kanji* encodings, they typically inferred correct meanings as well. It appears likely that experienced readers of Japanese have an inventory of *kanji* building blocks for compound words, especially learned ones, and that using this inventory, in concert with knowledge about compounding schemata, world knowledge, and contextual information, helps Japanese readers to figure out the meanings of unknown words of this type.

There is also a traditional belief that the semantic radicals provide a built-in conceptual categorization system which enhance the semantic search through the mental lexicon. There is little doubt that analysis by 'chunking' of the component parts of a *kanji* character does take place, and that the semantic radicals are important chunks to be taken into account in this analysis. In some processing tasks, each such radical in *kanji* is treated as a unit, rather than as an unorganized clutter of strokes. But some *kanji* are also taken in at a processing glance, so that they are treated as a whole unit, rather than analyzed into their component parts.

The evidence for this is mixed, and sometimes semantic radicals offer only vague, and sometimes unreliable, information about semantic groupings in the mental lexicon. Certainly this is the impression one gets from Flores d'Arcais and Saito's (1990) failure to find clear priming effects for semantic components of complex *kanji* characters. Subjects were presented with a prime word followed by a target word, and asked to name the target word as quickly as possible. If the target word was represented by a component of the prime word, and the meaning of the target word was associated with the meaning of the component, then theoretically subjects should name the target word more quickly than if the prime word did not have as a component the character representing the target word. But there was no significant difference in response when prime and target words were so 'related'.<sup>6</sup>

Flores d'Arcais, Saito, and Kawakami (1995) contrasted the contributions of the semantic radical (the *hen* component on the left-hand side of complex characters) with the phonetic radical (the *tsukuri*, on the right-hand side) to investigate phonological and semantic activation in Japanese *kanji* which have these features. Recall that the semantic radical only gives a vague idea of the general semantic field through which a set of *kanji* characters might be 'semantically' related, and that the phonetic radical is not a very reliable indicator of pronunciation for most words in Japanese lexicon. Nevertheless, these shortcomings notwithstanding, a pair of experiments manipulated characters that did encode both phonological and semantic information separately in their two radicals. The method was to present such semantic and phonetic radicals with an onset asynchrony, so that either the phonetic or the semantic radical was presented before the whole character. Assuming that both components are activated in the lexical search, this would give a

---

<sup>6</sup> Because Flores d'Arcais and Saito thought that the task might not reveal the effect of semantic priming, they then tried for effects when subjects judged whether word pairs were semantically related. If the two words are unrelated and if one of the two characters contains a component that has a similar meaning to the meaning of the other character, it should take longer to judge words as unrelated, because the presence of the semantically similar components interferes with the production of a negative response. And this is what did happen, namely, negative responses took longer to verify; the implication is that semantic information about components of complex characters is accessed during processing for a semantic judgment task. This, however, may be the case when processing attention is called to such semantic components, but leaves open the question of automaticity and reliability of such information.

momentary advantage to either the phonological or the semantic information, depending on which radical was presented ahead of the entire character. The results suggest that both phonological and semantic information are activated, since subjects in these two experiments made use of the information as soon as it was supplied. Phonological information seems to become available more effectively in the naming task, adding another processing task to the list of those in which the automatic retrieval of phonological information is activated.

### 2.3 Compound *Kanji*

There is a clear correlation between morphological simplicity and frequency of use, in that the simpler a *kanji* is, the more frequently it is used. But orthographic simplicity vs. orthographic complexity does not necessarily result in processing difficulty. For example, 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 actually facilitates *kanji* processing (see Kaiho, 1979). High frequency *kanji* are typically easier to read, but when frequency is constant, more complex *kanji* are easier to read than less complex *kanji*, because their orthographic complexity in terms of stroke number facilitates their reading (see Kawai, 1966). Subjective judgments of visual complexity in *kanji* are very sensitive to orthographic attributes like the number of strokes and symmetry in the horizontal, parallel, and diagonal planes. Not only are *kanji* with fewer strokes considered less complex, so also are symmetrical *kanji* (see Kashi, Ishihara, Inoue, Saito and Maeda, 1979).<sup>7</sup>

But this focus on individual *kanji* does little to illuminate the cognitive procedures employed in dealing with the many common and technical Japanese words which are compounds of two or more *kanji*. Insofar as compound *kanji* are concerned, the research suggests that recognition units of *kanji* are formed on the word level rather than on the level of the individual *kanji* character. Readings for Japanese *kanji* are likely computed at the

---

<sup>7</sup>

Attempts to determine the effect of stimulus exposure time and stimulus complexity on *kanji* identification also show that complex *kanji* and symmetrical *kanji* easier to identify than less complex and a symmetrical *kanji* under minimal exposure conditions (see Saito, 1986).

word level, not the individual character level. The phonological rendering of the *kanji* is highly dependent on the intra-word context, and is finalized at the word level, not at the character level. A series of six experiments by Wydell, Butterworth, and Patterson (1995) confirm that Japanese is different from both English and Chinese in this respect. This result is tied to the fact alluded to earlier, that Japanese can have two types of reading for its *kanji*, *on* or *kun* readings. And recall, furthermore, that these readings can vary for individual *kanji* according to the level of intra-word context, and not the individual pieces of the character in respect to phonetic or semantic radicals.

This is further confirmed by Morton, Sasanuma, Patterson, and Sakuma's (1992) experimental inquiry into how single and compound *kanji* are related within the organization of the Japanese lexicon. They too addressed the question of whether compound *kanji* are recognized as integrated units or whether their recognition is contingent upon the recognition of their individual *kanji* components. Two experiments revealed that both single and compound *kanji* words are facilitated only by pre-training with the identical word, again suggesting that the unit of *kanji* recognition is a word rather than a character. No facilitation was observed between compound *kanji* pairs which shared a character, nor was facilitation observed between single and compound *kanji* words. We must conclude that recognition units of *kanji* are most often formed on the word level rather than on the level of the individual *kanji* character.<sup>8</sup>

It may also be that frequency of the two component *kanji* in a two-*kanji* compound word has an effect on the path of lexical access. Tamaoka and Hatsuzuka (in press) tested for just such an effect from *kanji* frequency in both naming and lexical decision tasks. A first experiment on naming created 80 two-*kanji* compounds by controlling frequency (high

---

<sup>8</sup> This may be related to the fluidity with which compounds appear and disappear in Japanese. This is exemplified in Saito and Kawakami's (1992) examination of where pseudo-compound *kanji* words might fit into the mental lexicon. Subjects were given 248 *kanji* compounds and 368 pseudo-compounds, and asked whether they knew the compounds and whether they could be found in the dictionary. Two-thirds of the subjects judged that approximately 20% of the pseudo-compounds could be found in the dictionary, suggesting that readers differentiate pseudo-compounds from *kanji* compounds not so much on actual lexical addresses as on their lexical likelihood. However, to be able to access the actual lexical address one must know the compound as an existing compound word, with its own unique configuration of phonological and semantic attributes.

vs. low) and position (left-hand vs. right-hand character in the compound). The results revealed that high frequency *kanji* in the left position facilitated accuracy and speed in the naming responses. Of course, since naming initiates phonological activation, the frequency of the left-hand character will inevitably affect naming. A second experiment on lexical decision augmented the above stimuli with the same number of pseudo-homophonic compounds, whereby one of the compounding elements in a given *kanji* was replaced with a homophonic *kanji*. Subjects were then asked to judge as quickly and accurately as possible whether the stimulus compound was a legitimate *kanji* compound or not. In this case, high *kanji* frequency in the right position facilitated accuracy and speed in the lexical decision task. Because the lexical decision task cannot be realized without processing the right-hand *kanji*, the frequency of the right-hand *kanji* shows an effect.

