ISCA Archive
http://www.isca-speech.org/archive

3rd International Conference on
Spoken Language Processing (ICSLP 94)
Yokohama, Japan
September 18-22, 1994

THE INCONSISTENCY OF CONSISTENCY EFFECTS IN READING: THE CASE OF JAPANESE KANJI PHONOLOGY

Taeko Nakayama Wydell and Brian Butterworth

Department of Psychology, University College London, Gower Street, London WC1X 6BT, UK

ABSTRACT

Most Japanese Kanji characters have several different pronunciations, at least one ON-reading (of Chinese origin) and a KUN-reading (of Japanese origin); the appropriate pronunciation is determined by intra-word context. There are also Kanji characters which have a single ON-reading and no KUN-reading. With 2-character ON-reading Kanji words as stimuli, naming experiments were carried out to investigate print-to-sound consistency effects, as seen in studies of English. The consistent Kanji words were those where neither constituent character has an alternative ON-reading or a KUN-reading, hence there can be no pronunciation ambiguity for these words. The inconsistent items were ON-reading words composed of characters which have KUN-readings that are appropriate to other words in which the characters occur, hence there should be some ambiguity about the pronunciation of the constituent characters. Experiments reported here yielded reliable effects of both word and character frequency/familiarity on speed and accuracy of word naming, but virtually no evidence for consistency effects. It is concluded that for Kanji, phonology is computed dominantly at the word rather than the character level.

I. INTRODUCTION

The broader issue considered here is the process by which phonology is computed from orthography, and the more specific question is whether various "sizes of unit" contribute to this process for the two different writing systems, i.e., English and Japanese. A prominent technique for investigating the question of unit size is to assess the impact, on accuracy and speed of word naming, of the consistency of spelling-sound correspondences within neighborhoods of orthographically similar words. The principle underlying this line of investigation is that all *whole* words have a single conventionally correct pronunciation (except for rare homographs like WIND and LEAD in English, where the reader requires extra-word context to select between two pronunciations); but in many writing systems, including both English and Japanese, sub-word sized units may take several different alternative pronunciations, with the correct one determined by intra-word context. If the reader translates spelling to sound at the level of the whole word only, then the existence of several competing pronunciations for sub-word chunks should not interfere; but if the computation of phonology from orthography also occurs for units smaller than the word, then words containing "inconsistent" units --, i.e., those with different pronunciations in other words -- might be at a disadvantage in accuracy or speed (or both) in word naming tasks.

Many studies have addressed this question in English [1]; [2]; [3]. Based on the frequent observation [4] that words with regular or typical spelling-sound correspondences (such as FIVE) produce shorter naming latencies and lower error rates than words with exceptional correspondences (e.g. GIVE), regularity was originally considered to be the critical variable. However, Glushko [2] argued that consistency, rather than rule-defined regularity, provided a better account of empirical results. Although FIVE may be a regular word 'by rule', its spelling-sound relationship is inconsistent with orthographically similar words such as GIVE. To the extent that the process of computing phonology from orthography is sensitive to the characteristics of the neighborhood, then performance on a regular but inconsistent word like FIVE should also be adversely affected. Glushko [2] did indeed demonstrate longer RTs for regular inconsistent words than for regular words from consistent neighborhoods. In all studies manipulating either regularity or consistency, the effect has been shown to be stronger for low- than high-frequency target items, and is often statistically reliable only for the lower frequency words.

It thus appears that the computation of a word's phonology in English has contributions from both whole-word and sub-word levels; the former is demonstrated by the fact that consistency effects are always modulated by the frequency of the target word, with very common words largely immune to the existence of unfriendly neighbors; the impact of the consistency of a (lower-frequency) word's orthographic neighbors provides evidence of generalization at the sub-word level [6].

