DISSOCIATING CONGRUENCE EFFECT IN LETTERS VERSUS SHAPES: THE CASE OF KANJI AND KANA IN JAPANESE

Nobuyuki Jincho[1], Thomas Lachmann[2,3], and Cees van Leeuwen[3]
1: Lab. for Language Development, Brain Science Institute, RIKEN, 2-1 Hirosawa, Wako-shi, Saitama, Japan
2: University of Kaiserslautern Pfaffenbergstr. 103, 67663 Kaiserslautern, Germany
3: Lab. for Perceptual Dynamics, Brain Science Institute, RIKEN, 2-1 Hirosawa, Wako-shi, Saitama, Japan

Abstract

Alphabet letters and non-letter shapes are dissociated at the early visual processing stage, which was demonstrated by positive congruence effect for non-letters and negative congruence effect for letters. The present study reviewed attempts extending those findings into other orthographic system, kanji and kana in Japanese. Letters and pseudo-letters were targets in a choice-response task. Targets were presented in isolation or surrounded by congruent or incongruent shapes. Congruence effects were obtained for letters and pseudo-letters when response categories were distinguished by target's shape. When targets were distinguished by their content (letters or pseudo-letters) or individual items, congruence effects were still observed for pseudo-letters but no longer for letters. Such a task-specific dissociation in effect is in accordance with previous observations for alphabet. In addition, dissociation between letters and non-letters was stronger in kanji than in kana. Implications for letter perception are discussed.

In a social life, reading is one of the fundamental behaviors. First, we learn to read. Then, we read to learn many kinds of knowledge. Our reading skills depend on the ability to encode visual materials such as letters and words in reference to their role as symbols, i.e. as graphemes and lexical items. Letters are not intrinsically different in visual appearance from geometrical shapes. For instance, if a triangle is replaced into the letter "A" consistently in a text, it would not cause any ambiguity in reading. Therefore, letters and non-letter shapes are represented similarly in the earliest stages of visual processing. For understanding the reading process, we are trying to examine how early in visual processing letters and shapes begin to differ. In this paper, we followed feature-integration as a key concept and investigated dissociations in congruence effects between letters and non-letter shapes. In addition, interesting characteristics of Japanese orthography was used for an extension of previous findings into non-alphabetic language.

Positive and negative congruence effects in alphabetic language

As mentioned above, letters and non-letters may share the processing system at the very beginning of visual analysis. However, both may differ in a feature-integration stage. For instance, non-letter shapes were processed faster when it is flanked by a congruent shape than by a incongruent one. This effect is called congruence effect and demonstrated by letter identification (Eriksen & Eriksen, 1974) and shape discrimination (van Leeuwen & Bakker, 1995). The congruence effect (Pomerantz & Pristach, 1989) is understood to indicate holistic perceptual processing; the target and its surrounding features are integrated together, thus providing an emergent feature that is more distinctive than any target feature by itself. Holistic processing emphasizes properties such as symmetry that can be used for greater efficiency in encoding non-letters graphics. We tend to see the properties of their shape as representing a wider class. For this reason, we are quickly to recognize items that are same under transformation.

However, this flanker effect may hinder processing a letter. A letter stimulus should be processed holistically like a geometrical shape at the beginning. Then, feature integration has to be actively suppressed for analytic processing (Bavelier, Deruelle, & Proksch; 2000; Briand, 1994; van Leeuwen & Bakker, 1995). Separation of target and non-target features at an early stage will facilitate identification at a higher level in terms of a phonological (Posner, 1978) or abstract letter-identity code (Bigsby, 1988). This suppression of feature integration process may take a cost for processing a stimulus as a letter.

In order to test this hypothesis, van Leeuwen and Lachmann (2004) presented letters and shapes in a choice-response task. Participants had to decide which of two alternative categories a given item belonged to "natural" categories, such as "letters" vs. "shapes" or, alternatively, arbitrarily mixed categories. In some trials, a congruent shape surrounded the target, in others an incongruent one. For the shape targets in Fig. 1 (bottom half), the positive congruence was expected because the surrounding shape is integrated into the target and facilitate holistic processing. In contrast, this may not be the case of the letter targets (Fig. 1 upper half) sincee the surrounding frame biases to process the image holistically. This source may be stronger if the frame is congruent in shape with the letter, and so holistic processing will be harder to suppress in this case. Thus, the negative congruence effects could be interpreted as active suppression of symmetry and other global regularities for optimal efficiency in processing letters.

