The Comprehension of Headed and Headless Relative Clauses in Mandarin: Evidence from Monolingual and Mandarin-English Heritage Bilingual Children

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For head-initial languages like English, there is a strong consensus that subject RCs are acquired earlier and are processed more easily than object RCs. However, for head-final languages like Mandarin, theoretical predictions and findings are in conflict on whether there is a universal subject preference. Moreover, less attention has been given to language-specific factors like the omission of head nouns that might influence RC processing in Mandarin. This study examined the comprehension of headed and headless subject and object RCs in Mandarin by Mandarin-English heritage bilingual (4;00-10;11) and their vocabulary-matched monolingual children (4;00-5;09). The results show that in the character-sentence matching task, both bilinguals and monolinguals comprehended subject RCs more accurately than object RCs, as the similarity between object RCs and simple SVO transitives led to the incorrect head noun assignment. Moreover, this subject RC advantage was not influenced by the omission of the head noun, indicating that bilinguals and monolinguals as young as four years were able to recover omitted head nouns from the context. Compared to monolinguals, bilinguals who were more English dominant made more errors in head noun assignment for Mandarin object RCs, suggesting that both SVO transitives in English and language dominance contribute to cross-linguistic influence.

1. Introduction

Subject and object relative clauses (RCs) can be used to describe the same event (see examples (1) and (2), RCs are indicated in square brackets). However, it is a well-established finding that children (and adults) learning English and other head-initial languages find it easier to process subject RCs (see example (1)) than object RCs (see example (2)) (e.g., Adani, 2011; Adani et al., 2010; Brandt et al., 2009; Diessel & Tomasello, 2000, 2005; Kidd et al., 2007).

S **V** **O**

(1) **the horse** [that _ hugged the pig]

O **S** **V**

(2) **the pig** [that the horse hugged _]

A number of theoretical accounts have been developed to explain this subject RC advantage from perspectives of typology, processing ease, and frequency effects (see Lau & Tanaka (2021) and Tanaka et al. (2024) for a detailed review). From a typological point of view, the Noun Phrase Accessibility Hierarchy (Keenan & Comrie, 1977) generalized the differential ease of relativizing different syntactic positions cross-linguistically. Keenan and Comrie's hierarchical ranking of syntactic positions is reported in (3):

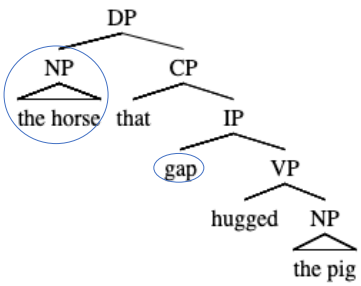
(3) Noun Phrase Accessibility Hierarchy (">" means "is more accessible than")

subject > direct object > indirect object > oblique > genitive > object of comparison

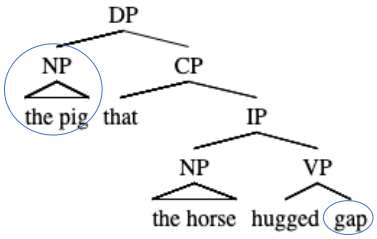
In this framework, the higher an item's position on the hierarchy, the easier (and more common) it is for it to be relativized. This hierarchy has been widely used to explain RC acquisition and processing (e.g., Hawkins, 2007). As the subject occupies the highest position in the hierarchy, subject RCs are considered easier to acquire and to process than any other RC type, including object RCs.

The structure-based account also implies a universal subject RC preference (Hawkins, 1999, 2004; Lin & Bever, 2006; O'Grady, 1997). It claims that the longer the structural distance between a head and its relativized position (i.e., gap) (circled in examples (4) and (5)), the deeper the gap is embedded in the hierarchy structure, and the more processing effort required. As subject gaps appear higher in syntactic structures than direct objects gaps across languages, subject RCs are predicted to be more accessible than object RCs.

(4) the horse that hugged the pig



(5) the pig that the horse hugged



In contrast to the structure-based account, the linear distance-based account suggests that RC processing depends on the linear distance between a head noun and its gap (e.g.,

Dependency Locality Theory; Gibson, 1998, 2000). The longer the linear distance between a head noun and its gap, the greater the working memory cost. As shown in examples (1) and (2), subject RCs have a shorter linear distance between the head noun (in bold) and its gap (underlined) than object RCs, which should make subject RCs easier to process in English and related languages.

Lastly, instead of proposing an inherent difficulty of certain constructions, usage-based approaches emphasize that language acquisition and processing are tightly linked to an individual's language experience (e.g., Ambridge et al., 2015; Diessel & Tomasello, 2000, 2005). It is suggested that children acquire complex constructions from simpler related constructions that they have previously acquired. Moreover, the more frequently children hear a construction, the more firmly the construction is entrenched in their mental grammar, and thus the more easily the construction will be activated. In English, subject RCs (1) follow the canonical SVO word order (i.e., the most common word order in English), whereas object RCs (2) display a non-canonical OSV word order. From a usage-based view, English subject RCs are expected to be easier to process, as they resemble simple SVO transitive sentences and are more frequent in the input than object RCs (e.g., Diessel & Tomasello, 2000; Kidd et al., 2007). In line with usage-based approaches, expectation-based approaches also emphasize the role of frequency: the more frequent an individual experiences a specific sentence structure, the easier and faster the structure is comprehended (e.g., Hale, 2006; Levy, 2008; MacDonald & Christiansen, 2002).

