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What makes a complement false? Looking at the effects of verbal semantics and perspective in Mandarin children's interpretation of complement-clause constructions and their false-belief understanding

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Abstract: Research focusing on Anglo-European languages indicates that children's acquisition of the subordinate structure of complement-clause constructions and the semantics of mental verbs facilitates their understanding of false belief, and that the two linguistic factors interact. Complement-clause constructions support false-belief development, but only when used with realis mental verbs like 'think' in the matrix clause (de Villiers, Jill. 2007. The interface of language and Theory of Mind. *Lingua* 117(11). 1858–1878). In Chinese, however, only the semantics of mental verbs seems to play a facilitative role in false-belief development (Cheung, Him, Hsuan-Chih Chen & William Yeung. 2009. Relations between mental verb and false belief understanding in Cantonese-speaking children. *Journal of Experimental Child Psychology* 104(2). 141–155). We argue that these cross-linguistic differences can be explained by variations in availability and usage patterns of mental verbs and complement-clause constructions across languages. Unlike English, Mandarin-Chinese has a verb that indicates that a belief might be false: *yi3wei2* '(falsely) think'. Our corpus analysis suggests that, unlike English caregivers, Mandarin-Chinese caregivers do not produce frequent, potentially unanalyzed, chunks with mental verbs and first-person subjects, such as 'I think'. In an experiment, we found that the comprehension of complement-clause constructions used with *yi3wei2* '(falsely) think', but not with *jue2de2* 'think', predicted

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Mandarin children's false-belief understanding between the ages of 4 and 5. In contrast to English, whether mental verbs were used with first- or third-person subjects did not affect their correlation with false-belief understanding.

Keywords: chunks; complement clauses; cross-linguistic; false belief; verbal semantics

1 Introduction

According to Cognitive Linguistics, language interacts and is interdependent with conceptualization and social cognition (e.g., Croft and Cruse 2004; Diessel 2017). While research with adults can shed some light on the relation between language, conceptualization and social cognition, developmental research is especially suitable to explore this issue because it allows us to see in which order children acquire specific linguistic constructions and develop the corresponding conceptual knowledge and social-cognitive abilities. In other words, developmental research allows us to investigate whether language builds on conceptual knowledge and social-cognitive skills or vice versa, or whether there is a bi-directional relationship between linguistic and cognitive development. It also allows us to investigate whether cross-linguistic differences in the use of linguistic constructions affect children's conceptual and socio-cognitive development. In the current study, we investigate cross-linguistic differences in mental-state language (comparing English and Mandarin Chinese) and how these differences might affect children's understanding of mental states and others' perspectives. Before we introduce the current study in more detail, we will summarize previous research and discuss (1) interactions between language, conceptualization and social cognition and (2) how cross-linguistic differences can lead to differences in conceptualization and social cognition. Given the focus of the current study on mental-state language and children's understanding of mental states, we will mainly discuss interactions between linguistic and social cognitive development.

1.1 Interactions between language, conceptualization, and social cognition

It is probably undisputed that language builds on social cognition. We would produce a lot of incomprehensible utterances if we did not take our interlocutors' perspective and their mental states into account. As stated by de Villiers (2021: 73), "point of view is ubiquitous in linguistic expressions". Whether we refer to someone as *I* or *you* or to something as *the shoe* or *it* depends on our own and our interlocutor's perspectives and whether we have shared knowledge (i.e., Common Ground). In addition, it has been shown that language development builds on early social-cognitive skills. For example, in order to learn a new word from an adult, children must be able to take the adult's point of view and follow their attention to the object that they are labeling with that new word (e.g., Baldwin 1995).

A main claim of Cognitive Linguistics is that language does not only depend on social cognitive skills, but also points to and can make us aware of different perspectives and mental states (e.g., Langacker 1987; Verhagen 2012). This claim can also be backed up by developmental research. Especially when it comes to children's developing understanding of mental states, it has been demonstrated that language supports or might even be a prerequisite of this social cognitive skill (e.g., de Villiers 2021). One big milestone in children's developing understanding of mental states is their understanding of false belief. In classic false-belief tests, children need to demonstrate their understanding that a character can have a belief that is different from their own belief and different from reality. For example, children are shown and told a story where a character places a toy in container A and then leaves the scene. In the first character's absence, a second character enters the scene and moves the toy from container A into container B. Then the second character leaves the scene and the first character returns, and the children are asked *where will s/he look for the toy*. Only around the age of 4 years do children provide the correct answer (container A) to demonstrate that they can take the first character's perspective instead of answering the question based on their own perspective (i.e., they would go for container B because they know that the toy has been moved there) (Wellman et al. 2001).

Interestingly, Schick et al. (2007) showed that deaf children growing up with hearing parents, and thus without linguistic input from native signers at home, are delayed in their false-belief development. At the same time, the false-belief development of deaf children whose parents are also deaf and use sign language at home does not differ from the false-belief development of typically developing hearing children. This pattern was also found in false-belief tasks with minimal verbal demands.[1] In addition, even some deaf adults show limited or no understanding of false belief. When Pyers and Senghas (2009) tested signers of Nicaraguan Sign Language, only the cohorts who have acquired a more advanced version of this newly emerging

1 Note that we are only concerned with explicit tests of false-belief here. These explicit tasks typically require children to predict how someone with a false belief would behave in a certain situation. Additional details and examples will be provided in the Methods section. Whether or not implicit false-belief tasks measure the same developmental skill is a debate that goes beyond the scope of the current study.

sign language were able to demonstrate an understanding of false belief. Taken together, these studies with deaf children and adults strongly suggest that language is a prerequisite to develop an understanding of false belief. It should be noted though that some studies have also found a bi-directional relationship between false belief and children's understanding of mental-state language (e.g., Boeg Thomsen et al. 2021), which suggests that children's linguistic and social cognitive skills are interdependent.

In addition, researchers do not agree on which aspects of language support or facilitate false-belief understanding (for an overview see Astington and Baird 2005). Some argue for a general language effect and suggest that taking part in everyday conversations makes children aware of the fact that people can differ in their perspectives, attitudes, and beliefs (e.g., Harris et al. 2005). Others argue that caregivers' use of mental verbs, such as *think*, *know*, and *wish* makes children aware of false beliefs and other mental states that are labeled by these verbs (e.g., Ruffman et al. 2002). Finally, it has also been suggested that children's syntactic knowledge supports their understanding of false belief (Astington and Jenkins 1999). More specifically, de Villiers and others argue that complement-clause constructions, such as *the alien thinks the earth is flat*, allow children – and adults – to represent false beliefs (e.g., de Villiers and Pyers 2002; Hale and Tager-Flusberg 2003). According to de Villiers (2007), complement-clause constructions play a key role in children's false belief development because they are the only linguistic construction that allows us to represent someone's false belief. This is because the whole sentence (e.g., *the alien thinks the earth is flat*) can be true while the complement clause (e.g., *the earth is flat*) is false. This is not the case for other complex constructions. When we say, for example, *the alien left because the earth is flat*, both the main clause and the subordinate clause are assumed to be true. In other words, the use of complement-clause constructions uniquely allows one to express both a conceptualizer (e.g., *the alien*) and the conceptualizer's representation of reality (e.g., *the earth is flat*) when that representation differs from one's own representation of reality.

In the current study we expand on Lohmann and Tomasello's (2003) suggestion that there might be multiple routes to false-belief development. In a training study with German-speaking children, they found that in a context where children experienced deceptive objects, such as candles looking like apples, both the use of complement-clause constructions (e.g., *yes, I also think it's a candle*) and the use of simple clauses (e.g., *right, it is really a candle*) led to better false-belief understanding than the use of minimal language (e.g., *and now look*). Similarly, whereas Mo and colleagues (Mo et al. 2014) found that Mandarin-Chinese children's understanding of false belief can be boosted by an exposure to complement-clause constructions, a training study by Lu et al. (2008) suggests that encouraging Chinese children to just talk about other people's actions can also lead to improved false-belief understanding.

1.2 Cross-linguistic differences in language and social cognition

Summarizing previous research on language and false-belief development, it is not entirely clear whether a specific linguistic construction plays a privileged role in false-belief understanding *within* a given language. The picture gets even more complicated when we compare studies *across* languages. At the same time, cross-linguistic differences in conceptualization and social cognition are expected within the theoretical framework of Cognitive Linguistics (e.g., Talmy 2000; for a recent review paper on the importance of cross-linguistic research in Cognitive Linguistics and Cognitive Science see Blasi et al. 2022). Similarly, following the "Thinking for Speaking" hypothesis by Slobin (1996), previous research has suggested that children's social cognitive development and adults' social cognitive skills can differ according to cross-linguistic differences. Particularly, it has been suggested that when children learn a language with obligatory evidential markers, such as Turkish or Korean, this will make them more aware of others' source of information and mental states than children who learn a language where marking source of information is optional (e.g., Aksu-Koç et al. 2009; Lucas et al. 2013; but see Ünal and Papafragou 2020).

