

Interfering Embodiment Effects on Chinese “Transfer Verbs”

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This research aims to explore the processing of embodied meaning during the comprehension of Chinese transfer verbs which is different from the typical structure of transfer verbs in English and other Indo-European languages. An Action-sentence Compatibility Effect (ACE) paradigm was used, in which participants were asked to read sentences describing a transfer verb either away from (*At the court, a player throws tennis ball to opposite side*) or toward themselves (*At the court, a player throws tennis ball to my side*). Following the transfer verb, a visual motion cue appeared on the screen after one of the three stimulus onset asynchrony (SOA), prompting participants to move their hand either away from or toward themselves by pressing a button. The results showed that under short SOAs (cue presented 100 ms or 200 ms after the verb onset), interference occurred in the matching conditions. After larger delaying of the cue (350 ms), facilitation emerged in matching conditions. The results reflect special features in describing motion events by using Chinese transfer verbs, providing evidence that the comprehension of transfer-verb sentences in Mandarin activates the sensory-motor systems of our body, either interfering or facilitating a motor response performed in parallel.

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The embodied cognition approach differs from other conventional approaches to linguistic meaning (e.g., amodal theories), holding that language comprehension is grounded in the body and the perceptual, motor, affective and social experience of the world. Moreover, language comprehension can be conceived as the internal simulations reusing the brain’s modal systems (Barsalou, 2010; Buccino Colagè, Gobbi, & Bonaccorso, 2016; Glenberg, 1997; Kiefer & Pulvermüller, 2012; Meteyard, Rodriguez Cuadrado, Bahrami, & Vigliocco, 2012; Pulvermüller, 2002; Zwaan, 2014).

Within the framework of embodiment approach, the classic Action-sentence Compatibility Effect (ACE) paradigm is frequently used (Glenberg & Kaschack, 2002). The frequently used design is that participants read or listen to sentences that describe motor actions away from them (e.g., *You gave Mary a toy*) or toward them (e.g., *Shannon gave you a book*), and they are asked to judge how sensible the sentences are. For some participants the ‘yes’ response requires moving their hand away, whereas for other participants ‘yes’ is assigned to moving their hand toward themselves. These motor responses either match or mismatch the action direction described by the sentences. Glenberg and Kaschack (2002) reported faster motor responses for trials in which participants moved their hands in the same direction as the described action (meaning-action matching) than in the opposite condition (meaning-action mismatching). Other ACE experiments replicated this matching advantage, exploring the meaning-action interaction throughout the sentences (Borreggine & Kaschack, 2006; Buccino et al., 2005; Kaschack & Borreggine, 2008; Taylor & Zwaan, 2008, 2009; Zwaan & Taylor, 2006). For instance, Zwaan and Taylor (2006) used sentences referring to clockwise (*The thirsty marathon runner opened the water bottle*) or counterclockwise (*The music was too loud and she turned down the volume*) hand actions. The participants self-paced the sentences word by word, either performing the action in the same or opposite direction as the direction indicated by sentences (turning a knob to the right or turning it to the left). A matching advantage was found while reading the verb (e.g., ‘*opened*’ and *turning the knob clockwise*), indicating that the facilitation occurred as soon as the readers got enough information from the manual action direction.

However, other studies reported interfering rather than facilitatory ACE, namely, faster responses in the meaning-action mismatching than in the matching conditions (Boulenger et al., 2006; Buccino et al., 2005; Sato, Mengarelli, Riggio, Gallese, & Buccino, 2008; de Vega, Moreno, & Castillo, 2013). The timing of the action verb and the hand motion could be a critical factor to determine the facilitatory or interfering ACE. For example, Boulenger et al. (2006) revealed that processing the action verb interfered

with an ongoing motor response as early as 160-180 ms after the response was initiated. When the motor response followed the action verb the facilitatory effect occurred. Note, however, that these experiments included isolated action verbs rather than action sentences, with a complex go-nogo procedure involving kinematic measures. In another research de Vega et al. (2013) crucially manipulated the timing between the transfer verb and the requested motor response, while reading sentences with transfer actions. They hypothesized that the degree of temporal overlapping between the transfer verb and the requested matching motor response might yield either interference or facilitation between the two tasks. They found that with short verb-cue intervals (100-200 ms) interference effect was found, whereas with larger intervals (350 ms) facilitation effect was found in matching conditions. Moreover, the interaction was bidirectional, modulating both motor response time and the choice time in a later semantic choice task. Therefore, based on the previous experiments, it can be roughly generalized that interfering effects occur at an earlier stage, and facilitation afterward. Based on de Vega et al.'s (2013) experimental design, we conducted an experiment with Chinese Mandarin speakers using the ACE paradigm employed by de Vega et al. (2013). As mentioned above, the timing difference between action verb and motion response was manipulated by the different presenting time of the action verb, as a result in different kinematic measurements realized by participants performances in experiments.

The purposes of replicating ACE phenomena in Chinese is twofold. The first purpose is to confirm the extent to which the interfering or facilitatory ACE is determined by temporal parameters, given the fact that recent studies cast doubts on the validity of the embodiment approach to linguistic meaning (Mahon, 2015; Mahon & Caramazza, 2008) and about the robustness and replicability of ACE (Papesh, 2015). According to Papesh's (2015) study, the ACE reported in the literature was elusive, statistically weak or admitted alternative disembodied explanations. She performed a series of 8 experiments using a different ACE paradigm, failing to replicate the intended effects under strict statistical tests. The second purpose is to testify the embodiment effect in Chinese Mandarin, which is challenging due to the orthographic, syntactic and lexical differences between Chinese and Indo-European languages. Focusing on motion verbs, Talmy (1991) established two typologies of languages, concerning how they parse path information in the verbs. Satellite-framed languages (S-language), like English, convey the motion manner in the verb nucleus and displace the direction to a subordinate satellite (e.g., *she ran into the house*), whereas verb-framed languages (V-language), like Spanish, conflate the direction in the main verb and optionally describe the manner with a subordinate

gerundive verb (e.g., *ella entró en la casa [corriendo] / she entered the house [running]*). However, Mandarin seems to belong to a third category of equipollent-framed languages (E-framed), which employs the serial combination of two unmarked verbs with similar grammatical status referring to the manner and the path, respectively to describe the complete motion event (Chen & Guo, 2009; Ma, 2008; Slobin, 1997; Yang, 2014). Therefore, the present study defines “transfer expression” in Chinese as two parts including the main verb and path verb. Moreover, the Chinese character “把” (Chinese pronunciation ‘ba’), associated with the noun and preceding the transfer verb was added in all the sentences as a structure mark. This prepositional mark does not impact either the semantic or syntactic function of Chinese “transfer verbs” but announces how the following objects will be handled by motion events, namely, the direction of the motion events in the present study (Lv, 2010; Shi, 2010; Weng, 2012; Zhang, 2001). For instance, one example in the experiment was “在球场, 选手把网球扔过去到对方, 网球将穿过? 1.球门 2.球网 (At the court, a player throws (throw away) the tennis ball to the opposite side. The tennis ball will pass over the 1. target / 2. net).