Through a lexical decision task, Hirose's (1992) three priming experiments also seem to have found some support for the role of the first *kanji* in the storage and retrieval of *kanji* compounds in memory. A first experiment tested for the features used to retrieve compound words from memory, and found that the initial character in *kanji* compounds primes *kanji* compounds. A second experiment tested the effect of *kanji* primes which differed in pronunciation, but were identical to the initial *kanji* in the compound to be activated; there was no significant effect attributable to difference in pronunciation, suggesting that it is the meaning associated with a character that is activated in the retrieval process. The third experiment manipulated *kanji* primes in respect to their frequency of occurrence as elements in *kanji* compounds; low frequency primes showed a greater priming effect than high frequency *kanji*, suggesting that compounds which share an initial *kanji* are clustered together in the mental lexicon, according to the meaning of the first *kanji* in the compound word.

Frequency also interacts with the kind of morpheme represented by the *kanji*. Not all *kanji* are created equal, so to speak! Some *kanji* fall into the category of bound morphemes, and can only be used in that context, much as derivational Latinate prefixes in English are limited in occurrence. Yamada (1994) tested their status by employing a naming latency task to contrast two views of *kanji* recognition and naming the

post-lexical access hypothesis (i.e., meaning-to-sound) and the competition or horse-race hypothesis (i.e., competition between the phonological and semantic routes). Thirty subjects were given an audiovisual tachistoscopic task in which they had name as quickly as possible the following three types of *kanji* (i) single bound morpheme *kanji*, lacking a specific meaning when not part of a compound word; (ii) *kanji* compound words, containing the bound morpheme *kanji* as the initial compounding element; and (iii) possible *kanji* compound words which could be generated from the bound morpheme given. Subjects took longer to name the *kanji* compound words from which only the initial bound morpheme *kanji* was given than to name the single bound morpheme *kanji*. The author therefore favors competition over post-lexical access explanations because such single bound-morpheme *kanji* are generally named by directly accessing the phonological level instead of directly accessing the lexical level. But the point, insofar as our discussion is concerned, has to do with the variable status that *kanji* have. Not all *kanji* should be considered to have the same function or access path in the architecture of *kanji* storage in the Japanese mental lexicon.

### 3. *Kana*

There are two syllabary types in Japanese, the *katakana* syllabary and the *hiragana* syllabary. The *katakana* syllabary is more angular in the shape of its symbols, and is commonly declared as the appropriate transliteration medium for loan words into Japanese from other languages. However, it sees a good deal of use in modern printed Japanese as a kind of visual italics, useful for highlighting exclamations in literature and comic strips, neologisms, and useful in advertisements which call attention to brand names or brand qualities. *Hiragana*, on the other hand, is more cursive in its symbols, and its shapes are more easily discriminated one from the other. Although it can be and is used for writing some content words, it is commonly used in writing the non-content words and grammatical morphemes not usually presented by *kanji* characters; in short, it is used for morphologi-

cal endings, function words, and the rest of the grammatical scaffolding of Japanese sentences.<sup>9</sup>

Although Japanese research has concentrated more on the possible processing differences between its two orthographic types, syllabary vs. *kanji*, some work has also attended to possible processing differences between its two syllabary types, *hiragana* vs. *katakana*. Some have taken this to mean that the two syllabaries are domain-specific, with the main function of *katakana* tied to its representational function for foreign loan words. Hatta, Katoh, and Kirsner (1984), for example, contrasted lexical decision rates for English-speaking learners of Japanese with native Japanese speakers, in order to tease out the nature of lexical representation for loan words in Japanese. They suggest that native Japanese readers possess two separate, but partially overlapping lexicons: a foreign word lexicon to which *katakana* corresponds and a Japanese word lexicon to which *hiragana* script corresponds. In contrast, they claim that native English learners possess only one lexicon, a Japanese word lexicon, to which both *hiragana* and *katakana* correspond.

However, Hatta and Ogawa's (1983) experimental results seem to suggest otherwise for Japanese subjects themselves. They tested whether significant repetition effects occurred for the two *kana* types; if not, the two *kana* representational types can be considered similar. Significant differences were found, however, and the two types are to some extent distinct. *hiragana* and *katakana* did not completely overlap for their Japanese subjects, but did share some representational features. And so they should, for they can be used to represent the same word, although typically a word will appear in one or the other script.

And this fact of ultimately accessing the same lexical address is seen in Komatsu and Naito's (1992) three experimental tests of repetition priming with *kana* in word-

---

<sup>9</sup> Kana has never replaced kanji completely for a variety of reasons. A common argument is that Japanese has too many homophones, words with the same pronunciation whose differing meanings are efficiently shown by their having different kanji characters. For example, in discussing design problems associated with Japanese keyboard input, Yamada (1983) cites a vocabulary count of one popular Japanese dictionary as showing 36.4% of the entries to be homophones. The flip side of this classic argument is that spoken Japanese seems to flow effectively without visual support of the kind claimed as necessary through kanji. Correct interpretations are, for the most part, immediately and accurately assigned simply on the basis of discourse and contextual cues.

fragment completion. They manipulated *katakana* and *hiragana* to determine the effects of a script change between study and test on later word-fragment completion. Stimuli consisted of foreign loan nouns which would normally be written in *katakana*, but not *hiragana*. Such manipulations allow exploration of explanations based on imaging strategies to the phenomena of cross-script, cross-modal, and conceptual priming. The results revealed reliable cross-script priming between *katakana* and *hiragana*, as well as substantial cross-modal priming when the presentation modality was changed from auditory to visual. Ultimately, word recognition will take place, but there is no question that the path to word recognition will be facilitated by the fact of script familiarity for either *katakana* or *hiragana* presentations. At some level, these are seen as alternate paths to the same lexical address. Hirose (1985) also found evidence of this effect in a two-trial lexical decision task in which subjects were first asked to decide if words appearing on a screen were legitimate words or not. Two types of stimuli written in *katakana* were prepared: Japanese words whose normal orthographic representation is in *hiragana*; and loanwords, whose normal representation is in *katakana*. A second trial differed from the first in that half of the stimuli differed from those in the first trial. Not surprisingly, in the first trial the Japanese words written in *katakana* were processed slower and less accurately than the loanwords. However, in the second trial the Japanese words were processed faster and more accurately than in the first trial, showing a clear facilitation effect. No such facilitation effect was observed for the loanwords, suggesting that this facilitation effect in familiarization must have taken place at the level of visual processing in the first trial.

The primacy of *katakana* for loanwords is also questioned for by two experiments which examined the effect of orthographic familiarity on recalling English loanwords (see Yokoyama, 1991). A first experiment had undergraduates read aloud each of 72 words appearing on a screen. These stimuli, classified into high vs. low imagery words, were written both in *katakana* (the typical orthographic form for loanwords) and *hiragana* (an atypical way of representing loanwords). The subjects' task was then to recall as many words as possible in a 60-second period, and although high imagery words were better recalled than low imagery words, there was no significant orthographic effect. A second experiment had another group of

undergraduates perform the same task, but also had them engage in a mathematical task for 30 seconds before recalling the words. The result was that high vs. low imagery had no effect on recall, but there was now a significant orthographic effect. Orthographically unfamiliar *hiragana* words were now recalled better than orthographically familiar *katakana* words, perhaps because of the cognitive effort required to read the orthographically unfamiliar words.

As for the findings with non-native learners of Japanese, the results are colored by the fact that *katakana* representations are invariably more difficult for non-native learners of Japanese. The graphic distinctiveness of *hiragana* is typically easier for foreign learners to use in discriminating Japanese words, whereas the graphic overlap of the angular *katakana* is often a source of processing difficulty. This is borne out in Hatta and Hirose's (1984) pair of experiments testing whether foreign learners of Japanese differ from Japanese in processing *kana* words. A first experiment presented 200 Japanese words and English loanwords to 26 Japanese native speakers, while the second experiment presented them to 14 Australian students of Japanese with an average of 4.2 years of study behind them. Both Japanese words and English loanwords were processed faster by Japanese subjects when these words were presented in their conventional *kana* types (i.e., *hiragana* for Japanese words and *katakana* for loanwords). *hiragana* facilitated processing for the Australian subjects, while *katakana* failed to do so.