Moreover, frequency effects can occur at multiple levels of language, and individuals are sensitive not only to sentence structure but also to specific constraints like animacy associated with each type of RC (e.g., Ambridge et al., 2015; Levy, 2008). For example, English object RCs have been found to occur overwhelmingly with inanimate head nouns and pronominal RC-internal subjects in naturalistic speech (e.g., ***the car*** *that* ***she*** *borrowed had a*

low tyre) (Fox & Thompson, 1990; Reali & Christiansen, 2007; Roland et al., 2007). Several comprehension studies have pointed out that when the object RCs used in the comprehension experiment match the object RCs that children and adults most frequently hear and speak in everyday life (i.e., with inanimate head nouns and pronominal RC-internal subjects), the processing of object RCs can be made as easy as the processing of subject RCs (e.g., Brandt et al., 2009; Kidd et al., 2007; Macdonald et al., 2020). However, the animacy manipulation is not part of the scope of the current study. We used both animate head nouns and animate RC-internal noun phrases.

Whereas all theoretical approaches discussed above predict a subject RC advantage in English and other head-initial languages, turning to head-final languages allows us to better distinguish between the theoretical accounts. In the following sections, we first describe the typological differences between Mandarin and English RCs and review the empirical evidence for each of the accounts. Second, we extend the discussion from monolingual children to bilingual children by emphasizing the potential cross-linguistic influence between Mandarin and English. Third, we present our research questions and hypotheses. We then illustrate our experimental method and report the results of this study. Finally, we offer a general discussion of our findings.

2. RCs in Mandarin

The main typological difference that distinguishes RCs across languages is the position of the head noun in relation to the RC (i.e., head direction). In European languages like English, the head noun precedes the RC (i.e., head-initial RCs). In contrast, in East Asian languages like Mandarin, the head noun follows the RC (i.e., head-final RCs) (see examples (6) and (7)). According to Dryer (2013a, b), a large majority of languages with canonical SVO word order have head-initial RCs like English and Italian, while more than half of SOV languages have

head-final RCs like Japanese and Turkish. The combination of canonical SVO word order[1] with head-final RCs like Mandarin is very rare.

V O S

(6) [_ 抱 小猪] 的 **小马**

[_ bao xiaozhu] de **xiaoma**

hug pig DE horse

"the horse that hugged the pig"

S V O

(7) [小马 抱 _] 的 **小猪**

[xiaoma bao _] de **xiaozhu**

horse hug DE pig

"the pig that the horse hugged?"

Mandarin is also different from English in allowing argument omission. In Hsiao et al. (2014)'s corpus study, 4035 simple transitive sentences with overt direct object phrases were extracted from the Chinese Treebank 7.0 (Xue et al., 2010), which included sources from newswire, news magazine, broadcast conversation, broadcast news and web newsgroups. The results showed that 2445 out of 4035 (61%) simple transitive sentences contained overt subjects and 1590 (39%) had omitted subjects. In child and child-direct speech, there is also a substantial portion of sentences produced by the children aged 1;08-

[1] The canonical SVO word order is overwhelmingly frequent in Mandarin, but it also allows various non-canonical word orders, such as SOV, OSV and VOS word order (Lee & Naigles, 2005; Sun & Givón, 1985).

6;05 and their interlocutors with omitted subjects (children: 48.98%; interlocutors: 49.83%) and omitted objects (children: 33.19%; interlocutors: 34.42%) (Zhu & Gavarró, 2019).

In the case of Mandarin RCs, subject or object arguments and head nouns can also be omitted as long as they are known to both speakers and hearers (e.g., Huang & Phillips, 2021; Lin & Bever, 2010). For example, the head noun *xiaoma* "the horse" in (8b) and the head noun *xiaozhu* "the pig" in (8c) can be omitted (indicated by ø), as it has just been mentioned in (8a). In Zhang (2022)'s corpus study, around one-third of subject and object RCs in the spontaneous speech of one to three-year-old monolingual Mandarin-speaking children and in their input have omitted head nouns.

(An experimenter is talking with a child)

(8) a. 你 看！ 小马 在 抱 小猪。

ni kan xiaoma zai bao xiaozhu

you look horse is hug pig

"Look! The horse is hugging the pig."

b. 现在 [抱 小猪] 的 ø 在 哪里?

xianzai [bao xiaozhu] de ø zai nali

now hug pig DE is where

"Where is (the horse) that is hugging the pig now?"

c. 现在 [小马 抱] 的 ø 在 哪里?

xianzai [xiaoma bao] de ø zai nali

now horse hug DE is where

"Where is (the pig) that the horse is hugging now?"