In the present paper, based on de Vega et al.’s (2013) experimental design, we conducted an experiment with Chinese Mandarin speakers using the ACE paradigm employed by de Vega et al. (2013), which explored ACE with Chinese transfer verbs markedly differing from English and Spanish verbs in the way they pack motion mode and direction in the verbs (扔过来扔过去) (‘come here/ go there’). As mentioned above, the timing difference between action verb and motion response was manipulated by the different presenting time of the action verb, as a result in different kinematic measurements realized by participants performances in experiments. The experiment results demonstrate, specifically, for short verb-action SOAs (100 or 200 ms) there will be interference because of the competition for motor resources, whereas for long SOA (350 ms) facilitation or priming is expected. The replication in Mandarin is especially relevant because Chinese is distinctive in its way to describe motion events by using transfer verbs parsing the parameters of transfer (manner and path) in the verb in a different manner from Spanish (V-framed) or English (S-framed).

METHODS

Participants. 102 Chinese university students (30 males and 72 females), between 18 and 35 years old (average: 24.11) participated in the experiment voluntarily. They were recruited by advertising in social media and they received monetary compensation for their participation. They all

gave informed consent according to the Declaration of Helsinki. They were randomly divided into three groups with 34 participants in each group. All of them were native Chinese speakers, right-handed with normal or corrected-to-normal vision.

Materials. The linguistic materials consisted of 96 sentences, 48 of which were experimental sentences describing a transfer action either away from or toward oneself (see Table 1). The transfer events contained in the sentences were the combination of a manner verb and a path verb. We selected 12 high-frequency manner verbs referring to hand motions from a Chinese corpus (CCL) and 2 path verbs. The selected path verbs were also used frequently in daily life and referred to motions in horizontal dimension. When they are used independently, their meaning is similar to “coming here” or “going there” in English. The structure mark “把” (*ba*) appeared before the transferred object, and then the two verbs (manner + path) followed. Each sentence finished with two alternative words, one was a correct ending of the sentence and the other was a filler. These alternative words were employed in a semantic choice task that will be described in the Procedure and Design sections. Each sentence was separated into five segments according to the semantic group, and each group contains either 2 or 3 Chinese characters. The length of the whole sentences ranged between 20 and 22 characters. The remaining 48 sentences were filler sentences, created by using non-transfer verbs (e.g., writing, remembering, etc.). In the end of a trial, a question was set, and the corresponding length of the question was consistent among the experimental materials.

Table 1: Examples of experimental and filler sentences in the original Mandarin, and the literal and the canonical translations (the fourth of each experimental sentence is the transfer segment):

Transfer verb: Away from participants:						
在球场	选手	把网球	扔过去	到对方	网球将穿过?	1. 球门 2. 球网
At the court	player	tennis ball	throw (throw away)	to opposite side	Tennis ball over	1. target 2. net
At the court, a player is throwing the tennis ball to the opposite side. The tennis ball will pass over the 1. target / 2. net						
Transfer verb: Toward participants:						
在球场	选手	把网球	扔过来	到我方	网球将穿过?	1. 球门 2. 球网
At the court	player	tennis ball	throw (throw toward)	to my side	Tennis ball over	1. target 2. net
At the court, a player is throwing the tennis ball to my side. The tennis ball will pass over the 1. target / 2. net						

Filler sentence:						
Non-transfer verb						
在课上	学生	把公式	认真记	在本上	公式将解决?	1. 问题 2. 麻烦
At class	student	formula	write carefully	down the note	formula solving	1. question 2. trouble
At class, a student is carefully writing down the formula in the notebook. The formula will solve the 1. question / 2. trouble						

Procedure and design. Figure 1 (upper part) is the flow chart of a trial. Each trial started with the characters “Yuan Quan” (circle) in the middle of the screen, prompting participants to press the resting key with the right index finger. Then two convergent lines appeared on the screen and remained visible throughout the entire sentence; these lines aimed to resemble a road from the participants’ perspective and were immediately followed by a 500-ms fixation point appearing between them. Then the first three segments of the sentences (consisting of place, protagonist, mark character “把” (‘ba’) and transferred object) were presented successively in the same position as the fixation point. Each of the three segments was presented on the screen for 800 ms and was followed by a 300 ms blank image. The fourth segment was the “transfer verb”, composed of two parts, the main verb and the path verb. The “transfer verb” remained in the middle of the two frame lines for a variable period of time (100, 200 or 350 ms), and then apparently “jumped” away from or toward the participants as a cue that prompted them to release the resting key and to press the corresponding “away” or “toward” key with the index finger of their right hand. In half of the trials, the direction of the motor response prompted by the motion cue matched the transfer direction in the sentence, whereas in the remaining trials the direction of the motor response mismatched the transfer direction. The last segments of the sentences then followed and remained in the screen for 800 ms. After that, the two choice alternatives were presented and lasted 1000 ms or till the participant pressed one of the choice keys. Participants should make a choice according to the previous meaning of the sentences by pressing the “1” or “2” key on the left side of the keyboard with the index finger of the left hand. This semantic choice task, aimed to ensure that participants pay enough attention to the meaning of the transfer sentence, while performing the cue-based motor response. All of the sentence characters were presented in the font Song typeface 48, and the visual motion effects of the ‘jumping’ verbs were enhanced by increasing the font size to 72 (for toward motion) or reducing it to 36 (for away motion), keeping always the characters within the perspective lines, and producing a strong sense of movement. All the experimental and filler sentences were presented randomly. Participants were

required to press the buttons with the right index finger for the motor task and with the left index finger for the semantic choice task. A modified computer keyboard (the keyboard was rotated by 90° in the anticlockwise direction) was used to collect participants' responses, as Figure 1 (lower part) illustrates. All the function keys were covered by a black piece of paper except the keys used for the motor task, namely the resting key (KH), the away key (KL) and the toward key (KD), as well as the semantic choice keys (K1 and K2). The motor task keys were marked with icons: concentric circles for the "resting" key and directional arrows for the "away" and the "toward" keys; the semantic choice task keys were marked with enhanced Arabic numbers "1" and "2". The keyboard was placed about 20 cm from the participants' chests perpendicularly to the body. The response times and accuracy were recorded both for the motor task and the semantic choice task.