II. KANJI PHONOLOGY

In two experiments reported here, we attempted to establish whether Japanese readers naming words written in Kanji show consistency effects paralleling those just described for English. The Japanese orthography comprises two scripts: syllabic Kana and logographic Kanji [5]. The feature of Kanji that is particularly germane to an understanding of how Japanese readers might compute phonology from orthography is that a typical Kanji character has two (or sometimes more) pronunciations, a KUN-reading and one or more ON-readings. A KUN-reading pronunciation is part of the original Japanese language and was assigned to Chinese characters from their meanings when Japan adopted the Chinese writing system. At the time of importing Chinese characters, however, not only were Chinese characters introduced but Chinese words and their pronunciations were also added to the Japanese vocabulary; these are ON-readings. Also, a number of Kanji characters now have more than one ON-reading, as a consequence of the same Chinese characters being introduced to Japan at several different periods.

For Kanji characters with more than a single ON-reading (be it a KUN- or an additional ON-reading), the appropriate pronunciation is determined by the intraword context, that is the other character(s) with which the particular character combines to constitute the word in question. For example, the Kanji character 親 (meaning parent) is pronounced "oya" (the KUN-reading) when it occurs in compound words such as 親方 "oyakata" (meaning foreman) but the same character is assigned the ON-reading "shin" when it occurs in the compound word 親類 "shinrui" (relatives). Any word containing the character 親 can therefore be described as an inconsistent word, since pronunciation of the character varies across the orthographic neighborhood of words containing it.

There are, however, some Kanji characters which *do not* have KUN-readings and also have just a single ON-reading. Kanji compound words comprised of these characters therefore have no pronunciation ambiguity, because each constituent character has but a single possible pronunciation (e.g., for 気候 "kikou", meaning climate, each constituent character 気, "ki", and 候, "kou" has no KUN-reading, and no other ON-reading). These words, which can be described as consistent, must have been the ones added to the Japanese vocabulary at the time of borrowing Chinese characters.

One of the notable differences between English and Japanese is that each Kanji character is a morphographic element which cannot be decomposed phonemically in the way that an alphabetic word can be. There are no separate components of the character 親 that correspond to the individual phonemes in "oya" or "shin". Whereas incompatible words from a neighborhood of shared-body words in English (e.g., -AST (shared-body) in HASTE and CASTE) will often have several phonemes in common, incompatible words from a neighborhood of shared-character words in Kanji (since as "oyakata" and "shinrui") will typically have no phonological elements in common. Nonetheless, with regard to the potential impact of inconsistency on word naming, the theoretical interpretation seems largely parallel in the two cases. The fact that inconsistent English words give rise to longer RTs/higher error rates than consistent words suggests that sub-word levels play a significant role in the computation of word phonology. Analogously, if inconsistent Kanji words were to yield longer RTs/higher error rates than consistent words, this would suggest that the sub-word level of constituent character plays a major role in computing the phonology of written Kanji words.

In this study, therefore, experiments were designed to evaluate whether Kanji words with consistent character-to-sound correspondences have a naming advantage over Kanji words with inconsistent correspondences.

II. EXPERIMENTS

Experiment 1

Subjects

Twenty Japanese male and female native speakers (aged between 18 and 31) served as subjects in this experiment.

Apparatus

A Macintosh IIsi computer with the softwares, Psychlab and SweetJam, was used to run the experiments in Japanese Kanji. Reaction times (RTs) were recorded by the computer through a throat microphone connected to a voice key.

Stimuli

The experimental stimuli consisted of 200 2-character Kanji nouns, all with ON-reading pronunciations. The words were divided into five conditions, each with 40 stimulus words, defined according to 'pronunciation consistency' as follows:

Condition 1: Neither of the two characters in a word had either an alternative ON-reading or a KUN-reading. Thus, there is no ambiguity in the pronunciation of these words.

Condition 2: One of the two characters in a word has a KUN-reading, but this KUN-reading does not occur in other 2-character Kanji words. Therefore, the pronunciations of these words are still fairly consistent.

Condition 3: Both characters in a word have KUN-readings, but these KUN-readings do not occur in other 2-character Kanji words.