Results were consistent with the hypothesis. A congruence effect was obtained for non-letter shapes: items in congruent surrounding were processed faster than in incongruent ones. However, a negative congruence effect was obtained for letters: faster processing in incongruent than in congruent conditions. This opposite pattern was in the case when pseudo-letters, which did not have familiar names such as a triangle and a circle, were contrasted with letters. This also suggests that negative congruence effect happens prior to an abstract code processing.

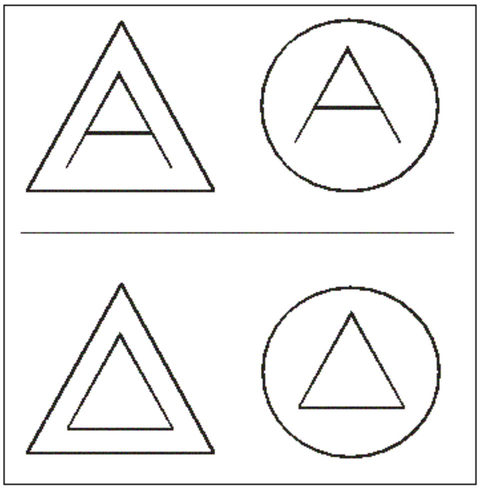

Fig. 1. An example of stimuli used in van Leeuwen and Lachmann (2004); Letters (upper half) versus shapes (lower half) in congruent (left) versus incongruent (right) surroundings.

Lachmann and van Leeuwen (2004) examined the congruence effect between letters and non-letters in a sequential same-different judgment task. In their study, a letter and a pseudo-letter were always followed by the same type of material (a letter and a pseudo-letter). They found a positive congruence effects for pseudo-letters. In contrast, no congruence effect was found for letters. They interpreted this weaker dissociation between letters and non-letters that it might be easier to suppress the holistic shape processing strategy for letters with expectation of the target category.

Orthography of Japanese language

In Jincho, Lachmann, and van Leeuwen (submitted), whether the previous findings, which were obtained in alphabet language, might be replicated in a non-alphabet language such as Japanese was examined. In modern Japanese, a mixture of two writing systems, kanji and kana, is used. Kana are phonographic characters representing syllables. There exist two subtypes of kana, hiragana and katakana. Hiragana is used mainly (but not exclusively) for auxiliary elements such as particles and inflections. Katakana, by contrast, is used among others to write loan words. In principle, a Japanese text could be written entirely in kana. In contrast to kana, kanji characters are graphic elements representing morphological units, such as nouns, verb and adjective stems.

Kanji characters are generally more complex than kana in their visual appearance. Kanji can use up to 20 strokes, where kana uses no more than six. Thus, kanji usually contains higher spatial frequency components, while kana is likely to contain less complexity. In terms of phonological transparency, kana are more like alphabets than kanji. Kana represents the mora, which is basic phonological unit of Japanese, in a transparent manner. That is, each character within the writing system representing a single mora and vice versa. Kanji orthography is less transparent to phonology than kana. Typically, a character has two or three possible phonological representation in Japanese. In addition, there are large numbers of homophones in Japanese. For instance, a letter which sounds “hi” can be represented by different kanji characters, meaning fire, sun, ratio, monument, or error.

Japanese kanji and kana study as an extension of alphabetic study

In Jincho et al. (submitted), the following two questions were addressed and investigated by using interesting characteristics of Japanese orthographies. First, what kind of strategies do lead the dissociation between letters and non-letters? Second, what kind of factors in letters could affect the dissociation in congruence effects from non-letters.

