

# Processing Four-Character TCM Terms by Foreign Students of TCM in China: A Cultural Neuroscience Approach

Ningjun Xu, Hongxia Zhang<sup>\*</sup>

College of Humanities and Management, Zhejiang Chinese Medical University, Hangzhou, PR China

## Email address:

judexu@zcmu.edu.cn (Ningjun Xu), evezhanghx@sina.com (Hongxia Zhang)

<sup>\*</sup>Corresponding author

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**Abstract:** Traditional Chinese Medicine (TCM) has been in China for thousands of years, which is the collective wisdom of Chinese people and has made huge contribution to the health care of China and neighboring countries. Yet, in the modern era, it has undergone criticism for being non-scientific. One approach to this unfair criticism is to explore the neurological basis of some classic TCM terms known as four-character TCM Terms (FcTTs) by foreign students majoring TCM in China because it is clear that one major obstacle for learners of TCM to fully appreciate TCM is to crack the difficult classic Chinese as most of the TCM canons are written two or three thousand years ago whose language is full of metaphors. Currently, cultural neuroscience has provided a suitable paradigm to explore the tripartite relationships among culture, communication, and molecular genetics with the hypothesis that culture influences human brain. The current research is therefore carried out with the help of Event-related Potential technology in order to uncover the neurological basis of FcTTs. Under the guidance of Prime-Target Paradigm, an ERP experiment is carried out with 21 foreign students from key Belt and Road Initiative countries, which is fully in conformity with the Declaration of Helsinki. Statistical analysis of data elicited from ERP experiment shows the prominence of N400, a reliable indicator of difficulty in retrieving figurative meaning during reading, thus prove that CFL learners also show a direct access to literal or non-literal meaning in accordance with the prominence of the context.

**Keywords:** TCM Globalization, Belt and Road Initiative, CFL Learners, N400, ERP

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## 1. Introduction

Cultural neuroscience, as an interdisciplinary branch belonging to cognitive neuroscience, incorporating the methodology and theories from cross-cultural psychology, neuroscience, and molecular genetics, is trying to uncover the tripartite interrelations among “gene-culture-behavior” in terms of some conventional yet mysterious psychological activities such as empathy, perspective-taking, among others [1]. Some leading scientists in this area such as Y. Chiao claim that human brains are equal to cultural brains, functioning three key aspects of human life, i.e., modulating social studies, human interaction, and cultural transmission [2]. The plasticity of human brains is attributable to long-time evolution and social experience, the change of which could be permanent. The majority of neuroscientists mainly focuses on the commonality of human brain, trying to

establish an immutable model, ignoring the cultural effect on the behavior, which could tweak, though subtly or imperceptibly, the structure of human brain, especially the neuronal circuits, thus imprinting a near-permanent mark in the brain. Cultural neuroscientists, however, highlight the influence of culture on the behavior as well as on the structure of the brain, thus, enabling to provide a much more persuasive explanation as to the impetus of human activity.

The culture of traditional Chinese medicine (TCM for short) is considered an influential part in shaping the mindset of Chinese people. The mindset of Chinese people are imbued with those concepts such as Ying and Yang, Five-phase, or “Qi” (inner energy), which are essential for understanding TCM. With the high-quality development of the Belt and Road Initiative, the number of foreign students coming to China to study TCM has witnessed a new round of increase, even under the impact of COVID-19 which, to a great extent, obstructs the flow of people around the globe.

Since the barrier to understanding TCM canons basically rests upon the possibility of cracking Chinese and *Huangdi Neijing* (黄帝内经), one of the four classical TCM canons, is full of four-character terms, how much one understands these terms determines how much one understands the whole book. Therefore, an understanding of how learners of Chinese as a second language perceive relevant TCM cultural elements as embodied in four-character terms might shed light on how culture shapes and is shaped by a particular concept.

