The Languages Impact on the Stroop Effect: Comparison in Chinese and English

Yujia Hu[1, a, †] Xinwen Kang[2, b, †] Ran Mao[3, c, *, †]

[1] *School of BI academy, Chongqing, China*
[2] *School of Stony Brook University, Stony Brook, New York, Unitede States*
[3] *School of Wen Zhou Medical University, Wen Zhou, Zhejiang, China*
Corresponding author. Email: maoran8156@st.btbu.edu.cn
[†]*These authors contributed equally.*

ABSTRACT

Since the discovery of the Stroop effect, researchers have conducted in-depth exploration on it from various angles, but the impact of language on it is not very clear. Therefore, the current study aims to investigate the different languages effects on the Stroop effect of Chines-English bilinguals based on the modified Stroop test. Chinese and English versions of Stroop test were used to test the reaction of 30 Chinese native speakers (14 males and 16 females) who were proficient in English. Participants will be shown with 10 English words and then 10 Chinese words. After a 1-minine-breake, 10 Chinese words and 10 English words will be shown. According to the analysis, the main effect of language type was significant, and participants took longer to respond correctly to the Stroop task in the second language version than in the native language version. Moreover, the main effect of word color consistency and the interaction between them were not significant. This study revealed that language type had a significant impact on the results of Stroop task. Future research should further explore the impact mechanism and compare the results between Stroop tasks using different language versions or based on different cultural backgrounds. These results shed light for how language types affected Stroop effect and offer a guideline for the relationship between bilinguals and Stroop effect.

Keywords: Languages, Stroop test, Bilinguals

1. INTRODUCTION

The whole name of the Stroop test is the Stroop Color and Word Test, which was developed by Stroop [1]. He found that participants took a longer time to name the color of the word when the name of the color is incongruent with the color of the letters. For example, if the word is green, the color of the letters is yellow, participants will take a longer time to name yellow. Therefore, the interference will be larger when the color of the word is printed and the name of the color is incongruent than when the color of the letters is congruent with the name of the color, which is also called the Stroop effect.

There were lots of previous studies focus on the Stroop test. Researchers found there are many factors can affect the result of the Stroop Test. Hartley and Adams [2] found that noise could be the one of the factors to influence the Stroop test. Based on their results, if the participants only exposed to noise for a short time, it was beneficial and decreased the interference. However, if the participants exposed to the noise for a longtime, then the interference would be increased. There was another study found that age could be another factor affects the Stroop test. Cohn, Dustman, and Bradford [3] conducted a research to find how age affect the Stroop test. The result indicated that the participants whose age were the oldest showed the longest reaction time. They also found that the Stroop test was most affected by age in a variety of tests. As for languages, this question came up because all the researchers in this study are Chinese. The original Stroop test was only written in English. Regarding to the words are presented in other languages, (e.g., Chinese), the results of the previous studies were different.

Some studies found that different languages lead to different results. These two studies investigate the

results in two different perspectives. This previous research conducted by Biederman and Tsao [4] separate the Chinses participants and American participants and asked them to do only Chinese and English version of the Stroop test. They found Chinese participants show a greater Stroop effect in Chinese than American participants in English. They suspected that this might because there are some fundamental differences in the processing of Chinese and English. There is another research found the Chinese-English bilinguals' performances were different in Chinese and English Stroop test. In prior study, participants must do both Chinese and English version of the Stroop test. The researchers found that the proficient bilinguals showed a smaller Stroop effect in Chinses than non-proficient bilinguals. In addition, the proficient bilinguals and non-proficient bilinguals showed similar Stroop effect. However, proficient bilingual recognized the English words quicker than the non-proficient bilinguals and recognized the Chinese words slower than the non-proficient bilinguals [5].

Some studies found that there's no differences if the language is different. Smith and Kirsner [6] doubted the conclusion of Ref. [4], which concluded that there were no significant differences between Chinese and English in the Stroop test. They also found that Chinese-English bilinguals, whose first language was Chinese, show less Stroop effect in Chinese than in English. There is another previous research paper found that there's no significant difference in the Stroop effect, no matter the test was written in Chinese nor in English [7].