While the Noun Phrase Accessibility Hierarchy and the structure-based account predict a universal subject RC advantage, the linear distance-based, usage-based and expectation-based accounts expect an object RC advantage in Mandarin[2]. Due to the head-final property, Mandarin object RCs (7) have a shorter linear distance between the head noun and its gap than subject RCs (6). They also follow the more canonical SVO word order. This object RC advantage should also hold when head nouns are omitted, as Mandarin simple transitives and RCs allow the frequent omission of subject or object arguments and head nouns when they can easily be retrieved from the discourse.

Support for the linear distance-based, usage-based and expectation-based approaches comes from corpus studies analysing spontaneous speech, where it has been found that Mandarin-speaking children produce object RCs earlier and more often than subject RCs (Chen & Shirai, 2015; Hsu, 2014; Liu, 2015; Tsoi et al., 2019, Yang, 2019). Moreover, the object RC advantage found in the spontaneous speech of monolingual children and their caregivers does not seem to be influenced by the omission of head nouns (Liu, 2015; Zhang, 2022).

However, when we turn to experimental studies, there seems to be more support in favour of the Noun Accessibility Hierarchy and the structure-based account: A subject RC advantage has been found in children's comprehension of Mandarin RCs using the character-sentence matching task (e.g., Hu et al., 2016; Hu & Guasti, 2017, Tsoi et al., 2019). This task provides two pictures, each containing a pair of cartoon characters performing reversible actions (e.g., horse hugging pig, pig hugging horse) (see Figure 1). Children are asked to point out one of the characters according to their interpretation of subject RCs (9) and object RCs (10). For example, to answer object RCs (10) correctly, children need to interpret

[2] Based on the review articles from Lau and Tanaka (2021) and Tanaka et al. (2024), head-initial languages such as English show a strong subject RC preference, but for head-final languages such as Mandarin, Japanese and Turkish, the results are mixed in general, with some studies showing a subject RC advantage, some no preference, and others indicating an advantage for object RCs.

xiaozhu "the pig" as the head noun of the RC and thus point to the pig in the left-hand picture. However, several experiments have reported that when comprehending object RCs, Mandarin-speaking monolingual children tend to misinterpret the RC-internal noun phrase *xiaoma* “the horse” as the head noun for object RCs (i.e, they point to the horse in the left-hand picture), leading to a subject RC advantage in Mandarin (e.g., Tsoi et al., 2019).

[Figure 1 here]

(9) [抱 小猪] 的 小马 在 哪里？

[bao xiaozhu] de xiaoma zai nali

hug pig DE horse is where

“Where is the horse that is hugging the pig?”

(10) [小马 抱] 的 小猪 在 哪里？

[xiaoma bao] de xiaozhu zai nali

horse hug DE pig is where

“Where is the pig that the horse is hugging?”

This type of error is called a Head Error, and it has been suggested that it is caused by the similarity between Mandarin object RCs and simple SVO transitives (e.g., Chan et al., 2017; Tsoi et al., 2019; Yang, 2019). As mentioned above, several corpus-based studies have found that Mandarin-speaking children produce object RCs more often and earlier than subject RCs, which could be because children develop their RCs gradually based on the simple SVO transitives they have already acquired. However, the similarity between Mandarin object RCs and simple SVO transitives could create competition between them in specific experimental tasks, leading to misinterpretations of object RCs as SVO transitives (e.g., Abbot-Smith & Behrens, 2006; Rowland et al., 2014). Following the SVO

interpretation, children would assume that the subject/agent occurs first and precedes the verb. In example (10) they would interpret the RC-internal noun phrase *xiaoma* "the horse" as the subject/agent of the sentence. In addition, both subjects and head noun phrases tend to be the topic of ongoing discourse, and there is an expectation for subjects to be relativized (e.g., Diessel & Tomasello, 2005; Mak et al., 2006, 2008). Based on these syntactic and discourse-based constraints, children could expect the RC-internal noun phrase in object RCs to align with the head noun.

To our knowledge, previous comprehension experiments only looked at Mandarin RCs with overt head nouns (e.g., Hu et al., 2016; Hu & Guasti, 2017, Tsoi et al., 2019). It remains unknown whether the comprehension of Mandarin RCs is affected by the absence of head nouns. As discussed above, when head nouns are present, children are likely to make Head Errors by interpreting the RC-internal noun phrase as the head noun (Tsoi et al., 2019). When head nouns are absent, children may show an even stronger tendency to take the RC-internal noun phrase as the head noun because it is the only overt noun phrase. However, the discourse-based omission of subject or object arguments is very frequent in Mandarin SVO transitives. Mandarin-speaking children have been found to produce sentences with omitted arguments and RCs with omitted head nouns around the age of two (Huang, 2011; Wang et al., 1992; Zhang, 2022; Zhu & Gavarró, 2019). There is a high possibility that children are familiar with the discourse-based omission of arguments and are able to recover most of the omitted arguments from the linguistic context. Therefore, we would not expect that the omission of head nouns affects children's comprehension of Mandarin subject and object RCs.

