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The Effect of Language Experience on Stroop Effect by Chinese English Learners

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ABSTRACT

Due to the different speed of information processing, word meaning contradicting the color would hinder color recognition, a phenomenon known as Stroop interference effect, however whether there is a language experience effect on Stroop effect is less known. In order to investigate this issue, 20 Chinese college students from English and non-English majors were recruited to conduct word and color recognition task using Chinese and English stimuli respectively with Eprime program. It was found that participants spent much longer time in color recognition whereas did not in word recognition when the stimuli did not match, supporting Stroop effect, in addition, Stroop effect was found both in first language (L1) and second language (L2), and the degree of interference would be affected by language experience.

Keywords: *language experience, Stroop effect, word and color recognition, Chinese English learners*

I. INTRODUCTION

Word and color recognition belong to different cognitive processes. Despite that these two aspects are processed in parallel, the speed differs a lot. It was revealed that word processing was faster than color naming (Logan, 1980). That is to say, if the word meaning is consistent with color, color recognition will not be disturbed, even be facilitated, but if they are not consistent, the word processing would interfere with color recognition and lengthen the reaction time (Cohen & Dunbar, 1990; Logan, 1980; Macleod, 1991; Scarpina & Sofia, 2017). This phenomenon is known as Stroop effect. It was proved in an experiment that adults were instructed to name the color which contradicted the word meaning, such as writing the word “green” in red ink. The results found that participants would spend much longer time if the word meaning did not match the color, however the interference of word processing on color was not being found at pupils aged six years old. This seemingly paradoxical finding could attribute to the language experience. To be specific, adults exposed to language much longer are more proficient in literacy and become automatic in word processing, therefore, when recognizing colors, adults would firstly process words unconsciously as conditioned reflex, hindering the processing of color which is slower in speed. However, in contrast to adults, children have been in initial contact with literacy, not yet proficient, the processing of which has been out of automatic, comparable to color recognition. Therefore, the interference of word processing on color is subtle. (Stroop, 1935; Wang, 1994). The influence of language on the interference effect of Stroop was documented (Biederman & Tsao 1979; Chen *et al*., 2007; Gao *et al*., 2017). Biederman and Tsao (1979) found that Stroop interference effect was found larger in Chinese subjects rather than English counterparts. Chen *et al*. (2007) conducted an ERP study of Chinese speakers’ Stroop effect within Chinese and English contexts and found a significant Stroop interference effect in both languages that the reaction time under inconsistent conditions was significantly longer than that under consistent conditions. However, the interference effect of Stroop was found larger in Chinese rather than in English context, suggesting that language might function differently in cognitive processing. Gao *et al*. (2017) studied bilingual advantage in Stroop under L1 and L2, and found that skilled bilingual showed more inhibitory control than unskilled one in L1, but did not in L2. But how language experience in L1 and L2 exerts an effect is still unknown. Specifically, whether L1 and L2 exert different impacts on Stroop interference effect? If so, how language experience with L2 influences Stroop effect remains to be further investigated.

II. THE PRESENT STUDY

Based on previous studies, the present study conducts a behavioral experiment with Eprime 2.0 program to examine Stroop effect of twenty Chinese students differing in English proficiency by four tasks: 1) word recognition in Chinese, 2) color recognition in Chinese, 3) word recognition in English, 4) color recognition in English, aiming to investigate the effect of language experience on Stroop effect. In specific, the present study aims to explore the following questions: Does Stroop effect exist in both L1 (Chinese) and L2 (English)? If so, is there a difference? 2) How does second language proficiency influence Stroop interference effect? Based on previous study, it is expected that for both two languages, Stroop effect exists that word meaning would exert a significant interference effect on color than vice versa when the color and word meaning contradict each other. In addition, it is expected that language experience would influence the degree of interference effect of word on color recognition that is participants would show more Stroop effect in L1 tasks than in L2 tasks. In addition, advanced English learners would be influenced stronger than low proficiency peers by Stroop effect in color recognition due to the L2 proficiency of the former is closer to L1.

III. METHODS

A. Participant

This experiment recruited 20 graduate students from Hunan University in Changsha, among which 10 subjects majored in English from the School of Foreign Languages (4 male and 6 female), aged 22 to 24 years, with an average age of 23.3 years, and all of them passed TEM-8[Test for English Majors-Band 8]and reached excellent level[TEM-8 has three levels, excellent (>80), good (70-79) and pass (60-69), all subjects majored in English in the present study all reached excellent]. The other 10 subjects from Electronic Science and Technology majors (6 male and 4 female), aged 22-26 years, with an average age of 23.8 years. All of them were self-reported being unskilled in English and at CET-4 level or below.

All participants of both groups were screened by one questionnaire relevant to their personal information. All subjects had normal cognitive and intelligence levels, right-handedness and normal corrective vision, no color blindness. And all of them were firstly exposed to English by compulsory education from primary school, having no experience of going abroad. For all of them, Chinese is their primary language in daily life. Informed consent in compliance with a protocol approved by Human Research Ethics Committee of Hunan University was given to each participant, and they were reimbursed for their participation.