The very fact that *kana* is used to transcribe real words gives it an informational value, much as grammaticality contributes to the recognition and recall of sentence-like strings. For example, Miura (1978) found a word superiority effect for *hiragana* strings when testing for the effect of syllabification by tachistoscope. Orthographic regularity and meaningfulness in respect to symbolization of real words may be important determinants of the word superiority effect, but *kana* unitization which depends upon syllable-like structures is not.

Some authors even suggest that the nature of the resulting phonological representations may be different for scripts based on alphabets and syllabaries. Both *kana* orthographies are based on the syllabic structure of Japanese, and are thus converted into phonology, but Besner (1990) claims that the phonology derived from reading syllabic

Japanese *kana* script is more closely tied to articulatory activity than is the phonology derived from reading the alphabetic English orthography. But Tamaoka and Taft (1994) found that the smallest unit of phonological processing in Japanese is the phonemic segment, not the mora which is orthographically represented by *kana*. They modified *katakana* words for a lexical decision task in which words like *ka-me-ra* 'camera' could appear in three different ways: (i) the vowel of the initial mora was altered, giving *ko-me-ra*; (ii) both vowel and consonant of the initial mora were altered, giving *so-me-ra*; or (iii) two initial morae were altered, giving *so-ki-ra*. Subjects were presented with 30 stimuli sets on a videoscreen and asked to decide whether the stimulus was a word or not. Longer response times were required for *ko-me-ra*, suggesting that subjects only accessed lexical information for the first type. Although the mora is the smallest unit of orthographical representation, Japanese subjects were sensitive to phonemic segments in processing these *kana* words, suggesting that phonemic segments are the smallest unit of phonological processing. Although the *hiragana* and *katakana* syllabaries of 48 symbols represent the same inventory of

111 syllable shapes in Japanese,<sup>10</sup> they do not completely overlap.

External factors such as script familiarity exert an influence on lexical decision tasks. Reaction times increase in proportion to word length for unfamiliar script words, that is, in inverse proportion to the frequency with which a given word is normally seen in either *katakana* or *hiragana* script. Conversely, this increase is not found with familiar script words. And we shall say more about this phenomenon, and other processing differences between the two syllabary types, in the following sections.

#### 4. *Katakana*

Orthographic attributes contribute to making *kana* letters hard or easy to read. A lack of distinctiveness, and similarity between *kana* shapes, interferes with legibility for both *hiragana* and *katakana*. When two hundred junior high students were asked to cross out specified symbols from sets of *katakana* and *hiragana* as quickly and as accurately as

---

<sup>10</sup> According to the Nihongo Hyakka Daijiten, the generally accepted number of syllable shapes in Japanese comes to 111 in number.

possible. Simplicity and less curviness contributed to *hiragana* legibility, while simplicity and the presence of a horizontal or parallel line (vs. the absence of a diagonal line) contributed to *katakana* legibility (Matsubara and Kobayashi, 1966). But *katakana* appear to pose a greater processing burden than *hiragana*, possibly because of their lack of discriminability owing to graphic overlap.

This is borne by work on the effect of letter sizes on recognition. Three different letter sizes (3.0x3.0, 5.5x5.5, and 8.0x8.0 mm.) for the 26 alphabetic letters and 48 *katakana* were presented to subjects charged with alphabet recognition and *katakana* recognition, respectively. Accuracy increased as size increased for both alphabet and *katakana*, but *katakana* recognition was worse than alphabetic (Tasaki, 1992). Yokoyama and Yoneda (1995) found no significant decrease in recognition rate for *kanji* when noise levels were introduced, but there was a linear decrease for *kana*, with *katakana* recognition rates under noise conditions worse than *hiragana*. Kaiho's (1968) multiple regression analysis charts the factors which affect *katakana* legibility. Frequency of *katakana* have no positive effect on *katakana* legibility under noise conditions, but orthographic features do have a positive effect on legibility. For example, the salient factors which emerge are horizontal and longitudinal directionality and redundancy.

The Semantic Differential has also been used to show how orthographic type affect subjective evaluation of script appropriateness. Common words like *chair* and *watch* were presented in *kanji*, *hiragana*, and *katakana* to 85 undergraduates, who evaluated them on a seven-point SD scale. Script effects were obvious, with the angular scripts inherent in *kanji* and *katakana* factoring out separately from the more cursive *hiragana*, possibly owing to the historical derivation of *katakana* from *kanji*, with *hiragana* arising from different origins (see Sugishima and Kashu, 1992).

#### **4.1 Familiar *Katakana* Words**

The received view on lexical access for Japanese words was at first that words written in *kana* necessarily rely on their phonological values for lexical access. In contrast, words written in *kanji*, it was thought, would be accessed directly from their visual image. But visually familiar sequences of *kana*, particularly common *katakana* words, are often treated

as chunks in reading, in a way that visually unfamiliar sequences are not. This means that *kanji* are not the only forms that, theoretically at least, can be accessed directly from their orthographic image.

Besner and Hildebrandt (1987) offer some interesting evidence on whether lexical access for words written in *katakana* can be achieved without reference to phonological recoding. *Katakana* words were presented in three ways visually familiar words usually written in *katakana*, visually unfamiliar words usually written in *kanji*, and non-words. Japanese subjects read the stimulus words aloud as rapidly as possible, and naming latencies were recorded. Visually and orthographically familiar words were named faster than both visually unfamiliar words and non-words, suggesting that such *kana* words have a more direct lexical access. This shows up as an advantage in oral reading over those *kana* words that must resort to sound-spelling correspondence rules, and one infers that lexical access for some familiar words printed in *katakana* can be achieved without recourse to the preliminary steps involved in phonological recoding.

The effects of script frequency on word recognition may be noticeable for words written in *katakana*, because of their special visual status as 'one of a kind'. Tanaka and Konishi (1990) contrasted both words and non-words, presented in four different orthographic conditions high frequency *katakana* words; high frequency *kanji* words; low frequency *katakana* words, usually written in *kanji*; and low frequency *hiragana* words, usually written in *kanji*. The words were presented to both the left and right visual fields of 10 adult subjects, who had to discern as quickly as possible non-words from words. In another session, they also sorted the words into semantic categories. As expected, there was a clear frequency effect separating high and low frequency *katakana* words, with high frequency words processed faster than their low frequency counterparts. But there was also a visual field difference; the low frequency words showed the involvement of the right visual field, whereas the high frequency *katakana* words did not. Lastly, there was a word-length effect for low frequency words; the longer the word, the slower the processing time. One might infer that low frequency *katakana* words require phonemic processing, whereas high frequency *katakana* words allow direct access to their meaning.

## 5. *Hiragana*

Although the effects of script frequency on word recognition are experimentally supported for words written in *katakana*, the same must be true for those many non-content words of the grammatical morpheme type that are typically written in *hiragana*. However, most of the work on script familiarity focusses on the typicality of the two syllabary types, and not much work focusses on *hiragana* itself.

### 5.1 The Issue of Script Familiarity for *Kana*

Script familiarity will invariably exert an influence on lexical decision tasks, such that orthographic familiarity of *kana* strings is a major variable in lexical access procedures. Kawakami (1993) examined this by using familiar/unfamiliar words, three to five *kana* in length, which were half-written in the *kana* script they are not usually written in. Subjects judged whether these stimuli words, 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. A second experiment had subjects again making lexical decisions, but reading from right to left instead of in the usual order. This unusual reading condition increased reaction times for both familiar/unfamiliar script words in direct proportion to word length. We may infer that visually familiar sequences of *kana* are treated as chunks in reading, in a way that visually unfamiliar sequences are not. Similarly, Sasanuma, Sakuma, and Tatsumi (1988) conclude that orthographically familiar *kana* words have direct access to the lexicon on the basis of the orthographic code, while orthographically unfamiliar words require recourse to phonological recoding. Their conclusion is based on reaction time differences in lexical access procedures for different types of *kana* strings. Orthographically familiar *kana words* (words which are normally written in *kana*) were contrasted with non-words and *words in kana* (words which are not normally written in *kana*, as for example, *kanji* transcribed into *kana* or *katakana* loan words transcribed into *hiragana*). Response times for orthographically familiar words were significantly faster than for non-words, and often faster for orthographically unfamiliar words.