In consideration of the contradiction among the different studies. The goal of the current research is to compare the Stroop effect in Chinese and English for Chinese-English bilinguals. Because the mother language of all the participants is Chinese, which means they are more proficient in Chinese. Additionally, the interference between the meaning of the word and the color of the word might be larger.

The hypothesis of this study is the Chinese-English bilinguals, whose first language was Chinese, will show a greater Stroop test effect when they are doing the Chinese version of the Stroop test compare to the English version. The original Stroop test was an in-person experiment. The participants would say the color of the words directly to the researchers. The current experiment will be conducted online due to COVID-19. There is total 20 English words and 20 Chinese words shown to the participants, their reaction time to press the specific bottoms on the keyboard when they see the words will be recorded through the Internet. Afterward, we will analyze the data that collected to find if there are any significant differences.

2. METHOD

2.1 Participants

Participants in this experiment were recruited from the Internet, and any gender could participate in this test. There were 30 participants with 14 males and 16 females completed this experiment. In this Stroop test, the main participants are undergraduate students (17), one PhD student, and 12 international high school students were also collected to make the sample more representative. In order to make the data efficient, two participants' data were removed due to their excessive long reaction time. These participants all meet the requirements as having the ability to recognize different colors through English. In addition, human beings who had previous or current brain damage and color blindness were excluded. Each participants came voluntarily with informed consent. We also promised that we'll never share their personal information to the public and use their data on other fields.

2.2 Design and Material

Our experimental paradigm is based on John Riddley's [1] version of Stroop test, and we modified it to a bilingual version (Chinese and English).

This experiment is a within-subject design. The independent variable of this experiment are different language versions of the text (Chinese and English) and the correspondence between the meaning of words and ink colors in the Stroop test, whereas the dependent variable as the reaction -time. All the participants will be shown with both Chinese and English words in the Stroop test.

2.3 Procedure

This experiment was programmed by using both English words and Chinese words through Psychopy (a commonly used software for designing psychological experiment) and separated the 40 trails into two sections: first with 20 trails (first 10 English words and then 10 Chinese words), and after a 1-minute break, another set with same trails (of color) but in different language sequence. The purpose was to prevent fatigue or familiarity, which would affect our validity of data.

Due to the inconvenience of Psychopy as participants have to install certain application to test, we used the Pavlovia to convert the experiment into a link, i.e., they can accomplish the test with any devices with keyboards. Participants finished the test approximately within 5 minutes, and they had to follow the instructions written in front page, which were (1) ignore the meaning of words but notice the ink color of words; (2) click corresponding key as ink color shows up.

3. RESULT

The independent variables of the current study are the different languages of the Stroop test and the congruency of the words presented in the test. The dependent variable is the reaction time. All the data that analyzed was the reaction time for the correct responds, the reaction time for the incorrect responds was deleted. Moreover, the reaction time which is way too large or small was deleted on account of the representativeness of the data. As shown in Table 1, the mean reaction time of English congruent words ($M = 1.53$, $SD = 0.68$) is less than the English incongruent words ($M = 1.60$, $SD = 0.80$). As for Chinese, the mean reaction of Chinese congruent words ($M = 1.30$, $SD = 0.49$) is also less than the Chinese incongruent words ($M = 1.43$, $SD = 0.59$).

Table 1. The mean and standard deviation reaction time for different language versions of the Stroop test.

Reaction Time	English		Chinese	
	Congruent	Incongruent	Congruent	Incongruent
M	1.53	1.60	1.30	1.43
SD	0.68	0.80	0.49	0.59