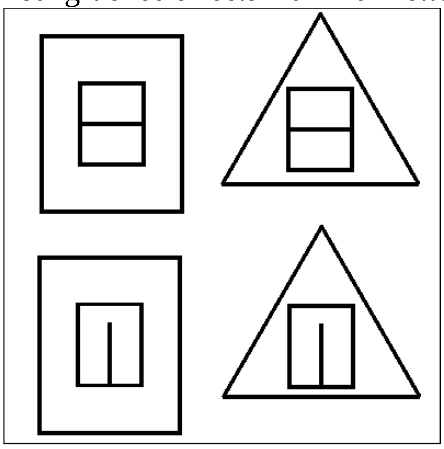

Fig. 2. A sample of Japanese stimuli used in Jincho, Lachmann, and van Leeuwen (submitted). Kanji (upper half) versus pseudo-kanji (lower half) targets in congruent (left) versus incongruent (right) surroundings.

Participants performed a two-alternative choice response task. A kanji letter or a pseudo-kanji shape was presented alone or with congruent or incongruent surrounding shapes as in van Leeuwen and Lachmann (2004, see Fig. 2).

In Experiment1, what kind of strategies lead dissociations between letters and non-letters was examined. The task was varied in three conditions between participants: shape, letter-shape, and letter condition. In all conditions, there were always two kanji characters and one pseudo-kanji shape together in each response category. In the shape condition, the kanji letters and the pseudo-kanji shape were assigned to a response category in terms of their geometrical shapes. It was not necessary to discriminate letters and non-letters in this condition since targets (both kanji and pseudo-kanji) having a same geometrical shape were included in one response category. In the letter-shape condition, the two kanji letters that had a similar shape and a pseudo-kanji with a different shape were included in a response category. In this condition, participants had to determine whether a target was a letter or a non-letter. In the letter condition, one response category consisted of two kanji letters whose shapes were different and a pseudo-kanji shape. Participants must discriminate whether a target was a letter or a non-letter as in the letter-shape condition. In addition, they had to identify each kanji for a correct response.

Results showed a congruence effect for pseudo-kanji targets generally across task conditions, although it failed to reach significance in the letter-shape condition. For kanji targets, there is a congruence effect in the shape condition. Congruence effects were absent, however, for kanji in the other conditions. These results suggest that for letter-shape and letter dissociation in effect was obtained between kanji and pseudo-kanji. It is sufficient for the dissociation to arise, therefore, that the task requires a categorical distinction between the two.

Jincho et al. (submitted) interpreted these results that the early visual system differentiates holistic shape and analytic letter processing based on top-down, categorical information about the stimuli, rather than on the degree of visual similarity between the response alternatives. These results are consistent with that for alphabet in van Leeuwen and Lachmann (2004) and eliminate the confounding of categorical information and similarity from this study. However, absence of the negative congruence effect in kanji targets could be understood as an Einstellung-effect (Luchins & Luchins, 1995). That is, it may be easier to suppress the holistic shape processing strategy for letters with expectancy. This might happen because the stimuli comprise of twice as many kanji as pseudo-kanji.

The purposes of Experiment 2 were two-fold. First, they compared kanji and hiragana letters in terms of the dissociations from non-letter shapes. Second, they investigated whether no congruence effect for kanji targets were obtained when participants were not biased to analytic processing. In one block, kanji and pseudo-kanji targets were presented alone, or surrounded by congruent or incongruent shape as in Experiment 1. Another block had hiragana and pseudo-hiragana shape targets. Unlike in Experiment1, letter and non-letter shapes were presented in equal ratio and distributed to both left and right response categories in balance. Therefore, in kanji blocks, kanji letters were divided into two different response categories, and pseudo-kanji shapes were also divided and assigned to the category in which there was a kanji letter whose outline shape was different. In hiragana blocks, hiragana letters and pseudo-hiragana shapes were divided and assigned to response categories in the same way.