Yamada, Imai, and Ikebe (1990) tested for the effect of variables such as lexicality (words vs. non-words), *kana* type (*hiragana* vs. *katakana*), string length (long vs. short), and vocal interference (silence vs. concurrent vocalization). The results show that the more conventional strings are, the more quickly they are recognized, thus substantiating the generality of conventionality and lexicality effects in reading symbol strings in various orthographies. They conclude that a visual orthographic lexicon for *kana* reading exists in normal adult Japanese, such that many higher frequency words are recognized on a visual orthographic basis and lower frequency words on a phonologically analytic basis. But subjects did divide into two groups, orthographic lexicon users and phonological assemblers, differing in the size of their respective sight vocabularies, but both employing sight vocabularies. These results point to the involvement of both an orthographic route and phonological assembly route which is consonant with the dual-route hypothesis. It certainly contradicts the common view that *kana* words must be accessed through phonological mediation alone.

#### **6. *Kana* Script vs. *Kanji* Script Processing**

Are there processing differences between *kana* and *kanji* script types? Are words written in *kana* named faster than the same words written in *kanji*? Are there hemispheric differences in laterality preferences that are associated with *kana* processing vs. *kanji* processing?

Japanese speakers are certainly prepared to make subjective judgments of appropriateness of script type for everyday words. One experiment had 219 undergraduates choose the script type they considered as the best fit for each of 119 common words, such as *glasses* and *box*. A second experiment had 193 undergraduates judge whether a given script type was appropriate for each of 119 words. Both experiments revealed consistency in subjects' judgments, with almost half of the words deemed to be best as *kanji* (see Ukita, Minagawa, Sugishima, and Kashu, 1991).

Early views projected processing differences between *kanji*-reading and *kana*-reading, and held that *kana* would generally take less time to read than *kanji*. But *kana* reading speed was said to slow down as the number of *kana* increased, while the number

of *kanji* did not affect reading speed for *kanji* (Saito, 1982). The notion, of course, was that *kana* require phonemic intervention to access to their semantic referents, but that *kanji* would directly access their semantic referents (see Saito, 1981). But *kanji* research revealed that even purely graphemic tasks evoke phonemic processing of the lexical unit involved, suggesting that *kanji* and *kana* both involve graphemic, phonemic, and semantic processes. The main difference in reading *kanji* and *kana*, however, was then postulated as involving differing processing routines, differing in the way that the path to lexical access was realized. Specifically, *kana* would invoke graphemic, phonemic, and then semantic processing, while *kanji* would invoke graphemic, semantic, and then phonemic processing (Saito, 1982).

Feldman and Turvey (1980) did find some evidence for the speed of *kana* processing. They tested the relationship of orthographic type in Japanese to the availability of phonological information by comparing latency differences in naming *kanji* and *kana* words. It was hypothesized that naming words written in *kana* exploits both an orthographic strategy (based on letter-sound correspondences) and a word-specific strategy (based on visual shape); naming words written in *kanji* only allows the latter because *kanji* have no phonological properties. Six color names were written in both scripts and presented to two Japanese subjects, who were instructed to read the stimulus words as rapidly as possible. On the one hand, one might expect that word frequency and visual scanning efficiency would predict shorter naming latencies for *kanji* than for *kana*, because color names appear more frequently in *kanji* and with compact graphic patterns. On the other hand, the phonologically-based nature of *kana* would suggest an advantage for *kana* in vocalization. The results show that the response latencies were consistently faster for *kana*, suggesting that the phonologically-based orthographic form of *kana* accounts for greater facility in naming.

But these findings must be tempered by the results of three experiments on the effect of syllable length in *kana* and *kanji* word recognition. These results revealed that the number of syllables in *kana* words affected recognition times, but this was not true for words which consisted of a single *kanji*. Recognition times were affected, however, by the

number of syllables in words which consisted of two *kanji* and were typically longer (Tada, 1975). And script frequency for *kanji* and *kana* words also exerts its effect on processing speed. Hirose (1984) examined the effect of script type and frequency on lexical access by having undergraduates classify words into semantic types. Script type and frequency were manipulated to form three groups words written in *kana* though their regular script type is *kanji* (low-frequency *kana* words); words written in *kana* just as they are usually represented (high-frequency *kana* words); and words written in *kanji* (*kanji*-words). Findings were that the low-frequency *kana* words took longer to process than the *kanji* words; however, there was no difference between the high-frequency *kana* words and *kanji* words in processing time. We may infer that the type of orthography per se does not affect processing time; rather it is familiarity with the frequency of the orthographical shape which has an effect on lexical access.

*Kanji*, *hiragana*, and *katakana* recognition is differentially affected by noise levels. When these three script types were filtered through three levels of visual noise (15%, 20%, and 25%), *kanji* were better recognized than *kana* at all noise levels for both humans and an Optical Character Reader. There was no significant decrease in recognition rate for *kanji* as the noise level increased, but there was a linear decrease for *kana*, with *katakana* worse than *hiragana*. Yokoyama and Yoneda (1995) attribute the robustness of *kanji* recognition to iconicity and the distinctive number of strokes involved (see also Yokoyama, 1995).

Most studies of *kana* and *kanji* focus on reading differences between the two scripts, but other areas in *kana* and *kanji* research have also elicited experimental attention. For example, script frequency affects not only reading, but also affects recall of *kana* and *kanji* words. One experiment reports using three types of words as stimuli in both reading aloud and incidental recall tasks for 44 undergraduate subjects words which are regularly written in *kana* (*kana*-type); words which are regularly written in *kanji* (*kanji*-type); and words which are regularly written either way (*kana/kanji* type). In the reading aloud task, the reading of the *kanji*- and *kana/kanji*-type words which were represented in *kanji* was as fast as the same types of words represented in *kana*, indicating that the *kana* (i.e., phonological)

mode of representation itself does not necessarily enhance reading speed. In the recall task, recall for *kana*-type words which were represented in *kana* were as good as those represented in *kanji*, indicating that the *kanji* (i.e., semantic) mode of representation itself does not necessarily enhance recall speed (see Sugishima, Ukita, Minagawa, and Kashu, 1993).

Imagery also has an impact on recall and memory. In another experiment, subjects were unexpectedly asked to recall *kana* and *kanji* words which had been ranked in terms of high vs. low imagery. Imagery had an impact on the recall of *kanji* words, but a variable impact on recall for *kana* words, illustrating the significance of orthographic types on recall and memory (Yokoyama, 1995).

### **7. Mixed *Kana-Kanji* Texts**

But the basic fact of everyday printed Japanese is that phonetic and non-phonetic script are intermingled in ordinary text to be read. And so one must be careful to discriminate between those models of word recognition and the mental lexicon which pose explanations through autonomous vs. interactive models. Such explanations differ crucially in their treatment of contextual effects on lexical access; the autonomous model denies contextual effects, whereas the interactive model depends upon them. We know from previous work on lexical ambiguity, that resolution is tied to the final processing stage, and that at a very early stage of processing homophones at least, multiple readings unaffected by context are considered. This initial stage is immediately replaced by the selective reading which fits the contextual restrictions (see Kess and Hoppe, 1981; Kess and Nishimitsu, 1990; Kess, 1992). We may have to adopt a compromise model which specifies at which temporal course of information processing lexical access is autonomous or interactive (see Yi, 1987).

