

# *Relationship Between Bilingual Verbal Working Memory and Language Dominance*

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**Abstract:** The purpose of the study is to explore how language dominance impacts bilingual individuals' verbal working memory. The study recruited 36 participants who are bilingual in both English and Chinese Mandarin age between 18 to 25 years old. In 90-minute experimental sessions, participants' verbal working memory capacities both English and Chinese were measured by Following Instruction. And their language proficiencies in both English and Chinese were measured by Elicited Imitation Test. The result shows that Chinese dominant bilingual participants' verbal working memory capacity were significantly impacted by their language dominance, but English bilingual participants' verbal working memory capacity were not significantly impacted by their language dominance. Future research should consider to study whether Following Instructions is a reliable measure for bilingual populations' verbal working memory.

**Keywords:** Bilingual verbal working memory, Following Instruction, Elicited Imitation Test, Language dominance

## **1. Introduction**

Working memory (WM) is key to learning; it enables an individual to store incoming information and manipulate it in order to perform a task. Because "Following Instructions" is a verbal working memory measure, it would be essential to establish its validity with multilingual individuals. Although working memory is often considered a domain-general skill implicated in various specific cognitive domains such as language and math [1], a subcomponent of WM involves both verbal/phonological processing loop [2]. To date, studies on WM and bilinguals suggest that there may be a bilingual advantage for nonverbal WM; however, the effects on verbal WM are more mixed [3]. Some scholars attribute the lack of bilingual advantage in verbal tasks to the findings that word processing tends to be more difficult (e.g., take more time) for bilinguals than for monolinguals [4]. Language inhibition and switching may come into effect for bilinguals [5]. Yet, in these studies, the verbal WM tasks tended to be tested only in one language. Therefore, the primary aim of this study is to explore bilingual participants' verbal working memory in both of their languages using the "Following Instructions" [6].

## **2. Method**

### **2.1. Setting**

The study was conducted in a laboratory setting, in a cubicle room with a closed door located in a university school of Education building. The room has white wall with dark blue carpet. There are three tables and two chairs inside of the room. The equipment for Following Instruction (FI) is placed on the first table that sitting in the middle of the room. Participants and the administrators sit on the two opposite sides of the first table. And there is a PC with a keyboard and a laptop on the second table that is next to the first table. Participants use the PC to answer the demographic survey and the self-reflection survey. And the research administrators use the laptop to play audios of Elicited Imitation Test (EIT). An office file cabinet next to the second table. All participant's scoring sheets were stored in this cabinet. The third table is on the back of the room behind the administrator's chair. This setting was chosen because it is inside of a research lab, therefore it is close to all the equipment this study requires. Such as a PC, a camera, a tripod, an audio recorder, the FI equipment, etc. Having the study equipment in a close distance allowed administrators set up the study conveniently.

### **2.2. Participants**

This study recruited 36 bilingual (English and Mandarin Chinese) participants who were either recruited through a university human subjects lab pool or through word of mouth. The age range of participants is from 18 to 25 years old. All of the participants were either in college or graduated from college. Some participants are Chinese dominant (e.g., Chinese international students), while others are more English dominant (e.g., generation 1.5 or 2.0 Chinese American). Each participant received either class extra points or a \$15 gift card for one hour of participation.

### **2.3. Apparatus**

In order to ensure the internal reliability of this study, participants were audio recorded while doing EIT- a language proficiency measure by a 32GB EVIDA 2324 Voice Recorder. Participants were video recorded while doing FI- a verbal working memory task by a Kodak PIXPRO Camera with a 128GB memory card. Participants used a Lenovo computer desktop to complete the surveys. Research administrators used a Lenovo Chromebook laptop to play EIT audios and upload the recorded audios and videos to a private google drive.

### **2.4. Confidentiality**

Participants were auditory and visually recorded during the study. Before a research session started, administrators informed participants that they would be recorded during the study. Participant then signed consent forms. To protect participants' confidentiality, participants' faces were not in the camera pictures. And all of the recordings were coded without participants' personal identifiable information.

### **2.5. Procedures**

Experiment Structure. All participants completed an initial demographic survey to collect demographic data. They then completed Elicited Imitation Test (EIT)- a language proficiency test (English or Chinese, counterbalanced across subjects) followed by Following Instruction (FI)-a working memory task administered in either language (randomized to be either English or Chinese). Following a short 5-minute break, participants then completed the EIT and FI in the language not test in the first session (English and Chinese). Next, participants were asked to complete a self-reflection

survey, which included questions to assess their subjective view of their own performance on the working memory tasks. The entire experimental session took approximately 90 minutes (Table 1).