B. Material

There are total four colors, red, yellow, blue, green, combining with each other, making 16 word-color pairs: red-red; red-yellow; red-blue; red-green; yellow-red; yellow-yellow; yellow-blue; yellow-green; blue-red; blue-yellow; blue-blue; blue-green; green-red; green-yellow; green-blue; green-green. The word representing color is written in a picture with four colors. There are two versions, Chinese version with Chinese characters, and English version with English words. In order to avoid bias, the consistent color-word pair would be repeated 9 times while inconsistent pair would be repeated 3 times to keep the number equal, making total 72 stimuli in one session.

C. Procedure

The whole experiment consisted of four sessions: Chinese word recognition (CWR); Chinese color recognition (CCR); English word recognition (EWR); English color recognition (ECR), which was conducted in a quite classroom individually via a laptop under the supervision of the experimenter (the author). Eprime 2.0 was used for presenting the stimuli and collecting the data. The sequence of sessions was counterbalanced across the participants. In each session, 72 stimuli were randomly presented. After finishing each session, participants have one minute for rest, and the whole experiment would last 15 minutes.

One example of experimental procedure could be seen in "Fig. 1". Before the testing, firstly, a writing experimental instruction would be shown to each subject. After understanding the instruction, participants would begin to conduct a practice test including 8 stimuli to be familiar with procedure, which would not be included into final performance. The participants would see a red fixation lasting 500ms, after which they would see a picture with word written in color. The task of participants is to recognize word meaning or color of the text according to the requirement. Practice part could be repeated, only participants understood the instruction, they were allowed to begin the formal test. Each session would proceed with a practice part. In the practice part, participants would receive feedback. The keyboards would be used by participants to give response. "A", "S", "K", and "L" represent "red", "yellow", "blue", and "green" respectively. To ease the burden of the participants by memorizing the letter characterized by colors, which could affect the response time, the keys were pasted with corresponding color. Despite without time limit, each participant was instructed to response as soon as possible. Once participants gave a response, the next stimulus would appear 500ms later automatically. Participants would not receive any feedback during the formal experiment. After the experiment, only the accurate response within 2000ms would be calculated. Actually, error rate is very low by both groups.

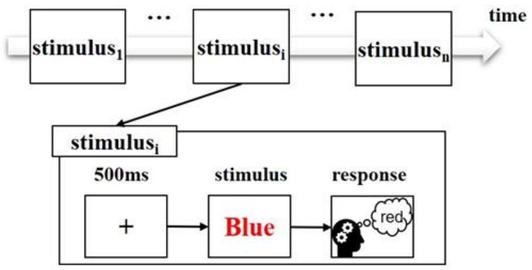

Fig. 1. Experimental flow chart of English color recognition task.

IV. RESULTS

Data collected by Eprime were screened by accuracy and time limitation, and imported into SPSS for analysis. Mean response time divided by language and task type could be seen in "Fig. 2".

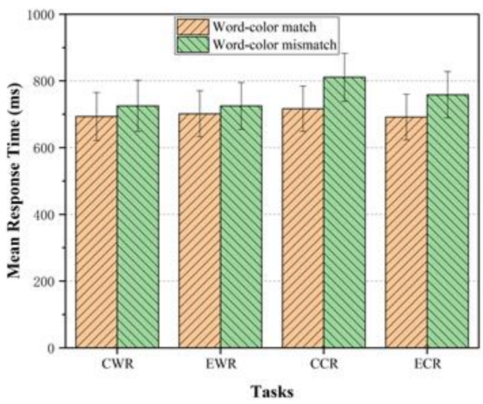

Fig. 2. Mean response time in four sessions divided by language (Chinese vs. English), task type (word recognition vs. color recognition).

Firstly, three-way mixed effect ANOVAs were conducted on Chinese and English tasks respectively, major (English vs. Non-English) as between-subject variable while task type (word recognition vs. color recognition) and stimulus type (word-color match vs. word-color mismatch) as within-subject variables. In Chinese tasks, the result shown that there was a main effect of task type and stimulus type as well as interaction effect between them [F(1,18)=43.826, p<.001, η^2=.71; F(1,18)=222.79, p<.001, η^2=.93; F(1,18)=40.803, p<.001, η^2=.69]. Specifically, mean response time in color recognition and in mismatch situation was significantly longer than word recognition and in match situation. In addition, the effect of major was not significant, suggesting that all groups performed similarly in native language environment. To unlock the interaction between task type and stimulus type, independent t tests were performed on word recognition and color recognition respectively to examine the effect of stimulus type and found that there was a significant difference between mean response time of color-word match and that of color-word mismatch in color recognition task [t (38) = -4.272, p<.001, Cohen's d=1.38] whereas there was not a significant effect in word recognition task, indicating that word processing indeed hindered color recognition when contradicting each other whereas color did not interfere with word, supporting Stroop effect. In addition, three-way mixed effect ANOVA was again conducted in English tasks. Similarly, the effect of stimulus type and the interaction effect between task type and stimulus type were significant, [F(1,18)=319.296, p<.001, η^2=.95; F(1,18)=79.676, p<.001, η^2=.82]. In addition, the interaction among task type × stimulus type × major was also significant, [F(1,18)=23.808, p<.001, η^2=.57], however, there was no main effect of the major. Therefore, similar to Chinese tasks, independent t tests were administrated in English word recognition and color recognition by stimulus type. And the result shown that mean response time of word-color match and word-color mismatch in color recognition differed significantly [t(38)=-3.068, p<.01, Cohen's d=0.99] whereas did not in word recognition, indicating that regardless of L1 and L2 context, Stroop effect exists. In addition, independent t tests were conducted four times to unlock task type × stimulus type × major interaction, and found that only in word-color mismatch color recognition task of English, two groups differing in English proficiency reached a near significant discrepancy in response time that advanced level group responded slower than low level counterparts [t(18)=1.967, p=.065, Cohen's d=0.92] seen in "Table I", suggesting that advanced L2 participants would experience stronger Stroop effect in word recognition.