Condition 4: Both characters in a word have KUN-readings, and the KUN-reading of one of these does occur in other 2-character KUN-reading words. Therefore, pronunciations of these words are relatively inconsistent.

Condition 5: Both characters in a word have KUN-readings, and these KUN-readings occur in other 2-character Kanji words. Therefore, the pronunciations of these words are maximally inconsistent.

The initial phonemes and word frequency/familiarity of the stimulus words were matched as closely as possible across the five conditions [6]. Also, the number of syllables of the stimuli were matched across the conditions.

Procedure

Each trial began with the presentation of a fixation dot for 500 ms. The fixation dot was then replaced by a target word, which remained visible until a response. The subjects were instructed to pronounce the target word as quickly and accurately as possible upon its presentation.

Results

The mean RTs for correct responses and the mean percentage errors are given in Table 1. A one-way ANOVA on RTs revealed that there was a significant effect of condition over subjects and items, (both at $p<0.01$). Pair-wise t-tests over subjects and items revealed that the RT difference between Condition 4 and Condition 5 was not significant, and also that there were no significant RT differences among Conditions 1, 2 and 3. However, RTs for both Conditions 4 and 5 were significantly shorter than those for Conditions 1, 2 and 3 (all at $p<0.01$). In other words, the stimulus words whose component characters have inconsistent pronunciations yielded faster word-naming responses than those with perfectly or relatively consistent pronunciations.

Because of the nature of Kanji words, characters with multiple pronunciations appear in many more words than do characters with consistent pronunciations; hence, although whole-word frequencies were matched as closely as possible across conditions, words in Conditions 4 and 5 were composed of more commonly occurring (and therefore more familiar) characters than words in the first three conditions. Indeed, a multiple regression analysis showed that, in addition to a significant effect of whole-word ($p<0.002$), the frequency of both the first and the second character [7] of each stimulus word significantly predicted RT ($p<0.04$). An analysis of covariance (ANCOVA) was carried out in order to estimate the differences between experimental conditions as if the covariates of character frequencies been properly matched across the five conditions. This analysis revealed that RT differences between conditions were no longer significant ($F<1$). The adjusted means for the five conditions are shown in Table 1 in italics.

Maximal Consistency Condition	1	2	3	4	5 Maximal Inconsistency
RT	646	647	642	627	623
Adjusted RT	*640*	*642*	*639*	*633*	*631*
Error	2.15	3.28	3.01	3.80	3.80

Table 1 - Naming latencies (in ms.) and errors (%) in Kanji Naming (Exp.1)

Experiment 2

In Experiment 2, both word familiarity and consistency were treated as dichotomous variables. If there is any tendency toward consistency effects in Kanji naming, this should be revealed in a frequency by consistency interaction, as seen in other languages [3].

Subject

Twelve Japanese male and female native speakers (aged between 18 and 46 years) served as subjects in this experiment.

Stimuli

There were 80 ON-reading 2-character Kanji nouns, 40 with consistent pronunciations as in Condition 1 of Experiment 1, and 40 with inconsistent pronunciations as in Condition 4-5 in the previous experiment. Half of the words in each consistency group were relatively common words (high familiarity) and half were relatively uncommon (low familiarity). Number of syllables, word familiarity and initial phoneme were matched, pairwise, between the two consistency conditions.

Procedure:

The procedure was the same as that in Experiment 1.

Results

Table 2 shows mean RTs for correct responses (in ms) and errors (in %) per condition.

RTs:

A 2-way ANOVA on RTs, with independent variables of consistency and familiarity, and with repeated measures over subjects and items showed a significant main effect of familiarity (both at $p<0.001$). Although there was a small RT advantage of consistent over inconsistent words, neither the main effect of consistency nor the interaction between familiarity and consistency was significant in either subject or item analyses (all F's<1).