According to Figure 1, the difference between the mean reaction time of Chinese congruent words and Chinese incongruent words was larger than the difference between the mean reaction time of English congruent words and English incongruent words. The mean reaction time for the English words (congruent and incongruent) is longer than the Chinese words (congruent and incongruent). However, the inferential statistics is needed to judge whether these differences are significant or not.
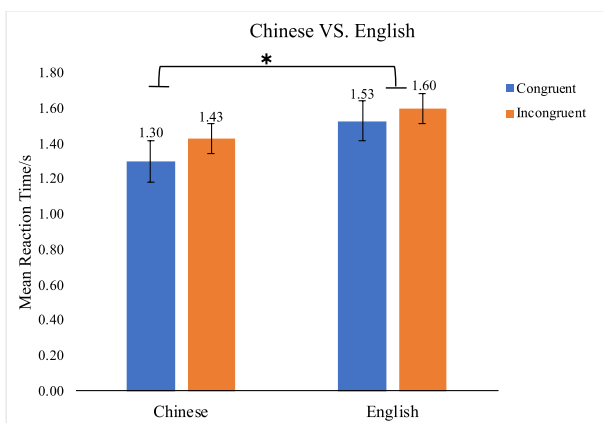

Figure 1. Comparison for the reaction time of Chinese and English version of the Stroop test.

4. DISCUSSION

Since the discovery of Stroop effect, it has been favored by cognitive research. Its research paradigm is becoming more and more mature, and its research field is expanding. There are many factors that affect and restrict the processing of words in Stroop task. The purpose of this study is to explore the differences in response time between Chinese and English bilingual Stroop tasks. The results showed that the main effect of language type was significant, but the main effect of word color consistency was not significant. Besides, the interaction between them was not significant. In the experiment, it is found that the subjects took less time to respond correctly in the Chinese Stroop test, which was contrary to our previous hypothesis.

In previous studies, it was found that character recognition ability would affect Stroop effect [8]. The more proficient the participants were in stimulating language, the higher the degree of automatic processing of word meaning and the greater the interference of word meaning. However, in this experiment, we found that compared with Chinese, English is the non-dominant language of the subjects. Moreover, the interference of word meaning in the English version of Stroop test is significantly higher than that in the Chinese version of Stroop test. Our study was consistent with the results of previous related studies. Fang et al. [9] conducted a study on Chinese-English and Spanish-English bilinguals and found that participants took longer to respond to the second language. Gerhand et al. [10] conducted a study on Gaelic English bilinguals and stated that participants showed significantly more word meaning interference in English than Gaelic (mother tongue). Datta et al. [11] carried out a study on 44 Hindi-English bilinguals whose mother tongue was Hindi. The results also found that the participants spent more time on the second language Stroop task. La Heij et al. [12] put forward an explanation in the study of Dutch-English bilinguals. Compared with their mother tongue, participants were translating while responding to less proficient languages, resulting in greater response time. Tzelkov et al. [13] in their study of Hebrew and Arabic bilinguals, concluded that Stroop interference could be controlled, and language proficiency was the prerequisite for control. The participants' native language was Chinese, and the automatic processing of word meaning was faster. However, they had higher control over Chinese in the meantime, controlling the interference of dominant response to non-dominant response, i.e., the reaction time decreased.

In our study, another finding was that the main effect of word color consistency (Stroop effect) was not significant. This was inconsistent with many previous research results. However, some studies have found that the ability of color recognition would also affect the Stroop effect. In the experiment of Bruno et al. [14], they added the subjects' color recognition ability to the Stroop experiment for the first time and found that color matching would affect the Stroop effect. They conducted experiments according to the opposite

process theory in color vision theory and found that when the color and word meaning were incongruent, the number of Stroop interference caused by opposite colors (e.g., red "green" words) was significantly less than that caused by non-opposite colors (e.g., red "yellow" words). However, our experimental materials used more non opposing color words. Therefore, the Stroop effect may have a less significant impact on the results.

There were also many limitations in this experiment:

1. Due to the epidemic situation, we adopted the method of online experiment. Participants' concentration may be weaker than that in offline environment, which may have a certain impact on the experimental results. In the future, we will take the offline experiment and equip 1-2 testers to guide the participants.

2. In order to make the experimental results more different, we will further screen the subjects. For example, we will explore the response of American students who master a certain level of Chinese to the results of Chinese English bilingual Stroop test, and further explore the impact of language on Stroop effect

At present, the research of Stroop effect has penetrated many fields, e.g., emotional Stroop effect and brain mechanism of Stroop effect. In the future, the experiment will be improved, and the related contents will be further discussed.

