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Linking counterfactuality with theory of mind: evidence from developmental studies with *Yàobúshì* in Chinese

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Abstract

This paper revisits Chinese counterfactuality with 要不是 *yàobúshì* 'if it were not' by presenting additional data from elementary school children and high school teenagers to determine the availability of counterfactual reasoning with psycholinguistic studies. Constituent comparisons of propositional representations were hypothesized in the mental model of sentence processing. Results indicate both developmental groups processed counterfactuals with *yàobúshì* similarly to college students, demonstrating that the mismatch of structures and semantics does not exist in counterfactuals with *yàobúshì* in Chinese. Relevance to theory of mind in processing counterfactuality with Chinese as an example is proposed and discussed.

Keywords: Theory of mind, Counterfactual reasoning, Chinese, Developmental studies

1 Introduction

Due to the absence of morphological inflections of the subjunctive mood in Chinese, Chinese speakers use contextual information to disambiguate conditional statements from hypothetical, imaginative, or counterfactual meanings (Liu 1985; see Rafetseder and Perner 2010 in English classification). However, only a few classical Chinese words have been identified as conditional expressions, such as 假使 *jiǎshǐ* 'if', 若使 *ruòshǐ* 'if', and 微 *wéi* 'if not' (Eifring 1988; Jiang 2018) and some other constructive structures, such as 如果…早就 *rúguǒ…zǎojiù* 'if-something should have been done' and 如果早… *rúguǒzǎo* 'if something has been done earlier' (Jing-Schmidt 2017). Moreover, there has been little supporting evidence from psycholinguistic studies. Hsu (2013) coerced counterfactual reading with 如果 *rúguǒ* 'if' and 沒有 *méiyǒu* 'not' in antecedent clauses, together with 不會 *búhuì* 'not' and the aspect marker of completion *le* (了) in consequent clauses, demonstrating counterfactual reading by Chinese speakers from the mismatch of syntax and semantics on different developmental stages. Further investigations found that 要不是 *yàobúshì* 'if it were not' can serve as a counterfactual conjunction in Chinese, initiating semantic-based representations of contrary-to-fact sentences (Hsu 2014). The paper focuses on *yàobúshì* because it is a Chinese word that has the counterfactual lexically represents and does not require any contextual information to infer counterfactuality (Hsu 2014; Jiang 2018). Hence, it allows investigation of the development of counterfactual reasoning without the complexity of the

contextual inference. This paper aims at providing (1) linguistic evidence for developmentally comprehending counterfactuals through *yàobúshì* and (2) a proposal for highlighting the psychological relevance of theory of mind with examples of Chinese counterfactuality with *yàobúshì*.

1.1 Theory of mind

Theory of mind is a term coined by Premack and Woodruff (1978) to describe chimpanzees' ability to understand others' minds. Wimmer and Perner (1983) conducted tasks on theory of mind in humans. Theory of mind refers to an ability to infer a full range of mental states such as beliefs, desires, intentions, imagination, and emotions (Baron-Cohen et al. 1985). The standard protocols are changes in locations and contents.

One protocol for a location change is a Sally-Anne story, which is given as the following: "Sally and Anne were playing marbles together in a room. A few minutes later, before going outside, Sally put her marble in a basket and left Anne alone in the room. Anne was very naughty. She took out Sally's marbles and put them in a box. Then, a child was asked where Sally would go to find her marbles after coming back." All the actions are presented to the participants in full view. Four-year-old children correctly point to the basket in which Sally originally put the marbles, demonstrating their ability to infer mental states from others' perspectives. Children who are younger than this age point to the box from which Anne removed the marbles after Sally was absent, showing their inability to reason others' mental states or their holding of false beliefs referenced to the present. One protocol for a content change is as follows: "The children were shown a tube of smarties and were asked what was inside. Although most children replied smarties, an experimenter opened the tube and found that there were pencils inside. Then, the child was asked what other children would think the content was inside the tube." The age threshold for passing the test is the same as the Sally-Anne story.

In these two protocols, representations are assumed to be formed in accordance with initial conditions and consequences of changes (Frye et al. 1995). The protagonist who did not see the process of location change and was not aware of the mismatch between the appearance and the reality of the tube would form a contrastive representation to the current situation, or false beliefs. To prevent the formation of false beliefs, participants applied theory of mind to shift their perspectives. The representations of initial states and changed consequences are basically in conflict and an adjustment must be made. Three-year-olds are unable to switch perspectives, thereby resulting in difficulties that lead them to make a high percentage of realistic errors.

1.2 Causal reasoning in counterfactuality

Errors in false-belief tasks are symptomatic of a broader difficulty with counterfactuality because of the lack of or unsuccessful causal reasoning. In the studies by Riggs et al. (1998), children 3–4 years of age listened to two stories and were required to make inferences based on a physical state and a mental state. For example: "Peter and Sally were in their house. Peter did not feel well, so he went to bed. Sally then went out shopping. After a little while, a phone rang, and Peter got the call. He was asked to help put out a fire in a post office. Therefore, Peter went out. Sally went home after finishing shopping." The children were asked a physical state question: "If there had been no fire,

where would Peter be?" and a mental state question: "Where does Sally think Peter was?" The children were able to recall earlier situations of the testing event. However, instead of replying with correct locations to mental state questions, 3-year-old children had difficulty in inferring contrary-to-fact conditions.

Counterfactual thoughts might be produced through unpleasant feelings or positive emotions, which, in turn, strengthen counterfactual thinking as a cognitive loop (Jing-Schmidt 2017; Roese 1997). The essential feature of mental states is the causal role of distinctive causes and mental or behavioral consequences (Sterelny 1990). For example, the characteristics of anger are a belief of wrongdoing and a desire to do violence. Through causal computations, for comprehenders, the narrators' intentions are interpreted and inferred, including solitary mind and others' minds; for speakers, counterfactual reasoning is beneficial to learning from experience (Liu 1985). In development, children must learn to distinguish others' minds from their own (Flobbe et al. 2008).