3. Cross-linguistic Influence

Children have been found to make more Head Errors for Mandarin object RCs than Mandarin subject RCs in specific experimental tasks. As we mentioned above, the Head Errors for

Mandarin object RCs could be due to the similarity with simple SVO transitive constructions in Mandarin. Cross-linguistically, Mandarin object RCs also resemble SVO transitives in English, which could reinforce a simple SVO interpretation of Mandarin object RCs. As proposed by Hulk and Müller (2000), structural overlap is a necessary condition for cross-linguistic influence to occur. Specifically, "syntactic cross-linguistic influence occurs only if language A has a syntactic construction which may seem to allow more than one syntactic analysis and, at the same time, language B contains evidence for one of these two possible analyses" (Hulk & Müller, 2000, p.228-229). Following up on this hypothesis, Mandarin-English bilingual children are expected to show a stronger tendency to misinterpret Mandarin object RCs as simple SVO transitives and consequently make more Head Errors than monolingual children by assigning RC-internal noun phrases as head nouns for Mandarin object RCs.

Kidd et al. (2015) looked at the comprehension of Cantonese subject and object RCs by Cantonese-English heritage bilingual children and their vocabulary-matched Cantonese-speaking monolingual peers using the character-sentence matching task. Of note, Cantonese and Mandarin are similar in their combination of head-final RCs and canonical SVO word order. In support of Hulk and Müller (2000)'s hypothesis, they found that Cantonese-English heritage bilingual children produced more Head Errors for Cantonese object RCs than their vocabulary-matched Cantonese-speaking monolingual peers. In addition, Kidd et al. (2015) examined whether language dominance would also predict bilingual children's Head Errors in Cantonese object RCs and found that bilingual children who were more Cantonese dominant made fewer Head Errors for Cantonese object RCs.

Using the same task, Chan et al. (2017) also found that Cantonese-English-Mandarin trilingual children made more Head Errors for Cantonese object RCs than their age-matched Cantonese-speaking monolingual peers. Chan et al. (2017) further suggested that not only the

structural overlap between Cantonese object RCs and English SVO transitives, but also the structural overlap between Cantonese object RCs and English subject RCs (also SVO) could motivate the incorrect head noun assignment. Chan et al. (2017) also examined the effect of language dominance on trilinguals' Head Errors for Cantonese object RCs but did not find significant results.

Inconsistent with Kidd et al. (2015) and Chan et al. (2017), Tsoi et al. (2019) used the same task but did not observe that the structural overlap alone led to differences between monolinguals and bilinguals. Specifically, Mandarin-English bilinguals did not comprehend either subject or object RCs differently from their vocabulary-matched Mandarin-speaking monolinguals at the group level. Instead, the structural overlap interacted with language dominance, leading to cross-linguistic influence. Bilinguals who were more English dominant made more Head Errors for Mandarin object RCs. Of note, Tsoi et al. (2019) and Kidd et al. (2015) tested bilinguals living in the English-speaking country Australia, who are likely to be more English dominant overall, while Chan et al. (2017) tested trilingual children living in Hong Kong.

In addition, Mandarin RCs with omitted head nouns could be another candidate case for cross-linguistic influence, since Mandarin allows the discourse-based omission of head nouns and arguments while English does not. Following Hulk and Müller (2000)'s hypothesis, bilingual children would not be as sensitive as monolinguals in spotting and recovering the omitted head nouns from the discourse and therefore may make more Head Errors by taking the RC-internal noun phrase (i.e., the only overt noun phrase) as the head noun for both Mandarin subject and object RCs. However, if the structural overlap interacts with language dominance, bilingual children would be on a par with their monolingual peers at the group level, but those who are more English dominant would be more likely to make Head Errors for both Mandarin subject and object RCs. Previous studies only focused on

bilingual children's comprehension of Mandarin RCs with overt head nouns (e.g., Tsoi et al., 2019). The current study is the first comprehension experiment aiming to address this issue.

With the current study, we aim to revisit the comprehension of Mandarin subject and object RCs by Mandarin-speaking monolingual and Mandarin-English bilingual children. Data from Mandarin-English bilingual children can better aid our understanding of how the acquisition of Mandarin RCs is affected by related structures in Mandarin (i.e., Mandarin SVO sentences) and how it is affected by the acquisition of related structures in English. In particular, we are interested in whether structural overlap alone is sufficient to cause cross-linguistic influence or whether other factors such as language dominance also play a role. This study is novel in also looking at children's interpretation of Mandarin RCs with omitted head nouns. The goal is to access whether monolingual and bilingual children are able to coordinate the syntactic and discourse-pragmatic information (i.e., the linguistic context provided for the appropriate use of the RCs) in their comprehension of RCs.

4. Research Questions and Hypotheses

Following Tsoi et al. (2019), the current study examines Mandarin-English bilingual children's and their vocabulary-matched monolingual children's comprehension of Mandarin subject and object RCs in the character-sentence matching task. The study addresses the following research questions (RQs):

RQ1: Is there a subject-object asymmetry in children's comprehension of Mandarin RCs and are there any differences between monolinguals and bilinguals at the group level?

RQ2: Does the presence or absence of a head noun influence the subject-object asymmetry in children's comprehension of Mandarin RCs and are there any differences between monolinguals and bilinguals at the group level?

RQ3: At the individual level (i.e., individual differences in language dominance), do bilingual children with greater English dominance comprehend Mandarin RCs less accurately?

