STROOP EFFECT WITH SYNONYMOUS HOMOGRAPHIC HETEROPHONEMIC WORDS IN JAPANESE KANJI

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Abstract

One of the three types of Japanese orthographic systems, kanji, consists of ideograms rather than phonograms. Most of the kanji originally introduced from China can be read in two ways: in "on" (Chinese old pronunciation; relatively lower reading proficiency) and in "kun" (Japanese inherent pronunciation; relatively higher reading proficiency). In the current experiment, the participants were asked to name the color of Stroop color words in kanji, which were accompanied by an alternation with either "on" or "kun," their corresponding auditory words from one trial to the next. The accompanying auditory words in "kun" in higher proficiency had no impact on the Stroop interference, whereas those in "on" in lower proficiency had substantial effect on the Stroop interference.

Many studies have provided evidence of phonological impact on the Stroop congruency effect (Burt, 2002; Roelofs, 2003, 2005). Japanese language has the kanji writing system and includes two kinds of reading; one is a way of reading using the "on" (old guest word reading) pronunciation system, which originated from Chinese old-style pronunciation more than approximately 1,500 years ago, and the other is the "kun" (Japanese own traditional) pronunciation system. Thus, Japanese people generally have higher proficiency with the "kun" (Japanese own) pronunciation system than the "on" (old guest word) pronunciation system. We used two kinds of phonological codes for kanji in terms of proficiency, and presented the Stroop color words (Stroop, 1935; MacLeod, 1991, for a review) printed in kanji with congruent words (e.g., word *red* printed in red) and incongruent words (e.g., word *red* printed in green). In addition, we presented an auditory spoken word semantically matched in the word dimension of each color word in each trial. The auditory spoken words varied between "on" and "kun" pronunciations in terms of the phonological codes. The participants were instructed to name the color in colored color-words in kanji through either "on" or "kun" in each trial block. The goal of the present study was to determine whether the extent of proficiency, induced by two kinds of spoken words in kanji, impacts the Stroop congruency effect.

Method

Participants. The participants were 12 graduate and undergraduate students at Kobe University. *Materials and Devices.* An E-Prime 1.2 program (Psychology Software Tools, Inc.) presented the visual–auditory stimuli and collected response latency data. Four printed, colored color words (赤, 緑, 青, and 黄, referring to *red*, *green*, *blue*, and *yellow*, respectively) consisted of congruent (e.g., the word *red* printed in red) and incongruent (e.g., the word *red* printed in green) stimuli. Two kinds of spoken words in reading for four color words ("on" and "kun," for example, for 赤 [red], "seki" and "aka," respectively) were prepared in synthesized voice with the computer software. *Design.* The basic design included four within-subject factors: Independent variables were 2 (Congruency: congruent vs. incongruent) × 2 (Response Phonological Code: on or kun) × 2 (Phonological Correspondence: corresponding vs. non-corresponding to *response set*) × 2 (SOA: –100 ms or 100 ms) as within-subject design. The dependent variable was response latency. *Procedure.* After they completed the practice block, which included 16 trials, the participants completed 4 experimental blocks that included 96 trials each. In each trial, the fixation cross was presented at the center of the screen for 500 ms, followed by one of four types of printed color words (赤, 青, 緑, and 黄, *red*, *blue*, *green*, and *yellow*, respectively) in kanji. In addition, a spoken word corresponding to the printed word in either of the two kinds of reading, varying from one trial to the next, was presented in stimulus onset asynchrony (SOA) (–100 ms or 100 ms). The instructions emphasized that participants should respond to the color dimension but ignore the printed word dimension and auditory word as soon as possible without giving an incorrect response. The participants' responses were recorded using a microphone, and the experimenter in the adjacent room listened to the correct responses through a wireless computer-loudspeaker.

Results and Discussion

Before analyzing the data of reaction times (RTs), we eliminated 29 trials with an RT of less than 300 ms (0.15% of trials) or greater than 2,000 ms (0.35% of trials) and trials with repetition priming (108 trials; 2.3%). We also eliminated trials with error responses (193 trials; 4.2%). Consequently, 7.03% of the trials were excluded from analysis. Analysis of variance (ANOVA) with four repeated factors indicated the significant main effect of Congruency, $F(1, 11) = 138.23$ $p < .0000$, with incongruent distractor words producing larger RTs than congruent stimuli (770.1 ms vs. 641.9 ms), thereby indicating the usual Stroop effect; of Response Phonological Code, $F(1, 11) = 17.79$, $p < .005$, with "on" reading having larger RTs than "kun" reading (765.1 ms vs. 646.8 ms), thereby indicating that the former have a lower proficiency than the latter; and of SOA, $F(1, 11) = 5.15$, $p < .05$, with exposure of spoken word preceding the printed word at 100 ms producing shorter RTs than the exposure of the printed word preceding the spoken word (679.8 ms vs. 732.2 ms, respectively). However, the analysis produced no significant effect of Phonological Correspondence, $F(1, 11) = 2.05$, $p = .18$. Further, it indicated a two-way interaction between Congruency and Response Phonological Code, $F(1, 11) = 11.60$, $p =.0059$, with "on" reading with lower proficiency having a larger Stroop congruency effect than "kun" reading with higher proficiency (159.3 ms vs. 97.0 ms, respectively), and a three-way interaction between Congruency, Response Phonological Code, and Phonological Correspondence, $F(1, 11) = 4.95$, $p = .048$. No other interaction was significant, $F < 4.5$ (Figure 1). That is, "kun" reading produced no effect of either congruency or phonological correspondence ($F < 1$), whereas "on" reading produced a significant effect of both congruence and phonological correspondence, $F(1, 11) = 17.33$, $p < .005$.