Following a previous study by Hsu (2014), who demonstrated that sentences with *yàobúshì* led to counterfactual reading in Chinese and a differentiating of realities/beliefs and imaginations/desires, this differentiation is similar to decoupling in pretend play, a cognitive concept that emerges in early childhood (Leslie and Thaiss 1992). Decoupling introduces an additional mental structure that operates on the basis of beliefs, making reasoning possible in cognition. For instance, a mother (an agent) pretends that a banana (an anchor) is a telephone (an imaginary or a pretend situation) in playing with children. This pretense evidences a mechanism of theory of mind working. It is proposed that Chinese counterfactuality with *yàobúshì* takes the theory of mind mechanism with decoupling reality/beliefs as antecedents and imaginations/desires as consequents, as in

(1) 要不是我遲到了, 車子就不會開走了
yàobúshì__wǒ__chídào__le, chēzi__jiù__búhuì__kāizǒu__le
if-it-were-not__I__late__ASP, car__only__would-not__drive-away__ASP
If it was not that I had been late, the car would not have been driven away

The antecedent clause states the current situation or true belief of the narrator; hence, the consequent clause describes the imaginary desire of the narrator, who wishes that the car was still there for the narrator to catch it in time. This counterfactual sentence clearly conveys the speaker's intention and feeling toward this event. Listeners comprehend the contrary-to-fact meaning and infer the speaker's mental states. Subsequently, listeners might provide possible solutions or comforting words to the narrator. Accordingly, an interpersonal social interaction arises. Without morphological inflections, the counterfactual conjunction *yàobúshì* allows Chinese speakers to enter into an imaginative world with social and psychological elements. The relevance of linguistic counterfactuality to psychological theory of mind is more evidenced in counterfactual reasoning in Chinese.

2 Method

2.1 Participants

Three groups of participants were recruited as follows: (1) college students ($n = 20$, 5 females/15 males, mean age = 20.1 years), (2) junior high school students ($n = 20$, 13 females/11 males, mean age = 14 years), and (3) elementary school students ($n = 19$, 10

females/9 males, mean age = 12 years). Participants representing different developmental stages were recruited based on developmental psychologist Jean Piaget's theory of cognitive development (Piaget 1936). Based on the theory, four stages of cognitive development are proposed as follows: the sensorimotor stage (birth to 2 years old), the preoperational stage (2 to 7 years old), the concrete operational stage (7 to 11 years old), and the formal operational stage (12 years old onward). Starting from the fourth stage, children can think abstractly and form hypothetical ideas. To gain possible comparisons across developmental ages from childhood to adulthood on this issue (other than location change in the Sally-Anne story and content change in the Smarties test) and to have a workable design to truly probe counterfactual comprehension in reading (other than the cognitive development limitation of the participants), 12-year-old participants were recruited.

2.2 Materials and design

The stimuli were the same as those in Hsu (2014). Based on the constituent comparison model (CCM) (Chase and Clark 1972; Clark and Chase 1972; Carpenter 1973; Carpenter and Just 1975), four types of test sentences were generated with the form of a factual or counterfactual statement in an antecedent clause and a consequent clause, including factual-factual (FF), factual-counterfactual (FC), counterfactual-factual (CF), and counterfactual-counterfactual (CC). Four scenarios covering the four types of test sentences were created. Hence, there were 16 test sentences, or 32 clauses, as the stimuli.

The FF test sentences combine factual antecedents and factual consequents, e.g.,

(2) 颱風來了, 機場也關閉了
táifēng__lái__le, jīchǎng__yě__guānbì__le
hurricane__come__ASP, airport__also__close__ASP
The hurricane came, the airport was closed

which describes the actual state of the event in which the airport closure was due to the hurricane. In the CC test sentences, the counterfactual expression occurred with the conditional conjunction *yàobúshì* in the antecedents and the negation *búhuì* with an aspectual particle 了 *le* in the consequents, e.g.,

(3) 要不是颱風來了, 機場就不會關閉了
yàobúshì__táifēng__lái__le, jīchǎng__jiù__ búhuì__guānbì__le
if-it-were-not__hurricane__come__ASP, airport__only__not__close__ASP
If it wasn't that the hurricane had come, the airport would not have been closed

In the FC test sentences, the counterfactual expression occurs similarly to the consequents in the CC test sentences, with an additional conjunction, 否則 *fǒuzé* 'otherwise', to allow this sentence to be interpreted naturally, e.g.,

(4) 颱風來了, 否則機場就不會關閉了
táifēng__lái__le, fǒuzé__jīchǎng__jiù__búhuì__guānbì__le
hurricane__come__ASP, otherwise__airport__only__not__close__ASP
The hurricane came, otherwise the airport would not have been closed

Here, *fǒuzé* functions as 要不然 *yàobùrán* 'if not so' in interpretation. In the CF test sentences, the method of expressing counterfactual meaning in the antecedents is the same as that in the CC test sentences, e.g.,

(5) 要不是颱風來了, 機場也會關閉一陣子
yàobúshì__táifēng__lái__le, jīchǎng__yě__huì__guānbì__yízhènzi
if-it-were-not__hurricane__come__ASP,
airport__also__would__close__for-a-short-while
If it wasn't that the hurricane had come, the airport would have been closed shortly

Although the CF combination is a non-canonical sentence type in Chinese counterfactuality, to compromise with the experimental 2 × 2 design of clause types (factual, counterfactual) and clause positions (antecedent, consequent), CF sentence experimental materials are included. While this type of test sentence is non-canonical in Chinese counterfactuality, the participants processed this combination as a CC type of counterfactual (see the results).

