On Mongolian College Students’ Chinese-English Word Recognition Based on Eye Movement

Guiyun Guan¹, Hewei Zhang²
¹School of Foreign Languages, Norwest Minzu University, Lanzhou, Gansu, 730030, China
²Library, Lanzhou University, Lanzhou, Gansu, 730000, China
*Corresponding author’s e-mail: 839709195@qq.com

Abstract. For Mongolian college students, the typical trilinguals, the word processing is quite different from that for bilinguals. The article designed two experiments, including visual and auditory word recognition (the priming words were Chinese, while competitive words were English). Eye tracker was used to capture the data and SPSS was utilized to analyze the results, finding that the cross-language word recognition (from Chinese to English) for Mongolian college students was completed through phonological mediation.

1. Introduction
With the development and combination of cognitive linguistics and psycho-linguistics, more and more researchers utilize eye-tracking technique to explore speakers’ psychological word-processing. Accordingly, Mongolian college students, as the typical trilinguals, have attracted many researcher’s attention in recent years (Guan, Guiyun., et al., 2019). Auditory input in the form of sound waves, coupled with problems with stress and intonation in some languages, and problems with coarticulation, makes listeners hear phonemes that are not in linear order. Therefore, auditory word recognition is rarely studied due to its complexity.

In the process of visual vocabulary recognition, the foundation and premise of reading can be completed only by correctly understanding the vocabulary, while the premise and foundation of auditory word recognition is the auditory speech communication, and the further understanding of auditory sentences and texts can be completed only by correctly understanding the lexical semantics. Therefore, this study designed two parts: visual word recognition and auditory word recognition. The perception channel and eye movement data caused by visual input stimulus and auditory input stimulus are different, so the recognition intensity of glyph, word sound and word meaning under two different stimuli is the main guiding idea of this experimental design.

2. Methods
2.1. Objectives
The experiment is done with the use of eye tracker to study the inner code-switching mechanism to provide meaningful helps to the Mongolian college students’ English teaching. During the process of word recognition, what’s the relationship among word pronunciation, form, meaning? What are the processing intensity and order among them? And which route is more appropriate for their trans-language (from Chinese to English) word recognition? Direct access, phonological medication,
or dual-route model?

2.2. Participants
In order to ensure the experiment to be reliable, the subjects of the experiment are Mongolian, with Chinese as their second language, English as their third language. They accepted Chinese education from grade one in primary school and passed MHK level 3 test. They accepted English education from junior high school and didn’t pass CET 4. 15 (six males and 9 females) subjects participated in the experiment. All the subjects had naked or corrected visual acuity of more than 1.0, right-handed, no color blindness, color weakness, hearing dyslexia and other problems. The subjects were informed of the content of the experiment before it began, and then they signed an informed agreement.

2.3. Experimental Instrument
The experiment uses the Hi-speed eye tracker produced by SMI in Germany. This instrument adopts infrared camera to take eye images of subjects and sends them to the computer for image data acquisition and analysis. The instrument is a high-precision eye tracker, with a sampling rate of 1250 hz, that is, 1250 times per second to record the eye movement data of the subjects while reading, which ensures the high accuracy of the experimental data. The instrument has its own iView X software and Experiment Center software and BeGaze software for real time data for analysis.

2.4. Experimental Design
This experiment took word recognition as the task. 2*4 factors were designed within the subjects, that is, 2 priming modes included visual priming and auditory priming, and 4 competing word types were homophone or phonetic close word, close-shaped word and semantically related word and irrelevant word.

2.5. Experimental Materials
In the experimental materials, 30 common Chinese words were selected from the Modern Chinese Dictionary published in 2014 as the priming words, and then matched with homophonic words, close-shaped words, semantically related words and unrelated words. A total of 120 words were used as the competition words. The English competition words are selected from the most common words in the English-Chinese Dictionary published by the Commercial Press in 2018.

In the experiment of visual word recognition, the Chinese priming words are in Song Typeface No. 48. The English competitive words are in Times New Roman No. 48 and placed in a 5*5 table. The margins of the A4 page are all set to 0, and then they are divided into 25 equal parts. The competitive words are placed in the four interest areas of 7, 9, 17 and 19 in the table respectively (as shown in the figure below). Then, it was exported to PDF format and presented on the subject’s display screen. No border appeared during the experiment.