Errors:

Error scores were square-root transformed after addition of a constant of 0.1, and were submitted to a two-way ANOVA as with the RT analyses. Subject analyses showed that the main effects of consistency ($p<0.018$) and familiarity ($p<0.001$) as well as the interaction between consistency and familiarity ($p<0.003$) were all significant. More errors were made with inconsistent than consistent words, and with low familiarity than high familiarity words. Further, a-priori means comparison tests revealed that the effect of consistency was significant only for the low familiar words, and that there was no significant difference between consistent and inconsistent high-familiarity words. Item analyses, however, showed only a significant effect of familiarity ($p<0.01$); the consistency effect was only approaching significance ($p=0.069$). The interaction between consistency and familiarity was not significant ($F<1$).

	Consistent High Fam.	Consistent Low Fam.	Inconsistent High Fam.	Inconsistent Low Fam.
RT (ms)	640	700	646	713
Error (%)	0.5	2.3	0.9	6.8

Table 2 - Naming Latencies (ms) and Errors (%) in Kanji Naming: Consistency and Familiarity (Exp.2)

III. DISCUSSION AND CONCLUSION

The initial analyses of *Experiment 1* revealed that inconsistent words (Conditions 1, 2 and 3) appeared to yield significantly shorter naming latencies than consistent words (Conditions 4 and 5), however, this reverse effect of consistency was due to a confounding between consistency and frequency of constituent characters. This confounding is a natural characteristic of the vocabulary in Japanese. When character frequencies were artificially controlled across conditions by an ANCOVA, the re-estimated latencies across conditions showed no significant differences. That is, according to the results from *Experiment 1*, the degree of consistency of a Kanji word had no reliable impact on its naming latency. Even with character frequencies controlled, however, the effects of word familiarity were apparent, with shorter naming latencies to words of high familiarity.

Experiment 2 revealed that naming latency was significantly affected by word familiarity but not by pronunciation consistency of component characters; there was also no significant familiarity-by-consistency interaction. Virtually all of the relatively few errors occurred on lower-familiarity words; and although more errors were made on inconsistent than consistent words, the ANOVA produced a significant main effect of consistency and a significant familiarity-by-consistency interaction for errors over subjects, but not over items. Once again, then, we have failed to uncover any RT effects of character-sound consistency in naming Kanji words, and have detected only a tiny trend towards such effects in the accuracy data.

We, thus, observed no significant character-to-pronunciation consistency effects in Kanji word naming. The only statistically reliable effect on RT in the experiments was familiarity. Perhaps even more noteworthy than the absence of an RT effect was the lack of word-naming errors that would have been a clear signature of consistency effects. In English word-naming experiments, the difference between 'regular' and 'irregular' words often reveals itself more in error rates than in RTs [8]. The most common error to an irregular English word is the assignment of an alternative, more common pronunciation of the inconsistent segment (typically the body/rime). In contrast, the present experiments yielded almost no Kanji naming errors that would be the equivalent of assigning an alternative pronunciation to an inconsistent segment, i.e., alternative ON/KUN reading errors, while typical rates of regularization errors to low-frequency inconsistent English words are in the range of 6-15% [2].

We turn now to a consideration of what factor(s) in the characteristics of Kanji may be responsible for its lack of susceptibility to consistency effects. The first important thing to establish in this regard is that we do NOT propose, as some theorists perhaps used to speculate, that words written in Kanji might be named by a different set of processes from those applying to alphabetic words, i.e., by accessing meaning from orthography and then phonology from meaning. This is very unlikely to be the case. Japanese children learn to compute phonology directly from Kanji orthography, and indeed this direct transcoding continues to play an essential role in adult Japanese reading, as evidenced by various forms of experimental evidence [9], neurological data [10]. We confidently assert that the difference between reading in Kanji and other writing systems is not in the role played by phonological codes, but rather in the details of the process by which phonological codes are computed.

The obvious interpretation is that, whereas readers of other languages learn orthographic-to-phonological computations that generalise over commonly recurring sub-word patterns, readers of Japanese Kanji learn that the only reliable level of generalization is the whole word.