## 2. Literature Review

During the past 20 years, scientists in North America, later, around the world, have been working on the interaction between brain and culture, resulting in many prominent findings which have attracted both hard scientists such as neuroscientists and soft scientists such as intercultural communication researchers. For a lot of times, especially in the field of social cognition, those findings done by cultural neuroscientists have confirmed what the behaviorists once claimed. For instance, researchers in the 1970s and 1980s in the field of cross-cultural communication claimed that people from such cultural backgrounds as individualism and collectivism usually foster a very different conceptualization of honesty about themselves and others without knowing how the two brains function so differently with same or similar structure [3]. Now, cultural neuroscientists could provide a very satisfactory answer to this puzzle by discovering that while the subjects from American culture are conceptualizing self-honesty and other-honesty, the same area of their brain has been activated; however, different areas of the brain of subjects from Asian culture have been activated while they are perceiving self-honesty and other-honesty [4]. In other words, different neural circuits are activated while processing self-honesty and other-honesty between American and Asian subjects, which could be attributable to cultural disparity. In another study [5], researchers try to explore the cultural influences on the brain by looking into self-enhancement, which plays a key role in interpersonal communication. It is well acknowledged that people of Asian descent tend to ignore self-enhancement because Asian culture downplays compliments. On the contrary, people of European descent tend to embrace self-enhancement as much as possible as a typical representative of individualist culture. The ERP experiment confirms this finding because N170, an important component of ERP to recognize facial expression as well as negative semantic processing, exhibits differently between Chinese subjects and English-speaking subjects.

In other cases, the research findings done by cultural neuroscientists could posit serious challenges to the long-held theories in the field of behavioral science. It is long been considered as valid that people under the influence of western culture would focus on the interaction per se while people from Asian culture take other factors into consideration such as power, and/or long-time goal. Edward Hall, one of the earliest leading theorists and practitioners in

the field of intercultural communication pioneered the theory of high-context vs. low-context cultural paradigm, which has become a firmly accepted theory to explain the seemingly behavioral difference between the east and the west [6]. However, through fMRI technology, Gutchess et al [7] discovered that though it is possible to conclude, based on the imaging, that three areas in the American subjects, i.e., gyrus temporalis medius (associated with semantic processing), right temporal and superior marginal gyrus (associated with spatial information processing), and superior parietal lobule (associated with locality decoding) have been activated more highly than those of Chinese subjects, it is hardly evident enough to notice any difference in terms of processing background information between Chinese and American subjects. The experimental findings are among some of the most convincing neural evidence to disprove the self-report or so-called scientific survey-elicited data to uncover the underlying reason leading to communicative impediments or even breakdown. In other words, the neural experiments designed to monitor the brain activities during processing certain types of incidents can make up and complement the deficiency elicited from reported or self-reported survey methods that are quite prevalent in the field of behavioral science. It could also shed light on how the three components of human life, brain, culture, and behavior are interconnected to each other.

Many scholars in the field of internalization of TCM culture attribute its quandary to the differences of thinking mode between the Orient and the Occident, yet without knowing it is the fundamental difference in terms of cultural consideration. Literature collection and research has long been considered an important part of inheriting and developing TCM. As one of the key areas in the field of TCM research, TCM culture is valued the most for the simple reason that it underlies some fundamental aspects of TCM. As can be imagined, traditional Chinese culture such as what is contained in the *Book of Changes*, *Ying-Yang Theory* etc. is naturally considered as part of TCM culture. yet, researchers differ as to the concrete conceptualization of TCM culture. Some researchers try to highlight the significance of TCM culture by claiming “TCM culture is not just a value orientation between the medicine and object, but more importantly an overall consideration of how the doctors use their minds and hearts to deal with their patients” [8]. Others try to substantiate the components of TCM culture by resorting to social science research methodology such as collecting data through distributing questionnaires or conducting interviews [9]. Their data shows that TCM culture can be summarized as “Way and Law out of Nature, Uprightness with Precision, Care of Body as well as Mentality, Medicine from Nature”. Vague as it is, it indeed succinctly recapitulates the core part of TCM culture, yet failing to meet the requirements of measurement. Zhang Qicheng [10], a leading figure in the field of TCM culture research, began to lay out the basic function of TCM culture, and then put forward his version by claiming that four Chinese characters can be combined to amount to TCM culture, i.e., “benevolence, harmony, perfection, uprightness”. Still, it is

impossible to evaluate whether this conceptualization is valid or not as it is too subjective and esoteric.