Regarding RQ 1, following Tsoi et al. (2019), we hypothesize that in the character-sentence matching task, the word order similarity between Mandarin object RCs and Mandarin simple SVO sentences will hinder monolingual children's comprehension of Mandarin object RCs, which leads to a Mandarin subject RC advantage. We also hypothesize that, at the group level, Mandarin-English bilingual children will roughly match their vocabulary-matched monolinguals in the comprehension of both subject and object RCs.

For RQ2, we hypothesize that whether or not a head noun is present will not affect the way monolingual children comprehend Mandarin RCs in terms of subject-object asymmetry. This is because Mandarin simple SVO transitives allow for the omission of arguments that can be retrieved from the linguistic context. Due to the influence of Mandarin simple SVO transitives, monolingual children will be able to recover most of the omitted head nouns based on the linguistic context. Moreover, the design of the current study provided visual support (i.e., visual access to referents), which could make it easier for children to identify the omitted head nouns. Similarly, following Tsoi et al. (2019), we do not expect that at the group level Mandarin-English bilingual children will show significant differences from their vocabulary-matched monolinguals.

For RQ3, we expect that at the individual level, the more bilingual children are dominant in English, the more likely they are to make Head Errors for Mandarin object RCs, due to the influence of English SVO transitives and subject RCs (Tsoi et al., 2019). Moreover, due to the fact that the omission of arguments and head nouns is not grammatically acceptable in English, we expect that at the individual level, Mandarin-English

bilinguals who are more dominant in English will make more Head Errors for headless subject and headless object RCs than headed ones in Mandarin.

5. Method

The current study has a 2 (Language group: bilingual vs. monolingual) x 2 (Type: subject RC vs. object RC) x 2 (Head: headed RC vs. headless RC) design. Children's age and language dominance are also considered as factors that might affect their Mandarin RC comprehension.

5.1. Participants

Seventy-seven children participated in total. The bilingual group consisted of 38 UK-based Mandarin-English bilingual children between the ages of 4;00 and 10;11 (17 males, 21 females), who were recruited online via social media. The selection criteria for the bilingual children were the following: At least one parent is a native speaker of Mandarin; from birth, the child has been regularly exposed to their heritage language Mandarin at home; the child has been exposed to their dominant language English later when receiving mainstream formal education; the child did not have any language impairment or hearing loss. Following Tsoi et al. (2019), the bilingual children were divided via a median split into two age groups because of their large age range: a younger group (4;00-7;06, M = 69.26 (months), SD = 13.07) and an older group (7;07-10;11, M = 108.37 (months), SD = 14.45). Data from one additional bilingual child were collected but excluded because the child could not understand the instructions provided in Mandarin.

Thirty-nine Mandarin-speaking monolingual children between the ages of 4;00 and 5;09 were recruited online via social media as a comparison group (20 males, 19 females). They were all born in Mainland China and grew up being exposed to Mandarin at home and in school. None of them had a language impairment or hearing loss. In order to compare with the two bilingual age groups, the monolingual children were also divided via a median split

into two age groups: a younger group (4;00-4;08, M = 51.89 (months), SD = 3.09) and an older group (4;09-5;09, M = 63.1 (months), SD = 4.61). Data from one additional monolingual child were also collected but excluded because the child refused to finish the tasks.

The parents of the bilingual children were asked to complete a questionnaire soliciting details of language use and exposure, which was established by Kidd et al. (2015) and Tsoi et al. (2019). The questionnaire addressed the following four questions: (a) If the child was born or had lived in Mandarin-speaking countries or regions like Mainland China, Taiwan and Singapore, (b) how many hours on average per week the child spends in Mandarin- and English-speaking environments, (c) how frequently the child speaks Mandarin and English at home, as rated by the parent (measured with a 5-point Likert scale from 1 = *never* to 5 = *all the time*), and (d) how well the child understands spoken Mandarin and English, as rated by the parent (measured with a 7-point Likert scale from 1 = *poor* to 7 = *excellent*).

The results show that around half of the younger children (10/19) and one-third of the older children (7/19) had spent time living in Mainland China (younger children: 2-28 months, M = 3.42 months, SD = 6.45; older children: 2-23 months, M = 4.36 months, SD = 8.07). While, on average, the older children had lived in Mainland China longer than the younger children, the difference did not reach statistical significance, t (34.35) = 0.40, p = 0.69, d = 0.09.

The results of Question (b) were excluded from the analyses, as parents had trouble accurately and reliably counting the language exposure time of each of their children's languages. For example, some caregivers estimated home time exclusively as Mandarin exposure time. However, some children actually watched English TV and spoke English with siblings at home. In addition, Covid-19 had a significant effect on children's exposure times for both languages.

Table 1 lists the bilingual children's frequency of speaking Mandarin and English at home, and their abilities to understand each language. Based on their parents' rating, younger children spoke Mandarin significantly more often than English at home, t (30.45) = 2.87, p = 0.007, d = 0.57. In contrast, the older children's frequency of speaking Mandarin and English at home was not statistically different, t (35.96) = -0.33, p = 0.74, d = -0.06. Similarly, the parents rated younger children's ability in Mandarin to be better than in English, t (35.29) = 1.88, p = 0.07, d = 0.51, but older children's parent-rated abilities in Mandarin and English were not significantly different, t (33.21) = -1.02, p = 0.32, d = -0.2.