In the normal course of events, printed Japanese typically intersperses *kanji* and *kana* in printed sentences. When one considers normally integrated syllabary-logograph texts, reading times are faster for the mixed *kana-kanji* script type than for the *kana*-alone type. The number of compound *kanji* does exert an influence, however, so that nursery tales are read faster than scientific essays. Highly specific content words, like technical or scientific

terms, tend to be learned as *kanji* at their first appearance, and these words are commonly written in *kanji* at all stages in the education system. When one compares *hiragana*-only texts with mixed-*hiragana/kanji* texts, mixed texts are processed faster than the *hiragana*-only texts. Eye-voice span, the difference between eye-movements and actual vocalization, reveals no difference between the two types of text, however. When Kitao (1960) then had subjects fill blanks with appropriate words in a cloze test, mixed texts facilitated more accurate responses than *hiragana*-only texts. Mixed texts are not only easier to read than *kana*-only texts, but they seem to facilitate the extraction of meaning from the text as well.

There are also differences in how the concurrent vocal interference effect plays out in reading comprehension. Hayashi and Hayashi (1991) measured reading comprehension for *kana* and mixed *kana/kanji* sentences in the presence of concurrent vocal interference.<sup>11</sup> Script types for sentences were either mixed *kana-kanji* or *kana* alone in eight stories whose contents were either scientific essays or nursery tales. Mean reading times were computed for each condition and taken as an estimate of the relative difficulty of reading a given sentence under the various conditions. Reading times were found to be faster for the mixed *kana-kanji* script type than for the *kana* alone type, and nursery tales were faster than scientific essays. Intersentential comprehension of the scientific essay was negatively affected by the concurrent vocalization task, especially when written in the *kana* alone script type. General or basic content words, such as those in the nursery tales, may have been experienced in both the *kana* and *kanji* scripts, while specific content words tend to be learned as *kanji* at their first appearance, and it is more natural for these words to be written in *kanji* at all stages in the education system. These facts must also be taken into account when reviewing the findings regarding discourse type.

Kimura (1984) had subjects judge whether pairs of words written in *kana* or *kanji* were related in meaning, but under conditions of concurrent vocal interference. The results revealed that concurrent vocal interference impaired performance for *kana* words but not

---

<sup>11</sup> Concurrent vocal interference involves subjects repeating irrelevant material aloud while reading of making judgments and is thought to disrupt the auditory/articulatory channels because it interferes with the phonological code but leaves the visual code unaffected.

for *kanji* words, suggesting that vocal interference disrupts prelexical phonological coding in the *kana* script. A more recent study by Kinoshita and Saito (1992) finds somewhat different results in their attempt to determine whether concurrent articulation of irrelevant material disrupts the interpretation of words presented in *kanji* and *kana*. The authors assumed that words written in *kanji* are interpreted visually by the internal lexicon, while words that are usually written in *kanji* but are presented in *kana* must be interpreted by determining the sounds corresponding to each symbol. They thus predicted that concurrent articulation would disrupt the interpretation of *kana*-transcribed words more than *kanji* words. Subjects were presented with word pairs that differed in pronunciation by only one syllable and were asked to decide if the words had the same vowel in this syllable. Four conditions manipulated the script (words were presented either both in *kanji*, or one in *hiragana* and the other in *katakana*) with the presence or absence of concurrent articulation. Concurrent articulation interfered most with the interpretation of *kanji* words, but this surprising result was explained when the researchers discovered that subjects had judged the *kana* words by comparing orthographic symbols until a mismatch was found. The authors suggest that when the task is performed in this manner, one would expect concurrent articulation to be more disruptive for the *kanji* words. A second study using the same design had subjects judge whether word pairs were homophones. The results again indicated that concurrent articulation interferes more with judgments of *kanji* words than of *kana*-transcribed words. A third study had subjects judge *kanji* and *kana*-transcribed strings as words or non-words, either with or without concurrent articulation. The results indicate that concurrent articulation had no significant effect on the lexical decision task for words presented in either script. These authors conclude that concurrent articulation does not hinder prelexical phonological recoding.

When one takes the variable of vocal interference into children's processing of *kanji* and *kana*, one begins to suspect that metalinguistic differences also enter the picture. Tamaoka, Leong, and Hatta (1992) classified 108 elementary school students from grades 4-6 as skilled and less skilled readers, and had them judge sentences as being semantically correct or incorrect. Embedded in each sentence was a commonly-used word, usually

written in *kanji*, but now presented in *hiragana* or the normal *kanji*. Two treatment conditions involved either no interference or vocal interference, which was created by having subjects count repeatedly in Japanese from one to ten while performing the task. The results show that even though words in *kanji* were processed faster than words in *hiragana*, vocal interference had a similar effect on the processing of both scripts. And interference impaired less skilled readers more than skilled readers and younger children more than older children. A second study using a similar methodology had the same students judge the semantic correctness of sentences containing a commonly-used word, usually written in *katakana*, but now presented in *hiragana* or the normal *katakana*. Again, the authors found that vocal interference inhibited less skilled readers more than skilled readers and younger children more than older children, suggesting that age, reading ability, and metalinguistic difference affect lexical access for children.

## 8. *Romaji*

Not a great deal has been done with the alphabetic script called *romaji*, so called because the Japanese use of 22 of the 26 letters of the alphabet is based on the Roman, or Latin, alphabet. Discussions of literacy and word recognition in Japanese research is usually limited to the three scripts we have just reviewed.<sup>12</sup> But the *romaji* script has made such inroads into popular Japanese printed media that it must be accounted for a separate system within the Japanese orthographic inventory. *Romaji* is common in road signage and media advertising, as well as in everyday Japanese and even colloquial conversations; for example, consider *OB*; *OL* 'old boys', as in 'old boys' network'; 'office ladies or office girls'. It does not matter whether abbreviated company names are Japanese (*KDD*=*Kokusai Denshin Denwa* 'International Telegraph and Telephone) or English (*NTT*=*Nippon Telephone and Telegraph*). It has become indispensable for designating certain commercial layouts, sizes, or conventions. Consider the standard format for real estate ads exemplified by *3DK*, meaning '3 rooms, plus dining room and kitchen', or the L, M, S sizing for *T-shirts* or *V-neck suetaa* 'V-neck sweaters'.

---

<sup>12</sup> Through English, Arabic numerals have also appeared to take the place of kanji numerals in most horizontal writing.

According to Saint-Jacques (1987), the increase in *romaji* is exponential, and the cumulative effect such *romaji* is increasingly perceived as a standard form of writing. It certainly can no longer be regarded as an alien form of writing, exotic and incomprehensible to the average Japanese. Words from English, French, German, and other languages that only a few years ago were written in *katakana* are now often imported and written in the original Roman alphabet. Even some Japanese words and proper names have begun to appear in *romaji*, even in the middle of a normal Japanese sentence. Aside from the advertising panache attached to foreign imports, the reason is simple. A *romaji* word will stand out from the rest of the script presentation, simply because it is so different.

*Romaji* has also become the vehicle by which computer keyboards access the other three Japanese scripts in word processing and dictionary software packages. Inevitably, a more efficient system had to replace the traditional 'hunt-and-peck' method of sorting through the 3,000 base characters in Japanese typewriting and typesetting, and *romaji* provides the key to unlock the ergonomic puzzle to entering input simply and conveniently (see Yamada, 1983). It is not a pedagogical subject in the same way that the *kana* syllabaries are, but the *romaji* chart is introduced as early as Grade 4 textbooks. Nevertheless, some educators see this as a disadvantage rather than a bonus. The argument is that *romaji* hinders rather facilitates the acquisition of English vocabulary because the gap between English words such as *table*, *computer* and Japanese borrowings like *teeburu*, *konpyutaa* is simply too large to be anything but confusing. There is, however, experimental evidence to show that knowledge of *romaji* is linked to the ability to read English words (see Yamada, Matsuura, and Yanase, 1988).