In 2021, Chinese government published an *Outline of Publicity of TCM along with One Belt One Road* (2021-2025), setting out national plans to establish TCM overseas center, TCM international standard, and TCM overseas exchange and cooperation model sites, which provides a solid foundation in terms of policy. However, still scholars claim it is the difference of thinking mode that thwarts the spreading of TCM abroad. Jiang Jibiao [11] even enumerates six dimensions such as “cultural distance, psychological distance, system distance, management distance, economic distance, geographical distance”, whose philosophy reminds us of Hofstede’s cultural dimensions. Still others endeavor to incorporate the cross-cultural acceptance of TCM culture from anthropological perspective, which, in essence is within the framework of intercultural communication [12].

If it is true that cultural barriers are to blame for the failure of the wide acceptance of TCM in other countries, especially, in western countries, then the first step to do in order to facilitate the cultural transmission should focus on how the cultural barriers are reflected in TCM culture. If language is the carrier of culture, and if TCM culture is recorded in many TCM canons, then, the decoding of TCM canons such as *Huangdi Neijing* (Yellow Emperor’s Internal Canon) is the first step to dissecting the mystery of TCM culture in intercultural communication. Research shows that many four-character TCM terms abound in TCM literature [13]. The four-character TCM terms (FcTT) are defined as the terms or phrases that consist of four Chinese characters, most of which are noun phrases, some clauses. They are pithy in structure, yet profound in meaning, many of which are metaphorical in nature [14]. Many translation strategies are put forward to deal with how to translate these four-character terms into English. Yet the cognitive understanding of these terms is still quite vague. If the first step of spreading TCM culture is to introduce TCM culture to the world through translation, then the next crucial step is to work out how human brains process TCM culture reflected in those four-character terms, revealing physiological and neural mechanism, which could lead to the final acceptance. As a lot of four-character terms are metaphors, then it is crucial to know how humans process metaphors. Conceptual blending theory, a key model in the current research literature surrounding the processing of metaphors [15], is well acknowledged as a valid theory that can explain how our brain processes metaphors cognitively and psychologically, which is used here in this paper as a supporting theory to design the experiment.

### 3. Theoretical Foundations and Research Questions

Metaphors abound in human history and human life. Well-known philosophers and politicians including Socrates in ancient Greece and Confucius in ancient China have

emphasized the importance of using metaphors to express their philosophical ideas. In the 1930s, English rhetorician and linguist Richards extended the usage of metaphor to our daily life [16]. In 1980s, Lakoff and Johnson [17] even put forward the famous claim that metaphor is the basic thinking method by which humans live. Liu Yuhong [18] argued that humans are unable to express their ideas and engage in communication once metaphor is robbed. Simply put, metaphor is the direct link between the tenor (object being described) and vehicle (object compared to). Simple as this definition is, researchers are curious about how audiences uncover the link between the two objects. Traditionally, from a psycholinguistic perspective, the first step of understanding a sentence is to do segmentation, and match that with mental lexicon to get the meaning of each component and meaning of the whole sentence is deduced by reorganization of meanings. As metaphor involves not only literal meaning, but more importantly the non-literal meaning, the traditional theory obviously cannot provide satisfactory answer as to how human brain processes metaphor.