Languages also differ in their inventory of mental verbs. For example, both Chinese and Spanish have a verb that would be translated as 'falsely think', which signals that the following complement clause is false. And it has been shown that Spanish-speaking children show advanced performance in false-belief tasks (Blasi et al. 2022), and that Chinese-speaking children perform better in false-belief tasks when the test questions contain this 'falsely think' verb (Lee et al. 1999). At the same time, Chinese-speaking children's false-belief development seems to be less affected by their acquisition of complement-clause constructions (e.g., Cheung et al. 2009). As pointed out by de Villiers (2021: 80), "most of the failures to find a unique role for complements over other language (…) come from studies with Chinese-speaking children (Mandarin and Cantonese), in which the syntactic marking is very lean". As we will discuss in more detail below, semantic and syntactic differences between English and Chinese complement clauses might explain why they affect children's false-belief development differently.

1.2.1 Cross-linguistic differences in complement-clause constructions, mental verbs, and false-belief development

From a formal perspective, complement-clause constructions contain a matrix clause and a subordinate clause, with the latter functioning as the complement of the matrix verb. This matrix verb is usually a mental-state or a communication verb (e.g., *he thinks/says [that she he is nice]*). Originally, de Villiers and colleagues proposed that the subordinate structure of complement-clause constructions serves as a representational tool for false belief and that children need to acquire this syntactic structure in order to develop an understanding of false belief. As mentioned before (see Section 1.1), complement-clause constructions (e.g., *the alien thinks the earth is flat*) seem to be the only syntactic construction that allows us to express both a conceptualizer (e.g., *the alien*) and the conceptualizer's representation of reality (e.g., *the earth is flat*) when that representation differs from our own representation of reality (e.g., de Villiers and de Villiers 2000; de Villiers and Pyers 2002). In order to disentangle the effects of the subordinate structure of complement-clause constructions and the semantics of the matrix verbs, de Villiers and Pyers (2002) used test items with mental verbs (e.g., *she thought [she found a monster]*) as well as items with communication verbs in the matrix clause (e.g., *she said [she found a monster]*). In their longitudinal study with English-speaking children, they found that children's understanding of both types of complement-clause constructions predicted their later false-belief understanding (for a bi-directional relationship between complement-clause constructions and false belief, see Boeg Thomsen et al. 2021). This finding led them to argue that the subordinate structure of complement-clause constructions, not the semantics of the matrix verbs, plays a crucial role in children's false-belief development (for similar results from training studies with English- and German-speaking children see Hale and Tager-Flusberg 2003; Lohmann and Tomasello 2003).

At the same time, results from a cross-sectional study with German-speaking children (Perner et al. 2003) suggest that the semantics of the matrix verbs also has an effect on children's understanding of these constructions, and how they are related to false-belief development. Like de Villiers and Pyers (2002), Perner and colleagues tested children's understanding of complement-clause constructions and false belief. In addition to using complement-clause constructions with mental and communication verbs, they also presented children with complement-clause constructions with desire verbs in the matrix clause (e.g., *Mutter will, dass Andreas ins Bett geht* 'Mum wants [that Andy goes to bed]'). Unlike in English, desire verbs can be used with finite sentential complements in German. Perner et al. (2003) found that children understood complement-clause constructions with desire verbs before they understood complement-clause constructions with mental or communication verbs, and that the understanding of these constructions with desire verbs showed no developmental link to children's false-belief understanding. Therefore, they argued that children's understanding of false belief is not supported by their acquisition of the subordinate structure of complement-clause constructions.

Similar results have been found with Chinese-speaking children. Cheung et al. (2009) showed that the comprehension of complement-clause constructions only predicted Cantonese-Chinese children's false-belief understanding when children were tested on items with the non-factive verb *ji5wai4* 'falsely think' in the matrix clause – as opposed to communication or other mental verbs. Like de Villiers and Pyers (2002), they asked children to answer complex questions containing complement clauses and communication verbs (e.g., *what did Mark say [he bought]*). In addition, they administered a different task with complement-clause constructions containing factive versus non-factive mental verbs ('know' vs. 'falsely think' respectively) and factive versus non-factive action verbs ('discover' vs. 'lie' respectively). In Chinese, these verbs can all be used together with the same type of sentential complement. However, whereas the factive verbs 'know' and 'discover' signal that the following complement is true, the non-factive verbs 'falsely think' and 'lie' signal that the following complement may be false (e.g., Glass 2022). After children heard, for example, *May falsely thought [that Mary was gone]*, they were asked whether Mary was gone. For the non-factive verbs 'falsely think' and 'lie' the correct answer was 'no'. For the factive verbs 'know' and 'discover' (e.g., *May knew [that Mary was gone]*), the correct answer was 'yes'. Cheung et al. (2009) found that, when controlling for general language, non-verbal intelligence, and age, the strongest and most reliable predictor for children's false-belief understanding was their understanding of complement-clause constructions with the non-factive mental verb 'falsely think'. The understanding of complement-clause constructions with the communication verb 'say' did not explain any additional variance in children's false-belief understanding. This suggests that the main linguistic factor in Cantonese-Chinese children's false-belief development is the understanding of the semantics of certain mental verbs associated with factivity rather than the understanding of the structure of complement-clause constructions. Similarly, Mo et al. (2014) showed that children learning Mandarin Chinese could progress on false-belief understanding without progressing on the understanding of complement-clause constructions.

Why do English-speaking children, but not Chinese-speaking children, show developmental links between false belief and complement-clause constructions? One potential reason is the lack of tense in Chinese. Unlike English that clearly distinguishes between infinitival and tensed complement clauses (e.g., *he wants her to leave* vs. *he thinks she's left*), this distinction is not marked in Chinese grammar (e.g., Cheung et al. 2004). De Villiers (2007, 2021) suggested that only tensed complements would support children's false-belief development. The key difference between infinitival and tensed complements is that only tensed complements can be evaluated as being true or false. When we say, for example, *he thinks she's left*, the proposition of the complement clause (*she's left*) can be either true or false (either she has or hasn't actually left). However, when we say *he wants her to leave*, it is not possible to say whether she will actually leave or not, at least not at the time of speaking. This distinction might explain why previous studies have not found strong links between complement-clause constructions and false-belief understanding in Chinese (e.g., Cheung et al. 2004, 2009), when complement clauses are not clearly marked as infinitival *or* tensed. Before we introduce our own cross-linguistic study on complement clauses, mental verbs and false belief, we will first briefly discuss cross-linguistic differences in usage patterns of mental-state language.

1.2.2 Usage patterns in complement clauses

As discussed above, in Chinese and other languages (e.g., Spanish), verbal semantics can affect whether the following complement clause is interpreted as true or false. In Chinese, for example, when the complement clause is preceded by *yi3wei2* 'falsely think', it should be interpreted as false. When it is preceded by 'know', it should be interpreted as true. When it is preceded by 'think', it could be either true or false (Glass 2022). Studies with German- and English-speaking children suggest that the type and frequency of matrix-clause subjects can also affect whether the following complement clause is interpreted as true or false (e.g., Brandt et al. 2010; Diessel and Tomasello 2001; Howard et al. 2008). In particular, when the matrix clause contains a first-person subject and a frequent mental verb such as *think* (e.g., *I think [it's bedtime now]*), the complement clause is often interpreted as true and assertive (see also Lewis et al. 2017). One reason for this is that, in languages like English and German, some frequent mental verbs are almost exclusively used with first-person subjects, and through repeated use, strings such as *I think* turn into unanalyzed chunks in which the semantics of the mental verb is bleached and does not necessarily signal a low degree of factivity or certainty anymore. It has been suggested that frequent chunks, such as *I think*, mostly function as epistemic markers, which are not the focus of the ongoing conversation (cf, Brandt et al. 2010; Diessel and Tomasello 2001; Thompson 2002). On the other hand, when the matrix clause contains a less frequent, e.g., third-person, subject (e.g., *Mary thinks [it's bedtime now]*), the mental verb *think* still carries its original meaning and signals a relatively low degree of factivity and certainty concerning the truth value of the following complement clause. Moreover, several studies found that the relationship between third-person complement-clause constructions and false belief is stronger than the relation between first-person complement-clause constructions and false belief (e.g., Brandt et al. 2016; Gerstadt et al. 1994), providing further evidence for the assumption that verbal semantics interacts with linguistic context. Relatedly, it has been shown that most of children's early complement clauses in spontaneous speech contain first-person pronouns and that these utterances occur before children have a fully developed understanding of false belief (e.g., Diessel and Tomasello 2001).