In the example materials, the subjects could see the priming word “cat” on the screen, and after turning the page, the subjects would see four competitive words: homophonic word “mall”, form-close word “cap”, semantically related word “dog”, and unrelated word “water”. During the formal experiment, none of the borders will appear. The subjects did not know the type of the competing word, but simply scanned it freely according to the priming word.

eg:

|     |    |    |
|-----|----|----|
| mall| cap|
| dog | water
In the experiment of auditory word recognition, the priming words were presented in listening form. The presentation way of competitive words was the same as in the visual word recognition experiment.

2.6. Experimental Procedures
The subjects sat before the eye tracker, 80cm distant from the subject’s screen, put the chin on the bracket of the eye tracker, the forehead on the upper part of the eye tracker, right hand on the hand frame of the eye tracker, and left hand on the “↓” key on the keyboard. The procedures are listed as below:

3. Data Analysis of the Experimental Results
First, the experiment of visual word recognition was done. According to the relevant research of Yan Guoli (2010), the data with fixation time less than 80ms and beyond three standard deviations were excluded. Besides, the data of those students with high error rates were also deleted (about 8.5% trials). According to Yan Guoli et al (2013), first fixation duration (FFD), fixation count (FC) and total fixation time (TFT) were chose as the eye-movement measures. Then SPSS 19.0 was used to analyze the remaining obtained data.

Table 1. Mean and standard deviation of the first fixation duration, fixation count and total fixation time

| VWR             | FFD(ms) M | SD  | FC(n) M | SD  | TFT(ms) M | SD  |
|-----------------|-----------|-----|---------|-----|-----------|-----|
| HP              | 392.98    | 77.43 | 1.83    | 0.56 | 550.81    | 59.60 |
| CSW             | 434.37    | 75.74 | 2.15    | 0.68 | 710.32    | 77.65 |
| SRW             | 418.32    | 69.90 | 1.95    | 0.55 | 640.89    | 58.70 |
| UW              | 442.15    | 80.69 | 2.37    | 0.65 | 811.28    | 68.44 |

VWR: visual word recognition; HP: homophone; CSW: close-shaped words; SRW: semantically related words; UW: unrelated words

The data of the first fixation time of Chinese-English visual word recognition were analyzed with Levene, $p=0.196>0.05$, indicating that the variance was homogeneous, $F=17.042$, $p=0.000<0.05$, indicating that the first fixation time was significantly different among homophones, close-shaped words, semantically related words, and unrelated words. Then, LSD was used to analyze ANOVA. The results showed that there was a significant difference in the first fixation time between the two groups, and the effect of the first fixation time was very significant. The difference was significant between the homophones and semantic-related words ($p=0.001<0.05$), and that between the homophones and unrelated words ($p=0.000<0.05$) was also significant. The difference of the first fixation time between close-shaped words and semantically related words was $0.01<p=0.031<0.05$, indicating that the first fixation time of the two groups was significantly different. There was almost no significant difference between close-shaped words and unrelated words ($p=0.296>0.05$), and the effect of the first fixation time was not significant. The difference between semantically related words and unrelated words ($p=0.001<0.05$) was significant, and the effect of the first fixation time was significant.

The homogeneity of variance analysis was carried out on the fixation count data of Chinese-English visual word recognition, indicating that the variance was uneven. $F=31.147$, $p=0.000<0.05$, indicating that the fixation count was significantly different in the four groups. Then,
Tamhane’s T2 was used to analyze ANOVA. The results showed that the difference between homophones and close-shaped words \(p=0.000<0.05\) in fixation count was significant; and that between the homophones and semantically related words \(p=0.190>0.05\) was not significant. The difference of fixation count between the groups of close-shaped words and semantically related words \(p=0.004<0.05\), and that between the groups of close-shaped words and unrelated words \(p=0.006<0.05\) were significant. There was a significant difference in the fixation count between semantically related and unrelated words \(p=0.000<0.05\), and the effect of fixation was significant.

The homogeneity of variance analysis was performed on the total fixation time data of Chinese-English visual word recognition, showing that the variance was not homogeneous. \(F=572.106, p=0.000<0.05\), indicated that the total fixation time was significantly different among the four groups.

Then, Tamhane’s T2 was used to analyze ANOVA. The results showed \(p=0.000<0.05\) for all the groups, indicating that the total fixation time was significantly different, and the total fixation time effect was significant.