From a cognitive perspective, metaphor processing can be roughly divided into two types. One is Direct Access Model (DAM). Instead of embracing the traditional view that the literal meaning of the metaphor will be first accessed before being negated and transferred to the non-literal meaning, direct-access hypothesis proposed by famous psychologist Gibbs [19] argued that the non-literal meaning is first accessed, passing the useless literal meaning based on the claim that biasing context prompts the readers to choose non-literal meaning. This theory is applicable to very mature and conventionalized metaphor. Back to 2003, Giora [20] combined these two theories and argues that the access to the literal or non-literal meaning is dependent on different salience, thus called Graded Salience Hypothesis (GSH). A series of factors, i.e., conventionality, familiarity, frequency of words, representativeness of words, etc., play a role in determining whether the literal or non-literal meaning is prioritized. The opposite to this instant unilateral activation model is Parallel Distributed Processing (PDP) (for example, Rumelhart [21]). Based on the research of neurological activities in the brain which take place at the same time, cognition is also similar to other neurological activities, which leads to the competition of literal and non-literal meanings.

During the past 30 years, conceptual blending theory proposed by Fauconnier and Turner [22] began to gain momentum. Fauconnier and Turner claim that semantic processing is basically a process of conceptual blending. Mental space, also known as conceptual package is created out of human conversation or thinking. Four mental spaces, i.e., two generic spaces and two input spaces are cross-influencing with each other, resulting in emergent structures. Psycholinguists and neuro-linguists are trying to prove or disprove conceptual blending theory by collecting data using eye-tracking, ERP, and fMRI. While eye-tracking technology tries to correlate the focus of our eyes with what we are thinking [23], several important parameters such as fixation, saccade, and regression can show how much the

brain is processing information. This is an indirect way of “observing brain activities” during reading or other cognitive behavior. ERP, on the contrary, is trying to record the actual EEG during experiment. Components like N400 and P600, the former reflecting the difficulty of semantic processing, the latter focusing on syntactic processing, are widely used by researchers to explore brain activities [24]. Researches on semantic processing of metaphors abound. For example, Coulson and Petten [25] used ERP to prove Conceptual Blending Theory. They have discovered that N400 begins to become prominent during the process of interaction between the tenor and the vehicle, showing the correlation between the difficulties of metaphor processing and projection.

However, seldom do researchers try to uncover the semantic processing of four-character TCM expressions done by Chinese as a Foreign Language (CFL) learners. It is well known that Chinese language is among the most difficult languages to learn as a foreign language, let alone classic Chinese. Since classic TCM literature such as *Huangdi Neijing* is written in Classic Chinese, how CFL learners process four-character terms, most of which contain rich non-literal meanings, can shed light on the intercultural perception of TCM. Therefore, the current research focuses on the ERP-induced experiment, trying to uncover the neural basis of CFL learners’ processing of four-character TCM terms and expressions.

## 4. Research Design and Data Collection

### 4.1. Experiment Design

This study is one of the first kinds with an aim to explore

the online processing mechanism of FcTT by CFL learners, focusing on the metaphorical recognition. First of all, we adopt a Prime-Target paradigm. The priming context is created out of expressions biasing either the literal or non-literal perception of FcTT. The Target is the FcTT following the prime. The stimulus pool contains 80 FcTT selected from *Huangdi Neijing* as materials for the experiment. In order to create the priming context which either is conducive to literal interpretation (hereinafter LIC) or non-literal interpretation (hereinafter NIC), phrases indicating LIC or NIC are created, resulting in 160 paired “prime (LIC or NIC context)-target (FcTT)” materials in total, which is supposed to be the minimum priming contexts in the ERP-based experiment [26]. For example, those FcTT such as 大便干燥 (dry stool), 小便频数 (frequent urination), 气为血帅 (qi is the commander of blood), 血为气母 (blood is the mother of qi), 虚邪贼风 (deficiency-type pathogen and abnormal weather), 暑易入心 (summerheat tends to invade the heart), 百脉一宗 (all vessels are of the same origin), 客气邪风 (abnormal climatic factors), 夏应中矩 (in the summer, the pulse is like a carpenter’s square (i.e., surging and large)) are the targets. In each target, an LIC or NIC word cluster is created in such a way that the subject is supposed to reach its either literal meaning or non-literal meaning. For example, 生理表述 (physiological description) serves as a prefatory remark to set an LIC context before 大便干燥 and 小便频数, yet it serves as a prefatory remark to set an NIC context before 气为血帅 or other FcTT (Figure 1). The stimulus pool also includes 80 filler trials randomly mixed with the true stimulus trials in order to avoid any possible guess.