1.3 The current study

Previous cross-linguistic research suggests that complement-clause constructions show a stronger, and more unique, relation to children's false-belief understanding when the matrix clause signals that the following complement clause is or could be false. This false-complement signaling can be accomplished by specific verbs. The use of non-factive verbs, such as *ji5wai4* 'falsely think' in Cantonese-Chinese and *yi3wei2* 'falsely think' in Mandarin-Chinese, is an informative marker indicating that the following complement is false (e.g., Cheung et al. 2009). But these verbs are not available in all languages. In English and German, whether the complement clause is interpreted as true/false or more/less certain is also affected by usage patterns of specific linguistic items. Complement clauses preceded by chunks containing first-person subjects and frequent mental verbs (e.g., *I think*) are more likely to be interpreted as true/more certain than complement clauses preceded by matrix clauses such as *he thinks* or *Mary believes* (e.g., Howard et al. 2008). These findings provide an important, and a more nuanced, conceptual perspective for more comparisons on whether and how the form and function of specific linguistic structures relate to children's false-belief development cross-linguistically. Under this conceptual perspective, we extend our line of inquiry based on an earlier study on English (Brandt et al. 2016) to another major language, Mandarin Chinese, in this study.

Moreover, we suggest that the relative importance of the different linguistic factors in children's false-belief development depends on *whether* and *how* specific linguistic tools are used in a given language. First, we investigate how Mandarin-Chinese children and caregivers use mental verbs and complement-clause constructions and how this usage pattern compares to English and related languages. Then we look at how Mandarin-Chinese children understand and interpret complement-clause constructions with different subjects and mental verbs in the matrix clause and how their understanding compares to English-speaking children tested with the same experimental paradigm (Brandt et al. 2016). Finally, we determine how complement-clause constructions containing different subjects and mental verbs in the matrix clause are related to Mandarin-Chinese children's false-belief development. In addition, we are controlling for general language and inhibitory control, both of which might also have an effect on children's false-belief development and could correlate with children's understanding of complement-clause constructions and mental verbs (e.g., Carlson et al. 2002; Sabbagh et al. 2006). Before we present our experimental methods and results, we report a corpus study investigating how mental verbs and complement clauses are used in Mandarin Chinese.

2 Corpus study

We first analyzed caregivers' use of mental verbs and complement-clause constructions in spontaneous speech, as a basis to document Mandarin-speaking children's linguistic experience in this respect, and to speculate how this experience might shape their development of false-belief understanding.[2] We examined six different corpora that are available in the CHILDES database (cf. MacWhinney 2000). An overview of the corpus data is provided in Table 1. As pointed out by an anonymous reviewer, our corpus data include both cross-sectional and longitudinal data, and it could be interesting to separate the two types or to look at developmental trends within the longitudinal data, because caregivers might adapt to their

Table 1: Overview of Mandarin-Chinese corpus data.

Corpus	Age range of children (months)	Number of transcripts	Number of children	Type of study
Beijing	21–27	50	10	Caregiver–child interaction, longitudinal
Context	24	24	24	Caregiver–child interaction, cross-sectional
Chinese-	32–35	23	23	Narrative, cross-sectional
Tardif	36–47	286	284	
	48–60	294	287	
Zhou 1&2	14–32	49	46	Semi-structured play, cross-
	36–47	39	39	sectional and longitudinal
	48–59	41	41	
	60–72	60	60	
Tong	19–35	17	1	Dialogue, longitudinal
	36–40	5		
XuMinChen	15–41	53	5	Dialogue, longitudinal
Total	14–72	941	820	

2 Children's own production of frequent mental verbs and complement clauses can be found in Supplementary materials.

Table 2: Distribution (proportion and raw numbers) of overt subjects across mental verbs used with complement clauses in child-directed speech.

	First person		Second person		Third person		Ambiguous	Total *n*
	SG	**PL**	**SG**	**PL**	**SG**	**PL**		
Jue2de2 'think'	0.35 (*n* = 34)		0.57 (*n* = 56)	0.01 (*n* = 1)	0.04 (*n* = 4)	0.03 (*n* = 3)		98
Xiang3 'think'	0.18 (*n* = 10)	0.02 (*n* = 1)	0.76 (*n* = 42)		0.04 (*n* = 2)			55
Yi3wei2 'falsely think'	0.30 (*n* = 6)		0.20 (*n* = 4)		0.45 (*n* = 9)	0.05 (*n* = 1)		20
Zhi1dao4 'know'	0.39 (*n* = 64)	0.02 (*n* = 4)	0.49 (*n* = 82)		0.07 (*n* = 11)	0.01 (*n* = 2)	0.02 (*n* = 3)	166

SG, singular; PL, plural.

children's cognitive development by increasing their use of mental verbs or by using a greater variety of mental verbs and subjects as children get older. Unfortunately, the use of mental verbs in our corpus data is too sparse to detect any meaningful or significant quantitative changes (see Table 2). In addition, when we compared the two cross-sectional corpora, the patterns were mainly the same, even though the Context corpus is based on younger children than the Chinese-Tardif corpus. In both corpora, caregivers mainly used *zhi1dao4* 'know', followed by *jue2de2* 'think' and *xiang3* 'think'. Moreover, in both corpora, caregivers overwhelmingly used these mental verbs with a second-person singular pronoun.

We focused on four frequent mental verbs: *jue2de2*, *xiang3*, *yi3wei2*, and *zhi1-dao4*. The factive verb z*hi1dao4* is commonly translated as 'know' and signals that the accompanying complement clause is true. The other three verbs can all be translated as 'think'. In specific contexts, the verbs can also refer to other mental states, such as 'feel', 'want', 'remember', or 'miss'. However, when used with a complement clause, they commonly refer to 'think'.[3]

These 'think' verbs differ in their degree of factivity. *Yi3wei2* most strongly signals that the accompanying complement clause is false and can also be translated as 'falsely think'. Following other researchers (e.g., Cheung et al. 2009), we will therefore refer to this verb as non-factive. The other two 'think' verbs (*jue2de3*, *xiang3*) are more neutral in terms of whether they encode a true or a false belief (e.g., Cheung et al. 2009; Lee et al. 1999), and we will refer to them as neutral verbs. It should be noted though that

3 As in English, these mental verbs can also be used without a complement clause. Apart from *jue2de2*, the Mandarin-Chinese caregivers were most likely to use these verbs in constructions other than complement clauses (e.g., intransitive or transitive clauses).

jue2de2 is a hedging verb, indicating some uncertainty and expectation to be contradicted; while *xiang3* is more about preference and mental plan. In our experimental study, we have used the verb *jue2de2*. It is more frequent than *xiang3* in both caregivers' and children's speech (see Table 2; and Supplementary materials for children's data) and caregivers tend to use it with a complement clause rather than another syntactic construction. In addition, its hedging function makes it comparable to English *I think*, which has been used in the experiment looking at English-speaking children's interpretation of mental-state language and their false-belief understanding (Brandt et al. 2016), which is similar to the current study.

Utterances containing one of these four frequent mental verbs were extracted and coded by hand by the second author, who is a native speaker of Mandarin Chinese. For all utterances containing one of these four frequent mental verbs and a complement clause, we determined the subject used with the mental verb in the matrix clause. Utterances where the matrix-clause subject was dropped were excluded from this analysis (81 in total). Utterances that were unintelligible or incomplete were also dropped (except for some utterances, where the incompleteness or unintelligibility did not affect the analysis of these verbs). Table 2 shows the distribution of overt subjects across mental verbs in matrix clauses used with complement clauses in child-directed speech.