The experiment involved a factorial design: 2 Transfer direction (away/toward) × 2 Movement direction (away/toward) × 3 verb-cue stimulus onset asynchrony (SOA: 100, 200 and 350 ms). All factors were manipulated within-participants except the SOA. Participants were assigned to the SOA groups randomly. After receiving the instructions, participants were given 8 training sentences, and then they were asked to perform the main experimental task, consisting of 48 experimental transfer sentences and 48 filler presented in random order. The 48 experimental sentences were balanced among conditions; namely, 12 transfer away-movement away, 12 transfer away-movement toward, 12 transfer toward-movement away, and 12 transfer toward-movement toward.

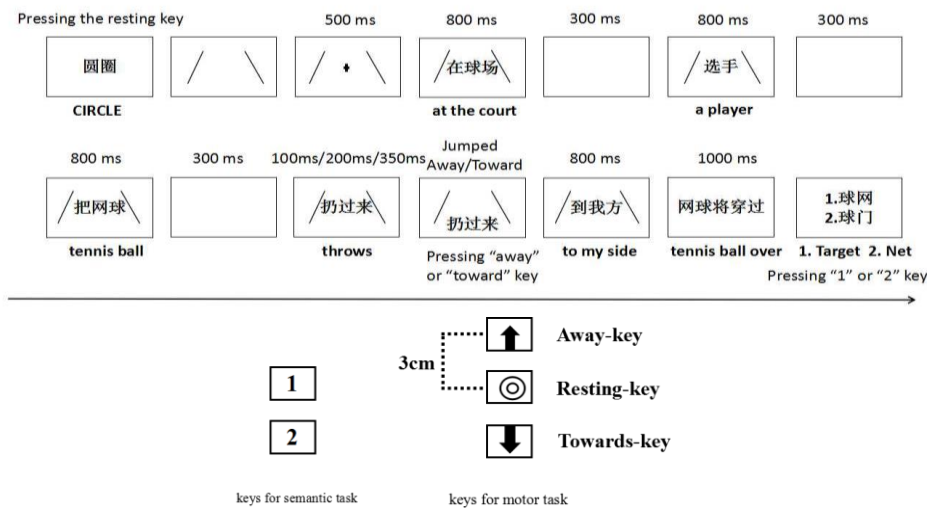


Fig. 1. Flow chart of a trial (above) and spatial distribution of response keys (below)

RESULTS

The response time in milliseconds and the response accuracy as percentage of errors were statistically analyzed as dependent variables both for the motor task and the semantic task, using the SPSS 23.0 software. The analysis of response time only included the trials with accurate responses, and the outliers of response time were substituted by Z-score ($2.5 \text{ St. d} + \text{mean}$). Nine participants were discarded from the analyses: 7 because of their low accuracy and 2 because of their extremely slow responses. As a result, the numbers of participants for 100 ms, 200 ms, 350 ms SOAs were 31, 32, 30. The plan of analyses was as follows. Firstly, three-way ANOVAs with the factors of transfer direction \times movement direction \times SOA was carried out. Secondly, the analysis of interaction between transfer direction and movement direction were examined separately for each SOA condition. Finally, pairwise comparisons between matching and mismatching conditions were also performed when the corresponding ANOVA showed interactive effects.

Response time and accuracy for the motor task

Response time. The motor response times were computed as the lapse from the appearance of the motion cue to the pressing of a direction key (away or toward). The substituted outliers were 2% in the motor task. Table 2 shows the results of the eligible data for the motor task.

Table 2. Mean motor response time in milliseconds (ms) and mean percentage of motor errors (%). In parenthesis the standard deviations (SD).

SOA	Movement	Transfer verb				
		Away		Toward		ACE
		Times (ms)	Errors (%)	Times (ms)	Errors (%)	mismatching – matching (ms)
100	Away	898 (140)	1	879 (144)	0.4	-19
	Toward	858 (143)	0.6	908 (159)	3	-50
200	Away	739 (258)	1.5	687 (207)	0.2	-52
	Toward	698 (244)	0.3	724 (205)	0.8	-26
350	Away	885 (185)	5	923 (205)	3.5	38
	Toward	868 (152)	5	851 (130)	4.7	17

The three-way transfer direction \times movement direction \times SOA interaction was significant: $F(2, 93) = 6.739$, $p < .002$, $\eta^2 = .130$. To better understand this interaction, separate analyses were performed for each SOA. In the 100 ms SOA, the interaction transfer direction \times movement direction was significant ($F(1, 31) = 11.027$, $p < .002$, $\eta^2 = .269$), indicating differences between the mismatching and the matching conditions. As Table 2 illustrated, motor responses were slower in matching than in mismatching conditions, and the results from the paired-samples T test showed significant differences

between “movement toward-transfer toward” and “movement toward-transfer away” ($p = .001$, Cohen’s $d = 0.33$) although the contrast “movement away-transfer away” and “movement away-transfer toward” did not reach statistical significance ($p = .174$, Cohen’s $d = 0.13$). In other words, at this earliest stage, interference occurred between matching transfer and movement involving toward direction.