Condition	Stimulus trials	
	Prime	Target
LIC	生理表述(physiological description)	大便干燥(dry stool)
NIC	疾病表征(diseases symptom)	气为血帅(qi is the commander of blood)
Filler	日常对话(daily conversation)	四肢疲软(feeling tired)

Figure 1. Example stimulus trials for ERP experiment.

### 4.2. Participants

All together 21 foreign students from South Asian countries (Belt and Road Initiative Member States) studying at one university of Traditional Chinese medicine with a major of TCM were recruited (13 female students and 8 male students) with no visual impairments and any neurologically related disorders. The participants voluntarily took part in the experiment. The whole experiment is in conformity with Declaration of Helsinki. They are all right-handed with competent Chinese reading and writing (HSK-4). Of the participants, 3 were excluded from data analysis technical problems during EEG data recording.

### 4.3. Procedure

Each participant took part in the test independently in a

softly lit lab with soundproof facilities in front of a computer within a distance of 1.2 m. Before the experiment, each participant was informed orally how to go through the whole procedure and also practiced several trial tests in order to familiarize themselves with it before the real task began. The test-taker was told that in the beginning there is a blank screen with a white fixation cross in the center of the screen, lasting 400ms. After that, the test-taker will see the prime for 800ms, followed by a white screen lasting 400ms. Then, the Target was presented for 1200ms, and followed by another white screen lasting 500ms. Lastly, the test-taker was asked to make a decision whether the Target is a metaphor or not by pressing either F if it is metaphorical or J if it is non-metaphorical. No key-in response indicates no definite answer. The simplified flowsheet showing the experiment procedure is shown in Figure 2.

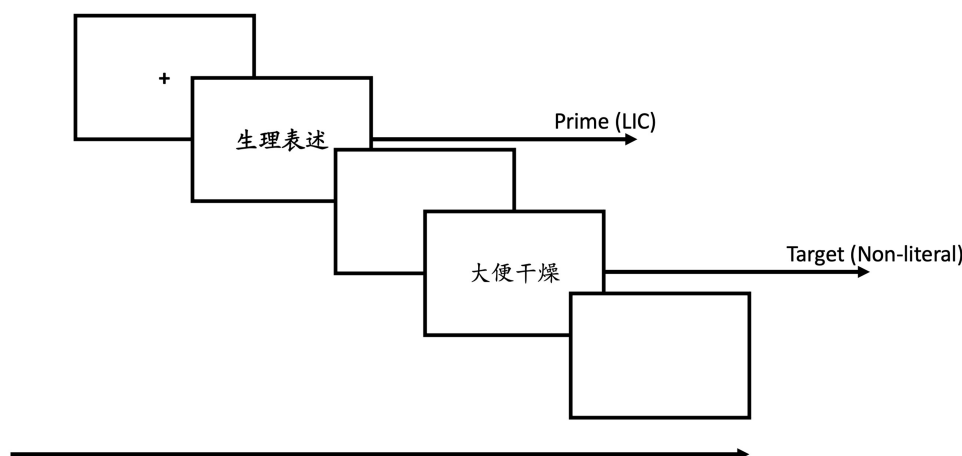


Figure 2. Schematic description of the experimental task.