Previous studies suggest that, compared to English, Mandarin-speaking adults produce relatively few mental verbs to refer to 'thinking'. In particular, Tardif and Wellman (2000) showed that, whereas English-speaking caregivers are equally likely to discuss either 'thinking' or 'knowing' when they use a mental verb (see Bartsch and Wellman 1995), Mandarin-speaking caregivers are much more likely to refer to 'knowing' when they use a mental verb. If we focus on the mental verbs analyzed both by Tardif and Wellman (2000) and in the current corpus study, we get a similar picture: Caregivers are much more likely to use *zhi1dao4* 'know' than *xiang3* 'think' (Table 2). Interestingly, this cross-linguistic difference can also be linked to cross-cultural differences. Broadly speaking, China and other Asian cultures are collectivist and are mainly concerned about acquiring knowledge from others and about consensual learning, whereas Western cultures are individualistic and more concerned about independent critical thinking and diversity of opinions. It has been suggested that these cross-cultural and cross-linguistic differences are also linked to subtle differences in Theory of Mind development (e.g., Cheung et al. 2022). Whereas English-speaking children tend to pass diverse-belief tasks before they pass knowledge-ignorance tasks, this order is reversed in Chinese (and Turkish) children's Theory of Mind development (Selçuk et al. 2018; Wellman et al. 2006).[4] This

4 In diverse-belief tasks, children have to guess whether something or someone is hidden/hiding in location A or B. When they say A, they are told that another character believes B, or vice versa. Then indicates that cross-linguistic and cross-cultural differences in mental-state discourse lead to cross-cultural differences in children's developing understanding of mental states, a point that we will come back to in the Discussion.

In the current study, we are not only interested in *which* mental verbs are used to discuss mental states, but also *how* they are used. Most importantly, we find that Mandarin-Chinese caregivers do not show a first-person bias when they use frequent mental verbs. Unlike German- and English-speaking adults (cf. Brandt et al. 2010; Thompson 2002), Mandarin caregivers use all frequent mental verbs with a variety of subjects. Most often, they refer to the children's beliefs and knowledge states by using a second-person subject, but the use of mental verbs with first- and third-person subjects is also common (see Table 2). These usage patterns indicate that, unlike English or German, first-person subject 'I' and mental verbs 'think' are not frequently used as grammaticized epistemic marker in Mandarin-speaking children's linguistic experience that would set this expression 'I think' functionally distinct from others such as 's/he thinks'.

Given these cross-linguistic differences, and to the extent that crosslinguistic and crosscultural variations in the relationships between language and false belief development are driven by how mental verbs and complement clause constructions are used in children's linguistic experience, one could hypothesize that whether these frequent mental verbs are used with first- or third-person subjects does not affect their interpretation and relation to false-belief development in Mandarin Chinese. This outcome would differ from findings from experimental studies with English-speaking children (e.g., Brandt et al. 2016; Gerstadt et al. 1994), which suggest that first-person complements show a weaker link to false belief. On the other hand, if Mandarin-speaking children show a similar effect of the type of matrix-clause subjects (first- vs. third- person complements) in its relationship with their performance in false belief tasks as in English-speaking children, this may indicate some general factors at play that underlie the cross-linguistic similarities in the relationship between language and false belief. Our experimental study aims to test these perspectives. Moreover, Chinese has different 'think' verbs that differ in their degree of factivity, and this typological feature will also be addressed in the experimental study.

they are asked whether that character will be searching in A or B. In order to give the correct answer, the children have to ignore their own belief and go with the character's belief. In contrast to false-belief tasks, the children also do not know the actual hiding location. In knowledge-ignorance tasks, the children are shown the content of a container. When the container is closed up again, another character enters the scene and the children are asked whether that character knows the content of the container. Based on the understanding that (not) seeing leads to (not) knowing, they should say 'no'.

3 Experimental study

Our experimental study tested Mandarin-speaking children's interpretation of complement-clause constructions used with factive, neutral, and non-factive mental verbs in the matrix clause (*zhi1dao4* 'know', *jue2de2* 'think', *yi3wei2* 'falsely think' respectively). In addition, these matrix-clause verbs were presented together with first- versus third-person singular subjects. We also tested children's general language abilities and their inhibitory control in order to control for skills that have also been found to play a role in false-belief understanding and might correlate with children's understanding of mental verbs and complement-clause constructions (e.g., Carlson et al. 2002; Sabbagh et al. 2006).

First, we tested whether children's interpretation of complement-clause constructions is affected by the semantics of the mental-state verb and/or by the subject. We hypothesized that children would find it easier to distinguish between factive and non-factive verbs than between factive and neutral verbs, because only non-factive verbs clearly indicate that the following complement is false (see also Zhang and Zhou 2022). For the different subjects, we hypothesized that Mandarin-speaking children would not show a difference between first- and third-person complement clauses, because, unlike English-speaking caregivers, Mandarin-Chinese caregivers do not show a first-person bias for frequent mental verbs in complement-clause constructions.

Second, we tested whether children's understanding of complement clauses with different verbs and subjects is related to their false-belief understanding. Based on previous research (e.g., Cheung et al. 2009), we predicted that complement clauses with non-factive verbs show a stronger relation to false belief than complement clauses with neutral verbs. Since Mandarin-Chinese caregivers do not show a first-person bias in their use of mental-state verbs, we did not expect that third-person complements would show a stronger relation to false belief than first-person complements.

3.2 Method

3.2.1 Participants

We tested a total of 39 4-year-olds and 34 5-year-olds. Seven 4-year-olds and two 5-year-olds had to be excluded from the analyses because they were absent from the main test (n = 8) or unwilling to complete the general-language and the main test (n = 1). The final sample contained 32 4-year-olds (M = 53.6 months, SD = 1.5, Range: 52–56 months, 17 girls) and 32 5-year-olds (M = 66.6 months, SD = 1.4, Range: 64–

68 months, 20 girls). All children were Mandarin-speaking monolinguals. None of the participants had any known language impairment.

3.2.2 Design and materials

Each child attended two testing sessions, which lasted about 25 min each. In the first session, the children were tested on their general receptive language skills. For this purpose, we used the Cantonese version of the Reynell Developmental Language Scales (RDLS) (Reynell and Huntley 1987) and translated it into Mandarin. We acknowledge that it is not best practice to translate a standardized language test that has been developed for a specific language community. However, at the time of testing, better alternatives were not available for Mandarin-Chinese, and this was the best option we had. There was no standardized general language assessment for Mandarin-speaking children widely accessible to the research community and our intention was to obtain an objective measure of the children's general language proficiency rather than compare their performance to established norms (see Kidd et al. [2015] and Tsoi et al. [2019] for similar nature of practice in using a translated version of a standardized language test as an objective measure of general proficiency of the target language). This general language test was followed by two inhibitory-control tests – the Dimensional Change Card Sort (DCCS) (Zelazo 2006) and the Day/Night task (Gerstadt et al. 1994), which will be described in more detail below (see Section 3.2.3).

In the second session, children first did the hidden-object task, which tests their understanding of different mental verbs and complement clauses (Moore et al. 1989). Then they did two own and two others' false-belief tasks. As will be described in more detail below (see Section 3.2.3), we used the classic Unexpected-content and Change-of-location tests (Perner et al. 1987; Wimmer and Perner 1983), as well as a version of the Change-of-location test, which tests children's understanding of their own false belief (for a detailed description see Brandt et al. 2016).

In the hidden-object task, we had two factors: (1) degree of factivity (factive *zhi1dao4* 'know' was either paired with neutral *jue2de2* 'think' or with non-factive *yi3wei2* 'falsely think') and (2) perspective (first person vs. third person subject). Degree of factivity was tested within subjects. Perspective (first vs. third person) was tested between subjects. Sixteen children from each age group were tested in each condition. They were randomly assigned to the first- or third-person condition. In the first-person condition, for each trial, children heard two contrastive statements from two hand puppets (cow and pig). The complement clauses were used with one of the three mental-state verbs described above and a first-person singular subject in the matrix clause (e.g., Pig: *<u>I (falsely) think</u> the sticker is in the blue box* – Cow: *<u>I know</u> the sticker is in the red box*). In the third-person condition, we had a human-looking hand puppet (girl) that spoke for the other two puppets, and the children heard, for example: *the pig (falsely) thinks the sticker is in the blue box – the cow knows the sticker is in the red box.* All test sentences were pre-recorded by native speakers of Mandarin Chinese and were played from little speakers hidden under the puppets.

Each child received twelve trials (six where we contrasted *zhi1dao4* ‘know’ and *jue2de2* ‘think’ and six with *zhi1dao4* ‘know’ and *yi3wei2* ‘falsely think’). Since we wanted to directly compare Mandarin children’s understanding of mental verbs and complement clauses to English-speaking children’s interpretation of the same verbs and structures (cf. Brandt et al. 2016), we always started with the factive *zhi1dao4* ‘know’ - neutral *jue2de2* ‘think’ contrast, the verbs most similar to English *think* and *know*. Across trials, we counterbalanced the order of the statements (whether the first statement contained ‘(falsely) think’ or ‘know’ in the main clause), the assignment of the statements to the hand puppets (whether the pig or cow ‘knew’ or ‘(falsely) thought’), and the assignment of the statements to the boxes (whether it was ‘known’ or ‘(falsely) thought’ that the sticker was hidden in the red or blue box).