The auditory word recognition experiment was done. The phonological priming task has been used to explore three issues at the interface of nonnative phonology and lexical processing (Gor, Kira., 2018)

Table 2. Mean and standard deviation of the first fixation duration, fixation count and total fixation time

|        | FFD(ms) | FC(n) | TFT(ms) |
|--------|---------|-------|---------|
| AWR    | M       | SD    | M       | SD    | M       | SD    |
| HP     | 375.62  | 66.39 | 1.79    | 0.47  | 523.97  | 58.26 |
| CSW    | 440.33  | 78.20 | 2.19    | 0.64  | 736.96  | 59.58 |
| SRW    | 412.42  | 71.74 | 2.21    | 0.66  | 611.74  | 60.49 |
| UW     | 452.47  | 80.70 | 2.65    | 0.64  | 766.07  | 66.65 |

AWR: auditory word recognition

The data of the first fixation time of Chinese-English auditory word recognition were analyzed with Levene, \(p=0.991>0.05\), indicating that the variance was homogeneous; \(F=43.144, p=0.000<0.05\), indicating that the first fixation time was significantly different among homophones, close-shaped words, semantically related words, and unrelated words. Then, LSD was used to analyze ANOVA. The results showed that there was a significant difference in all the groups \(p=0.000<0.05\) except the groups of close-shaped words and unrelated words \(p=0.153>0.05\).

The homogeneity of variance analysis was carried out on the fixation count data of Chinese-English visual word recognition, indicating that the variance was uneven. \(F=83.397, =0.000<0.05\), indicating that the fixation count was significantly different in the four groups. Then, Tamhane’s T2 was used to analyze ANOVA. The results showed that all the groups \(p=0.000<0.05\), indication that the differences were greatly significant, except the groups of close-shaped words and unrelated words \(0.01<p=0.035<0.05\), indicating the difference was significant.

Finally, the homogeneity of variance analysis was performed on the total fixation time data of Chinese-English visual word recognition, showing that the variance was not homogeneous. \(F=702.097, p=0.000<0.05\), indicated that the total fixation time was significantly different among the four groups. Then, Tamhane’s T2 was used to analyze ANOVA, with the result \(p=0.000<0.05\) for all the groups, indicating that the total fixation time was significantly different.

4. Discussion

The amount of time spent looking at the word reflects the amount of time it takes to process the word. (Yang, Shun-nan., 2006) The first fixation duration can well reflect the early processing and load of word recognition; fixation count can effectively reflect the cognitive processing load of reading materials, and the more counts the more load; total fixation time can effectively reflect the post-processing and load of word recognition (Yan, Guoli., et a.l, 2013).
In visual word recognition, the subjects first saw the Chinese priming words, meanwhile they switched the language code. During the process of switching language code from Chinese to English, pronunciation was first activated instead of word form, so the first fixation duration and total fixation of homophones were the shortest, and the fixation count of homophones was the least. Then semantically related words were activated after the activation of homophones. Close-shaped words were then activated and unrelated words were the last. So in visual word recognition, it can be directly completed through “sound”, but the activation of word meaning does not necessarily involve the participation of “form”, and the activation sequence of lexical representation information is “sound-meaning-form”.

In auditory word processing stage, the subjects first heard the sound Chinese priming words, so “sound” is first activated and then word acquisition was directly completed. While “form” does not directly participate in the process of word acquisition in the whole stage, which also indicated there was no need for form to complete the word acquisition directly through sound. Therefore, the activation sequence of lexical representation information is also “sound-meaning-form”.

Actually, using the heat map and scan path (as in the following figure) on Begaze attached to SMI can also prove the above-mentioned conclusion.

![Figure1. sample of heat map](https://example.com/heat_map.png)

![Figure2. sample of scan path](https://example.com/scan_path.png)

5. Conclusion
In both visual and auditory priming paradigm, “sound” was first activated and then word recognition was completed. Therefore, phonological meditation route was appropriate. It is just because for Mongolian college students, their mother tongue is Mongolian, a typical pinyin language, in which “sound” is very important and it is an essential factor, which plays an important role in word processing and promotes the generation and recognition of words. (Niu, Xue. et al, 2017) So for Mongolian college students, while studying a foreign language, sound plays an essential role, especially in word recognition. Hence, for an English teacher teaching Mongolian college students even other minority students, he or she should know the importance of sound for those students and utilizes sound to make them remember words quickly, which can stimulate the students’ studying interest and make it easier for them to remember English words.

Acknowledgement
This study was financially supported by Innovation Team of Foreign Language Education Research (Gran No. 1110130137) and the Fundamental Research Funds for the Central Universities of Northwest Minzu University (Grant No. 31920190137).

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