In the 200 ms. SOA, again the interaction transfer direction \times movement direction was significant: $F(1, 32) = 4.329$, $p < .046$, $\eta^2 = .123$. Again, an interfering ACE occurred, namely slower responses in matching than mismatching conditions (Table 2). However, none of the relevant paired-samples T test reached statistical significance: “movement away-transfer away” versus “movement away-transfer toward” ($p = .071$, Cohen’s $d = 0.22$), and “movement toward-transfer toward” versus “movement toward-transfer away” ($p = .341$, Cohen’s $d = 0.12$). Finally, in the longest SOA, the interaction of transfer direction and movement direction was again significant: $F(1, 30) = 5.666$, $p < .024$, $\eta^2 = .163$. However, in this case the observed ACE was facilitatory rather than interfering; namely, response time was shorter in matching conditions than in mismatching conditions (See Table 2). The paired-samples T test revealed significant differences between “movement away-transfer away” and “movement away-transfer toward” ($p = .017$, Cohen’s $d = 0.19$), but no “movement toward-transfer toward” and “movement toward-transfer away” ($p = .363$, Cohen’s $d = 0.12$).

Accuracy. As Table 2 showed the percentage of errors in the SOAs 100 and 200 ms tended to be larger in matching than mismatching conditions consistently with the advantage of mismatching conditions observed in the response time results. However, the three-way ANOVA transfer direction \times movement direction \times SOA conducted with percent of errors did not reach significant effects: $F(2, 93) = .168$, $p = .846$, $\eta^2 = .004$. nor the two-way transfer direction \times movement direction ANOVAs conducted separately for each SOA: SOA 100 ms: $F(1, 31) = 3.041$, $p = .091$, $\eta^2 = .092$), SOA 200 ms: $F(1, 32) = 3.274$, $p = .080$, $\eta^2 = .096$ and SOA 350 MS: $F(1, 30) = .625$, $p = .436$, $\eta^2 = .021$.

In sum, when the transfer verb and the cue for motor action had a close temporal overlapping (in the 100 and the 200 ms SOAs), performance in the matching conditions, compared to the mismatching conditions, was impaired (slower responses) indicating interference. In contrast, when the transfer verb and the cue for motor action weretemporally distant (350 ms SOA) performance in the matching conditions was better (faster responses) indicating facilitation.

Response time and accuracy for the semantic choice task. The response time was recorded from the question onset to the choice key

pressing in the semantic task (see Table 3). The outliers substituted were 3% in the semantic task. The ANOVA transfer direction \times movement direction \times SOA did not reach statistical significance: $F(2, 93) = .418$, $p = .523 > .05$, $\eta^2 = .013$. In the same vein, none of the transfer direction \times movement direction ANOVAs performed for each SOA was significant; SOA 100 ms: $F(1, 31) = .117$, $p = .734 > .05$, $\eta^2 = .004$, SOA 200 ms: $F(1, 32) = .418$, $p = .523 > .05$, $\eta^2 = .013$ and SOA 350 ms: $F(1, 30) = .021$, $p = .885 > .05$, $\eta^2 = .001$.

When error analysis of semantic task was carried out, the results were intriguing. The three-way ANOVA showed significant transfer direction \times movement direction \times SOA interaction: $F(2, 93) = 16.696$, $p < .0001$, $\eta^2 = .271$. When the SOAs were analyzed separately, only in the 200 ms SOA a transfer direction \times movement direction interaction was obtained: $F(1, 32) = 36.204$, $p < .0001$, $\eta^2 = .539$. In the 200 ms SOA there was an advantage for matching over mismatching conditions, which showed different result from the motor task.

Table 3. Mean semantic choice time in milliseconds, and mean percent of choice errors. In parenthesis the standard deviations.

SOA	Movement	Transfer verb			
		Away		Toward	
		Times (ms)	Errors (%)	Times (ms)	Errors (%)
100	Away	1345 (260)	30	1399 (329)	27
	Toward	1346 (225)	9	1386(306)	12
200	Away	1299 (116)	6	1331 (179)	16
	Toward	1315 (125)	16	1330 (117)	5
350	Away	1317 (186)	4	1314 (230)	6
	Toward	1316 (185)	19	1308 (210)	18

Note: M = mean; CI = confidence intervals.

DISCUSSION

The present research employed the ACE paradigm to testify fine-grained embodiment effects in Chinese transfer verbs. The results showed that the comprehension of hand-related action language interfered or facilitated performance on a concurrent matching manual response, depending on the degree of temporal overlapping between the two tasks. Namely, with short verb-motor cue SOAs (100 ms. and 200 ms. SOAs), mismatching conditions revealed faster responses than matching conditions, revealing the interfering effect. However, with a longer verb-motor cue delay (350 ms. SOA) responses were slower in mismatching than matching conditions, indicating that facilitation only emerged at a later stage. These action-sentence interactions were observed in the motor response task, but not in the semantic choice task.

The crosstalk between meaning and action observed in this study, confirmed previous results reported in the literature demonstrating that the processing sentences containing information related to hand action was modulated by manual actions performed during the task (Aravena et al., 2010; Glenberg & Kaschak, 2002; de Vega et al., 2013; Sell & Kaschak, 2010; Zwaan & Taylor, 2006), supporting the claim that action language and motor performance could share motor networks in the brain. Moreover, some studies using the ACE paradigm with sentences found the same temporal modulation: interference with short meaning-action SOAs (Buccino et al., 2005; de Vega et al., 2013) and facilitation in later temporal windows (Borghi & Scorolli, 2009; de Vega et al., 2013; Marino, Gallese, Buccino, & Riggio, 2012).

The more intriguing question to be answered is why action sentences interfere with matching actions for short SOAs and facilitate matching actions for longer SOA. An explanation is that immediately after the action verb onset, the processing of the verb triggers motor resonance in the hand networks, temporally overlapping with the preparation of the matching motor response, competing both the motor task and the semantic choice task for motor resources in the brain. With longer meaning-action SOA, short-lived resonance fades, enabling sentence level integrative processes of verb and the previous context to produce a complete and long-lasting representation of the transfer event, priming the delayed motor response (de Vega et al., 2013). The temporal course of the early (interfering) motor resonance is also consistent with that of the neurological evidence obtained with magnetoencephalography (MEG), demonstrating that the activation of the somatotopic cortex reaches its maximum peak 200 ms after the critical action-related word onset (Pulvermüller, Hauk, Nikulin, & Ilmoniemi, 2005). Additionally, a model proposed by Garcia and Ibáñez (2016) provides a much clearer explanation of the underlying neural dynamics in ACE for hand action sentences. They posit that interference or facilitation effect is determined by the motor activation threshold level while performing the two concurrent tasks, which partially shared neuronal networks. In the short-delay conditions, the first task (e.g., the action verb) raises activity above threshold level and then the second task (e.g., motor response preparation) will not have timely access to its required resources, thus causing the interference to occur. However, if the response process is delayed, then the resonance triggered by the action verb falls below the threshold level, resulting in a motor pre-activation that primes the motor response preparation leading to faster completion. For instance, in matching conditions of the current experiment, at short SOAs (100 ms and 200 ms), processing the meaning of the directional action denoted by the verbs reaches a pick demand above threshold of motor

resources at the time that the movement cue appears. The cue prompts moving the finger in the same direction, competing for the motor system resources and resulting in momentary interference. By contrast, in the longer delay condition (SOA 350 ms), the motor activation associated with the action verb drops below the threshold and facilitates the motor response to the cue.

