

Linguistic Interference in Reading Stroop Card

Upadhayay N, Guragain S, Khadka P

Department of Physiology,
Devdaha Medical College and Research Institute,
Devdaha, Rupandehi.

Corresponding Author

Namrata Upadhayay
Department of Physiology,
Devdaha Medical College and Research Institute,
Devdaha, Rupandehi.
E-mail: namrataupadhayay@gmail.com

Citation

Upadhayay N, Guragain S, Khadka P. Linguistic Interference in Reading Stroop Card. *Kathmandu Univ Med J.* 2022;78(3):178-82.

ABSTRACT

Background

The Stroop test is a gold-standard cognitive function test that assesses selective attention. There are discrepancies of having language interaction in bilingual individuals on stroop test.

Objective

To assess selective attention of Nepalese in Nepali and English versions of stroop test and investigating gender differences in it.

Method

The study includes male (n 33) and female (n 33) of age 20-40 years. Their first home language is Nepali. The comparison of congruent and incongruent reaction time (selective attention) between two test versions was analyzed by Paired t-test. Gender differences on selective attention were analyzed by Independent sample t-test. Data are expressed as mean \pm SD, $p < 0.05$.

Result

The congruent time in Nepali test (47.34 ± 9.23) was higher than English (42.21 ± 10.17) test. The selective attention in Nepali (113.11 ± 24.04) was significantly better (low latency) than English version (119.67 ± 28.81) of the test. Female outperformed male in selective attention on both the versions.

Conclusion

Orthographically and phonologically dissimilar languages affect the reaction time of bilingual individuals. Nepali stroop test can be a valid tool in assessing selective attention on Nepalese population. Females outperform males on selective attention as assessed by stroop test.

KEY WORDS

Attention, Cognition, Phonology, Reaction time

INTRODUCTION

Cognitive function refers to an individual's perception, memory, thinking, reasoning, language and awareness.^{1,2} Stroop test is a part of the cognitive function assessment in Neuropsychology.³ It assesses the awareness or selective attention of an individual on color interference.⁴ From the early phase of academics, Nepalese people start learning by two languages i.e. English and Nepali. However, Nepalese are accustomed more to Nepali language as compared to English, because "Nepali" is the official language and used at many places such as home, society, private or governmental offices etc. Therefore, the practice of using stroop card in English language might not detect the actual reaction time of Nepalese population (bilinguals). The classical English stroop test is designed to assess the color interference. However, the obtained result can be affected by the language (English) when assessed in non-native English speakers. Some reports that the classical English Stroop test conducted among Nepalese or bilinguals shows poor performance in selective attention as compared to native English speakers.^{5,6} Therefore, Nepali version of stroop test might help in assessing selective attention in this population. Hence, this study is designed to assess the reaction time (or selective attention) of Nepalese in both English and Nepali versions of the tests. The second objective is to investigate the existence of gender differences on selective attention between two versions, citing to the various language studies reporting differences on attention and cognitive functions between male and female.⁷⁻⁹

METHODS

The study was a comparative cross-sectional study. The study site was at Bhaluhi, Devdaha Municipality. The duration of study was approximately 13 months. The sample size of the study was 66 (male: 33 and female: 33). The convenient sampling technique was used to enroll participants in the study. The data was collected through direct observation and questionnaire. After receiving ethical approval from the institutional review committee the study was conducted. The written informed consent from all the participants was taken prior to study.

The participants with first home language as Nepali were included in the study. Healthy adults (male and female) of age: 20 to 40 years without any systemic illness were included in the study. Participants with normal color vision as tested by Ishihara test were included in the study. Participants with drugs/nicotine/alcohol or any substance abuse and motor speech defect were excluded from the study. Females having irregular menstrual cycle were also excluded from the study.