To investigate the participants' understanding of each test sentence, four types of probe sentences examined truth values, and polarities were created. They were as follows:

(1) Probes with true affirmative (TA) as
颱風來了, 機場關閉了
táifēng__lái__le, jīchǎng__guānbì__le
hurricane__come__ASP, airport__close__ASP
The hurricane came, the airport was closed

(2) Probes with false affirmative (FA) as
颱風遠離了, 機場開放著
táifēng__yuǎnlí__le, jīchǎng__kāifàng__zhe
hurricane__far-away__ASP, airport__open__ASP
The hurricane was far away, so the airport was open

(3) Probes with true negative (TN) as
颱風沒有遠離, 機場沒有開放
táifēng__méiyǒu__yuǎnlí, jīchǎng__méiyǒu__kāifàng
hurricane__not__far-away, airport__not__open
The hurricane was not far away, therefore the airport was not open

and

(4) Probes with false negative (FN) as
颱風沒有來, 機場沒有關閉
táifēng__méiyǒu__lái, jīchǎng__méiyǒu__guānbì
hurricane__not__come, airport__not__close
The hurricane did not come, so the airport was not closed

Each clause in the test sentences was evaluated by the four probes of its truth value. For the target clause

(6) 要不是颱風來了
yàobúshì__táifēng__lái__le
if-it-were-not__hurricane__come__ASP
If it wasn't that the hurricane had come

half of the probes were true in the TA condition, as in

(7) 颱風來了
táifēng__lái__le
hurricane__come__ASP
The hurricane came

and in the TN condition, as in

(8) 颱風沒有遠離
táifēng__méiyǒu__yuǎnlí
hurricane__not__far-away
the hurricane was not far away

The proposition in the TA condition was the intended meaning of the counterfactuals and contained the exact proposition 來 *lái* 'come' noted in the surface structures. In addition, the TN condition expressed the true meaning with a negation, falsifying the desired proposition, as in

(9) 沒有遠離
méiyǒu__yuǎnlí
not__far-away
was not far away

The remaining probes were false in the FN condition, as in

(10) 颱風沒有來
táifēng__méiyǒu__lái
hurricane__not__come
the hurricane did not come

and in the FA condition, as in

(11) 颱風遠離了
táifēng__yuǎnlí__le
hurricane__far-away__ASP
the hurricane was far away

The FA condition incorrectly stated the desired situation as the real event, such as

(12) 颱風遠離
táifēng__yuǎnlí

hurricane__far-away
the hurricane was far away

Thus, 128 experimental trials were presented to all of the participants who were required to respond to the truth value of matching each probe sentence and the target clause based on their comprehension. Practice trials were given before the experiment began. Filler sentences stating situations opposite to the test sentences were randomly presented.

2.3 Procedure

A 500-ms fixation was displayed prior to a test sentence on the screen. The participants were instructed to read each sentence and to comprehend its meaning. After a 5-s presentation of the test sentence, a probe sentence appeared. The participants clicked the mouse to decide whether the probe matched the meaning of the target clause. The buttons for yes and no responses were counterbalanced. The response latency was recorded immediately after the onset of the probe sentence. When a response was detected, the probe disappeared. The antecedent clauses were presented prior to the consequent clauses.

Based on the CCM, sentences are mentally transformed as representations according to propositions. This transformation stands for internal structures of representations in terms of propositions. The representations of a test sentence and the probed sentence are exhaustively compared from innermost to outermost propositions. A plus sign (+) is used to label a match of proposition comparison, whereas a minus sign (–) is used to tag a mismatch. Whenever a mismatch is encountered, it initiates comparisons from the beginning. This model assumes that the reinitiated comparison turns a mismatch into a match to avoid generating a loop. The last response index, as true or false, indicates the comparison result. In Table 1, the TA probes undergo different numbers of mental operations compared to the two representations from the target clause and the probe. One more mental operation is required to compare the test sentence with a false statement (FA) to comprehend factual clauses.

In Table 2, the hypothetical mental processes of counterfactual sentences with *yàobúshì* are given. The conjunctive *yàobúshì* is represented as a conditional conjunction

Table 1 Hypothetical mental operation of affirmative probe sentences compared to factual clauses

Condition	True affirmative (TA)	False affirmative (FA)
Target clause	The hurricane came	The hurricane came
Test sentence	The hurricane came	The hurricane was away
Target representation	(came, hurricane)	(came, hurricane)
Test representation	(came, hurricane)	(far away, hurricane)
Mental operations	+ ☑	– ☒
Response index: false ☒		+
true ☑	Response = true	Response = false
	K comparison (*K* = 1)	*K* + 1 comparisons
Chinese text in target	颱風來了,……	颱風來了,……
Chinese text in probe	颱風來了,……	颱風遠離了,……

Table 2 Hypothetical mental operation of affirmative probe sentences compared to counterfactual clauses

Condition	True affirmative (TA)			False affirmative (FA)		
Target clause	*Yàobúshì* the hurricane came			*Yàobúshì* the hurricane came		
Test sentence	The hurricane came			The hurricane was far away		
Target representation	[CF, (came, hurricane)]			[CF, (came, hurricane)]		
Test representation	(came, hurricane)			(far away, hurricane)		
Mental operations	−	+	☒		−	☒
	+	+	☑	−	+	☑
				+	+	☒
Response index: false ☒	Response = true			Response = false		
true ☑	*K* comparisons (*K* = 4)			*K* + 1 comparisons		
Chinese text in target	要不是颱風來了,……			要不是颱風來了,……		
Chinese text in probe	颱風來了,……			颱風遠離了,……		

in the mental model to denote counterfactual thinking. For the same test sentences evaluating the comprehension of counterfactual target clauses, it is hypothesized that four mental operations are needed to compare the TA probe sentences but that five operations are needed for the FA sentences for the counterfactual target clauses. Thus, the TA condition is considered easier than the FA condition based on the mental processes necessary to derive meanings.

When the test sentences embed negation, they cause a mismatch and necessitate additional mental operations for factual-clause processing, as illustrated by Table 3. The TN sentences require five operations due to two mismatches of the inner proposition and the polarity, whereas the FN sentences require four comparisons. It is hypothesized that the FN condition is easier because the FN condition undergoes fewer mental operations compared to the TN condition. Together with Table 1, compared to factual clauses, the four types of probe sentences can be ordered in a continuum from the easiest to the most difficult as TA < FA < FN < TN in terms of the hypothetical number of mental operations required. This order implies that when Chinese speakers process factual clauses in the mental model, polarity triumphs over the truth value in accessing the correct meaning.