Some studies with the ACE paradigm reported bidirectional effects between motor performance and semantic processing of sentences. Specifically, Aravena et al. (2010) in their study with the event-related potentials (ERPs) found modulation of sentence compatibility on motor potentials and on the N400 component, in which the findings showed incompatibility with motor processes in sentences comprehension in a semantic fashion, indicating the motor-language interaction in language comprehension, and de Vega et al. (2013) reported ACE response time in either motor response or semantic choice, suggesting the later facilitatory effect that the semantic processing of transfer verbs was modulated by motor compatibility. Unexpectedly, in the current experiment facilitatory and interfering ACE was only found in the motor response time, but not in the semantic choice task. The lack of replication might be due to the singularities of the language used in the present study. Considering the feature of the Chinese language, the object is immediately followed by the transfer verb, and then the motion events are described entirely. For the left part of other adverbial modifier, it is not the indispensable element for the motion events, therefore, it can be described as an independent part in the sentence. For example, in Chinese, “把网球扔过来” (*‘throw the tennis ball toward...’*) already contains the object (*‘tennis ball’*) of how to make a displacement, and the path of it is “toward” the subject. Thus, reporting that the tennis ball goes over the net or another object is superfluous concerning the description of the motion events in Chinese. Consequently, the semantic choice question arises when the motion event has been entirely processed and is no longer affected by ACE. As a result, in the present study the questions were presented after the participants already integrated sentences, which was fundamentally different from the semantic choice task used in previous study, which was set at the end to comprehend the meaning of the sentence.

Generally, this study explored ACE with Chinese transfer verbs markedly differing from English and Spanish verbs in the way they pack motion mode and direction in the verbs (扔过来/扔过去) (*‘come here/ go there’*). Regardless of these differences, the results showed similar fine-grained embodiment effects to those reported in Indo-European languages. This replication is relevant in three respects. First, the ACE differential effects with subtle variations in verb-action timing were obtained with Chinese

speakers, contributing to the reinforcement of the ACE replicability recently questioned by some researchers (Mahon, 2015; Mahon & Caramazza, 2008; Papesh, 2015). Secondly, this replication is especially important in light of the special structure of transfer verbs in Chinese, that is, the combination of two constituents of transfer verbs already describes the entire motion events, and then other supplementary constituents in the sentences add other meanings without using the language of the motion events. However, the additional meanings are reflected in the results of the semantic task. Last but not least, differences between Chinese and Western languages in terms of culture and mindsets do not override embodiment effects, indicating the universal aspect of semantics.

CONCLUSION

The research explored the embodiment effect on Chinese transfer verbs by a behavioral ACE experiment. In particular, interfering effect is precisely found in the time window in 100-200 ms, that is, responding faster responses in incompatible meaning-action conditions; after the priming effect, similar facilitation appears in the longest SOA (350 ms), responding faster in compatible meaning-action conditions. The study highlights the distinctive way to describe motion events by Chinese transfer verbs, concluding that the embodiment effect exists in Chinese as a language in the Sino-Tibetan language family, and to some extent, complementing the evidence for the universality of embodiment in language.

RESUMEN

El objetivo del presente estudio es indagar en el procesamiento del significado corporeizado (*embodied meaning*) durante la comprensión de verbos de transferencia del Chino Mandarín que difieren de las estructuras tradicionales que estos verbos exhiben en inglés y lenguas indoeuropeas afines. Empleando el paradigma de efecto de compatibilidad entre acción-oración, se le solicitó a los participantes leer descripciones oracionales de eventos de transferencia en donde la figura se acerca o se aleja del lector (*En la cancha, un jugador lanza la pelota de tenis hacia el lado opuesto/ hacia mi lado*). En una pantalla, se mostró a los participantes una señal visual en movimiento junto a un verbo de transferencia, induciéndoles así a presionar un botón alejando o acercando de ellos la mano. Los resultados del estudio mostraron que cuando el tiempo de espera antes de la presentación de la señal fue breve (100 ms or 200 ms), hubo interferencia entre las condiciones coincidentes. En el caso de un mayor tiempo de espera (350 ms), se produjo

un efecto de facilitación entre las mismas. Estos resultados muestran que los eventos de movimiento descritos por verbos de transferencia en chino mandarín presentan características especiales, evidenciando que la comprensión de verbos de transferencia en dicha lengua activa el sistema sensoriomotor, lo cual facilita o dificulta una respuesta motora paralela.

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APPENDIX**Transfer verb (toward group):**