Results showed predicted positive congruence effects for both pseudo-kanji and pseudo-hiragana. The reaction times for kanji echo the weak dissociation between pseudo-letters and letters observed in the first experiment. The absence of congruence effects for letters confirmed the results in Experiment 1 and extended the previous observations of alphabetic language (van Leeuwen & Lachmann, 2004). Moreover, there was a negative congruence tendency in the error rates. In short, the dissociation observed in Experiment 1 was neither strengthened nor weakened by eliminating the Einstellung-effect. Therefore, the weaker dissociation in kanji and kana as compared to alphabet resides in the greater figural complexity of the characters.

As regards to congruence effect in kanji and hiragana targets, Jincho et al. (submitted) found an even weaker dissociation in hiragana than in kanji. This difference was not accounted for by visual complexity of stimulus since it was carefully controlled. Therefore, the results may be related to the difference in phonemic transparency. Because the grapheme-phoneme mapping is more difficult to achieve for kanji, analytic processing in this stage is important to eliminate flanking context. This would automatically apply that phoneme-grapheme mapping is mandatory, given that a letter strategy is adopted. In accordance with this explanation, hiragana letters were processed considerably faster than kanji letters. Several previous studies revealed differences in processing kanji and kana at the word level (Ito & Hatta, 2003; Shimizu, Endo, & Nakamura, 1983; Yamaguchi, Toyoda, Xu, Kobayashi, & Henik, 2002). In contrast, Jincho et al. (submitted) showed contrasting effects between kanji and hiragana at the letter level. This suggest that letter and non-letter shape start to be processed differently in the earlier stage of visual processing.

Acknowledgements

The first author was supported by a Junior Research Associate fellowship awarded by the RIKEN during this research was coducted. Many thanks are due to Jessika Wuest (University of Leipzig) for her support.

References

Bavelier, D., Deruelle, C., & Proksch, J. (2000). Positive and Negative Compatibility Effects. *Perception and Psychophysics, 62*, 100-112.

Bigsby, P. (1988). The visual processor module and normal adult readers. *British Journal of Psychology, 79*, 455-469.

Briand, K. A. (1994). Selective attention to global and local structure of objects: Alternative measure of nontarget processing. *Perception & Psychophysics, 55*, 562-574.

Eriksen, B. A., & Eriksen, C. W. (1974). Effects of noise letters upon the identification of a target letter in a nonsearch task. *Perception & Psychophysics*, *16*, 143-149.

Ito, Y., & Hatta, T. (2003). Semantic processing of Arabic, kanji, and kana numbers: Evidence from interference in physical and numerical size judgments. *Memory & Cognition, 31*, 360-368.

Jincho, N., Lachmann, T., & van Leeuwen, C. (submitted). Dissociating Congruence Effects in Letters versus Shapes: Kanji and Kana.

Lachmann, T., & van Leeuwen, C. (2004). Negative Congruence Effects in Letter and Pseudo-letter Recognition: The Role of Similarity and Response Conflict. *Cognitive Processing, 5*, 239-248.

Luchins, A. & Luchins, E. (1995). The water jar experiments and Einstellung effects: II. Gestalt psychology and past experience. *Gestalt Theory, 16*, 205-259.

Pomerantz, J. R., & Pristach, E. A. (1989). Emergent features, attention, and perceptual glue in visual form perception. *Journal of Experimental Psychology: Human Perception and Performance, 15*, 635-649.

Posner, M. I. (1978). *Chronometric Explorations of Mind.* Hillsdale, NJ: Erlbaum.

Shimizu, A., Endo, M., & Nakamura, I. (1983). Tachistoscopic recognition of normal and mirror images of kana and kanji characters. *Folia Psychiatrica et Neurologica Japonica, 37*, 77-84.

van Leeuwen, C. & Bakker, L. (1995). Stroop can occur without Garner interference: Strategic and mandatory influences in multidimensional stimuli. *Perception & Psychophysics*, *57*, 379-392.

van Leeuwen, C., & Lachmann, T. (2004). Negative and congruence effects in letters and shapes. *Perception & Psychophysics, 66*, 908-925.

Yamaguchi, S., Toyoda, G., Xu, J., Kobayashi, S., & Henik, A. (2002). Electroencephalographic activity in a flanker interference task using Japanese orthography, *Journal of Cognitive Neuroscience, 14*, 971-979.