The data collection measures used was stroop card written in two languages English and Nepali. This was the first

study to translate the stroop test in Nepali. This was done to assess the effect of language on selective attention of bilingual individuals. There were some studies that translate the English version of stroop test to other language and have assessed the effect of language on selective attention in bilingual or multilingual individuals.⁶

Development of Nepali Stroop Card: Stroop test were designed to read the color. It consists of two types of cards: congruent and incongruent cards. It assesses the alertness or selective attention of the population in reading color interference. Nepali version of stroop card was designed by the principal investigator according to the Standard English Stroop card with the use of Nepali language (Devanagari script) (fig. 1). Its content validity was tested in ten students before its actual administration in the study. The items number and process was duplicated similar to the classical English Stroop card. The differences exist in the script (Devanagari) i.e. orthographical and phonological differences.

Stroop Card: Nepali Version
Test 1- congruent card

| | | | | | | | | | | |
|-------|-------|-------|-------|-------|--|-------|-------|-------|-------|-------|
| खैरो | हरियो | बैजनी | रातो | निलो | | रातो | निलो | खैरो | हरियो | बैजनी |
| रातो | खैरो | बैजनी | हरियो | निलो | | हरियो | खैरो | रातो | निलो | बैजनी |
| बैजनी | रातो | खैरो | हरियो | निलो | | रातो | खैरो | हरियो | बैजनी | निलो |
| खैरो | रातो | निलो | हरियो | बैजनी | | खैरो | निलो | बैजनी | रातो | हरियो |
| निलो | बैजनी | रातो | हरियो | खैरो | | हरियो | बैजनी | निलो | खैरो | रातो |

Figure 1. Sample of congruent card in Devanagari script

Data variables: The variables assessed were anthropometric variables (Age and Sex), and reaction time (congruent time and incongruent time) by stroop tests. The reaction time was assessed by two test cards (English and Nepali). Comparison of their reaction time was done to see the effect of language on performing stroop card.

Stroop Card Reading Procedure

a. Method of performing the test: In English stroop test, the congruent card consists of the normal response where the color names are written with the same ink colors as the text. For example 'Green' is written with green ink and the participants will read it as green. On the other part of the test, incongruent card, participant has to read ink color in place of text/written words i.e. color interference. For example, word 'Red' is written with green ink and subject has to read ink color as Green. Similarly, in Nepali stroop card (fig. 1), the items of word and colors were written in Devanagari script. However, the process for normal (congruent) and color interference (incongruent) reading is same as that of the English stroop cards. The two versions (English and Nepali) were administered and tested on the same day with a gap of 30 minutes between the tests (English and Nepali versions).

b. Error Adjustment: The total items in each card (congruent or incongruent) were of 100. The total time taken (reaction time to read one card) to complete each card was noted

through stopwatch. The number of errors made while reading colors were documented and later adjusted to calculate their actual reaction time in finishing reading a card. The formula for adjustment of errors while reading incongruent card was adopted from a study.¹⁰ While reading color interference (incongruent card) subjects make mistakes in reading items of the card. So, the average time (AT) to read each item was calculated by dividing the total reaction time (TRT) by number of items in a card. Here, "TRT" is the total time taken to read the whole card with errors. The formula for adjustment of error was given below.

$$i. AT = TRT / 100$$

Here, the total items present in each card were 100 and TRT is the total time taken to read a card with errors. AT: average time taken to read one item

$$ii. \text{Actual reaction time after error correction} = TRT + [2 (\text{number of errors multiplied by AT})] = \text{Incongruent reaction time (ICRT) without errors}$$

Data between two different tests (Nepali vs. English) were compared by using Paired T test. Independent sample T test was applied to compare between male and female groups. The p value less than 0.05 was considered as the significance level of the study. The SPSS software used for analysis was IBM SPSS Statistics 25.

RESULTS

All the participants were right handed and the age range was of 20-40 years. There were significant differences between Nepali and English stroop card reaction time. Both congruent reaction time (CRT) and interference (incongruent reaction time: ICRT) readings were different between Nepali and English stroop card. The CRT was significantly higher while reading Nepali stroop card as compared to English stroop card. In contrast, the selective attention assessed was better (low latency-ICRT) while reading Nepali stroop card as compared to English stroop card (table 1). Here, low latency indicates shorter reaction time.