1. 在船头, 渔民把渔网提过来到船头, 渔网将会搁置在 1.甲板 2.地板
At the bow, fishermen lift the nets over the bow. The nets will be set on the 1. deck 2. floor
2. 在楼前, 工人把油漆桶提过来到楼前, 油漆将粉刷于 1.墙面 2.地面
In front of the building, workers lift the paint buckets to the front of the building. The paint was painted on the 1. wall 2. ground
3. 在库房里, 师傅把货物拉过来到库内, 货物将经过于 1.库门 2.库窗
In the factory, master workers pull the goods over to the warehouse. The goods will pass through the 1. gate 2. window
4. 在进站口, 旅客把行李拉过来到入口, 行李箱将搁置在 1.传送带 2.隔离带
At the stop, passengers pull their luggage over to the entrance. The luggage will be placed on the 1. carousel 2. isolation belt
5. 在球内场, 球员把篮球投过来到内场, 篮球将进入到 1.球筐 2.球门
At the court, players throw the basketball into the infield. The basketball will go into the 1. basket 2. target
6. 在场地线内, 选手把标枪投过来到线内, 标枪将掉落在 1.场地 2.草地
Inside the field line, players drop the javelins inside the line. The javelins will drop in the 1. field 2. grass
7. 在赌场, 荷官把筹码推过来到我方, 筹码将摆放成 1.几摞 2.几条
In the casino, dealers push the chips over to our side. The chips will be placed into 1. piles 2. lines
8. 在款台, 顾客把购物车推过来到款台, 购物车将装着 1.商品 2.药品
At the counter, customers push the shopping carts over to the counter. The shopping carts will be loaded with 1. goods 2. medicine
9. 在考场, 学生把卷纸拿过来到课桌, 卷纸将提交给 1.考官 2.讲师
In the examination room, students take the papers to the desk. The paper will be submitted to the 1. examiner 2. lecturer
10. 在货架, 商家把商品拿过来到货架, 商品将标明着 1.价签 2.书签
At the shelf, sellers bring the goods to the shelf. The goods will be marked with 1. price tag 2. bookmark
11. 在餐桌, 店员把菜盘递过来到饭桌, 菜盘将放置在 1.餐桌 2.课桌
At the table, waiters hand the dishes over to the table. The dishes will be placed at the 1. table 2. desk
12. 在银行, 柜员把账单递过来到柜台, 账单将记录着 1.钱款 2.条款
In the bank, tellers deliver the bills to the counter. The bills will record the 1. money amounts 2. terms
13. 在床边, 住户把被子抱过来到床上, 被子将覆盖着 1.被套 2.枕套
At the front of the bed, the occupant puts the quilt on the bed. The quilt will be covered with 1. quilt cover 2. pillow slip
14. 在考场, 考官把卷纸抱过来到讲台, 卷纸将分发给 1.考生 2.讲师
In the examination room, examiners carry the papers to the platform. The paper will be handed out to the 1. examinee 2. lecturer
15. 在救护区, 医生把担架抬过来到医护区, 担架上躺放着 1.患者 2.护士
In the ambulance area, doctors carry the stretchers to the operating room. The stretchers will hold the 1. patient 2. nurse
16. 在舞台, 演员把道具抬过来到台上, 道具将经过于 1.幕帘 2.窗帘
On the stage, actors lift the props over to the stage. The props will pass through the 1. stage curtain 2. window curtain

17. 在楼前, 工人把水泥拖过来到楼前, 水泥中混合着 1.沙子 2.钢筋
In front of the building, workers drag the cement over to the front of the building. The cement will be mixed with 1. sand 2. rebar
18. 在客厅, 房东把家具拖过来到客厅, 家具将放置在 1.地板 2.甲板
In the living room, the landlord drags the furniture across to the living room. The furniture will be placed on the 1. floor 2. deck
19. 在窗边, 房东把摇椅搬过来到窗边, 摇椅将放置在 1.地板 2.甲板
At the window, the landlord moves the rocking chair over to the window. The rocking chair will be placed on the 1. floor 2. deck
20. 在教室, 学生把椅子搬过来到课桌, 椅子将面对于 1.黑板 2.展板
In the classroom, students move chairs over to the desk. The chairs will be front of the 1. blackboard 2. display board
21. 在河岸, 渔夫把鱼饵抛过来到岸上, 鱼饵将悬挂在 1.鱼钩 2.鱼篓
On the riverbank, fishermen throw the bait over the shore. The bait will hang on the 1. fish hook 2. weel
22. 在场地线内, 选手把铁饼抛过来到线内, 铁饼将穿过于 1.护笼 2.横杆
Inside the field line, players throw the discuses over the line. The discuses will pass through the 1. cage 2. crossbar
23. 在球场, 选手把网球扔过来到我方, 网球将经过于 1.球网 2.球门
At the court, the player throws the tennis ball over to my side. The tennis ball will pass over the 1. net 2. target
24. 在战场, 士兵把手雷扔过来到我方, 手雷将发生为 1.爆炸 2.扫射
On the battlefield, soldiers throw their grenades over to my side. The hand grenades will 1. explode 2. strafe

Transfer verb (away group):

1. 在船头, 渔民把渔网提过去到船尾, 渔网将会搁置在 1.甲板 2.地板
At the bow, fishermen lift the nets to the stern. The nets will be set on the 1. deck 2. floor
2. 在楼前, 工人把油漆桶提过去到楼后, 油漆将粉刷于 1.墙面 2.地面
In front of the building, workers lift the paint bucket to the back of the building. The paint will be painted on the 1. wall 2. ground
3. 在库房里, 师傅把货物拉过去到库外, 货物将经过于 1.库门 2.库窗
In the factory, master workers pull the goods out of the warehouse. The goods will pass through the 1. gate 2. window
4. 在进站口, 旅客把行李拉过去到出口, 行李箱将搁置在 1.传送带 2.隔离带
At the stop, passengers pull their luggage to the exit. The luggage will be placed on the 1. carousel 2. isolation belt
5. 在球内场, 球员把篮球投过去到外场, 篮球将进入到 1.球筐 2.球门
At the court, players throw the basketball to the outfield. The basketball will go into the 1. basket 2. target
6. 在场地线内, 选手把标枪投过去到线外, 标枪将掉落在 1.场地 2.草地
Inside the field line, players drop the javelins to the outside line. The javelins will drop in the 1. field 2. grass
7. 在赌场, 荷官把筹码推过去到对家, 砵码将摆放成 1.几摞 2.几条
In the casino, dealers push the chips to the opposite. The chips will be placed into 1. piles 2. lines
8. 在款台, 顾客把购物车推过去到货架, 购物车将装着 1.商品 2.药品
At the counter, customers push the shopping carts to the shelf. The shopping carts will be loaded with 1. goods 2. medicine