3.2.3 Procedure

3.2.3.1 Session 1: General language proficiency and inhibitory control

All children were tested by the same experimenter, a female native speaker of Mandarin Chinese. To assess general language ability, we used the Cantonese version of the receptive subtest of the Reynell Developmental Language Scales (RDLS) (Reynell and Huntley 1987) and translated it into Mandarin. The receptive subtest of RDLS contains ten sections with a total of 67 items. It assesses 1- to 7-year olds’ vocabulary, syntactic and semantic knowledge, and their inferencing skills.

Children’s general abilities to inhibit pre-potent responses were assessed by the standard versions of the Dimensional Change Card Sort task (DCCS) (Zelazo 2006) and the Day/Night task (Gerstadt et al. 1994). For the DCCS task, children were asked to sort six cards according to a certain rule (e.g., color), and afterwards sort another six cards according to a new rule (e.g., shape). For the Day/Night task, we used a deck with two kinds of cards: the face of half the cards was white with a sun, and the face of the other cards was black with a moon and stars. After verifying that the children were able to associate the sun with ‘day’ and the moon and stars with ‘night’, they were instructed to say ‘day’ when they saw the moon and stars card and ‘night’ when they saw the sun card. There were 16 test trials.

3.2.3.2 Session 2: Hidden-object and false-belief

The experimenter sat opposite the child at a small table. For each trial, she put a new pair of small opaque boxes on the table – always a red and a blue one. The red one was always placed to the left of the child. To introduce the game, the experimenter told the child that she and the two puppets (pig and cow) had hidden stickers in the boxes, and that pig and cow would help them find these. She also explained that the puppets might not remember all the hiding places. After the experimenter put the two boxes in front of the child, she asked the puppets: *Can you help X (child's name) find the sticker? Which box is the sticker in?* A Mandarin translation of all test sentences is provided in the Supplementary materials.

For each trial in the pretest, the child heard two non-contrastive statements about the location of the sticker from the two hand puppets. One statement was affirmative, the other was negated: For example, Pig: *the sticker is in the red box* – Cow: *the sticker is not in the blue box.* Whether the cow or the pig used the affirmative or negated statement and which statement came first was counterbalanced across trials. In the pretest, children were allowed to choose and open one of the two boxes after they had heard the two non-contrastive statements. Children who picked the right box in at least three out of four trials continued with the experiment. If they scored lower than three out of four trials, they received two additional trials. If they managed to pick the right box in four out of six trials in the end, they also continued with the experiment. All children passed this criterion.

In the following experimental trials, children were not allowed to look into any of their chosen boxes before they were finished with all twelve trials. In the first-person condition, the hand puppets uttered the test sentences. In the third-person condition, the hand puppets first whispered into a girl puppet's ears, who then uttered the test sentences. The whispering did not contain any real words and the pre-recorded utterances were played right after. To ensure good attention from the children, there was a break after the first block of six experimental trials during which the experimenter played a ring-throwing game with the child. They played this for about 5 min and then continued with the second block of another six experimental trials. Before continuing with the false-belief tests, children were allowed to look into the boxes they chose and collect their stickers. Note that, finally, all boxes contained stickers so that all children were rewarded equally.

Children's understanding of false belief was tested by four different tasks, Change-of-location own belief, Change-of-location others' belief, Unexpected-contents own belief, and Unexpected-contents others' belief, for which the Mandarin versions are provided in the Supplementary materials. We conducted four different types of false-belief tasks in order to distinguish between children who just guess the correct answer in one of the tasks and children who show more systematic understanding across tasks. In the classic Change-of-location others' belief test (Wimmer and Perner 1983), children had to answer a test question about another person's false belief. The experimenter told the story and acted it out with two little dolls and props: *Daddy puts a coin in his bowl. Daddy leaves the room. Mummy transfers the coin from Daddy's bowl to her cup. Daddy returns.* Then the experimenter asked (1) the test question *where will Daddy look for his coin,* (2) the reality control question *where is the coin now,* and (3) the memory control question *where did Daddy put the coin in the first place*.

The Change-of-location own belief test is based on the classic Change-of-location paradigm, but tests children's understanding of their own false belief about the location of an object (see Brandt et al. 2016). Similar to the Unexpected-content test, the experimenter had to first trick children into having a false belief. She placed two boxes (a green and a pink one) on the table and told the child that she was going to hide a small toy ball in one of them. Then she put an occluder on the table to block the child's view and put the toy ball into one of the boxes. At the same time, she slightly manipulated the position and the cover of the other box. After the occluder was removed, it looked like the experimenter had manipulated one box, but had not touched the other one. Then she asked the child (1) the manipulation control question *where is the ball*. Most children pointed to the box that looked like it had been manipulated and thus held a false belief concerning the location of the ball. The experimenter then showed the child that this box was actually empty and that the ball was hidden in the other one. She then put the ball back in the same box (i.e., the one which did not look like it had been manipulated) and asked (2) the test question *where did you first think the ball was*. As in the classic Change-of-location test, the experimenter also asked (3) the reality control question *where is the ball now*.

In the Unexpected-content task, the procedure was adopted from the original test (Perner et al. 1987). A crayon case that was filled with stickers was shown to the child and they were asked what they thought was in there. After the child answered *crayons*, *color pencils* or something similar, the experimenter showed them the actual content (stickers). Then the experimenter put the stickers back into the case, closed it again and asked (1) the memory control question *can you remember what is inside here*, (2) the own belief test question *what did you first think was inside here*, and (3) the other belief question *Pig has never seen this case. What will Pig think is inside this case*.

The Unexpected-content and Change-of-location tests were presented as blocks, and the order was counterbalanced. Within each block, we also counterbalanced the order of own and others' false-belief questions. In the three tasks testing false belief where mental state verbs were used in the test questions (e.g., *where did you think the toy was*), the verb with neutral factivity *jue2de2* 'think' was used to avoid a linguistic cues-induced bias (see Supplementary materials).

3.2.4 Scoring

In the RDLS (general language proficiency) test, the child got a score of 1 for each test item when they correctly performed according to the instructions. The maximum score for the RDLS test was 67. In the DCCS (inhibitory control) task, the child got a score of 1 in each trial when they correctly sorted the card in the post-switch phase (according to the new rule). The maximum score for the DCCS task was 6. In the Day/Night (inhibitory control) task, the child got a score of 1 in each trial when they responded 'day' to the moon and stars card; or 'night' to the sun card, with a maximum score of 16.

In the hidden-object task, the child got a score of 1 in each trial when they correctly chose the box marked by the factive statement with 'I know' or 'the pig/cow knows' in the first-person and third-person condition respectively.

For the false-belief tasks, the child got a score of 1 when they answered the test and corresponding control question correctly. When a child was not able to correctly answer a control question for a given task, this task was disregarded for that child. For a composite false-belief score, each child got a false-belief test score between 0 and 100%, which was calculated by dividing the number of correct responses to the test questions by the number of false-belief tests with correct answers to the control questions.

4 Results

4.1 Mental verbs and complement clauses in the hidden-object task

We first analyzed children's performance in the hidden-object task that tested their ability to understand complement clauses with mental verbs indicating different degrees of factivity and certainty. In order to be able to compare our results to a similar study with English-speaking children (Brandt et al. 2016), we always paired factive 'know' with neutral 'think' in the first block and factive 'know' with non-factive 'falsely think' in the second block. Any difference between the conditions with the neutral and non-factive verbs could thus be due to an order effect (i.e., children getting better with time). In order to exclude this possibility, we first looked for order effects within blocks. We separated each block into the first and last three trials. In the block with the factive and neutral verbs, the 4-year-olds performed better on the first three trials (M = 64% correct trials) than on the last three trials (M = 46% correct trials) (t = 2.55, df = 95, p = 0.01). The 5-year-olds showed no significant order effect (t = 1.19, df = 95, p = 0.24). In the block with the factive and non-factive verbs, there were no order effects for either the 4-year-olds or the 5-year-olds. For both age groups, the percentage of correct trials was almost identical for the first three and the last three trials. Therefore, the only order effect we found within blocks was a

Table 3: Mean number of correct trials in the hidden-object task.