#### 4.4. Electrophysiological Recording and ERP Data Preprocess

EEGs were continuously recorded with an elastic 32-channel cap from Brain Products Inc (BP). The electrode sites were following the extended 10–20 convention. The electrode is placed under the right eye in order to get the vertical EEGs while another electrode is under the outer corner of the test-takers' right eye to get the horizontal EEG. There are some conventional parameters in EEG recording: (a) the electrode impedances are less than 5 k $\Omega$ ; (b) the voltages of amplified analog are kept at 1000 Hz; (c) the bandpass is between 0.05Hz and 100 Hz. Brain Products Analyzer is used to analyze the EEG data. First, the signals below the level of low pass 30 Hz, within zero phase shift and above high pass 0.1 Hz have been deleted. Second, we set the minimum number of eye sweeps to 20, blink duration of no longer than 400ms, and with a 10% upper and lower threshold; all the optic artifacts that are out of this range have been removed. Third, with the rest of the ERP data after all the optic and movement artifacts have been filtered, the time duration between 200ms and 1000 ms has been chosen as the data for further analysis. As for the baseline, the period from the very beginning to 200ms is used and calculated by test-takers. Finally, the grand average ERPs of each condition (LIC, and NIC) were obtained.

## 5. Data Analysis and Discussion

### 5.1. ERP Data

Data from ERP recording first underwent statistical analysis. Participants responded significantly more slowly to non-familiar to metaphorical FcTTs. This indicates that it was challenging to determine whether the FcTTs were interpreted in a non-literal way. Grand averages elicited by the experiment at selected electrodes (C2, Cz, P3, Pz) are shown in Figure 3. As shown in the figure, a N100/P200

dyad is observed starting at 100 ms after the onset of the Target. Around 420ms a negative component can be observed and thus can be considered as N400.

### 5.2. Discussion

Data collected from ERP experiments clearly shows that the CFL learners in this experiment have met difficulties in interpreting metaphorical FcTTs. N400 is often considered as a reliable component to reflect the difficulty of getting additional or conceptual information associated with the expression. This finding suggests that encountering new information requires more pressure, even with the support of prompts, which in this experiment is provided by the Prime. The challenges in neural responses elicited by our experiment are in line with other similar report [26] in dealing with Chinese *Xiehouyu*, which also requires the test-takers to invest a large amount of energy trying to figure out the literal meaning.

According to GSH, at least two mechanisms are running in parallel during semantic processing: bottom-up and top-down. Saliency, which is conditioned in the prime, plays a key role as to whether the literal or non-literal meaning is accessed. The data elicited from current experiment seems to support GSH, which is summarized that the major role determining priority of access is saliency or prominence. For our experiment, the prime either biasing LIC or NIC indeed influences the appearance of N400, its intensified effect during the peak and later negativity.

On the contrary, data collected from ERP seems to fail to indicate the validity of PDP model during processing FcTTs by CFL learners. It can be explained away either because the linguistic competence of CFL learners are not strong enough to produce the co-existence of both literal and non-literal meanings, or because on some occasions non-literal meaning is more prominent and on other occasions literal meaning is more prominent, which goes back to support GSH.