Table 1: The structure of the study

| Task                      | Test Domain | Time     | Modified From          |
|---------------------------|-------------|----------|------------------------|
| Demographic Survey        |             |          | Montrul, 2012 [7]      |
| Following Instruction 1   | Language    | 20 min   | Gathercole et al, 2008 |
| Elicited Imitation Test 1 | Verbal WM   | ~ 10 min | Wu, 2013 [8]           |
| Break                     |             | 2 min    |                        |
| Following Instruction 2   | Language    | 20 min   | Gathercole et al, 2008 |
| Elicited Imitation Test 2 | Verbal WM   | ~ 10 min | Wu, 2013               |
| Self-Reflection Questions |             | 1~2 min  |                        |

Elicited Imitation Test (EIT) – A measure for language proficiency. EIT is a standardized oral language proficiency test. Participants are prompted to repeat as accurately as possible after hearing a sentence. The utterances start with short sentences with few key words (e.g., “I have to get a haircut”), and get increasingly long sentences with more key words (e.g., “The black cat that you fed yesterday was the one chased by the dog.”). There are 30 utterances in a set of EIT.

Participants’ EIT performances were graded in four categories: syntax, vocabulary, pronunciation, and meaning. Each participant’s EIT was evaluated by 2 raters. If there is a disagreement on the score, two raters review the recorded audio and come with a final score together.

Following Instruction (FI) – A measure for verbal working memory. FI entails participants to correctly perform a motor sequence after hearing a set of instructions, with the number of instructions increasing as an individual executes them correctly. The task starts out with very simple instructions (e.g., “touch the red box”), and gets increasingly difficult with more complex, longer action sequences (e.g., “Touch the yellow car and pick up the blue fish and put it in the red box. And then pick up the blue train and put it in the yellow cup.”). There are 24 questions in each set of FI.

Participants’ FI performances were measured in three ways: total questions correct, total memory span, total components correct. During FI, research administers manually record the participants’ actions as the participants move the objects. After the research session, researchers go back to FI video recordings to check if participants’ actions were accurately recorded before entering the data and calculating participants’ FI scores.

### 3. Results

This study sought to explore on whether bilinguals’ language dominance affect their verbal work memory performance when tested in different language. Data were collected from 36 bilingual young adults. Each participant completed a 90-minute experimental session, including a demographic survey, Following Instruction in English and in Chinese, Elicited Imitation Test in English and in Chinese, and a Self-Reflection Survey. Results show that Chinese dominant participants’ verbal working memory performances were affected by their language dominance; however, English dominant participants were not.

#### 3.1. Following Instruction Performance.

Chinese dominant participants’ English and Chinese version of FI performance is significantly different with each other. ( $p = .0038$ ) In other words, language dominance affects Chinese dominant participants’ verbal working memory performance. On the contrary, English dominant participants’

English and Chinese version of FI performance did better in their dominant language. ( $p = .093$ ) However, since the  $p > .05$ , the difference is not significant. In other words, language dominance does not affect English dominant participants' verbal working memory performance in a statistically significant level (Figure 1).

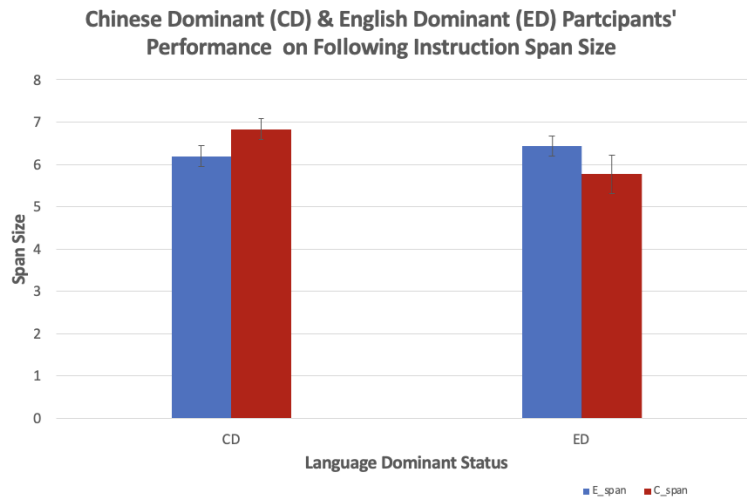


Figure 1: Chinese Dominant and English Dominant Participants' Following Instruction Performance