	4-year-olds		5-year-olds	
	First person	Third person	First person	Third person
Neutral ('think'–'know')	2.9	3.7	3.9	4.9
Non-factive ('falsely think'–'know')	3.4	3.9	4.5	5.6

Total number of trials = 6.

negative one (i.e., younger children getting worse with time). Thus, if the children performed better in the block with the explicit non-factive verbs presented after the block with the neutral verbs, it is unlikely that this has been caused by a positive order or learning effect.

The mean number of correct trials in each condition is displayed in Table 3. The 4-year-olds performed at chance in the neutral and non-factive first-person conditions (neutral: $t = -0.34$, $df = 15$, $p = 0.74$; non-factive: $t = 1.05$, $df = 15$, $p = 0.31$) and above chance in the neutral and non-factive third-person conditions (neutral: $t = 2.71$, $df = 15$, $p = 0.02$; non-factive: $t = 2.39$, $df = 15$, $p = 0.03$). The 5-year-olds performed above chance in both the neutral and non-factive first person conditions (neutral: $t = 2.61$, $df = 15$, $p = 0.02$; non-factive: $t = 4.11$, $df = 15$, $p < 0.001$) and in the neutral and non-factive third person conditions (neutral: $t = 5.51$, $df = 15$, $p < 0.001$; non-factive: $t = 11.86$, $df = 15$, $p < 0.001$).

The results indicate that Mandarin-speaking children's correct interpretation of complement clauses with mental verbs is driven by age and perspective (whether the verbs are used with a first or third-person subject). We confirmed this by running general linear mixed effects models (GLMM's) in R. Since the neutral and non-factive verbs were presented in two different blocks, and to run analyses that can be directly compared to a similar study with English-speaking children (Brandt et al. 2016), we first built two separate models (i.e., one for each block). Starting with the neutral condition, we first compared a null model with just the random effects of participant and item number to a full model with the same random effects and the fixed effects of age group (4 vs. 5-year-olds) and perspective (first vs. third person). The full model was significantly better to account for participants' performance on the hidden-object task with neutral verbs than the null model ($\chi^2 = 17.7$, $df = 2$, $p < 0.001$). Furthermore, the model with age group and perspective was significantly better than the model with age group only ($\chi^2 = 7.19$, $df = 1$, $p < 0.01$). We also checked whether adding an interaction between age group and perspective would improve the model, but the difference between the models with and without the interaction effect was not significant ($\chi^2 = 0.29$, $df = 1$, $p = 0.6$). The final model for Mandarin-speaking children's interpretation of complement clauses with neutral mental verbs is

Table 4: GLMM for Mandarin children's interpretation of complement clauses with the neutral verb *jue2de2* 'think' contrasted with *zhi1dao4* 'know'.

	Estimate	SE	*z*	*p*
Intercept	−3.92	1.26	−3.13	<0.01
Age group (5-year-olds)	0.94	0.28	3.42	<0.001
Perspective (third person)	0.74	0.27	2.7	<0.01

presented in Table 4. It confirms that both age and perspective affect Mandarin children's correct interpretation of complement clauses when the neutral mental verb *jue2de2* 'think' is contrasted with the factive verb *zhi1dao4* 'know', with the 5-year-olds performing better than the 4-year-olds and the third-person condition being easier than the first-person condition. This pattern of results is similar to what has been found with English-speaking children, using the same experimental task (Brandt et al. 2016).

Next, we built a model to investigate children's correct interpretation of complement clauses with the non-factive mental verb *yi3wei2* 'falsely think'. As for the complement clauses with neutral verbs, the full model was significantly better to account for participants' performance than the null model ($\chi^2 = 20.1$, $df = 2$, $p < 0.001$). And the model with age group and perspective was significantly better than the model with age group only ($\chi^2 = 6.4$, $df = 1$, $p < 0.05$). The difference between the models with and without an interaction between the fixed effects of age group and perspective was not significant ($\chi^2 = 2.9$, $df = 1$, $p = 0.09$) even though perspective seemed to have a slightly greater effect on the older age group (see also Table 3). The final model for Mandarin-speaking children's interpretation of complement clauses with non-factive verbs is presented in Table 5. It confirms that both age and perspective affect Mandarin children's correct interpretation of complement clauses when the non-factive mental verb *yi3wei2* 'falsely think' is contrasted with the factive verb *zhi1dao4* 'know', with the 5-year-olds performing better than the 4-year-olds and the third-person condition being easier than the first-person condition.

Table 5: GLMM for Mandarin children's interpretation of complement clauses with the non-factive verb *yi3wei2* 'falsely think' contrasted with *zhi1dao4* 'know'.

	Estimate	SE	*z*	*p*
Intercept	−6.42	1.93	−3.32	<0.001
Age group (5-year-olds)	1.63	0.43	3.76	<0.001
Perspective (third person)	1.03	0.42	2.46	<0.01

4.2 False-belief understanding

Next, we looked at children's false-belief understanding. Those children who passed a given test question also passed the corresponding control question(s). Overall, whether or not children passed the test questions, their performance on the reality and memory control questions was high across both age groups (at least 95% for each task), indicating that children were generally able to follow the stories. However, three of the 32 4-year-olds and eight of the 32 5-year-olds could not be tricked into having a false belief about the location of an object and were thus dropped from the own Change of location task because they did not give the expected answer to the manipulation control question. All subsequent analyses are based on a composite false-belief score. For the children who had to be dropped from the Change of location task, we divided the total number of correct trials by 3 instead of 4.[5] Based on this composite score, the 4-year-olds' performance on the false-belief tasks was below chance (M = 34% correct trials; $t = -3.43$, $df = 31$, $p < 0.01$), whereas the 5-year-olds' performance was above chance (M = 70% correct trials; $t = 4.20$, $df = 31$, $p < 0.001$).

4.3 Language, complement clauses and false-belief understanding

Finally, we investigated whether Mandarin-speaking children's understanding of false belief is equally related to their understanding of complement-clause constructions with neutral mental verbs and their understanding of complement-clause constructions with non-factive mental verbs in the matrix clause. In addition, we tested whether children's understanding of both first and third-person complement clauses correlates with their false-belief understanding. At the same time, we controlled for general language skills and inhibitory control, as both factors could be correlated with children's understanding of mental verbs and complement clauses as well as their understanding of false belief. In fact, correlational analyses suggest that most of our independent measures, including age, were related to Mandarin children's false-belief understanding, with the inhibitory-control measures (DCCS and Day-Night) showing the weakest and only partly significant correlations (see Table 6). Table 6 also indicates that many of the independent measures correlated with one another.

Since there was a high degree of correlations between our predictor variables, we also conducted linear regression analyses with the lm function in R (R Core Team

5 When we analyzed the data based on total number of trials, the main results did not change significantly.

Table 6: Spearman's correlations between all variables.

	Age	General language (RDLS)	Neutral mental verbs	Non-factive mental verbs	Inhibition (DCCS)	Inhibition (Day-night)
False-belief understanding	0.49***	0.48***	0.35**	0.44***	0.26*	0.23†
Age (months)		0.5***	0.33**	0.34**	0.13	0.12
General language (RDLS)			0.22†	0.35**	0.23†	0.26*
Neutral mental verbs				0.58***	0.08	0.16
Non-factive mental verbs					0.15	0.07
Inhibition (DCCS)						−0.04

$n = 64$; †$p < 0.1$; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$; neutral mental verbs = complement clauses with neutral mental verbs; non-factive mental verbs = complement clauses with non-factive mental verbs.

2014) to check how individual variables explain children's false-belief understanding when other factors are controlled for. The dependent variable was always the composite false-belief score. First, we checked how strongly our control variables (age, general language (RDLS), and inhibitory control (DCCS)) predicted children's false-belief understanding. The other inhibitory measure (day–night score) was not entered into any subsequent models because it did not correlate significantly with the false-belief score (see Table 6). First, we tested whether general language can predict false-belief understanding when age is already controlled for. The model including general language and age was significantly better than the model containing age only ($F = 5.51$; $p = 0.02$). However, when we added the DCCS score to the model with the other two control variables, this did not improve the model ($F = 1.98$; $p = 0.16$). Consequently, our basic model contained the control variables age and general language (see Table 7).

After we had built this basic model, we tested whether the understanding of complement clauses with factive and non-factive verbs further adds to children's false-belief reasoning. Since the complement clauses with the neutral verb *jue2de2*

Table 7: Basic model with the significant control variables.