Table 1. Comparison of variables between two versions of stroop test (n 66)

| Variables (Time in second) | Nepali Stroop card (Mean ± SD) | English Stroop Card (Mean ± SD) | P value |
|----------------------------------|--------------------------------|---------------------------------|---------|
| Congruent reaction time (CRT) | 47.34 ± 9.23 | 42.21 ± 10.17 | 0.0001 |
| Incongruent reaction time (ICRT) | 113.11 ± 24.04 | 119.67 ± 28.81 | 0.021 |

On comparison of data between male and female, we did not find a significant difference in CRT while reading English stroop card. However, CRT was higher in female as compared to male while reading Nepali stroop card. On the

other hand, the selective attention was significantly better (low latency-ICRT) in female while reading either Nepali or English stroop card, table 2.

Table 2. Independent Sample t-test

| Variables | Male (n 33) (Mean ± SD) | Female (n-33) (Mean ± SD) | P value |
|--------------------|-------------------------|---------------------------|---------|
| Age (years) | 22.73 ± 4.894 | 25.21 ± 7.07 | 0.102 |
| CRT-Nepali (sec) | 44.96 ± 7.14 | 49.711 ± 10.5 | 0.036* |
| CRT-English (sec) | 40.59 ± 5.35 | 43.83 ± 13.26 | 0.198 |
| ICRT-Nepali (sec) | 119.03 ± 26.19 | 107.183 ± 20.4 | 0.044* |
| ICRT-English (sec) | 127.65 ± 33.46 | 111.694 ± 20.86 | 0.023* |

*significant differences

DISCUSSION

The stroop test is the Gold standard of attention measures.¹¹ It assesses the selective attention of an individual while reading color in place of the text. The stroop effect (delay in reaction time) is encountered while reading stroop task. However, this delay in reaction time increases in the bilingual or multilingual individuals.¹² Hence, language interference has to be removed in order to assess the selective attention of bilingual individuals. Here, the participants are bilinguals and Nepali is their first home language. Therefore, we designed the Nepali version of stroop card and compared the reaction time between English and Nepali stroop tests. Secondly, we also compared selective attention between male and female in two different languages.

We found existence of stroop effect in both the languages. That indicates congruent time is less as compared to incongruent time in both the versions of the tests as similar to others findings.^{5,13} This indicates that more brain resources (synapses) are utilized on focusing to selective task that lead to delay in reaction time (Stroop effect).

In the present study, the congruent reaction time was significantly higher (poor performance) while reading Nepali test as compared to English version. The phonological differences present in two languages might be the reason for having differences in congruent reaction time. The Nepali language requires more time to speak or vocalize words as compared to English language. Moreover, two languages differ orthographically that might be the other reason in affecting the response time of an individual in congruent Nepali test. Contrary, it has been proposed that orthographically dissimilar languages with phonologically similar words can be processed by the brain in the same way as similar languages in bilingual individuals (Japanese and English).¹⁴ Nevertheless, both phonologically and orthographically two languages (English and Nepali) vary with each other in our study. Thus, processing of Nepali language was different to that of English language making this study outcome different to that of Japanese.

In our result, the selective attention (incongruent reaction time) was better (low latency) while performing Nepali

test as compared to English. This implies that Nepalese performed better in Nepali incongruent test than in English. It was almost similar to another study done in India with Hindi version of the test.¹³ They found less stroop effect in Hindi as compared to English. This suggests that the language proficiency and its adaptability in the daily life have advantage on selective attention. Therefore, selective attention was better in Nepali as compared to English in Nepalese people. Hence, our study signifies that the Nepali version of stroop card can be a valid tool to assess the cognitive function (selective attention) in Nepalese population with Nepali as their first home language.