### 3.2. Elicited Imitation Test Score Difference.

There was much more variance in Chinese proficiency levels of the participants when compared to the variance in English proficiency level. As showing in Figure 2., the largest difference between their Chinese and English ability was 70, so their Chinese EIT score was better than their English EIT score by 70. However, range for the negative difference is much wider. The largest difference for an English dominant speaker's Chinese and English ability was -170, meaning that their English EIT score was 170 points higher than their Chinese EIT score. It shows that participants' English was on a similar level, but levels of Chinese proficiency varied.

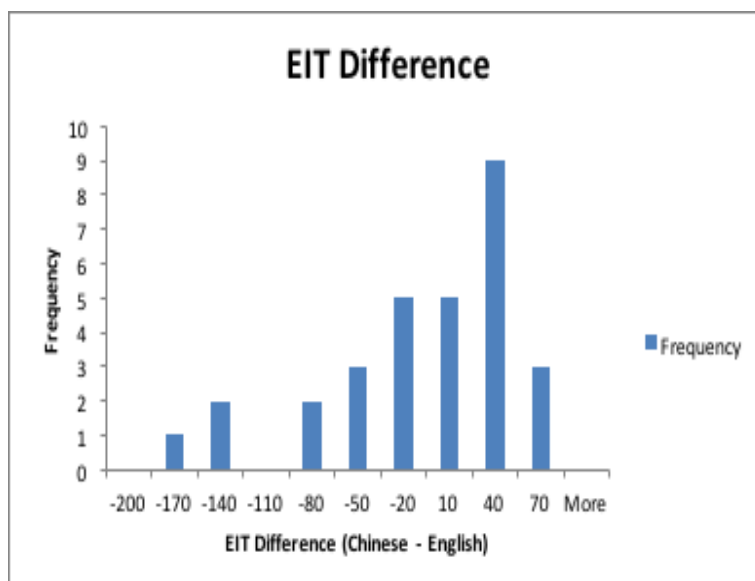


Figure 2: EIT Difference

### 3.3. Following Instructions & Elicited Imitation Differences.

Despite the EIT difference, participants' English verbal working memory performance for both English Dominant and Chinese Dominant in English was around the same (Figure 3). However, participants' Chinese verbal working memory performance were much varied (Figure 4).

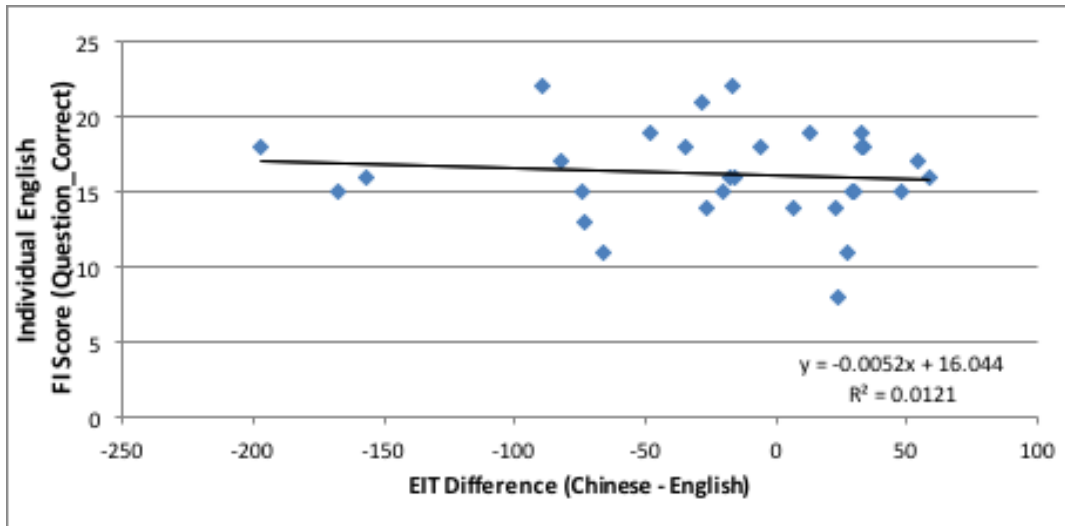


Figure 3: English FI with EIT Difference \*Note. The slope is not too steep, showing that performance for both ED and CD in English was around the same