	Estimate	SE	*t*	*p*
Intercept	−1.64	0.38	−4.3	<0.001
Age (months)	0.02	0.01	3.2	<0.01
General language (RDLS)	0.02	0.01	2.35	<0.05

'think' and the complement clauses with the non-factive verb *yi3wei2* 'falsely think' were presented in two separate blocks, we first did separate analyses for the two, starting with the neutral mental verb *jue2de2* 'think'. Adding children's understanding of complement clauses with neutral verbs did not significantly improve the basic model ($F = 3.74$; $p = 0.06$). However, there seemed to be a trend and we were also interested to see whether children's understanding of mental verbs used with third-person subjects showed a stronger link to false belief than their understanding of mental verbs used with first-person subjects. We did not find a significant difference between the model containing complement clauses with neutral verbs and the model that also contained perspective ($F = 0.06$; $p = 0.80$). Adding an interaction between the significant (control) variables did not improve the fit of the model either. Thus, when controlling for age and general language, Mandarin children's comprehension of complement clauses with neutral mental verbs used with either first- or third-person subjects was not significantly related to their understanding of false belief.

When we followed the same analysis strategy for children's comprehension of complement clauses with non-factive mental verbs, it turned out that the model containing children's comprehension of complement clause with non-factive verbs was significantly better than the basic model containing only age and general language ($F = 4.14$; $p < 0.05$). This suggests that Mandarin children's comprehension of complement clauses with non-factive mental verbs can predict the level of their false-belief understanding, even when we control for age and general language. This is equally true for first- and third-person complements. That is, adding perspective to the model did not improve its fit ($F = 0.14$; $p = 0.70$). Adding interactions between the significant factors to the model did not significantly improve its fit to the data either. The final model, which provided the best fit to the data, is presented in Table 8.

Finally, we examined the relative contributions of complement clauses with neutral and non-factive mental verbs to children's false-belief understanding. As reported above, the contribution of children's understanding of complement clauses with neutral mental verbs to false belief – after controlling for general language and age – was just short of being significant ($F = 3.74$; $p = 0.06$) and should therefore not be

Table 8: Linear regression: complement-clauses with non-factive mental verbs and false-belief understanding.

	Estimate	SE	*t*	*p*
Intercept	–1.47	0.38	–3.86	<0.001
Age (months)	0.02	0.01	2.64	<0.05
General language (RDLS)	0.02	0.01	1.96	0.06
Complement clauses with non-factive mental verbs	0.05	0.02	2.04	<0.05

completely neglected. However, due to collinearity issues, teasing apart the relative contributions of complement clauses with neutral and non-factive mental verbs and the other significant predictor variables proved difficult. As shown in Table 6 above, most variables did not only correlate with false belief, but also with one another. Perhaps not surprisingly, the highest correlation was in fact observed between complement clauses with neutral mental verbs and complement clauses with non-factive mental verbs.

Our first approach was to amend the regression models presented in Tables 7 and 8 and add children's understanding of complement clauses with non-factive mental verbs after controlling for their understanding of complement clauses with neutral mental verbs (and the other control variables) (Table 7) or vice versa (Table 8). Neither model was significantly improved by these additions, which is most likely due to collinearity. Therefore, our second approach was to build simpler models again, where we focused on the impact of children's understanding of complement clauses on false belief, leaving out the other control variables.

When we started these simple regression models with complement clauses with neutral verbs and entered the non-factive verbs in a second step, the addition of the non-factive verbs improved the model ($F = 6.96$; $p < 0.05$). Table 9 also shows that in a model that only contains complement clauses with neutral and non-factive verbs as predictors for children's false-belief understanding, only the non-factive verbs turn out to be significant.

When we started these regression models with complement clauses with non-factive verbs and entered the neutral verbs in a second step, the addition of the neutral verbs did not improve the fit of the model ($F = 2.47$; $p = 0.12$). These follow-up analyses confirm that complement-clause constructions with non-factive verbs show a stronger relation to Mandarin-Chinese children's false-belief development than complement-clause construction with neutral mental verbs in the matrix clause.

Table 9: Linear regression: neutral mental verbs, non-factive mental verbs and false-belief understanding.

	Estimate	**SE**	***t***	***p***
Intercept	0.04	0.12	0.38	0.7
Complement clauses with neutral mental verbs	0.05	0.03	1.57	0.12
Complement clauses with non-factive mental verbs	0.07	0.03	2.64	<0.05

5 Discussion

Our results indicate that, in Mandarin Chinese, children's understanding of complement-clause constructions with mental verbs in the matrix clause is positively related to their false-belief understanding, even when we control for their general language and inhibitory control skills. This is similar to findings in English and German (e.g., Boeg Thomsen et al. 2021; de Villiers and Pyers 2002; Lohmann and Tomasello 2003). However, regression analyses suggest that, in Mandarin Chinese, complement clauses only predict children's concurrent level of false-belief understanding when they are used with the non-factive verb *yi3wei2* 'falsely think' in the matrix clause (for similar results in Cantonese see Cheung et al. 2009). Unlike in English (cf. Brandt et al. 2016), both first- and third-person complements with non-factive verbs are positively related to false-belief understanding.

In the remainder of this paper, we will discuss cross-linguistic differences in children's acquisition of mental-state language and false belief and suggest that languages and cultures differ in how they refer to mental states and use mental-state language, which means that they offer different linguistic tools and different routes to false-belief understanding. Before we turn to these more general issues, we want to shortly discuss potential task effects.

5.1 The hidden-object task

We used the hidden-object task to test children's interpretation of complement clauses used with different mental verbs in the matrix clause. As described above (Section 3.2.2), children always heard a pair of two utterances that differed in which mental verb was used (e.g., 'I know' … vs. 'I (falsely) think' …). In order to pass this task, children had to follow the statement with the verb expressing more certainty. In the current study, that verb was always the same in each of twelve trials (*zhi1dao4* 'know'). Therefore, one could argue that children might have passed the task by just following the 'know' statement and ignoring the other statement (marked by either 'think' or 'falsely think').

One reason to believe that children might have just followed the 'know' statement is that the verb *zhi1dao4* 'know' is more frequently used than either *jue2de2* 'think' or *yi3wei2* 'falsely think', as we have shown in our corpus study (Section 2; see also Tardif and Wellman 2000). In addition, a study by Yi et al. (2013) indicates that both typically developing children and children with autism spectrum disorder find it easier to interpret statements with *zhi1dao4* 'know' than statements with *yi3wei3* 'falsely think' when each of them is presented in isolation.

Even though we cannot fully rule out the possibility that some children only paid attention to the 'know' statement, the fact that the 5-year-olds performed better than the 4-year-olds suggests that children gradually develop an understanding of the fine-grained semantic distinctions encoded by mental verbs. If children only relied on their understanding of 'know', it would not matter which other mental verb they would hear this with. However, research, including the current study, suggests that young children find it easier to interpret specific mental verbs when they are paired with mental verbs that are semantically most distinct. For example, Moore et al. (1989) showed that, at the age of four, English-speaking children start to understand the difference between *know* and *think*, but even at the age of eight, they still struggle to understand the more subtle difference between *guess* and *think*.

Converging evidence for the suggestion that, in the current study, children also paid attention to the statement with *yi3wei3* 'falsely think' and did not just follow the *zhi1dao4* 'know' statement comes from Cheung et al. (2009), where Cantonese-speaking 4-year-olds showed a better understanding of *ji5wai4* 'falsely think' than of *zi1dou3* 'know' when the utterances were presented in isolation. Relatedly, studies looking at Chinese children's false-belief development also demonstrated that the use of *yi3wei3* 'falsely think' in the test question can lead to better performance in false-belief tasks (e.g. Lee et al. 1999). Taken together, these findings suggest that children gradually learn and pay attention to the semantics of the different mental verbs used in the current study. We will now return to the question of how this semantic development is related to the acquisition of complement-clause constructions and children's false-belief development.

5.2 Semantics, pragmatics and syntax of complement-clause constructions with mental verbs

Our results provide a more nuanced perspective to revisit the assumption that complement-clause constructions support children's false-belief development and the cross-linguistic applicability of this assumption. Our results, together with results from Cantonese (e.g., Cheung et al. 2009) and German (Perner et al. 2003), collectively suggest that complement-clause constructions only support, or are related to, children's false-belief development when they are used with specific verbs. While de Villiers (2007) has suggested a similar interaction between verbal semantics and syntax for English, only cross-linguistic comparisons such as the current one allow us to investigate this proposal with a wider variety of verbs used in the same syntactic construction. Like German, Chinese is more flexible than English in allowing the use of a larger variety of verb types with the same type of sentential complement, and the language has a non-factive verb which signals that the following complement clause may be false. Previous work with Cantonese-Chinese children suggests that complement clauses are only related to false-belief understanding when they are used with this non-factive verb *ji5wai4* 'falsely think' (Cheung et al. 2009). Our results from Mandarin-Chinese children are in accordance with these findings.

