

Lexical Access and the Mental Lexicon for Two-Kanji Compound Words:
A Priming Paradigm Study
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The most common word structure in the Japanese language is the two-kanji compound word (Nomura, 1988). According to one estimate, these account for 70 percent of Japanese words (Yokosawa & Umeda, 1988). A number of different morphemic relationships underlie the formation of two-kanji compound words, such as modification (山桜 *yamazakura* 'mountain cherry'), verb + complement (登山 *tozan* 'mountain climbing'), complement + verb (外食 *gaishoku* 'eating out'), and associative pairs (飲食 *inshoku* 'drinking and eating').

Given the diversity in morphological relationships, an interesting question to ask is how are these compound words, represented orthographically by two morphographic kanji characters, processed in reading? There are two interrelated aspects to this question. The first, of lexical access, is concerned with whether the compound words are processed as whole units or as constituent morphemic elements. The second aspect, of lexical representation, relates to the storage and representation of lexical information, and asks how the representations of two-kanji compound words might be stored and linked in the mental lexicon.

The purpose of this presentation is to report the results of two morpheme-priming experiments that sought to investigate these issues concerning the mental lexicon for two-kanji compound words.

In a primed lexical decision task, Hirose (1992) compared the facilitation on the identification of a two-kanji compound word when a single-kanji prime was either the first element of the compound, the second element, or an unrelated kanji. Hirose (1992) found that although both the first- and second-element conditions showed significant priming compared to the unrelated condition, reaction times for the first-element condition were significantly faster than those for the second-element condition. Hirose (1992) interpreted this as evidence of serial processing of compound words (from left to right). Moreover, he suggested that the lexicon for compound words is structured so that words that share the same first kanji are linked in clusters, but words sharing the same kanji as a second element are not.

Experiment 1

Purpose. Two-kanji compound words are formed according to a number of different

principles (Kageyama, 1982; Tamamura, 1985; Nomura 1988). For instance, one important principle of compounding is modifier + modified, which is the principle for 新顔 'newcomer' (lit. 'new face'), 丸顔 'round face,' and 笑顔 'smiling face.' If, as Hirose (1992) suggests, the lexicon for compound words is structured to link only compounds sharing the same character as the first element, then none of these semantically related words (kinds of faces) will be linked. His hypothesis would also mean that words from different semantic areas, such as 青空 'blue sky,' 青物 'vegetables' (lit. 'green things'), and 青年 'adolescence' (lit. 'green years'), would be linked simply because they share the same first character. Both these situations would be strange, and suggest that the simple first-element/second-element relationship hypothesized by Hirose (1992) might not be the only principle involved in the organization of the mental lexicon.

Experiment 1, therefore, attempted to test whether Hirose's (1992) pattern of facilitation, with significantly faster reaction times for the first-element condition compared to a second-element condition, could be duplicated once the word-formation principle was controlled as an experimental variable.

Experimental Conditions.

Five word-formation principles were used as experimental conditions in this research.

1. Modifier + Modified 修飾語 + 被修飾語
旅館、豚肉、国道
2. Verb + Complement 動詞 + 補足
投球、飲酒、開店
3. Complement + Verb 補足 + 動詞
外食、夜勤、特定
4. Associative Pairs 並列
親子、生死、左右
5. Synonymous Pairs 類義語
利益、苦痛、変化

A corpus of 1000 two-kanji compound words, selected from the Kokuritsu Kokugo Kenkyūjo's (1984) survey of basic Japanese vocabulary, was surveyed for both word-formation principle classification and for familiarity. Two-kanji compound words with evaluation scores for both these of 5.5 or over on 7-point scales were used as stimulus items in the experiments. Another survey was also conducted for the word-like-ness of non-word items (stimulus items had word-like

evaluation scores of less than 2.0).

Participants. Forty-two undergraduate and graduate students of the University of Tsukuba took part in the experiment as volunteers.

Procedure. The procedure for Experiment 1 was similar to that used by Hirose (1992; Exp. 1). After a fixation point (1000 ms), the single-kanji prime was presented for 1000 ms. Then, after a blank (500 ms), fixation points for the target (1000 ms) and another blank (500 ms), a two-kanji compound target word was displayed. The target was displayed until the participant made a lexical decision by pressing a key on a response box.

Results. The results from Experiment 1 (and Experiment 2) are shown in the table below. As the overall error rate was very low (4.57% for 3780 responses), the focus of analysis was on the reaction time results.