9. 在考场, 学生把卷纸拿过去到讲台, 卷纸将提交给 1.考官 2.讲师
In the examination room, students take the papers to the platform. The papers will be submitted to the 1. examiner 2. lecturer
10. 在货架, 商家把商品拿过去到款台, 商品将标明着 1.价签 2.书签
At the shelf, sellers take the goods to the counter. The goods will be marked with 1. price tag 2. bookmark
11. 在餐桌, 店员把菜盘递过去到后厨, 菜盘将放置在 1.餐桌 2.课桌
At the table, waiters hand the dish to the kitchen. The dishes will be placed at the 1. table 2. desk
12. 在银行, 柜员把账单递过去到后台, 账单将记录着 1.钱款 2.条款
In the bank, tellers pass the bills to the office. The bills will record the 1. money amounts 2. terms
13. 在床边, 住户把被子抱过去到柜子, 被子将覆盖着 1.被套 2.枕套
At the front of the bed, the occupant takes the quilt to the cabinet. The quilt will be covered with 1. quilt cover 2. pillow slip
14. 在考场, 考官把卷纸抱过去到课桌, 卷纸将分发给 1.考生 2.讲师
In the examination room, the examiners carry the papers to the desk. The papers will be handed out to the 1. examinee 2. lecturer
15. 在救护区, 医生把担架抬过去到救护车, 担架上躺着 1.患者 2.护士
In the ambulance area, doctors carry stretchers to the ambulance. The stretchers will hold the 1. patient 2. nurse
16. 在舞台, 演员把道具抬过去到后台, 道具将经过于 1.幕帘 2.窗帘
On the stage, actors lift the props to the backstage. The props will pass through the 1. stage curtain 2. window curtain
17. 在楼前, 工人把水泥拖过去到楼后, 水泥中混合着 1.沙子 2.钢筋
In front of the building, workers drag the cement to the back of the building. The cement will be mixed with 1. sand 2. rebar
18. 在客厅, 房东把家具拖过去到玄关, 家具将放置在 1.地板 2.甲板
In the living room, the landlord drags the furniture over to the hallway. The furniture will be placed on the 1. floor 2. deck
19. 在窗边, 房东把摇椅搬过去到门边, 摇椅将放置在 1.地板 2.甲板
At the window, the landlord moves the rocking chair over to the door. The rocking chair will be placed on the 1. floor 2. deck
20. 在教室, 学生把椅子搬过去到讲桌, 椅子将面对于 1.黑板 2.展板
In the classroom, students move their chairs to the platform. The chairs will be front of the 1. blackboard 2. display board
21. 在河岸, 渔夫把鱼饵抛过去到水中, 鱼饵将悬挂在 1.鱼钩 2.鱼篓
On the riverbank, fishermen throw the baits into the water. The baits will hang on the 1. fish hook 2. weel
22. 在场地线内, 选手把铁饼跑过去到线外, 铁饼将穿过于 1.护笼 2.横杆
Inside the field line, players throw the discuses beyond the line. The discuses will pass through the 1. cage 2. crossbar
23. 在球场, 选手把网球扔过去到他方, 网球将经过于 1.球网 2.球门
At the court, the player throws the tennis ball over to the opposite side. The tennis ball will pass over the 1. net 2. target
24. 在战场, 士兵把手雷扔过去到敌方, 手雷将发生为 1.爆炸 2.扫射

On the battlefield, soldiers throw their grenades to the enemy. The grenades will 1. explode
2. strafe

Filler sentences:

1. 在教室，学生把笔记认真写在本上，笔记可能包括 1.定理 2.谜语

In the classroom, students carefully write down their knowledge points in the notebook. The knowledge points will include 1. theorem 2. riddle

2. 在书店，作家把签名认真写在扉页，签名里应该是 1.名字 2.日期

In the bookstore, writers seriously write down signatures on the title page. The signatures will be 1.name 2. date

3. 在机房，人员把代码认真写在电脑，代码将可能被 1.保存 2.关机

In the computer room, developers carefully write the codes on the computer. The codes will be 1. saved 2. shut down

4. 在考场，考生把答案认真写到题签，答案将可能被 1.评判 2.评价

In the examination room, students carefully write the answers on the answer sheets. The answers will be 1. marked 2. evaluated

5. 在公司，经理把条款认真写到合同，条款将被双方 1.签署 2.签署

In the company, managers carefully write the terms on the contract. The terms will be 1. signed 2. sold

6. 在课堂，老师把答案认真写在黑板，答案也许关于 1.考试 2.面试

In the classroom, teachers carefully write the answers on the blackboard. The answers will be about the 1. exam 2. interview

7. 在课上，老师把答案仔细说给同学，答案也许关于 1.考试 2.面试

In class, teachers carefully tell the answers to students. The answers may be about 1. exam 2. interview

8. 在公司，经理把方案仔细说给客户，方案可能涉及 1.交易 2.交换

In the company, managers carefully tell the plans to customers. The plans will involve 1. trade 2. exchange

9. 在药房，药师把功效仔细说给患者，功效将有助于 1.病症 2.病因

At the pharmacy, pharmacists carefully tell the benefits to patients. The benefits will help with the 1. symptoms 2. cause

10. 在市场，商贩把价格仔细说给顾客，价格理应是 1.钱数 2.个数

In the market, vendors carefully tell the prices to the customer. The prices will be 1. amount 2. quantities

11. 在采访，嘉宾把事实仔细说给记者，事实理应被 1.口述 2.笔述

In the interview, guests carefully tell the facts to reporters. The facts will be 1. oral 2. written

12. 在赛场，裁判把规则仔细说给选手，规则也许会被 1.打破 2.打碎

At the court, referees carefully tell the rules to players. The rules will be 1. broken 2. crashed

13. 在课上，学生把课文大声读给老师，课文正常包含 1.文字 2.代码

In class, students read the texts aloud to teachers. The texts will contain 1. words 2. codes

14. 在书店，读者把小说大声读给同伴，小说理应当有 1.作者 2.舞者

In the bookstore, readers read the novel aloud to their peers. The novel will contain 1. author 2. dancer

15. 在商店，卖家把说明大声读给顾客，说明对应的是 1.产品 2.菜品

In the store, sellers read the instructions aloud to customers. The instructions will involve 1. products 2. cuisines

16. 在厨房，助理把菜谱大声读给主厨，菜谱理应当包含 1.食材 2.药材

In the kitchen, assistants read the recipes aloud to chefs. The recipes will contain 1. ingredients 2. herbs