5. CONCLUSION

In summary, in the light of the contradictions among the conclusions of the studies that investigate how different languages influence the Stroop effect. he aim of this study is to compare the Stroop effect in Chinese and English for Chinese-English bilinguals.

The study found that language type had a significant impact on the results of Stroop task. Participants took significantly longer to respond correctly in the second language version of Stroop task than in the native language version of Stroop task. This paper provides an empirical basis for the study of the relationship between bilinguals and Stroop effect, which has attracted the attention of scholars in the fields of cognition, attention and language. In the future, we can study and compare Chinese-Japanese, Chinese-Korean and Chinese-French bilinguals to explore which second language has more advantages in learning. Since the subjects of the study are Chinese-English bilinguals, we cannot determine whether the reason for the results is language proficiency or language itself. In order to further explore the mechanism, the subjects ought to be further screened, e.g., exploring the response of American students who master a certain level of Chinese to the results of the Chinese English bilingual Stroop test, and the impact of language on Stroop effect. These results

offer a guideline for the relationship between bilinguals and Stroop effect.

REFERENCES

[1] Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology*, *18*(6), 643–662.

[2] Hartley, L. R., & Adams, R. G. (1974). Effect of noise on the Stroop test. *Journal of Experimental Psychology*, *102*(1), 62–66.

[3] Cohn, N. B., Dustman, R. E., & Bradford, D. C. (1984). Age-related decrements in stroop color test performance. *Journal of Clinical Psychology*, *40*(5), 1244–1250.

[4] Biederman, I., & Tsao, Y.-C. (1979). On processing Chinese ideographs and English words: Some implications from Stroop-test results. *Cognitive Psychology, 11*(2), 125–132.

[5] Wang, R., Fan, X., Liu, C., & Cai, Z. G. (2014). Cognitive control and word recognition speed influence the Stroop effect in bilinguals. *International Journal of Psychology*, *51*(2), 93–101.

[6] Smith, M. C., & Kirsner, K. (1982). Language and Orthography as Irrelevant Features in Colour-Word and Picture-Word Stroop Interference. *The Quarterly Journal of Experimental Psychology Section A, 34*(1), 153–170.

[7] Lee, T. M., & Chan, C. C. (2000). Stroop Interference in Chinese and English. *Journal of Clinical and Experimental Neuropsychology, 22*(4), 465–471.

[8] Mägiste, E. (1984). Stroop tasks and dichotic translation: The development of interference patterns in bilinguals. *Journal of Experimental Psychology Learning Memory & Cognition, 10(2),* 304–315.

[9] Fang, S. P., Tzeng, O. J. L., & Alva, E. (1981). Intra-versus inter-language. Stroop interference effect in bilingual subjects. *Memory & Cognition*, 9, 609–617.

[10] Gerhand, S. J., Deręgowski, J. B., & McAllister, H. (1995). Stroop phenomenon as a measure of cognitive functioning of bilingual (Gaelic/English) subjects. *British Journal of Psychology, 86*(1), 89–92.

[11] Datta, K., Nebhinani, N., & Dixit, A. (2019). Performance Differences in Hindi and English Speaking Bilinguals on Stroop Task. *Journal of Psycholinguistic Research*, *48*(6), 1441–1448.

[12] La Heij, W., Hooglander, A., Kerling, R., & Van Der Velden, E. (1996). Nonverbal context effects in forward and backward word translation: Evidence for concept mediation. *Journal of Memory and Language, 35*(5), 648–665.

[13] Tzelgov, J., Henik, A., & Leiser, D. (1990). Controlling Stroop interference: Evidence from a bilingual task. Journal of Experimental Psychology. *Learning, Memory, and Cognition, 16*(5), 760.

[14] Laeng, B., Lag, T., & Brennen, T. (2005) Reduced stroop interference for opponent colors may be due to input factors: Evidence from individual differences and a neural network simulation. *Journal of Experimental Psychology/Human Perception & Performance, 31*(3):438－452