[Table 1 here]

5.2. Materials

5.2.1. Mandarin Vocabulary Test

A version of the British Picture Vocabulary Scale III (Dunn et al., 2009) translated into Mandarin was used to assess the children's Mandarin receptive vocabulary[3]. The British Picture Vocabulary Scale III consists of 168 items grouped into 14 sets, each set containing 12 items. Each successive set is more challenging than the preceding one (Set 1 is the easiest). Each item includes four simple pictures on a page. In order to move this paper-based assessment online, the test materials were scanned with permission from GL Assessment.

5.2.2. Character-sentence Matching Task

The character-sentence matching task examined children's comprehension of subject and object RCs. The test sentences were manipulated for (a) Type: subject RC and object RC, and (b) Head: headed RC and headless RC. Thus, there were four conditions: headed subject RC (see example (9)), headed object RC (see example (10)), headless subject RC (see example 8b)), headless object RC (see example (8c)). For counterbalancing, four parallel forms of the

[3] We acknowledge that at the time of testing, there was no standardized vocabulary test for Mandarin-speaking children that we had access to. The translated version of the British standardized vocabulary test functioned as was the best substitute (see Brandt et al. (2023), Kidd et al. (2015), and Tsoi et al. (2019) for similar nature of practice).

task were constructed. Each form contained 26 sentences, including 16 test sentences (four in each condition), eight filler sentences and two practice sentences. Filler sentences and practice sentences were simple non-RC sentences such as *Da da de houzi zai zaili?* "Where is the big monkey?". A list of all test sentences, practice sentences and filler sentences can be found in Appendix A. The order of the test sentences was pseudo-randomized. No more than two consecutive test sentences from the same condition occurred together. Filler sentences were randomly interspersed between the RC test sentences. All sentences were pre-recorded by a female native speaker of Mandarin.

The test materials followed those established in Tsoi et al. (2019). The test sentences contained cartoon animals who performed reversible actions (e.g., horse hugging pig, pig hugging horse). Both head nouns and RC-internal noun phrases were always animate. Four transitive and reversable verbs were used: *wei* "feed", *bao* "hug", *qin* "kiss", *tui* "push". Each verb occurred once in each condition. 16 cartoon animals were used: horse, pig, lion, bear, monkey, dog, chicken, mouse, duck, rabbit, elephant, tiger, cow, giraffe, cat and sheep. In total, 16 picture pairs were constructed (e.g., horse and pig, tiger and bear). To control for the length of each test sentence (each test sentence contained nine to ten characters), the adverb *xianzai* "now" was placed at the beginning of headless RCs (see examples (8b) and (8c)).

Three visual stimuli accompanied each test sentence. First, a picture of two animals performing an action was shown (Figure 2A) and accompanied by a verbal description (11a), followed by another picture depicting the same two animals performing the reversed action (Figure 2B) with the verbal description (11b). These two pictures provided an appropriate context for the use of the test sentence. For the third visual stimulus (Figure 2C), both pictures (Figures 2A and 2B) were presented, along with the test sentence (11c). If a child failed to respond to the test sentence, the third picture and the verbal description were repeated one more time before moving on to the next item. Note that we added four

background colors (red, yellow, blue, and green) for the four animals in each set of pictures. This design was specifically adapted for online testing, making it easier for the experimenter to identify the animal the child picked. The order of the four background colors was the same for each test sentence (from left to right: red, yellow, blue, green). The two animals always acted left to right. The location of the target animal was counterbalanced, occurring equally often in the left- and right-hand picture. The number of times the target animal appeared in the first or second visual stimulus (e.g., Figures 2A and 2B) was also counterbalanced.

[Figure 2A here]

(11) a. 你 看！ 小马 在 抱 小猪。

ni kan xiaoma zai bao xiaozhu

you look horse is hug pig

"Look! The horse is hugging the pig."

[Figure 2B here]

b. 咦！小猪 在 抱 小马。

yi xiaozhu zai bao xiaoma

ooh pig is hug horse

"Ooh! The pig is hugging the horse."

[Figure 2C here]

c. [小马 抱] 的 小猪 在 哪里？

xiaoma bao de xiaozhu zai nali

horse hug DE pig is where

"Where is the pig that the horse is hugging?"

5.3. Procedure

Due to the COVID-19 pandemic, the study was conducted online using the video chat platforms Zoom and DingTalk for the UK and Mainland China participants respectively. A

private meeting invite link was emailed to the caregiver before the study. The caregiver and their child could join the meeting by clicking on the link. Before the study began, the experimenter double-checked with the caregiver and their child if the internet connection was stable, the webcam, microphone and speaker were working, and the test environment was quiet enough. If the caregiver wanted to sit beside the child during the test, the experimenter reminded them that they should not provide any visual or verbal clues to the answers.