## 9. Conclusion

Japanese research into the processing dimensions of a mixed orthography sheds light on the basic questions of word recognition and lexical access research in psycholinguistics. Our purpose in this paper has been to introduce this rich psycholinguistic paradigm, and to show how which considerations affect the path by which lexical access becomes word recognition in processing written Japanese when presented in exclusively syllabary, Chinese *kanji* characters, or mixed scripts. The picture for Japanese lexical access is

obviously not a simple one, but it is certainly an interesting one because of the complexity of the writing system. Certainly the picture is not so clear as to allow us to choose between one simple, thorough-going explanation which places logographic scripts on one side and alphabetic scripts on the other. It is obvious that the mental lexicon has a complex structure which allows some complex *kanji* to be retrieved either phonetically or semantically, enabling Japanese readers to figure out the meanings of unknown words by using the *kanji* lexicon in concert with compounding schemata, world knowledge, and contextual information. A better way of looking at the problem might be to suggest that *kanji* processing can employ either of two processing routes in accessing the specific properties of a lexical item presented in *kanji* script. In fact, this notion of a double-route is not limited to logographic systems using *hanji* or *kanji*, but it can apply to access strategies in alphabetic or syllabic systems which are phonologically based.

We are not, however, saying that *kanji* processing is the same as alphabetic or syllabary processing, especially in the earliest stage of processing. It seems reasonable to assume that pattern recognition processes are likely to be different for stimuli of the logographic type and stimuli of the alphabetic or syllabary type, with logographic stimuli having a greater dependence on visual pattern-matching stimuli. And, of course, there is a vast array of experimental literature using a variety of experimental tasks which suggests a contributory role of graphemic information (see Miyamoto and Kess, 1995; Kess and Miyamoto, 1996).

But, by the same token, we cannot support the equally simplistic view that *kanji* processing has a single route, with a cognitive leap from Orthography to Semantics which ignores the contribution of Phonological information. The most plausible cognitive model may mix its basic tenets in this respect. That is, depending upon the contextual setting for a given *kanji*, and its specific features of familiarity, frequency, and complexity, one of two processing routes may be taken. Both processing routes ultimately access semantic information, but one route is a sound-mediated route and the other route is a grapheme-mediated route. For many processing tasks that involve natural language, *kanji* symbols are like alphabet or syllabary symbols in that they must invoke phonological properties as the decoder searches through the mental lexicon. Tasks that are not simple pattern-matching

maneuvers take the decoder from Grapheme through Phonology to Semantics. We suggest that phonological properties are automatically accessed in most analytical tasks that are not pattern-matching or category-matching in nature.

We also suggest that there is a cognitive routing that can travel a grapheme-mediated route. This is the only way that we can account for how some tasks access information about, as well as make decisions on, *kanji* logographs that do not require phonological mediation. Moreover, Japanese *kanji* and Chinese *hanji* will employ a direct route especially in cases where *hanji* exhibit high frequency and high familiarity. There are, of course, examples in alphabetic systems like English where the processing route travelled is a direct route. For example, the English lack of a perfectly transparent sound-letter correspondence is overlooked in cases of morphophonemic identity such as the plural <-s>, the past tense <-ed>, the alternation /haws > hawz-/ in *houses*, and so forth. This is certainly the case in repeated instances of highly idiosyncratic spellings; these quickly become immune to phonological analysis and their spellings are soon ignored.

Words like *Ubysey* in British Columbia, *Liliuokalani* in Hawaii, *Thames*, *Gloucester*, and *the admirable Crichton* in Great Britain, and well as common words like *thyme*, are forms of this type. There is, of course, considerable experimental support for this. For example, in two experiments using a vocalization task, Seidenberg (1985) has shown that very frequent words in English are recognized visually, without phonological decoding, just as they are in Japanese and Chinese. Infrequent or newly-coined words were accessed by referring them to the process of phonological decoding, whereas high frequency words and characters were recognized visually without phonological mediation.<sup>13</sup>

Thus, it may not be an all-or-none hypothesis we should entertain in our explanatory model. A number of critical factors enter into the question of what will be the most efficient strategy for achieving the task at hand, If this expectation is valid, then we

---

<sup>13</sup> For Seidenberg's Chinese subjects, phonetic compounds were read more quickly than non-phonetic compounds when the characters were of a low frequency. In Seidenberg's experimental results, the interactive relationship of Chinese *hanji* compounds with low frequency may have exploited phonetic activation as the most effective processing strategy. This is also what Leong, Cheng, and Mulcahy (1987) conclude after analyses of variance underscored the individual contributions of reader ability, frequency of *hanji*, and complexity of the *hanji* to vocalization latencies in reading Chinese lexical items.

surmise that the claims for the absolute uniqueness of logographic systems of Japanese *kanji* and Chinese *hanji* are considerably weakened. The grapheme-mediated primary route would be unique to neither Chinese nor Japanese, but is a matter of degree, tied to how often this route is activated as the primary route. Such a dual route notion, with its suggestion of two possible routes to lexical representation, one a phonological route and the other a direct route, is congruent with experimental results arising from work on lexical access, word recognition, and reading in other languages.

Although the current philosophy of science inexorably draws our attention to the question of universal constraints on how the mental lexicon is searched, language-specific considerations of correspondence regularity, frequency, and familiarity exert an influence as well. Holding these factors constant, the analytical task type may drive the choice of the most efficient route for turning lexical access into word recognition. The three types of orthography, alphabetic, syllabic, and logographic, certainly differ in their representational basis, in being either phonologically based or morphologically based in principle. But they will not be inherently different in their processing nature, in that graphemic properties and phonological properties will be both processed, but to varying degrees in different tasks. For example, it is obvious that search procedures treat *kana* as more than strings to be phonologically recoded. Orthographically familiar words in *kana* script are named faster than both visually unfamiliar words and non-words, suggesting that such words bypass the orthographic code to direct lexical access. Thus, it is not the type of orthography that determines processing time; rather it is familiarity with the frequency of the orthographical shape which has an effect on lexical access. We must conclude that the degree to which we employ the two processing routes may differ across languages, but the fact of their availability will not vary across these languages.

\* \* \* \* \*

### References

Besner, Derek. 1990. "Orthographies, and Their Phonologies: A Hypothesis". *Bulletin of the Psychonomic Society* 28.395-396.

Besner, Derek, and Nancy Hildebrandt. 1987. "Orthographic and Phonological Codes in

the Oral Reading of Japanese *Kana*". *Journal of Experimental Psychology* 13.335-343.

Brown, R. and D. McNeill. 1966. "The 'Tip of the Tongue' Phenomenon". *Journal of Verbal Learning and Verbal Behavior* 5.325-337.

Chen, May Jane and Joseph Chak-Kau Yuen. 1991. "Effects of Pinyin and Script Type on Verbal Processing: Comparison of China, Taiwan, and Hong Kong Experience". *International Journal of Behavioral Development* 14.419-448.

Erickson, D., I. G. Mattingly, and M. T. Turvey. 1977. "Phonetic Activity in Reading: An Experiment with *Kanji*." *Language and Speech* 20.384-399.

Feldman, Laurie B. and M. T. Turvey. 1980. "Words Written in *Kana* Are Named Faster Than the Same Words Written in *Kanji*". *Language and Speech* 23.141-147.

Flores d'Arcais, Giovanni B. and Hirofumi Saito. 1990. "Semantic Activation and Lexical Decomposition in the Recognition of Complex *Kanji* Characters". Adrienne F. Bennett and Kevin M. McConkey (eds.) *Cognition in Individual and Social Contexts* ed, 101-109. Amsterdam: North-Holland.