Table 3 Hypothetical mental operation of negative probe sentences compared to factual clauses

Condition	True negative (TN)			False negative (FN)		
Target clause	The hurricane came			The hurricane came		
Test sentence	The hurricane was not far away			The hurricane did not come		
Target representation	(came, hurricane)			(came, hurricane)]		
Test representation	[Neg, (far away, hurricane)]			[Neg, (came, hurricane)]		
Mental operations		−	☒	−	+	☒
	−	+	☑	+	+	
Response index: false ☒	+	+				
true ☑	Response = true			Response = false		
	K + 4 comparisons			*K* + 3 comparisons		
Chinese text in target	颱風來了,……			颱風來了,……		
Chinese text in probe	颱風沒有遠離,……			颱風沒有來,……		

Compared with counterfactual clauses, the hypothetical negation embedded in the conditional conjunctive *yàobúshì* mismatches the negation in the probe sentences (see Table 4), which makes the process easier than affirmative probes. Hence, the order of mental processes from the easiest to the most difficult in accessing counterfactual clauses is TA < FA < FN < TN because of the increasing number of mental operations of four, five, eight, and nine, respectively. This order implies that the polarity weighs more importantly than the truth value in processing counterfactual clauses. This processing order in counterfactuals is similar to that in handling factual clauses. The conjunction *yàobúshì* is not a combination of *yàoshì* and *bú(shì)* because the resulting order of the four types of conditions was different (cf. Hsu 2014). According to the findings in Hsu (2014), *yàobúshì* is a counterfactual conjunction leading to counterfactual interpretations in Chinese. This similarity has been demonstrated in Hsu (2014), and the models were repeated here for ease of comprehension.

2.4 Predictions

Given the reported results on college students in Hsu (2014), clauses and sentences with counterfactual conjunction *yàobúshì* were interpreted in the same ordering (TA, FA, FN, TN) as factual clauses and sentences based on the mental representations hypothesized by the constituent comparison model (rather than the other ordering in FN < TN < TA < FA while hypothesizing *yàobúshì* as a combination of *yàoshì* and *bú(shì)*). As the junior high school teenagers and the elementary children were still developing their logical reasoning, they would need more time in comprehending counterfactual stimuli. Furthermore, based on Piaget's theory of cognitive development, the junior high group and the elementary group should be able to access the stimuli in the same ordering, the polarity outweighing the truth values.

3 Results

The participants' response times were taken as the comprehension time required to match probe sentences and test clauses. The response times were measured as the dependent variable (the percent correct in each group was high). The correct responses

Table 4 Hypothetical mental operation of negative probe sentences compared to counterfactual clauses

Condition	True negative (TN)				False negative (FN)			
Target clause	*Yàobúshì* the hurricane came				*Yàobúshì* the hurricane came			
Test sentence	the hurricane was not far away				the hurricane did not come			
Target representation	{CF, (came, hurricane)}				{CF, (came, hurricane)}			
Test representation	[neg, (far away, hurricane)]				[neg, (came, hurricane)]			
Mental operations			–	☒		–	+	☒
		–	+	☑	–	+	+	☑
Response index: false ☒	–	+	+	☒	+	+	+	☒
true ☑	+	+	+	☑				
	response = true				response = false			
	K + 5 comparisons				*K* + 4 comparisons			
Chinese text in target	要不是颱風來了,……				要不是颱風來了,……..			
Chinese text in probe	颱風沒有遠離,…				颱風沒有來,……..			

for the target clauses were subjected to analysis. A four-way repeated-measures ANOVA was conducted with the clause types (factual, counterfactual), truth values (true, false), and polarities (affirmative, negative) as within-participants factors together with each group (college students, junior high teenagers, elementary children) as a between-participants factor.

To comprehend the test sentences by matching the propositions embedded in representations, a four-way analysis of variances was conducted. Three between-participants factors reached significance. Faster responses to factual clauses (1811 ms) than to counterfactual clauses (1935 ms) were observed (main effect of clause type, $F(1,60) = 32.73$, $p < .001$). The probe sentences with true statements (TA, TN) had faster responses (1815 ms) than those with false statements (FA, FN) (1931 ms) (main effect of truth value, $F(1,60) = 23.68$, $p < .001$). The affirmative sentences (TA, FA) were understood faster (1696 ms) than the negative sentences (TN, FN) (2050 ms) ($F(1,60) = 214.41$, $p < .001$). One within-participant factor was not significantly different (main effect of group, $F(2,60) = 1.43$, $p > .05$), suggesting that the college participants generally performed the fastest responses (1760 ms) compared to the other participant groups (the junior high teenagers (1938 ms) and the elementary children (1921 ms)). No interaction with the group emerged, suggesting that the three groups showed similar patterns in the comprehension of counterfactual and factual clauses. An interaction between the truth value and polarity was observed ($F(1,60) = 123.34$, $p < .001$) with the simple main effect from the polarity difference on probe sentences of different truth values (TA < TN, $t(62) = -15.87$, $p < .001$; FA < FN, $t(62) = -4.62$, $p < .001$) and from the truth value difference on probe sentences of different polarities (TA < FA, $t(62) = -11.77$; FN < TN, $t(62) = 3.73$, both at $p < .001$). The processing order for both clause types was TA < FA < FN < TN, as proposed by the CCM, suggesting that counterfactual clauses with *yàobúshì* were processed in semantic-based representations as factual clauses across developmental stages, as shown in Fig. 1. No other interactions were observed.

Further analyses were conducted to investigate whether the counterfactual target clauses embedded in different test sentences caused a mental processing difference (the antecedents of CC sentences, hereafter, CC1; the consequents of CC sentences, CC2; the counterfactual target clause in CF sentences, CF1; and the counterfactual target

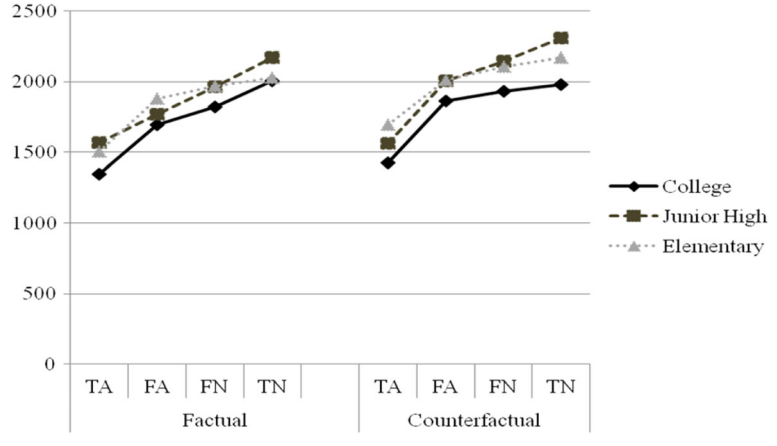

Fig. 1 The reaction times for factual clauses and counterfactual clauses in the three age groups