However, whereas Cheung et al. (2009) presented different verb types in different tasks, we presented all verb types in the same task. This is more similar to the approach taken in previous studies with English- and German-speaking children (e.g., de Villiers and Pyers 2002; Perner et al. 2003). It allows us to directly compare our results to findings in English and to exclude task effects as possible confounds of children's syntactic and semantic understanding. On this point, our study represents a methodological advance over the previous Chinese studies. Using the same task for the different verb types in Mandarin Chinese, we also found a unique relationship between complement clauses with non-factive verbs in the matrix clause and children's false-belief reasoning. This finding is empirically and theoretically significant, given the increasing emphasis on high-powered replications in current scientific inquiries.

As discussed above, in order to pass our hidden-object task, children could rely on the semantics of mental verbs in their relation to the following complement clause. For example, the use of a factive verb like 'know' signals that the proposition expressed by the following complement is true. Alternatively, children could solve our task based on their understanding of the pragmatic function of matrix clauses with mental verbs, which is to signal speaker certainty regarding the following complement. This pragmatic function is, of course, related to verbal semantics. For example, using a factive verb like 'know' expresses a higher degree of speaker certainty than using a neutral verb like 'think'. However, unlike the semantic features, the pragmatic functions of mental verbs also depend on the linguistic and nonlinguistic context. As discussed previously, whether mental verbs are used with first-person or third-person subjects can affect the degree of certainty they express in discourse. For example, in languages like English first-person *I think* expresses more certainty than third-person *he thinks* (e.g., Howard et al. 2008; Lewis et al. 2017). As will be discussed in the next section, some, but not all, of the results from our Mandarin-Chinese sample are in accordance with these findings from English.

5.3 Cross-linguistic comparisons and multiple routes to false belief

Using the same hidden-object task as in the current study, previous studies found that English-speaking children start to understand the semantics and the pragmatic functions of factive and neutral verbs around the age of four and that this understanding is also related to their false-belief understanding (Brandt et al. 2016; Moore et al. 1989). In the current study, only the Mandarin-speaking 5-year-olds showed above-chance performance. Like English-speaking children, they also showed better understanding of third-person complements than of first-person complements (see Table 3). Based on our corpus analysis, we did not anticipate finding this difference between first- and third-person complements in Mandarin. The difference between first- and third-person complements observed in English could be explained by how English-speaking caregivers tend to use frequent mental-state verbs. They overwhelmingly use them with first-person subjects. Subsequently, strings like *I think* turn into unanalyzed chunks and discourse markers, where the meaning of the mental verb is bleached and does not necessarily express a degree of uncertainty anymore (cf. Diessel and Tomasello 2001; Thompson 2002). In fact, Howard et al. (2008) found that American mothers are more likely to use strings like *I think* to express certainty than to express uncertainty, especially when they talk to their children. Consequently, children might find it difficult to distinguish between first-person complements with *think* and first-person complement with *know* (see also Booth et al. 1997; Lewis et al. 2017; Naigles 2000). Unlike English caregivers, Mandarin caregivers do not show this first-person bias in their use of frequent mental verbs (see Table 2). This suggests that the difference between first- and third-person complements observed in the hidden-object task in both English and Mandarin might not just be driven by usage patterns and frequency distributions in the input, and that this difference is a more universal phenomenon.

One factor that might make the distinction of mental verbs like ‘know’ and ‘think’ easier in the third-person condition of the hidden-object task is that this condition does not involve a shift in perspective. In other words, when hearing an utterance like *the cow knows/thinks the sticker is in the red box*, the child shares the speaker’s perspective. However, when they hear *I know/think the sticker is in the red box* from one of the puppets, they have to shift perspective: I should follow this puppet’s advice because *he knows* that the sticker is in the red box. It should also be noted that, in the first-person condition, children had to process statements coming from two different puppets, whereas it was always just one puppet in the third-person condition. Relatedly, the first-person condition might have required some extra processing and calibration. In particular, it might be more difficult to weigh the evidence from two different speakers, when, for example, one speaker could be generally more confident and certain than the other.

In addition, a third-person complement also indicates some endorsement by the speaker. That is, the speaker would not say *he knows*… if they did not agree with the puppet. In addition, when the speaker says *he thinks*…, this already indicates that they do not necessarily agree with the puppet. When hearing first-person complements, this (lack of) endorsement is not present as the statements come directly from the puppets. In the current study, we tried to minimize this endorsement effect by having a third puppet, rather than the experimenter, talk for the two hand puppets in the third-person condition. Endorsement by a puppet might not weigh as much as endorsement by an adult experimenter, but we cannot fully rule out the possibility that children benefit from endorsement in the third-person condition even when it only comes from another puppet.

Another potential factor that might explain why both Mandarin and English-speaking children performed better in the third-person condition than in the first-person condition of the hidden-object task is that the meaning of *know* might also change in a first-person context. If someone was sure of the hiding place of a sticker, we would not expect them to mark the statement with *any* kind of mental verb and just say *the sticker is in the red box*. Adding *I know* to a statement may indicate some degree of uncertainty or the likelihood of an alternative proposition. Further research will have to explore whether children (and adults) would be more likely to follow the advice of someone who just states something over someone who marks this statement with *I know*.

Despite this seemingly universal advantage for third-person complements in the hidden-object task, these complements did not show a stronger relation to Mandarin-Chinese children's false-belief understanding than first-person complements, unlike what English-speaking children showed when being tested in the same tasks (Brandt et al. 2016). In fact, neither first- nor third-person complements seem to play a unique role in Mandarin-Chinese children's developing understanding of false belief, as far as our data show. At least not when they are used with factive 'know' and neutral 'think'. We suggest that both Mandarin-Chinese children's relatively late understanding of mental verbs and the lack of a unique role of complements in relation to false belief can be explained by properties of their language input. As discussed by Wellman et al. (2006), the Chinese culture is more focused on acquiring shared knowledge than on the discussion of different knowledge states, attitudes, and beliefs (cf. Tobin et al. 1989). This emphasis on shared knowledge is also reflected in the observation that Chinese caregivers talk more about 'knowing' than 'thinking' (Tardif and Wellman 2000) and that Chinese children pass knowledge-ignorance tasks before they pass diverse-beliefs tasks (Wellman et al. 2006). The opposite has been found for English and other Western cultures, where caregivers use more 'thinking' terms (e.g., Bartsch and Wellman 1995) and children pass diverse-beliefs tasks before knowledge-ignorance tasks (see meta-analysis by Wellman et al. 2006). This could also explain why Mandarin-speaking children take relatively longer time to understand the semantics and pragmatic functions of mental verbs when they are used to express different beliefs, as in our hidden-object task.

Despite these differences in the order in which English and Chinese children pass different Theory of Mind tasks, the meta-analysis by Liu et al. (2008) found no systematic differences in the time window during which English- and Chinese-speaking children acquire a Theory of Mind. This suggests that even though mental-state language plays an important role in children's Theory of Mind development, as it seems to affect the order in which various Theory of Mind tasks are passed (cf. Wellman et al. 2006), it is not the only linguistic tool that enables children to acquire these concepts. Taken together the current findings and the current literature, our results suggest that children's general language skills are a strong candidate for an additional linguistic tool supporting Chinese children's false-belief understanding (see also Cheung et al. 2004; Tardif et al. 2007). Another candidate could be grammaticalized sentence-final particles that are frequently used to encode mental states and intersubjective awareness in Mandarin Chinese. Future research will have to investigate how Mandarin-Chinese children's comprehension of these other forms of mental-state language is related to their false-belief development.

6 Conclusion

In the current study, we have used a task that allows us to directly compare Mandarin-Chinese children's comprehension of complement-clause constructions with different verbs and subjects in the matrix clause and investigate how their performance compares to English-speaking children's performance in the same task. Our results support the multiple-routes hypothesis according to which different linguistic tools can support children's false-belief development and that the availability of these tools is subject to cross-linguistic and cross-cultural variability. Rather than trying to systematically and universally exclude specific linguistic factors as predictors of false-belief development, future research should aim to consider and explain the complex ways in which, for example, the syntax and pragmatics of specific sentence types interacts with the semantics of the items used in these sentence types.

Data availability statement

All raw data are available on the following OSF page: https://osf.io/7ctyp/.

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Supplementary Material: Mandarin-Chinese versions of hidden-object and false-belief tasks can be found in the Supplementary material.

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