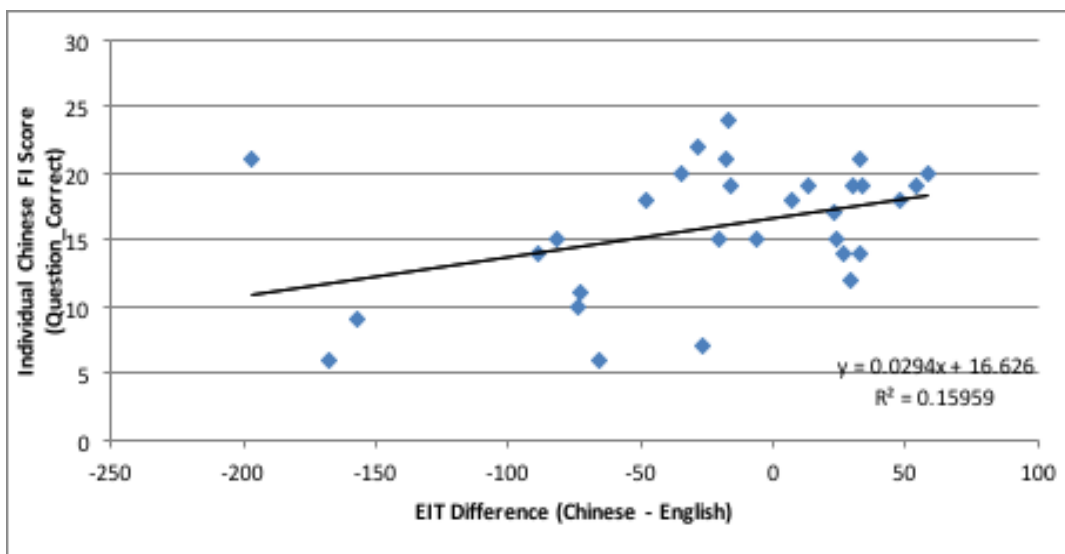


Figure 4: Chinese FI with EIT Difference ( $r=.40$ ,  $p=.03$ ) \*Note. Compared to the graph 3, the slope is much steeper, which means their performance is varied

### 3.4. Possible Explanations for the Results.

There are two possible explanations for this result. On one hand, all Chinese dominant participants' English proficiency is at a level high enough to enter American universities. But this is not the same case for English dominant participants. In other words, if we recruit English dominant participants whose Chinese level are similar to current Chinese dominant participants' English proficiency level, the result may be different. On the other hand, by doing a reliability check for Following Instructions,

the scale of reliability coefficient is approximately 0.71. By comparing this reliability for FI with other reliability for other study in the working memory field, it is a relatively low reliability scale. For example, studies in the same lab shows that FI reliability for kindergarteners is around 0.85. Therefore, it is possible that FI may not be a reliable measure for bilingual population.

#### 4. Limitations

The study was conducted in an English-speaking university with a small sample size, which may cause limitations on generalizing the data results. Also, even though Chinese dominant participants' English proficiency are similar, the English dominant participants' Chinese Mandarin level are varied. In other words, the participants' varied language proficiency on their second language may compounded the study results. Ideally, the research project should recruit Chinese dominant participants whose English proficiency level is similar to English dominant participants' Chinese proficiency level. In addition, in an ideal situation, the study should have more than 100 participants to improve the generalization of the result as much as possible.

#### 5. Suggestions for Future Research

In the current study, result showed Chinese dominant participants' verbal working memory capacity were significantly impacted by their language dominance, but English dominant participants' verbal working memory capacity were not. Compared to the FI reliability for other studies in the same lab, the current study's FI reliability is fairly low. Therefore, future research should consider to explore if Following Instructions is a reliable measure for bilingual populations. If it is not a reliable measure, it is important to explore what are some reliable measures for bilingual populations.

#### 6. Conclusion

This study presented how bilinguals' language dominance affect their verbal working memory capacity. During data collection, 36 bilingual young adults participated this study. Each participant completed two sets of Following Instructions task (a verbal working memory measure) and two sets of Elicited Imitation Test (a language proficiency test) in English and Mandarin Chinese. The data shows that Chinese dominant participants' verbal working memory capacity was significantly impacted by their language dominance. However, English dominant participants' verbal working memory capacity was not significantly impacted by their language dominance.

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