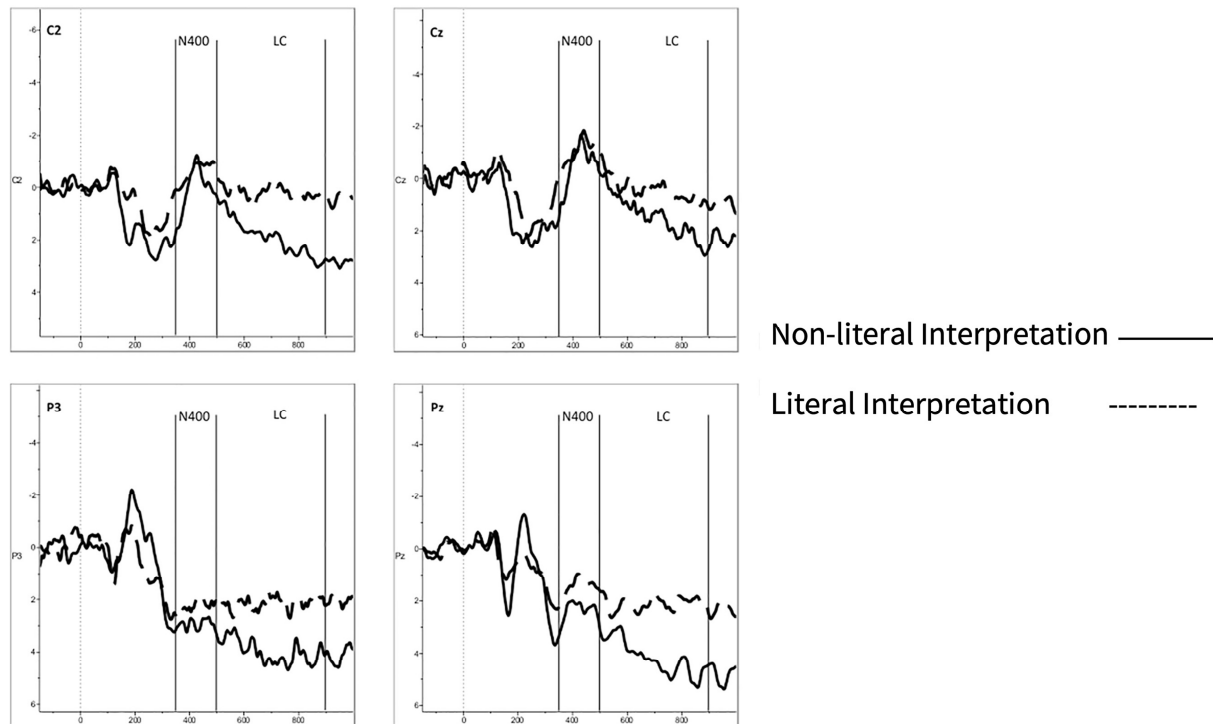


Figure 3. N400.

## 6. Conclusion

The current ERP experiment is aimed to explore the possible neurological basis for CFL learners during their reading of TCM canons, especially when they are encountering four-character TCM terms, most of which are metaphorical in nature, thus requiring non-literal interpretation mechanism to play. The findings prove the GPH as a valid explanation of how TCM metaphors are processed. Besides, the findings in this experiment confirms the importance of N400 component in analyzing the cognitive load of foreign students majoring in TCM, thus paving the way for the explanation of neurological barrier facing TCM interculturalization. The significance of the current research lies in the fact that after all the processing of FcTTs between native Chinese and non-native Chinese basically share the same neurological basis and have met the same difficulties. This finding once evidenced the possibility of communicating TCM across cultures. As the limit in methodology prevalent in humanities and social sciences, it is impossible to elaborate on the detailed causes of barriers that impede the effectiveness of intercultural communication by relying only on self-report of subjects. Take western medicine as an example. It has become a reality that in China, western medicine is the first resort when Chinese people get sick. The same thing happens almost around the world. How is it possible that western medicine can be embraced nearly without any impediment by people in every corner of the world, yet traditional Chinese medicine has hardly been accepted by Europeans and Americans? Is it mainly due to

cultural difference or physiological? These questions can at least be partially answer through current research.

A limitation of this experiment is that we only measure the effect of context biasing either literal or non-literal interpretation of the FcTTs, ignoring other possible influencing factors. Another very important factor that can be taken into consideration is the test-takers' familiarity with the metaphor. As is shown by other research [20], the foresight out of familiarity of certain metaphors definitely influence whether the literal or non-literal meaning is accessed first or are accessed simultaneously. Besides, metaphors in TCM canons come from a variety of forms: sometimes it is noun-noun form, other times noun-verb construction. However, we make no difference in this grammatical variety. It is also possible that such a syntactic structure play a role in cognitive processing.

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