First, the Mandarin vocabulary test was conducted via screen share. Children completed four trials before beginning the actual testing to understand the vocabulary test procedure. The procedure and materials used for the trials were the same as those for the test items. Children were asked to select one of four pictures on a page representing the word the experimenter spoke. Each child started from Set 1. If a child answered eight or more items wrongly in a set of 12 items, the testing would be discontinued after completing the set.

Then, the character-sentence matching task was also presented via screen share. The nature of the task was introduced to the children by using two simple non-RC practice sentences. For example, children were presented with a small and a big monkey on the screen, and were asked to say what the background color behind the monkey was after hearing a pre-recorded sentence like *Da da de houzi zai nali?* “Where is the big monkey?”. During the test, the children were required to say the background color of one out of the four animals on the screen according to their interpretation of the test sentences as they were asked to do in the test sentences. In both the Mandarin vocabulary test and the character-sentence matching task, the experimenter only provided positive feedback such as “well tried” or “good effort” after each response irrespective of the child’s performance.

5.4. Scoring

In the Mandarin vocabulary test, each child’s raw score was computed by subtracting the number of incorrect answers from the total number of answers before the Ceiling item. The

maximum total number of answers was 168. The Ceiling item was the last item in the set in which eight or more errors were made. This means that correct answers made by the child above the lowest ceiling were ignored.

In the character-sentence matching task, when participants identified the correct character in the correct picture, they got a score of 1. If not, they got a score of 0 and the errors they made were coded into the following categories: (a) Head Error: the correct picture but the wrong character were selected (i.e., in order to answer "*Where is the pig that the horse is hugging?*", the child selected the horse with the red background color of Figure 2C); (b) Reversal Error: the wrong picture but the correct character were selected (i.e., the pig with the blue background color of Figure 2C); (c) Other Error: the wrong picture and the wrong character were selected (i.e., the horse with the green background color of Figure 2C).

6. Results

6.1. Mandarin Vocabulary Test

Table 2 lists the bilingual and monolingual children's Mandarin vocabulary test scores. For both language groups, older children were significantly better than younger children in their Mandarin vocabulary knowledge (bilinguals: t (35.58) = 2.22, p = 0.03, d = 0.49; monolinguals: t (36.92) = 2.31, p = 0.03, d = 0.57). When comparing the two language groups, even though the monolinguals received higher scores than the bilinguals, the differences between them were not significant (younger: t (30.47) = 1.54, p = 0.13, d = 0.34; older: t (32.40) = 0.81, p = 0.42, d = 0.15).

[Table 2 here]

6.2. Character-sentence Matching Task

The data analyses were carried out using Generalized Linear Mixed-effects Models with the *lme4* package (Bates et al., 2015) in R, version 4.2.0. Null models included random effects for participants and items, and random intercepts for participants and items. Random slopes

were initially included but removed later as they lacked model convergence in most cases. *Type* (subject RC vs. object RC), *language group* (bilingual vs. monolingual), *age group* (younger vs. older) and *head* (headed RC vs. headless RC) were categorical variables, while *age (in months)* and *language dominance* were continuous variables. Based on the purpose of each analysis, certain variables were selected and entered into the model one at a time. Then the ANOVA function was used to compare the new models with the null model to assess the contribution of the added factor(s) (Baayen, 2008). Fixed effects that did not improve the fit of a model were dropped.

6.2.1. Comprehension Accuracy

The first analysis addressed RQs 1 and 2: (1) At the group level whether there was a subject-object asymmetry in bilingual and monolingual children's comprehension of Mandarin RCs, and (2) At the group level whether the presence or absence of a head noun influenced the subject-object asymmetry in bilingual and monolingual children's comprehension of Mandarin RCs. Following these RQs, *Type*, *language group*, and the interaction of *type* and *language group* were first entered into the model one at a time. Then, *head* and the three-way interaction of *type*, *language group* and *head* were entered into the model one at a time. The main effect of *head* and the three-way interaction of *type*, *language group* and *head* did not significantly add to the model and were therefore dropped. At last, *age group* and the three-way interaction of *type*, *language group* and *age group* were added to the model to test whether younger and older children performed differently.

The final model shows that only the main effect of *type* significantly added to the model, $\chi 2 = 178.57$, $df = 1$, $p < 2.2e\text{-}16$, which indicates that both bilinguals and monolinguals were more accurate on subject RCs than object RCs (see Figure 3). Moreover, this subject RC advantage in Mandarin was not influenced by the presence or absence of a head noun.

In addition, a significant interaction between *language group* and *type*, $\chi 2 = 11.12$, $df = 1$, $p = 0.0009$ also added to the model. As shown in Figure 3, the interaction was driven by the fact that at the group level the difference between subject and object RCs was bigger in the bilingual group than in the monolingual group. It indirectly provided evidence that bilingual children may have more difficulties comprehending Mandarin object RCs, as opposed to subject RCs. The results were not consistent with our hypothesis, in which we expected that bilinguals would roughly match their vocabulary-matched monolinguals in the comprehension of both subject and object RCs at the group level. The details of the final model are shown in Table 3.