Hatta, Takeshi and Hirose Takehiko. 1984. "Gairaigo, Higairaigo no Ninchi Shori ni Kansuru Kenkyu: Nihonjin Daigakusei to Gaikokujin Daigakusei no Yomi Jikan no Kekka Kara [Reading of Japanese and Foreign Loan Words by Japanese and Australian Students]". *Dokusho no Kagaku* 28.121-129.

Hatta, Takeshi, Hiroko Katoh, and Kim Kirsner. 1984. "Lexical Representation of Foreign Loan Words in Japanese Learners Among Native Readers of English". *Psychologia* 27.237-243.

Hatta, Takeshi and Tsugui Ogawa. 1983. "*Hiragana* and *Katakana* in Japanese Orthography and Lexical Representation". *Language Sciences* 5.185-196.

Hayashi, Ryuhay and Tami Hayashi. 1991. "Concurrent Vocal Interference Effect on Reading Comprehension of *Kana* Alone and *Kanji-Kana* Mixed Form Sentence". *Psychologia* 34.118-125.

Hirose, Hitoshi. 1992. "Jukugo no Ninchi Katei ni Kansuru Kenkyu Puraimingu-ho ni yoru Kento [Using the Priming Paradigm to Investigate Word Recognition for *Kanji* Compound Words]". *Shinrigaku Kenkyu* 63.303-309.

Hirose, Hitoshi. 1992. "*Kanji* no Yomi Katei ni Okeru Keitai Joho no Koka Onin Macchingu Kadai ni Okeru Kento [The Effects of Graphemic Information on *Kanji* Reading: An Experiment Using the Phonemic Matching Task]". *Kiso Shinrigaku Kenkyu* 2.109-113.

Hirose, Takehiko. 1984. "Kanji oyobi Kana Tango no Imiteki Shori ni Oyobosu Hyoki Hindo no Koka [The Effect of Script Frequency on Semantic Processing of Kanji and Kana Words]". *Shinrigaku Kenkyu* 55.173-176.

Hirose, Takehiko. 1985. "Tango no Ninchi ni Oyobosu Hyoki no Shinkinsei no Koka [The Effects of Orthographic Familiarity on Word Recognition]". *Shinrigaku Kenkyu* 56.44-47.

Kaiho, Hiroyuki. 1968. "KataKana Moji no Miyasusa no Kitei Yoin Jukaiki Bunseki ni yoru Kento [Factors Determining the Legibility of Katakana Letters: A Multiple Regression Analysis]". *Shinrigaku Kenkyu* 39.13-20.

Kaiho, Hiroyuki. 1979. "Kanji Joho Shori Kisei o Megutte [Information Processing for Kanji]". *Keiryō Kokugogaku* 11.331-340.

Kajiwara, Kotaro. 1982. "Shinbun no Kanji Ganyuritsu no Hensen: Meiji, Taisho, Showa o Tsujite [Shifts in Occurrence Rate for Newspaper Kanji Through the Meiji, Taisho, and Showa Eras]". *Kokuritsu Kokugo Kenkyusho Hokoku* 71.209-236.

Kashu, Kan, Iwataro Ishihara, Michio Inoue, Hirofumi Saito, and Yasuhiro Maeda. 1979. "Kanji no Shikakuteki Fukuzatsusei [Visual Complexity of Kanji]". *Kwansei Gakuin Daigaku Jinmon Ronkyu* 29.103-121.

Kawakami, Masahiro. 1993. "Kanago no Goi Kettei Kadai ni Okeru Hyoki no Shinkinsei to Shori Tan'i [Script Familiarity in Lexical Decision Tasks with Kana Words]". *Shinrigaku Kenkyu* 64.235-239.

Kawai, Yoshifumi. 1966. "Kanji no Butsuriteki Fukuzatsusei to Yomi no Gakushu [The Effect of Physical Complexity on Learning Kanji]". *Kyoiku Shinrigaku Kenkyu* 14.129-138.

Kess, Joseph F. 1992. *Psycholinguistics: Psychology, Linguistics, and the Study of Natural Language*. Amsterdam: John Benjamins Publishers B.V.

Kess, Joseph. and Hoppe, R.A. 1981. *Ambiguity in Psycholinguistics*. Amsterdam: John Benjamins Publishers B.V.

Kess, Joseph F. and T. Miyamoto. 1994. *Japanese Psycholinguistics: A Classified and Annotated Research Bibliography*. Amsterdam: John Benjamins Publishers B.V.

Kess, Joseph F. and Tadao Miyamoto. 1996. "Psycholinguistic Evidence for Laterality Preferences and Information Processing in Japanese". *Language Research* 32.351-371.

Kess, Joseph F. and Nishimitsu, Y. 1990. *Linguistic Ambiguity in Natural Language Japanese and English*. Tokyo: Kuroshio Shuppan Publishing.

Kitao, Horihiko. 1960. "Hiraganabun to Kanji Majiribun no Yomiyasusa no Hikaku Kenkyu [Comparative Study on Readability of Hiragana-only and Hiragana-Kanji-Mixed

Texts]". *Kyoiku Shinrigaku Kenkyu* 7.195-199.

Kimura, Yuko. 1984. "Concurrent Vocal Interference: Its Effects on *Kana* and Kanji". *Quarterly Journal of Experimental Psychology* 36A.117-127.

Kinoshita, Sachiko and Hirofumi Saito. 1992. "Effects of Concurrent Articulation on Reading Japanese *Kanji* and *Kana* Words". *The Quarterly Journal of Experimental Psychology* 44A.455-474.

Kohn, S. E., A. Wingfield, L. Menn, H. Goodglass, J. B. Gleason, and M. Hyde. 1987. "Lexical Retrieval: The tip-of-the-tongue phenomenon". *Applied Psycholinguistics* 8.245-266.

Komatsu, Shin-ichi and Mika Naito. 1992. "Repetition Priming With Japanese *Kana* Scripts in Word-Fragment Completion". *Memory and Cognition* 20.160-170.

Kuhara-Kojima, Keiko, Giyoo Hatano, Hirofumi Saito and Tomokazu Haebara. 1996. "Vocalization Latencies of Skilled and Less Skilled Comprehenders for Words Written in Hiragana and Kanji". *Reading Research Quarterly* 31.2.158-171.

Matsubara, Tatsuya and Yoshiro Kobayashi. 1966. "*Kana* Moji no Miyasusa ni Kansuru Kenkyu [A Study of the Legibility of *Kana*-Letters]". *Shinrigaku Kenkyu* 37.359-363.

Miura, Toshiaki. 1978. "The Word Superiority Effect in a Case of *Hiragana* Letter Strings". *Perception and Psychophysics* 24.505-508.

Miyamoto, T. and Kess, J. F. 1995. "The Japanese Brain Information Processing in the Right vs. Left Hemispheres". *Proceedings of the Japan Studies Association of Canada*, Victoria, September 30, 1995.

Morton, John, Sumiko Sasanuma, Karalyn Patterson, and Naoko Sakuma. 1992. "The Organization of the Lexicon in Japanese: Single and Compound Kanji". *British Journal of Psychology* 83.517-531.

Murakami, Yoshihiro. 1980. "Nodo made Dekakaru Gensho ni Okeru *Kana* to Kanji Tango no Kioku Tani ni Tsuite [Memory for *Kana* and Kanji Words in the Tip-of-the-Tongue Phenomenon]". *Shinrigaku Kenkyu* 51.41-44.

Nomura, Masaaki. 1984. "Kanji no Tokusei o Hakaru: Kanji no Keiryō Kokugogaku [Measuring the Characteristics of Kanji Mathematical Linguistics and Kanji]". *Kanji o Kagaku Suru [Making Kanji Scientific]* ed. by Hiroyuki Kaiho, 1-34. Tokyo: Yuhikaku.

Saint-Jacques, Bernard. 1987. "The Roman Alphabet in the Japanese Writing System". *Visible Language* 21.88-105.