The use of English stroop test in Nepali population will create two interferences: language and stroop effect. These individuals need an additional cognitive processing to react on English test. The additional processing leads to increase in stroop effect i.e. delay in selective attention due to hidden language interferences. Such delay might be due to different brain processing mechanisms in bilinguals or multilingual. The one of the suggested mechanisms in multilinguals' Stroop performance is to control or inhibit the non-target language.¹² Our study population is Nepali and they are non-native English speakers. Therefore, using stroop card in English language will activate the cognitive mechanism that will inhibit the non-target language (Nepali) while performing English stroop test. This will increase the interference time while responding to the stimuli. Further, there are reports mentioning that bilingual performance is slower than monolinguals, supporting our findings.⁶ It is reported that the best-spoken language shows better results on stroop test in unbalanced bilinguals. On the other hand, a study done in Spanish it has been found that the second language proficiency in bilinguals seems to improve inhibitory control while testing in native language.¹⁵ Therefore, there is an ongoing debate on development of separate assessment instrument to assess the cognitive abilities of bilinguals' speakers.¹⁶ Same instrument which is used for monolinguals cannot assess the cognitive abilities appropriately in bilinguals. Their brain pattern, synaptic connections and interpretation levels varies accordingly. Therefore, every cognitive tests used for monolinguals are not a valid instrument for bilinguals or multilingual individuals.

In our result, congruent reaction time was higher (poor performance) in female as compared to male while performing Nepali test. In this case, there is no selective attention and need of only execution of congruent word (text with same color) that favored male as compared to female. Therefore, in some of the executive tasks female performance is poorer than male. It is also evident that females have poor performance in visual reaction time as compared to males.¹⁷ However, the selective attention was significantly better (low latency- incongruent time) in female while performing either Nepali or English

stroop tests. This is a similar result as found in Indian and Kuwaiti population.^{9,18} This shows that the females have an advantage on selective attention as compared to males in stroop task. The proposed mechanisms for such advantage are like sex hormonal influences on brain neuronal development and its activity and better color shades perception in females.^{8,19,20} Moreover, females have anatomically larger planum temporale, Wernicke and Broca language associated brain areas as compared to males making them superior in language skills.^{19,21} Addition to this, the genetic variation of X-Y gene pairs lead to a development of hemispheric asymmetry in color processing between male and female. There is an existence of right hemisphere wavelength-differencing in male and left hemisphere frequency differencing in females.²² Therefore, the co-localization of color, memory and language processing in the same hemisphere (left) led females in having better description of color and words as compared to males.²³ However, such sex differences in stroop task between male and female are nullified after the age of 60 years.²⁴ The interesting finding is that the use of any language (either Nepali or English) led to better performance on selective attention in female as compared to males. Thus, language does not affect the performance of females or males in stroop task.⁹

This is the first study to assess the reaction time in Nepali language. Therefore, the shortcoming of this study is that we lack the prior evidence or research done in Nepali language to compare or contrast on our result. However, it has created a foundation for new research to continue in larger population. In future, to strongly support, quantify and generalize our findings on linguistic interference on stroop test, there is a scope to conduct a comparative study among monolingual, bilinguals and multilingual Nepalese populations.

CONCLUSION

Bilingual individuals need a separate valid tool to assess their selective attention instead of classical English stroop test. Orthographically and phonologically dissimilar languages affect the performance of bilingual individuals. Their selective attention found to be better in their first home language as compared to English test. Nepalese are non-native English speakers and Nepali is their official language. Therefore, Nepali version of stroop test can be used in Nepalese for assessing their selective attention. However, this can be used only when their first home language is Nepali. This might not be applicable for all the Nepalese people because there are many Nepalese who are multilinguistic with different home languages. Further, female outperformed the male on the selective attention in both the versions of the tests (English or Nepali). The plausible reason for females outperforming males on

selective attention could be the genetic asymmetry in their hemisphere for color space and having anatomically larger regions for language associated brain areas in females as compared to males. Further, the neuronal activity, brain

development and metabolism vary between male and female due to sex hormones that might have led to gender differences on selective attention.