Repeated measures ANOVAs for reaction times indicated a significant main effect of prime–target relation ($F_s(2, 82) = 104.42, p < 0.01$; $F_i(2, 170) = 54.71, p < 0.01$). Post-hoc analysis indicated that in all word formation principle conditions, the reaction times for the first-element and the second-element conditions were significantly faster than for the unrelated conditions.

However, reaction times in the first-element conditions and second-element conditions were not significantly different from each other. The results for word-formation principle over the prime–target conditions indicated that there were no significant differences at the 0.05 level.

Thus, the pattern of priming found in Hirose (1992) was not obtained in this experiment.

Experiment 2

Purpose. The SOA of 3000ms used by Hirose (1992) is very long. It may, therefore, be possible that the participants had time to adopt strategies in making their lexical decisions. Therefore, Experiment 2 sought to test whether the pattern of priming found in Experiment 1 could still be obtained with a short SOA of 250 ms, at a level of automatic priming (Neely, 1977, 1991).

Participants. Forty-five undergraduate students of the University of Tsukuba took part in the experiment as volunteers.

Procedure. A plus symbol for 250 ms, prime for 200 ms, and a symbol as mask to the single-kanji prime for 50 ms appeared one after the other.

Mean Reaction Times (RT) (in milliseconds), Reaction Time Differences (RT Diff) and Error Rates (ER) (as percentages) as a Function of Word-Formation Principle and Prime–Target Relationship in Experiment 1 and Experiment 2

Word Formation Principle	Experiment 1			Experiment 2		
	RT	RT Diff	ER	RT	RT Diff	ER
Modifier + Modified						
First Element	531	+60	0.39	539	+61	1.66
Second Element	548	+43	1.58	550	+50	2.14
Unrelated	591		5.55	600		3.57
Verb + Complement						
First Element	542	+66	1.98	544	+76	2.66
Second Element	559	+49	3.17	566	+54	2.00
Unrelated	608		11.50	620		5.33
Complement + Verb						
First Element	569	+45	3.96	564	+65	3.95
Second Element	556	+58	2.77	561	+68	2.22
Unrelated	614		9.12	629		6.91
Associative Pairs						
First Element	547	+62	3.17	550	+72	2.98
Second Element	542	+67	1.98	558	+64	2.22
Unrelated	609		6.74	622		6.89
Synonymous Pairs						
First Element	545	+68	3.96	531	+97	1.77
Second Element	536	+77	1.58	536	+92	0.67
Unrelated	613		8.73	628		6.00

These were followed immediately by the target, which remained on the screen until the lexical decision was made.

Results. The overall error rate was also low (3.82% for 6480 responses) in Experiment 2, and thus emphasis was again given to the analysis of reaction times.

Repeated measures ANOVAs for reaction times indicated a significant main effect of prime–target relation ($F_s(2, 88) = 146.45, p < 0.01$; $F_i(2, 138) = 156.64, p < 0.01$). Post-hoc analysis indicated that reaction times in both the first-element condition and the second-element condition were significantly faster than the unrelated condition. Although there was a significant difference in favour of the first-element in the verb + complement condition, no significant differences between the reaction times in the first- and the second-element conditions were found in the other word-formation principles. The results for word formation principle over the prime–target conditions indicated that there were no significant differences at the 0.05 level.

Thus, the results of Experiment 2 confirm the basic pattern of priming found in Experiment 1. This indicates that the priming found in Experiment 1 was not the result of strategy-adoption by the participants.

General Discussion

Overall, these experiments provide very little evidence for significant differences between the first-element condition and the second-element condition. Thus, they do not support Hirose's (1992) suggestions that compound words are structured in the mental lexicon centered on the first element, and that processing of compound words is serial from left to right.