TABLE I. MEAN RESPONSE TIME OF ENGLISH MAJOR AND NON-ENGLISH MAJOR GROUPS IN FOUR CONDITIONS OF L2 TASKS

L2 tasks	***English major group***	***Non-English major group***	***P value***
	M±SD(ms)		
color-word match of word recognition	691.4±59.9	711.5±78.5	0.529
color-word match of color recognition	694.7±76.5	688.2±63.7	0.836
color-word mismatch of word recognition	713.4±67	736±75.1	0.487
color-word mismatch of color recognition	786.8±68.3	729.9±60.6	0.065

Furthermore, for the sake of investigating the effect of language type (L1 vs. L2) on Stroop effect, a two way mixed effect AVOVA (major × language) was conducted in color-word mismatch of color recognition and it was found that there was a significant main effect of language [F(1,18)=12.013, p<0.01, η^2=.4], which indicated that participants needed more time to respond within Chinese context than English analogue. In addition, except language, there was no other effects being found, which indicated that regardless of L2 proficiency, all groups would have stronger Stroop effect for L1 than L2.

V. DISCUSSION

The present study investigates the effect of language experience on Stroop effect by Chinese English learners differing in English proficiency through an Eprime behavioral experiment. A total of three aspects would be discussed here. First, regardless of English and Chinese contexts, both groups performed similarly. In word recognition, the mean response time between color-word match and color-word mismatch conditions did not reach statistically significant. It indicated that unmatched color would not make an obvious interference effect on word recognition. Alternatively, with respect to color recognition, there was a significant difference of mean response time between the color-word match and mismatch conditions. Specifically, both groups performed much slower with mismatch stimuli, showing strong interference of word meaning on color recognition. Secondly, in terms of language effect, it suggested that Stroop effect existed in L1 and L2 to different extent due to different processing mechanisms, and a further investigation shown that for color recognition tasks, both groups exhibited significant faster reaction speed when the stimulus was presented by English rather than by Chinese, suggesting the influence of language experience on Stroop effect. In other words, although interference of word meaning on color recognition was found both in L1 and L2, the degree of interference was different that Chinese would hinder color recognition greater than English due to the degree of automation of Chinese would be higher than that of English since English was acquired later and was seldom used in daily life. This result was in line with previous studies (Chen, 2007; Sabourin & Vīnerte, 2014). This finding could be explained by the theory of information processing. Information processing is divided into automatic processing and controlled processing (Cohen et al., 1992; Logan 1980). The higher the degree of familiarity, the higher the degree of automation and the faster of the processing speed, thus less attention and control is required. Compared with English, participants were more familiar with Chinese and processed Chinese characters more automatic, leading to faster response and more disturbing effect of words on color. In addition, it was assumed that English major group would have stronger Stroop effect than non-English analogues since the automation of word processing would be enhanced along with the progress of English proficiency. However, the result did not fully support the hypothesis. By comparing performance of two groups in mismatched color recognition task, it was found that the difference did not reach significant although approaching. There are three possible reasons accounting for this result, one of which is resulted by participant selection. Due to both two groups are Chinese college students, having no experience of going abroad, English proficiency differs but does not achieve significance since English-major group also have limited exposure to L2 out of class, in addition, English words involved in the task is too simple to detect the difference by behavioral experiment. More precise technique, such as ERP should be considered. The third reason is from a small sample size that there were only ten people included in a group. In the future research, more participants could be recruited.

VI. CONCLUSION

This study investigates the effect of language experience on Stroop effect by two Chinese groups differing in English proficiency. The study confirmed the Stroop effect in both L1 and L2. In the case of contradiction between color and word meaning, literacy is superior to color recognition. Therefore, the faster processed word meaning would hinder color recognition which is slower in speed whereas color would exert little or almost negligible influence on word recognition. In addition, the effect of language experience was found that L1 had stronger Stroop interference effect than L2, suggesting that participants were more familiar with the language, the more Stroop interference effect they would experience. Furthermore, advanced L2 learners might have more Stroop effect than low proficiency counterparts in L2 environment, which could be examined with a larger sample size in the future research.

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