clauses in FC sentences, FC2). The analysis included three within-participants factors (target clause type, truth value, polarity) together with groups as a between-participants factor. A four-way repeated-measures ANOVA was employed. The finding showed the processing order was the same in CC1 and CF1: TA > FA < FN < TN. The detailed analyses were conducted as follows. A three-way interaction of the within-participants factors emerged ($F(3180) = 14.51$, $p < .001$), but no interaction with the groups was observed. The simple interaction of the truth value and polarity was significant in the CC1 ($F(1,62) = 73.51$, $p < .001$) and CF1 ($F(1,62) = 42.67$, $p < .001$) target clause types. Post hoc *t* test comparisons revealed the truth value effect on probe sentences with different polarities and the polarity effect on probe sentences with different truth values (in CC1, TA < TN, $t(62) = -9.79$, TA < FA, $t(62) = -7.93$, FN < TN, $t(62) = 4.17$, $p < .001$; in CF1, TA < TN, $t(62) = -10.46$, TA < FA, $t(62) = -6.52$, FN < TN, $t(62) = 2.75$, $p = .008$). No simple interaction in the CC2 and FC2 target clause types was observed. In sum, the three groups processed counterfactual target clauses differently according to the antecedents and consequents. The antecedents in non-canonical sentences (CF1) were processed in the same way as the antecedents in canonical sentences (CC1), as illustrated in Figs. 2 and 3.

Further investigation on the possible target clause position effect in counterfactual comprehension was analyzed. A four-way repeated-measures ANOVA was conducted with the target clause positions (antecedents as clause 1, consequents as clause 2), truth values (true, false), and polarities (affirmative, negation) as the within-participants factors, together with the groups (college students, junior high teenagers, elementary children) as the between-participants factor. The results revealed a three-way interaction of the within-participants factors without the group effect ($F(1,60) = 39.70$, $p < .001$). One of the simple interactions, from the interaction of the truth values and polarities on clause 1, was significant ($F(1,62) = 98.53$, $p < .001$). The simple main effect was from the truth value effect on the probe sentences with distinct polarities and the polarity effect on the probe sentences with different truth values (TA < TN, $t(62) = -12.51$; TA < FA, $t(62) = -9.35$; FN < TN, $t(62) = 4.70$; all $p < .001$). No interaction on clause 2 was observed. Other simple

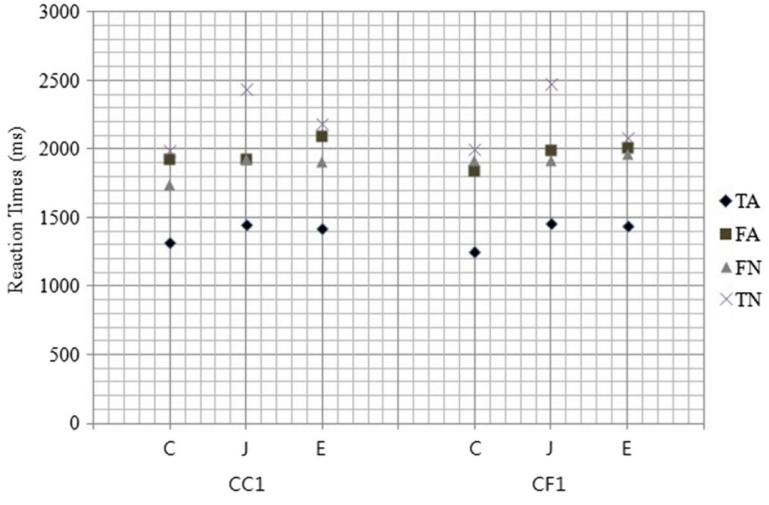

Fig. 2 The reaction times of the four probe sentence types for counterfactual target clauses in CC1 and CF1 in the three groups

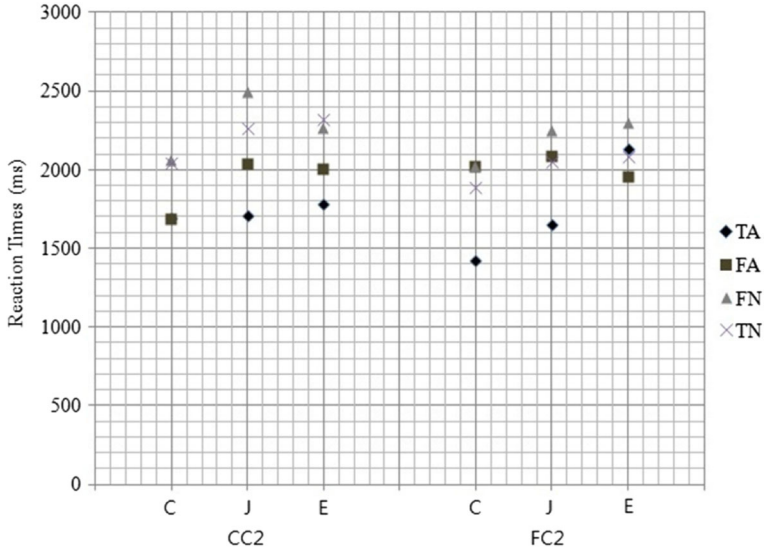

Fig. 3 The reaction times of the four probe sentence types for counterfactual target clauses in CC2 and FC2 in the three groups

interactions of the target clause positions and polarities were observed on the sentences with true statements ($F(1,62) = 33.50$, $p < .001$) and on the sentences with false statements ($F(1,62) = 11.93$, $p = .001$). Post hoc t test comparisons revealed that the target clause position effect (clause 1 < clause 2) on the affirmative probes with true statements (TA1 < TA2, $t(62) = -5.62$, $p < .001$) and on the negative probes with false statements (FN1 < FN2, $t(62) = -4.49$, $p < .001$) was significantly observed. These findings were consistent with the previous results that matched propositions between the target counterfactual clauses in which the sentences facilitated processing time in the mental model (see Fig. 4).