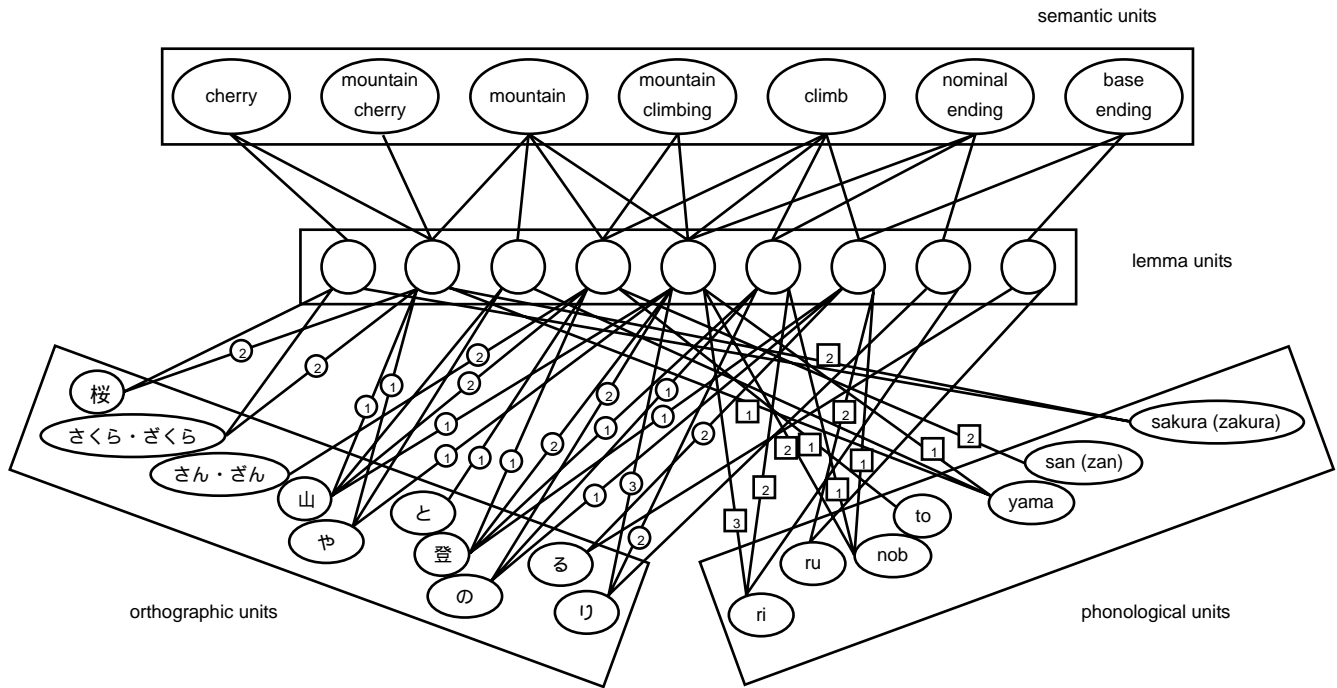
The lack of significant differences between the first and second element also provides little evidence for influence of word formation principle in terms of averaged reaction times. Although there does appear to be a slight tendency in the data for differences in the pattern of priming from the first- and second-element conditions for both modifier + modified and verb + complement principles compared to the other principles, these differences were non-significant in almost all cases.

The finding from these experiments, then, is that both related prime conditions facilitate responses to the target at similar levels, which suggests that both morphemic elements of a compound word contribute to lexical access. This finding is more consistent with a multilevel interactive-activation model, such as that proposed by Taft and others (Taft, Liu, & Zhu, 1999; Taft &

Zhu, 1995, 1997a, 1997b) for Chinese word recognition.

In developing this model, Taft and Zhu have argued that above the feature-level representations corresponding to the strokes of Chinese characters there are sub-lexical level representations for radicals (both semantic and phonetic markers) (1997a), and that above these there are Chinese-character, or morpheme level, representations (1995, 1997b). Although, these earlier versions of the model also included two-character (poly-morphemic) word level representations, in an important modification to the model Taft, Liu and Zhu (1999) have recently proposed the inclusion of lemma units, abstract modality-free units, mediating the links between orthographic, phonological, and semantic units. Similar to the concept nodes in the model of morphological processing proposed by Schreuder and Baayen (1995), these lemma units have the advantages of eliminating the representational redundancy of the previous versions, solving the problem of homographs, and providing an effective way to capture varying degrees of semantic transparency between polymorphemic words.

These advantages of the lemma unit version of the model would also be available when adapting the framework to account for the Japanese mental lexicon, for all the representational levels in this hierarchical structure are relevant to Japanese. In the case of a Japanese version of the multilevel interactive-activation model, these lemma units provide another extremely important advantage. For they also offer a very promising approach to modeling the complex relationships between meaning, orthography and phonology that arise from the Japanese writing system's multi-script nature and its dual-reading system. As shown in the figure on the next page, these lemma units can mediate the connections between semantic units and the access representation units. In the case of orthographic units, these would include both kanji and kana, and in the case of phonological units, there are both on- and kun-readings. When more than one unit at the same level link to a unit at another level, it is necessary to specify the order of the links (Taft, Liu & Zhu, 1999). Although, in the figure, this is indicated by numbers on the relevant connections, this should rather be seen as part of the lemma units themselves. These are assumed to involve mechanisms of licensing and composition (Schreuder & Baayen, 1995), employing syntactic, semantic and morphological information, such as that which underlies word-formation.



Lemma Unit Connections in Multilevel Interactive-Activation Model for Japanese

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