The fact that the naming experiments reported here produced reliable effects of individual character frequency, with faster naming latencies to words containing more commonly encountered Kanji characters, might seem to be at odds with our conclusion that the computation of phonology from orthography is dominated by the word level. We do not however think that this result is in conflict with our interpretation, for the simple reason that there is another plausible locus of the character-frequency effect: at the stage of orthographic analysis. There is only a small number of alphabetic characters (26 in English), and every one of which would be encountered in reading almost any text. By contrast, there are thousands of Kanji characters, some with very complex visual forms, and many of these may occur very rarely in a reader's experience. On the reasonable assumption that the efficiency of early orthographic analysis of a Kanji word will be modulated by the familiarity of its characters as orthographic patterns, the character frequency effect need have no direct implications for a model of phonological processing of Kanji words.

The idea that processing in Kanji relies primarily on a whole-word level finds some general support in a previous study [11]. We interprete our data in terms of lexical processing in which all computations correspond to transcoding between specific representations, of which the three important ones in reading are orthographic, phonological and semantic representations [12]. The transcoding between phonology and meaning must be dominated by whole-word level representations in all languages since, except for morphological variations, there is no useful level of sub-word generalization in the correspondences between phonology and meaning: words that sound alike do not mean alike. Although we had not predicted these results, our findings for the computation between orthography and phonology in Kanji produce a similar picture to that between phonology and meaning. In English and other alphabetic writing systems, words that are orthographically similar almost always have similar pronunciations; this is not true in Kanji, and the lack of consistency effects in Kanji word naming may be a logical consequence of this difference.

Acknowledgement

The research was supported by a project grant (No. G9015838N) from the Medical Research Council, UK.

References

[1] Andrew, S. (1982). Phonological recoding: Is the regularity effect consistent? *Memory and Cognition*, 10, 565-575.

[2] Glushko, R.J. (1979). The organization and activation of orthographic knowledge in reading aloud. *Journal of Experimental Psychology: Human Perception and Performance*, 5, 674-691.

[3] Jared, D., McRae, K. and Seidenberg, M.S. (1990). The basis of consistency: Effects in word naming. *Journal of Memory and Language*, 29, 687-715.

[4] Coltheart, M. (1978). Lexical access in simple reading tasks. In G. Underwood (Ed.), *Strategies of human information processing*. London: Academic Press.

[5] Sasanuma, S. (1986). Universal and language-specific symptomatology and treatment of aphasia. *Folia Phoniatrica* 38, 121-175.

[6] Wydell, T.N., Quinlan, P. and Butterworth, B. (in press). Japanese lexical database: 2,357 Japanese nouns rated on frequency, familiarity and imageability and other language statistics on Kanji characters/words

[7] Kokuritsu Kokugo Kenkyujyo Houkoku 56 (The National language Research Institute Report 56) (1976). Gendai Shinbun No Kanji (A study of uses of Kanji characters in modern newspapers). Tokyo.

[8] Andrew, S & Blayner, M. (1994). Masked repetition priming of regular and irregular words: Lexical and sublexical contribution. (paper submitted for publication)

[9] Wydell, T.N., Patterson, P. and Humphreys, G.W. (1993). Phonologically mediated access to meaning for Kanji: Is a ROSE still a ROSE in Japanese Kanji? *Journal of Experimental Psychology: Learning, Memory and Cognition*, 19, 3, 491-514.

[10] Sasanuma, S., Sakuma, N. and Kitano, K. (1992). Reading Kanji without semantics: evidence from a longitudinal study of dementia. *Cognitive Neuropsychology*, 9 (6), 465-486.

[11] Seidenberg, M.S. and McClelland, J. (1989). A distributed model of word recognition and naming. *Psychological Review*, 96, 523-568.

[12] Morton, J., Sasanuma, S., Patterson, K. and Sakuma, N. (1992). The organization of the lexicon in Japanese: Single and compound kanji. *British Journal of Psychology*, 83, 517-531.