In sum, the analyses yielded no group difference, showing adult-like counterfactual processing of 12-year-old children. Better comprehension (faster responses) of factual target clauses, affirmative clauses, and true statements was observed compared to

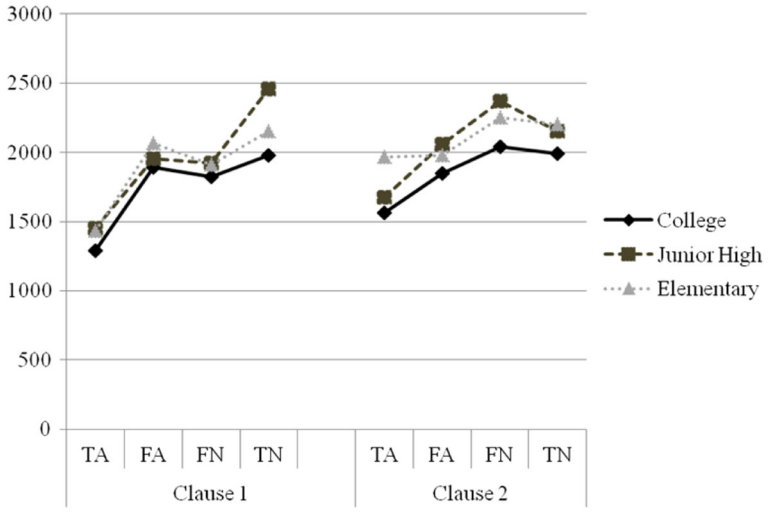

Fig. 4 The reaction times of counterfactual target clauses in antecedents (clause 1) and consequents (clause 2) of the three groups

counterfactual target clauses, negative clauses, and false statements. Both canonical and non-canonical counterfactual clauses were processed similarly, which is inconsistent with the proposals of this study based on the CCM (showing TA < FA < FN < TN ordering). Moreover, only antecedent counterfactual target clauses confirmed the processing ordering, but not consequent counterfactual target clauses, suggesting the counterfactual conjunction *yàobúshì* in the beginning position of a sentence led to contrary-to-fact thinking. This could be the evidence to argue against the necessary association of *yàobúshì* and collocates ((就)(不)會, (*jiù*)(*bú*)*huì* and many others) to obtain the counterfactual interpretations (Jing-Schmidt 2017).

4 Discussion and conclusion

The conjunction *yàobúshì* is a counterfactual marker in Chinese, as in

(13) 要不是我遲到了, 車子就不會開走了
yàobúshì__wǒ__chídào__le, chēzi__jiù__búhuì__kāizǒu__le
if-it-were-not__I__late__ASP, car__only__would-not__drive-away__ASP
If it was not that I had been late, the car would not have been driven away

The results were in line with the findings in previous studies coercing 如果 *rúguǒ* 'if' and 沒有 *méiyǒu* 'not' in antecedent clauses, together with the negation 不會 *búhuì* 'not' and the aspect marker *le* (了) in consequent clauses, as in

(14) 如果我沒有遲到, 車子就不會開走了
rúguǒ__wǒ__méiyǒu__chídào, chēzi__jiù__búhuì__kāizǒu__le
if__I__not__late, car__only__would-not__drive-away__ASP
If I had not been late, the car would not have been driven away

(Hsu 2013). Supporting evidence was obtained from different developmental stages, confirming *yàobúshì* as a counterfactual conjunction. By correctly constructing the representations of propositions and the relations between propositions, interpretations of beliefs are reached (Wimmer and Perner 1983). In Chinese counterfactuality, through the counterfactual conjunction *yàobúshì*, factual information is enabled in antecedents and the imaginary outcomes in consequents. Instead of using subjunctive moods as mediators, the mental processes of reality/beliefs and imaginations/desires in theory of mind tightly link counterfactual conditionals with *yàobúshì* in Chinese.

Developmental data provided further support to the findings in Hsu (2014) that the conditional conjunctive *yàobúshì* cannot be understood as the combination of a conditional marker 要是 *yàoshì* 'if' (and the negation 不(是) *bú(shì)* 'not' or *méiyǒu*. Based on the Academia Sinica Balanced Corpus of Modern Chinese (中央研究院漢語平衡語料庫,[1] Chen et al. 1996; Huang et al. 2017), most sentences with the combination of *yàoshì* and *bú(shì)* or *méiyǒu* simply describe possible conditional situations. For instance, consider

(15) 要是不合身怎麼辦?
yàoshì__bù__héshēn__zěmo__bàn
if__not__fit__how__do
If it is unfit, what can I do?

(16) 要是沒有颱風, 差不多每天都是一樣
yàoshì__méiyǒu__táifēng, chābùdūo__měitiān__dōu__shì__yíyàng
if__not__typhoon, almost__every-day__all__is__the-same
If there is no typhoon, there is no difference in daily life

(17) 要是還有不認識的字, 就查字典
yàoshì__háiyǒu__búrènshì__de__zì, jiù__chá__zìdiǎn
if__still-have__do-not-know__DE__word, only__look-up__dictionary
If there are unknown words, you can look them up in a dictionary

Yàobúshì is proposed as a single unit, making counterfactual expression possible, but it is not equivalent to the combination of *yàoshì-bú(shì)* or *yàoshì-méiyǒu*. This offline investigation provides support to our psycholinguistic findings that the mental representations of counterfactuals with *yàobúshì* in Chinese are not embedded negations but that a counterfactual conditional conjunction opens a door of imagination and allows speakers to enter into a hypothetical world. There are 45 out of 75 sentences (60%) with *yàobúshì* in the corpus indicating counterfactual meaning with imaginary negative consequences, as in

(18) 要不是大白鵝趕來救他, 早就送掉一條命了
yàobúshì__dàbáiér__gǎnlái__jiùtā, zǎojiù__sùngdiào__yìtiáomìng__le
if-it-were-not__big-white-goose__hurrily-come__save-him, already-at-an-earlier-time__give-away__one-CL-life__ASP
If it was not that a big goose had come to save him, he would have lost his life

(19) 要不是同學和房東熱心的幫助我, 真不知道該怎麼辦
yàobúshì__túngxúe__hé__fángdūng__rèxīn__de__bāngzhù__wǒ, zhēn__bùzhīdào__gāi__zěmobàn
if-it-were-not__classmate__and__landlord__enthusiastically__DE__help__I, really__don't-know__should__how-to-do
If it was not that classmates and the landlord had helped me enthusiastically, I would have never known how to manage it