17. 在赛场, 裁判把成绩大声读给选手, 成绩理应会被 1.排序 2.排场
At the court, referees read the results aloud to players. The results will be 1. ranked 2. arranged
18. 在客厅, 孩子把作文大声读给家长, 作文可能含有 1.题目 2.题干
In the living room, children read the articles aloud to parents. The articles will contain 1. title 2. question
19. 在幕后, 演员把台词仔细背给搭档, 台词正常包含 1.文字 2.代码
At the backstage, actors carefully recite the lines to partners. The lines will contain 1. words 2. codes
20. 在课上, 学生把古文仔细背给老师, 古文也许包含 1.历史 2.手机
In class, students carefully recite the ancient Chinese proses to teachers. The ancient Chinese proses will contain 1. history 2. mobile phone
21. 在训练, 选手把要点仔细背给教练, 要点可能包含 1.姿势 2.姿色
In training, players carefully recite the key points to coaches. The key points will contain the 1. posture 2. appearance
22. 在银行, 顾客把帐号仔细背给柜员, 帐号应该包含 1.数字 2.汉字
In the bank, customers carefully recite the account to tellers. The account will contain 1. numbers 2. Chinese characters
23. 在课后, 学生把单词仔细背在脑海, 单词可能包含 1.字母 2.数字
After class, students carefully recite the words in their minds. The words will contain 1. letters 2. numbers
24. 在会议, 人员把条款仔细背给领导, 条款可能用来 1.签订 2.签售
At the meeting, employees carefully recite the terms to leaders. The terms will be applied to 1. sign 2. sell
25. 在学校, 学生把知识认真学到心中, 知识将由老师 1.教授 2.教育
In school, students steadily acquire the knowledge in their minds. The knowledge will be 1. taught 2. educated
26. 在驾校, 学员把技能认真学到心中, 技能可能包括 1.倒车 2.倒立
At the driving school, students steadily acquire the skills in their minds. The skills will include 1. reversing 2. handstand
27. 在泳池, 学员把泳姿认真学到心中, 泳姿可能包括 1.蛙泳 2.蛙跳
In the swimming pool, students steadily acquire the swimming postures in their minds. The swimming postures will include 1. breaststroke 2. leapfrog
28. 在厨房, 主厨把菜谱认真学到心中, 菜谱理应包含 1.食材 2.药材
In the kitchen, chefs steadily acquire the recipes in their minds. The recipes will contain 1. ingredients 2. herbs
29. 在课堂, 学生把公式认真学在脑海, 公式可能用来 1.解题 2.解毒
In class, students steadily acquire the formulae in their minds. The formulae will be applied to 1. solve the question 2. Detoxify the body
30. 在训练, 选手把要点认真学在心中, 要点可能包含 1.姿势 2.姿色
In training, players steadily acquire the key points in their minds. The key points will contain 1. posture 2. appearance
31. 在食堂, 学生把饭菜慢慢吃到嘴里, 饭菜可能包括 1.蔬菜 2.药材
In the cafeteria, students slowly eat the food into their mouth. The food will include 1. vegetables 2. herbs
32. 在餐馆, 食客把料理慢慢吃到嘴里, 料理可能属于 1.川菜 2.川剧
In the restaurant, customers slowly eat their dishes into their mouths. The dishes may belong to 1. Sichuan cuisine 2. Sichuan opera
33. 在餐厅, 客人把饺子慢慢吃到嘴里, 饺子按理属于 1.面食 2.副食

In the restaurant, guests slowly eat the dumplings into their mouths. The dumplings may belong to 1. cooked wheaten food 2. non-staple food

34. 在厨房, 厨师把试菜慢慢吃到嘴里, 试菜可能包括 1. 蔬菜 2. 药材

In the kitchen, chefs slowly eat the dishes into their mouths. The dishes may include 1. vegetables 2. herbs

35. 在饭店, 顾客把菜肴慢慢吃到口中, 菜肴应该是被 1. 烹饪 2. 制药

In the restaurant, customers slowly eat the dishes into the mouth. The dishes will be 1. cooked 2. produced

36. 在医院, 病人把药片慢慢吃到口中, 药片理应用来 1. 治病 2. 饱腹

In the hospital, patients slowly eat the pills into their mouths. The pills will be used to 1. treat the disease 2. satisfy their hunger

37. 在课后, 学生把古文牢牢记在脑海, 古文也许包含 1. 历史 2. 手机

After class, students firmly keep the ancient texts in their minds. The ancient texts may contain 1. history 2. mobile phone

38. 在周末, 学生把周记认真记在本上, 周记理应涉及 1. 日期 2. 公式

On weekends, students carefully take the weekly dairy on the notebook. The weekly dairy will involve 1. date 2. formula.

39. 在机房, 人员把代码仔细记在电脑, 代码将可能被 1. 保存 2. 关机

In the machine room, developers carefully keep the codes in the computer. The codes will be 1. saved 2. shut down

40. 在厨房, 助理把食材认真记在本上, 食材将被用在 1. 烹饪 2. 制药

In the kitchen, assistants carefully keep the ingredients in the notebook. The ingredients will be 1. cooked 2. produced

41. 在课上, 学生把公式认真记在本上, 公式用来解决 1. 问题 2. 麻烦

In class, students carefully keep the formula in the notebooks. The formula will be used to solve the 1. problem 2. trouble

42. 在赛场, 裁判把结果公正记在表上, 结果最后将被 1. 公示 2. 销毁

At the court, referees put the results fairly on the table. The results will be 1. promulgated 2. destroyed

43. 在银行, 顾客把密码死死忘在脑后, 密码可能包含 1. 数字 2. 汉字

In the bank, customers badly forget the passwords. The passwords may contain 1. numbers 2. Chinese characters

44. 在考场, 考生把答案死死忘在脑后, 答案可能涉及 1. 定理 2. 道理

In the examination room, examinees badly forget the answers. The answers will involve 1. theorem 2. truth

45. 在门外, 住户把钥匙大意忘在屋内, 钥匙材质会是 1. 金属 2. 塑料

Outside the door, occupants leave the keys inside the house. The material of keys will be 1. metal 2. plastic

46. 在款台, 顾客把钱包大意忘在家中, 钱包理应装有 1. 钞票 2. 门票

At the counter, customers leave the wallets at home. The wallets may contain 1. banknotes 2. tickets

47. 在圣诞, 朋友把礼物死死忘在脑后, 礼物本应用来 1. 庆祝 2. 悼念

At Christmas, friends forget gifts. The gifts will be applied to 1. celebrate 2. mourn

48. 在舞台, 演员把台词死死忘在脑后, 台词可能包含 1. 文字 2. 代码

On the stage, actors forget the lines. The lines may contain 1. words 2. codes