Saito, H. 1981. "Toward Comparative Studies of Reading Kanji and *Kana*". *The Quarterly Newsletter of the Laboratory of Comparative Human Cognition* 3.2.33-36.

Saito, Hirofumi. 1982. "Kanji no Yomi ni Kansuru Joho Shori Katei [Information Processing in Kanji Reading]". *Jido Shinrigaku no Shinpo* 21.328-351.

Saito, Hirofumi. 1986. "Cost of Information and Integration Based on Inference". *Linguistics, Psychology, and the Chinese Language* ed. by Henry S. Kao and Rumjahn Hoosain, 55-71. Hong Kong: Centre of Asian Studies, University of Hong Kong.

Saito, Hirofumi and Masahiro Kawakami. 1992. "Renso Kioku ni Okeru Kensaku Katei Giji Jukugo no Jukugo Rashisa no Hyoka ni Okeru Shinteki Jisho no Kanyo [Retrieval Processes in Associative Memory Pseudo-Compound Words and the Mental Lexicon]". *Nagoya Daigaku Kyoyobu Kiyō* 36.67-99.

Saito, Hirofumi and Takashi Tsuzuki. 1989. "Retrieval Processes in Associative Memory Norms of Retrieval Variability for Forty-Eight Homophones in Japanese Kanji". *Nagoya Daigaku Kyoyobu Kiyō* 33.70-106.

Sasanuma, Sumiko, Naoko Sakuma, and Itaru Tatsumi. 1988. "Lexical Access of *Kana* Words and Words in *Kana*". *Annual Bulletin Research Institute of Logopedics and Phoniatrics* 22.117-123.

Seidenberg, Michael S. 1985. "The Time Course of Phonological Code Activation in Two Writing Systems". *Cognition* 19.1-30.

Sugishima, Ichiro, Jun Ukita, Masahiro Minagawa, and Kan Kashu. 1993. "Nihongo no Hyoki Hondo ga Go no Ondoku Senji to Sainin Kioku ni Oyobosu Eikyo [The Effect of Script-Frequency on Reading and Recalling of Japanese Words]". *Kwansei Gakuin Daigaku Jinmon Ronkyū* 43.71-82.

Sugishima, Ichiro and Kan Kashu. 1992. "Nihongo ni Okeru Hyoki Keitai ga Tango no Naihoteki Imi ni Oyobosu Eikyo [The Effect of Orthographic Representation on Lexical Connotation]". *Kwansei Gakuin Daigaku Jinmon Ronkyū* 41.15-30.

Tada, Hideoki. 1975. "Syllable Effects on Reaction and Recognition Times in Reading Letters in Japan". *Tohoku Psychologica Folia* 34.17-26.

Tamaoka, Katsuo and Makiko Hatsuzuka. (In press). "Kanji Niji Jukugo no Shori ni Okeru Kanji Shiyo Hondo no Eikyo [The Effect of Kanji Frequency on Processing Japanese Two-Morpheme Compound Words]". *Dokusho no Kagaku*.

Tamaoka, Katsuo and Marcus Taft. (1994). "Haku ga Onin Shori no Saisho Tani to Nariuru no ka? Giji Gairaigo no Goi Shogo Handan kara no Kosatsu [Is the Smallest Unit in Phonological Processing Equivalent to the Smallest Unit in Orthographic Processing? Lexical Judgments of *Katakana* Non-words]". *Shinrigaku Kenkyū* 65.

Tamaoka, Katsuo, Che Kan Leong, and Takeshi Hatta. 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.

Tanaka, Harumi and Kenzo Konishi. 1990. "Katakana Hyoki Tango no Shori Katei Hyoki Hindo no Eikyo [Semantic Processing of *Katakana* Words Effects of Script Frequency]". *Shinkei Shinrigaku* 6.231-239.

Tasaki, Ken'ichi. 1992. "Moji no Nodoteki Shoku Ninchi ni Oyobosu Shigeki no Okisa no Koka [The Effect of Letter Size on Haptic Letter Recognition]". *Shinrigaku Kenkyu* 63.201-204.

Ukita, Jun, Masahiro Minagawa, Ichiro Sugishima, and Kan Kashu. 1991. "Nichijo Buppinmei no Hyoki Keitai ni Kansuru Kenkyu: Kaku Hyoki no Shukanteki Shutsugen Hindo to Tekisetsusei ni Tsuite no Hyotei [On the Orthographic Representation of Everyday Objects: Evaluation of the Frequency of Orthographic Types and Subjective Judgments of Appropriateness]". *Kwansei Daigaku Jinmon Ronkyu* 40.11-26.

Van Orden, G. C. 1987. "A ROWS is a ROSE Spelling, Sound and Reading". *Memory and Cognition* 15.181-198.

Van Orden, G. C., Johnston, J. C., and Hale, B. L. 1988. "Word Identification in Reading Proceeds from Spelling to Sound to Meaning". *Journal of Experimental Psychology: Learning, Memory, and Cognition* 14.371-385.

Wang, Jinmin. 1988. "Kanji no Onin Shori to Imiteki Shori wa Doji ni Kanryo Suru ka [Does Phonological and Semantic Processing of Kanji Finish at the Same Time?]. *Shinrigaku Kenkyu* 59.252-255.

Wang, W. S-Y. 1981. "Language Structure and Optimal Orthography". Ovid J. L Tzeng and Harry Singer (eds.), *Perception of Print: Reading Reserch in Experimental Psychology*, 223-236. Hillsdale, NJ: Lawrence Erlbaum.

Wydell, Taeko Nakayama, Karalyn E. Patterson, and Glyn W. Humphreys. 1993. "Phonologically Mediated Access to Meaning for Kanji: Is a *Rows* still a *Rose* in Japanese Kanji?" *Journal of Experimental Psychology: Learning, Memory, and Cognition* 19.491-514.

Wydell, Taeko Nakayama, Brian Butterworth, and Karalyn Patterson. 1995. "The Inconsistency of Consistency Effects in Reading: The Case of Japanese Kanji". *Journal of Experimental Psychology: Learning, Memory, and Cognition* 21.115-1168

Yamada, Hisao. 1983. "Certain Problems Associated with the Design of Input Keyboards for Japanese Writing". William E. Cooper (ed.), *Cognitive Aspects of Skilled Typewriting*, 305-407. New York: Springer-Verlag.

Yamada, Jun. 1994. "Latencies for Naming Bound Morphemes and Words in Kanji". *Language and Speech* 37.251-258.

Yamada, Jun, Hiroyuki Imai, and Yuji Ikebe. 1990. "The Use of the Orthographic Lexicon in Reading *Kana* Words". *Journal of General Psychology* 117.311-323.

Yamada, Jun, Nobukazu Matsuura, and Yosuke Yanase. 1988. "Does Knowledge of

Romaji Facilitate English Reading?". *The Journal of General Psychology* 115.229-239.

Yi, Kwang-Oh. 1987. "Tango Ninchi ni Okeru Jiritsusei to Bunmyaku Izonei [Autonomy and Context Dependency in Word Recognition]". *Shinrigaku Hyoron* 30.387-401.

Yokoyama, Shoichi. 1991. "Ondoku Shori Sareta Shigeki Komoku no Saisei ni Oyobosu Hyoki no Jukuchisei no Koka [The Effect of Orthographic Familiarity on Recall of Stimulus Items Read Aloud]". *Shinrigaku Kenkyu* 62.195-199.

Yokoyama, Shoichi. 1995. "Nihongo Hyoki to Ninchi [Cognition and Orthographic Representations of Japanese]". *Nihongogaku* 14.9.65-72.

Yokoyama, Shoichi and Junko Yoneda. 1995. "Noizu ni Uzumoreta Kanji to Kana no Ninchi [Recognition of Kanji and Kana with Additive Noise]". *Kokuritsu Kokugo Kenkyusho Hokoku* 110.99-119.