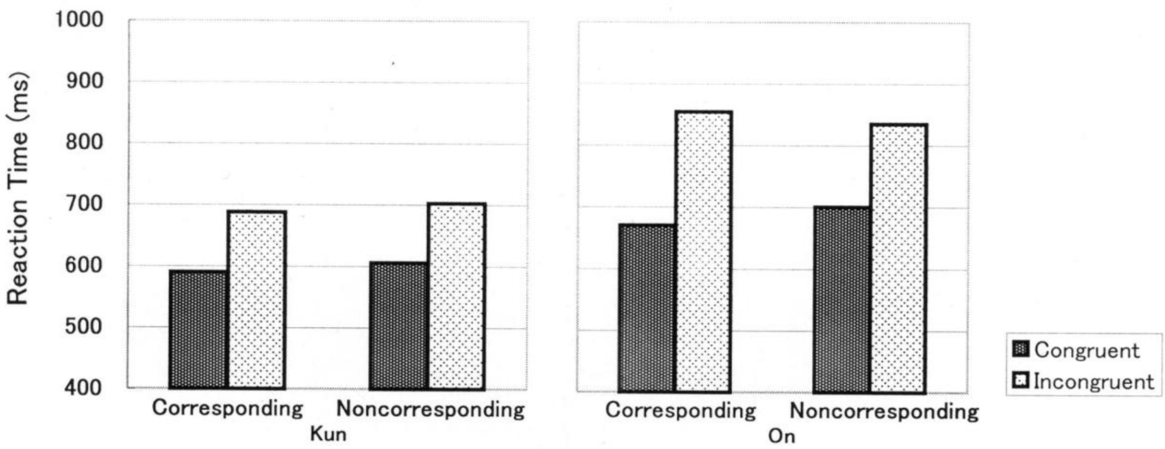

Fig. 1 Response latencies as a function of phonological correspondence in "kun" (left panel) and "on" (right panel).

We attempted to investigate (using Japanese kanji) whether or not the influence of phonological factors on the Stroop congruency effect was due to the proficiency of reading in the cross-modal situation; we separated the phonological component from the orthographical component of printed Chinese characters, with the Stroop stimuli accompanied by auditory distractors in two kinds of phonological codes in "on" and "kun" reading. We held constant the four kinds of the orthographic components of kanji character of color names (e.g., corresponding *red, blue, green,* and *yellow*) for the experiment trial blocks. We asked the participants to name the color of colored kanji characters using either "on" or "kun" reading code within the given trial block: the reading code in response was the *between*-blocks variable. In addition, we presented the printed colored character accompanied by the spoken word in two kinds of phonological code ("on" and "kun" reading code) varying from one trial to the next: the phonological code in spoken distractor was the *within*-blocks variable. By doing so, the combination of both between- and within-blocks variables produced the *response set effect* as *phonological correspondence*. The response set effect refers to the phenomenon of "less interference when the color word does not correspond to one of the colors used in the experiment" (Roelofs, 2003, p. 89; Klein, 1964). Consequently, for "kun" reading responses in higher proficiency, the congruency effect was not influenced by phonological correspondence, whereas for "on" reading responses, the congruency effect interacted with phonological correspondence. Recently, an argument was made with regard to "response exclusion on articulatory device" (e.g., see Hantsch, Jescheniak, & Schriefers, 2009; Janssen, Schirm, Mahon, & Caramazza, 2008). However, note the fact that this argument involved the use of non-color word or picture–word tasks, probably because people believe that they cannot manipulate the frequency or proficiency of color word through dissociating the phonological from the orthographical components of color word with constant meaning. However, we provided two ways of reading in two phonological codes by using color words in an effort to test this possibility. The question has been whether it is possible to manipulate the morphological and phonological components of color words independently. We conclude that vocal response using the articulatory code in lower proficiency produced both facilitation and interference effect in the color word task through manipulating only phonological components while holding the orthographical components constant.

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