(20) 要不是趙樹理, 我們早就餓死了
yàobúshì__zàoshùlǐ, wǒmén__zǎojìu__èsǐ__le
if-it-were-not__Zàoshùlǐ (name), we__already-at-an-earlier-time__hungry-to-die__ASP
If it was not that we had been with Zaoshuli('s help), we would have been starved to death

(21) 要不是我撥了電話, 恐怕你連中飯都省了
yàobúshì__wǒ__būo__le__dìanhùa, kǔngpà__nǐ__líen__zhūngfàn__dōu__shěng__le
if-it-were-not__I__call__ASP__telephone, I-was-afraid__you__even__lunch__all__spare__ASP
If it was that I had made the phone call, you would have missed the lunch

Nineteen out of 75 sentences (25%) with *yàobúshì* in the corpus denote counterfactual meaning with narrator's desires, for instance,

(22) 要不是春樹也參加了同一個補習班, 我也不想去呢
yàobúshì__chūnshù__yě__cānjīa__le__tóngyígè__bǔxíbān, wǒ__yě__bùxiang__qù__ne
if-it-were-not__Chūnshù (name)__also__attend__ASP__the-same-one__cram-school, I__also__don't-want__go__ASP
If it was not that Chūnshù had attended the same cram school, I would not have been there

(23) 要不是我運氣不好, 現在經理位子應該是我坐的
yàobúshì__wǒ__yùnqì__bùhǎo, xìanzài__jīnglǐ__wèizi__yīnggāi__shìwǒ__zùo__de
if-it-were-not__I__luck__not-good, now__manager__position__should__be-mine__sit__DE
If it was not that I had had bad luck, I would have been in the post as a manager

(24) 要不是氣氛詭異, 接下來我一定拍手逗他
yàobúshì__qìfèng__gǔiyì, jiēxiàlái__wǒ__yídìng__pāishǒu__dòutā
if-it-were-not__atmosphere__weird, next__I__must__clap-hands__make-him-laugh
If it was not that the atmosphere had become weird, my next act would have clapped my hands to make him happy

(25) 要不是辛巴誕生, 王位的繼承人應該是我
yàobúshì__xīnbā__dànshēng, wángwèi__de__jìchéngrén__yīnggāi__shìwǒ
if-it-were-not__Xīnbā (name)__born, king-position__DE__heir__should__be-mine
If it was not that Xīnbā had been born, I would have been second to none

Other sentences with *yàobúshì* do not entail contrary-to-fact interpretation, such as making contrasts (8/75, 0.11%) as in

(26) 要不是向敵人打信號, 就是在吸引敵人的砲火
yàobúshì__xìang__dírén__dǎxìnhào, jìushì__zài__xīyǐn__dírén__de__pàohǔo
if-it-were-not__toward__enemy__send-signals, exactly__ASP__appeal-to__enemy__DE__bombfire
If it was not that (someone) lights signals to the enemies or appeals to the enemies' attacks

(27) 要不是已經退休, 就是已過事業巔峰而到了該交棒的時候
yàobúshì__yǐjīng__tuèixiū, jìushì
__yǐgùo__shìyè__dīanfēng__érdàole__gāi__jīaobàng__de__shíhòu
if-it-were-not__already__retire, exactly__already-passed__career__top__then-moved-to__should__pass-on__DE__timing
If it was not that (they) had already retired or had passed the top of their career and had to find someone to inherit it

standing for if only (1/75, 0.13%), as in

(28) 只要不是離家太遠, 阿春總是擠在台下人堆裡搶著第一個拍手
zhǐyào__búshì__líjīa__tàiyǔan,
āchūn__zǔngshì__jǐ__zài__táixià__rénduīlǐ__qǐang__zhe__dìyīge__pāishǒu

if-only__not__leave-home__too-far, Āchūn (name)__always__crowd-in__ASP__below-stage__in-the-crowd__hurry__ASP__the-first__clap-hands
If only (the show) is not far away from Āchūn's house, he is always in the crowd to be the first one clapping his hands

Two uses have no context (2/75, 0.27%). These analyses suggest that most, although not all, sentences with *yàobúshì* are related to counterfactual expressions.

From the developmental trends, the negation 不 *bù* 'not' in *yàobúshì* does not function as a negator, but it is combined with *yàoshì* as a counterfactual conjunction to guide Chinese speakers into a contrary-to-fact world. This paper proposes that the conditional conjunction *yàobúshì* is a counterfactual conjunction in pragmatic use as a frozen expression without negation. Chinese speakers state counterfactuals by describing expected hypothetical situations as their desires/imagination in their minds, which are alternatives to actual situations. Simultaneously, Chinese speakers admit the existence of real situation and describe it in the antecedent as a premise or background to create a contradiction in a counterfactual conditional with *yàobúshì*. Hence, two representation levels coexist in the mental model: the actual belief and the opposite desire in imagination. Uttering counterfactuality with *yàobúshì* explicitly expresses desired outcomes that are contradictory to real conditions.

The construction of false beliefs takes time to develop, as Wimmer and Perner (1983) demonstrated in differentiation of deceitful from truthful states from the age of six onward. The participants received two stories describing a protagonist, Maxi, who observed his mother bring chocolate back home from a shopping trip and put it into a blue cupboard. Later, Maxi went out to the playground without witnessing his mother take out the chocolate and grate it to make a cake. Subsequently, his mother put the chocolate in a green cupboard. Then, Maxi came back from the playground and wanted to eat it. The participants were asked a belief question of "where will Maxi look for the chocolate?", a reality question of "where is the chocolate really?", and a memory question of "do you remember where Maxi put the chocolate in the beginning?". Before the reality question and the memory question were posed, two different narrations about mental states of competition or cooperation were provided to investigate whether the participants successfully inferred the mental states and uttered the expected responses. In the competitive condition, Maxi's brother showed up in the kitchen to get the chocolate, but Maxi did not want to share it. So, Maxi would tell him a different place from the original place where his mother had put it. In the cooperative condition, Maxi was too small to reach up to the cupboard where the chocolate was placed. At that time, Maxi's grandpa came to visit him, so Maxi asked for help from him. If the participants successfully inferred the mental state of the protagonist in competition, they were expected to respond with the green cupboard, which was the correct answer. However, if the cooperative state was reasoned, the participants would respond that the blue cupboard was where Maxi's mother actually put the target, which would be the wrong answer. The participants had to understand the belief of the protagonist and reason the conditions. Three groups of participants with different ages took part in the study: those aged four to five, six to seven, and eight to nine. The results revealed that children older than six tended to reply with a deceptive, incorrect answer of where the chocolate was, in their minds refusing to share (competitive condition), but they