REFERENCES

- Nouchi R, Kawashima R. Improving Cognitive Function from Children to Old Age: A Systematic Review of Recent Smart Ageing Intervention Studies. *Advances in Neuroscience*. 2014; 15.
- Merchán-Baeza JA, Rodríguez-Bailón M, Ricchetti G, Navarro-Egido A, Funes MJ. Awareness of cognitive abilities in the execution of activities of daily living after acquired brain injury: an evaluation protocol. *BMJ Open*. 2020;10:e037542.
- Scarpina F and Tagini S. The Stroop Color and Word Test Front. *Psychol*. 2017; 8:557.
- Williams E. The effects of amount of information in the Stroop color word test. *Perception and Psychophysics*. 1977; 22: 463–70.
- Ghimire N, Paudel BH, Khadka R, Singh PN. Reaction time in Stroop test in Nepalese Medical Students. *J Clin Diagn Res*. 2014; 8(9):BC14-BC16.
- Rosselli M, Ardila A, Santisi M, Arecco M, Salvatierra J, Conde A, Lenis A. Stroop effect in Spanish–English bilinguals. *Journal of the International Neuropsychological Society*. 2002; 8(6), 819–827.
- Downing K, Chan S, Downing W, Kwong T, Lam T. Measuring gender differences in cognitive functioning. *Multicultural Education & Technology Journal*. 2008; 2(1): 4–18.
- Upadhyay N and Guragain S. Comparison of cognitive functions between male and female medical students: a pilot study. *J of Clin and Diagnostic Res*. 2014; 8 (6):12–5.
- Datta K, Nebhinani N, Dixit A. Gender Differences in Performance on Hindi - English Stroop Task. *Indian J Physiol Pharmacol*. 2020; 64(1): 45–9.
- Ghimire N, Yadav R, Mukhopadhyay S. Comparative Study of Heart Rate, Blood Pressure and Selective Attention of Subjects Before and after Music. *BJHS*. 2019; 4(1)8:625–628.
- MacLeod, Colin M. The Stroop task: The "gold standard" of attentional measures. *Journal of Experimental Psychology: General*. 1992; 121(1): 12.
- Marian V, Blumenfeld HK, Mizrahi E, Kania U, Cordes AK. Multilingual Stroop performance: Effects of trilingualism and proficiency on inhibitory control. *Int J Multiling*. 2013; 10(1):82–104.
- Datta K, Nebhinani N, Dixit A. Performance Differences in Hindi and English Speaking Bilinguals on Stroop Task. *J Psycholinguist Res*. 2019; 48: 1441–8.
- Sumiya H, Healy AF. Phonology in the bilingual Stroop effect. *Memory & Cognition*. 2004; 32:752–8.
- Suarez PA, Gollan TH, Heaton R, Grant I, Cherner M, HNRC Group. Second-language fluency predicts native language stroop effects: evidence from Spanish-English bilinguals. *J Int Neuropsychol Soc*. 2014;20(3):342–8.
- Bailey C, Venta A, Langley H. The bilingual [dis]advantage. *Language and Cognition*. 2020; 12(2), 225–281.
- Jain A, Bansal R, Kumar A, Singh KD. A comparative study of visual and auditory reaction times on the basis of gender and physical activity levels of medical first year students. *Int J Appl Basic Med Res*. 2015; 5(2):124–127.
- Baroun K, Alansari B. Gender differences in performance on the Stroop Test. *Social Behavior and Personality: An International Journal*. 2006; 34(3), 309–18.
- Zaidi ZF. Gender Differences in Human Brain: A Review. *The Open Anatomy Journal*. 2010; 2:37–55.
- Jain N, Verma P, Mittal S, Mittal S, Singh A K, Munjal S. Gender based alteration in color perception. *Indian J Physiol Pharmacol*. 2010; 54(4), 366–70
- Harasty J, Double KL, Halliday GM, Kril JJ, McRitchie DA. Language-Associated Cortical Regions Are Proportionally Larger in the Female Brain. *Arch Neurol*. 1997; 54(2):171–176.
- Njemanze PC. Gender-related differences in physiologic color space: a functional transcranial Doppler (fTCD) study. *Exp Transl Stroke Med*. 2011;3(1):1.
- Njemanze PC. Gender-related asymmetric brain vasomotor response to color stimulation: a functional transcranial Doppler spectroscopy study. *Exp & Trans Stroke Med*. 2010; 2: 21.
- Chengappa S and Pranavam MM. Development of Stroop Effect in Bilinguals. *Language in India*. 2009; 9: 2.