responded to the grandfather with the correct answer in their minds (cooperative condition). Most of the time, the young group replied with the place where Maxi's mother had put the chocolate later after grating it, regardless of the different conditions of mental states, suggesting a lack of mentalizing ability in the early stage of development. The children 6 years of age and older showed deceitful behaviors in the competitive condition but a cooperative attitude with the grandfather. A follow-up study confirmed that the failure of young participants to reason regarding the protagonist's mental states was not because they reacted to questions too quickly, leading to low accuracy. From Wimmer and Perner's results (Wimmer and Perner 1983), it is clear that 6-year-old children, but not younger children, have developed reasoning capacities regarding other people's minds.

Our study with reading materials revealed that the elementary participants understood counterfactuals with *yàobúshì*, inferred mental states from expressions of reality/beliefs and imaginations/desires, and linked them to theory of mind without difficulty, similarly to college students. Unlike the significantly slow response latencies of the elementary students to respond to coercive counterfactual reading with *rúguǒ*, *méiyǒu*, *búhuì*, and *le* in Hsu (2013), elementary students develop an adult-like ability early to comprehend the counterfactual conjunction *yàobúshì*. As revealed by the protocols of theory of mind in location change (Sally-Anne story) and content change (Smarties test), 4-year-olds possess this cognitive ability and pass false belief tests of ability to infer the mental states of others. Our elementary participants were, on average, 12-year-olds, who have developed reasoning abilities. We leave exploration of early childhood (< 2 years old) development on Chinese counterfactual reasoning with reading materials and its association with theory of mind for future studies. Other potential counterfactual conjunctions, such as 早知道 *zǎozhīdao* 'had it known' or classical Chinese lexical words such as 假使 *jiǎshǐ* 'if', 若使*ruòshǐ* 'if', and 微 *wéi* 'if not', need psycholinguistic support regarding this availability.

With subjunctive moods in Chinese, it is proposed that Chinese speakers emphasize contrasts of realities/beliefs and desires/imaginations in comprehending counterfactuals. This proposal is in line with a study showing that adults do not fully apply theory of mind in comprehension (Keysar et al. 2003). In Keysar et al. (2003), a participant and a director were tested in a communication game. The participant had to react to the director's instructions concerning the following pair of objects: one visible intended object and the other an invisible hidden object in a brown bag. Two studies were conducted as follows: (1) only the participants knew the objects inside of the bags, while the directors had no idea about the object, and the participants realized the director's ignorance; (2) the directors were informed that certain objects were inside of the bags, but in actuality, different objects were in the bags, and the participants knew the directors had false beliefs about the contents of the bags. The rationale of the tests' design was to investigate whether the participants would incorporate the directors' states of knowledge of the bag into their responses. For example, a participant was instructed by a director to move the tape from a visible cassette tape and an invisible hidden roll of tape in the bag. Measurements of behavioral responses regarding executing actions and eye tracking fixation plus gaze duration were perspective-taking indexes. The results showed that under situations of the directors' ignorance and false beliefs, the participants (71%) actually moved the invisible hidden objects at least once. Compared to the

baseline conditions, i.e., truly different categories of objects (e.g., a battery) from targets (e.g., a roll of tape) in brown bags, the participants fixated on the hidden objects five times more, and the gaze duration was six times more in the experimental conditions. Moreover, the decision time (measured as final fixation on the intended objects) was delayed in 82% of the participants or doubled in the experimental conditions compared to the baseline conditions. These findings indicated that adult participants did not consider the directors' perspectives of ignorance or false beliefs of hidden objects in responding to the instructions, suggesting sparseness in the application of theory of mind in adults.

In Chinese, counterfactuals without a subjunctive mood, but instead containing the lexical expression *yàobúshì*, differentiate alternative situations from reality. In English, the subjunctive mood is the indicator for denoting contrary-to-fact thought. However, in Chinese, using the counterfactual conjunctive *yàobúshì* at the lexical level achieves the same function. Chinese speakers use *yàobúshì* to express hypothetical situations by stating the real situation as a proposition (Hsu 2014). Counterfactual reasoning requires the construction of the mental model of contrary-to-fact unreality for processing and requires two cognitive operations: first, entering a possible world, and then, differentiating the time frame of the event in the possible world (Hsu 2013). In counterfactual reasoning, comprehenders make inferences regarding events that are contrary to past events. To achieve successful counterfactuality and comprehension of counterfactual conditionals, one must first combine reality with alternatives and then understand this reality as truth. Reality plays an important role in counterfactual reasoning. The mental model is based on an imagined event, which itself is dependent on reality. In English, the processes of entering a possible world are by comprehending the conditional marker *if* and differentiating time frames through the use of the subjunctive mood to clarify counterfactual reasoning. In English, these two cognitive operations are achieved through linguistic elements. However, in Chinese, there is no linguistic inflection that parallels the English subjunctives. Because of this morphological simplicity, any if-then construction in Chinese may refer to mental models of reality, hypothetical/imaginative unreality, or counterfactual unreality. In Chinese, a possible world is constructed through conditional conjunctives such as *yàobúshì*. Then, comprehenders differentiate time frames through tightly linking realities/beliefs and alternatives/desires. With application of theory of mind, hence, various coercions and collocations can make Chinese counterfactuals possible. In contrast, if salient morphological inflections could serve as mediations to reach counterfactuality, there would be less or no need to apply theory of mind in counterfactual reasoning. Comparisons of counterfactual processing in Chinese and English with similar stimuli in the same study need to be employed in the future.

5 Endnotes

[1]Academia Sinica Balanced Corpus of Modern Chinese 中央研究院漢語平衡語料庫 Available at http://asbc.iis.sinica.edu.tw/. Accessed 10 April 2016 and 20 July 2017.

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Competing interests
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