[Figure 3 here]

[Table 3 here]

6.2.2. Error Analysis

The second analysis addressed whether the comprehension difficulty of Mandarin object RCs was due to the word order similarity between Mandarin object RCs and Mandarin simple SVO transitives. If so, both bilinguals and monolinguals were predicted to make more Head Errors with object RCs than with subject RCs.

Head Errors children made were analyzed using the same analytical strategy as for the accuracy data[4]. Following RQ1 and RQ2, *type*, *language group*, the interaction of *type* and *language group* were first entered into the model one at a time. The main effect of *language group* and the interaction of *type* and *language group* did not significantly add to the model and were therefore dropped. Then, *head* and the interaction of *type* and *head* were entered to test whether the presence or absence of a head noun made a difference.

[4] Reverse Errors and Other Errors were not included in the error analysis and the following individual difference analysis, as the number of Reverse Errors was very small and Other Errors could not be interpreted (see Appendix B).

The final model indicates that the main effect of *type* significantly added to the model, $\chi 2 = 317.23$, $df = 1$, $p < 2.2e\text{-}16$, which confirms that both monolinguals and bilinguals made significantly more Head Errors for object RCs than for subject RCs, $\beta = -2.59.$, $SE(\beta) = 0.17$, $z = -15.14$, $p < 2e\text{-}16$, leading to the subject RC advantage in Mandarin.

In addition, a significant main effect of *head*, $\chi 2 = 4.85$, $df = 1$, $p = 0.03$ also added to the model. It indicates that Head Errors were made more often with headless RCs than with headed RCs in general, $\beta = 0.35$, $SE(\beta) = 0.16$, $z = 2.13$, $p = 0.03$. However, the visual inspection of the data (see Figure 4) suggested a potential three-way interaction between *type*, *head*, and *language group* (i.e., for bilinguals, there seems to be an effect of *head* on subject RCs but not object RCs, while for monolinguals, there seems to be an effect of *head* on both subject and object RCs, though it is weaker for object RCs.). Therefore, we included this three-way interaction in the model, but it did not significantly add to the model.

We further took a closer look at the number and proportion of Head Errors across *type* and *head* for monolingual and bilingual children. As shown in Table 4, both monolingual and bilingual children exhibited a similar proportion of Head Errors for headed and headless object RCs. At the same time, they made more Head Errors for headless subject RCs compared to headed subject RCs, but the number of Head Errors for subjects RCs was small overall, and the interaction between *type* and *head* was not significant in the model. These further inspections suggest that the significant main effect of *head* might be misleading, as it was likely due to the data being aggregated. When the data was partitioned into subgroups, this effect was not observed anymore.

[Figure 4 here]

[Table 4 here]

6.2.3. Individual Differences

Our last analysis addressed RQ3: At the individual level, whether language dominance contributed to cross-linguistic influence. We expected that the more bilingual children were dominant in English, the more likely they were to make Head Errors for Mandarin object RCs. Moreover, the more bilingual children were dominant in English, the more likely they were to make Head Errors for headless (subject and object) RCs than headed ones. The bilingual children's English dominance was determined by their frequency of speaking English at home and their ability to understand English, which were rated by their caregivers in the questionnaire. These two measures were analyzed separately. If not, the models would fail to converge, which is probably due to the correlation between those two factors (r_s = 0.21, p = 1.237e-07).

For the relationship between bilinguals' frequency of speaking English with Head Errors, *frequency of speaking English*, *head*, *type*, and their interactions were successively entered one at a time as fixed effects. The results show that the interaction between *frequency of speaking English* and *type* significantly added to the model, $\chi 2$ = 7.60, df = 1, p = 0.006. The interaction was driven by the fact that the impact of *frequency of speaking English* was only found for object RCs. That is, bilingual children who spoke more English at home produced more Head Errors for Mandarin object RCs, β = -0.94, $SE(\beta)$ = 0.34, z = -2.80, p = 0.005. However, there was no significant interaction between *frequency of speaking English* and *head*, meaning that bilinguals who spoke more English at home did not make more Head Errors for headless RCs than headed RCs. When replacing *Frequency of speaking English* with *Ability to understand English*, there were no significant main effects or interactions.

Finally, we added an extra analysis to examine whether bilingual children's Head Errors would decrease with increasing age (in months). Similarly, there was a significant interaction between *age (in months)* and *type*, $\chi 2$ = 9.33, df = 1, p = 0.002. With increasing age, bilingual children made fewer Head Errors for object RCs, β = 0.03, $SE(\beta)$ = 0.01, z =

2.99, $p = 0.003$. However, the results did not show any differences between headed and headless object RCs.

To summarize, bilingual children's object RC accuracy was affected by their language dominance and age (in months). The more bilingual children spoke English at home, the more likely they were to make Head Errors for Mandarin object RCs. On the other hand, with increasing age, they made fewer Head Errors for Mandarin object RCs. However, the results did not show any differences between headed and headless object RCs. As for bilingual children's subject RC accuracy, it was not affected by language dominance or age, which could be because the number of Head Errors on subject RCs was very small in general.

7. Discussion

7.1. Subject-object Asymmetry in Headed and Headless Relative Clauses

Unlike the consistent subject RC advantage suggested and reported in English, theoretical predictions and findings in Mandarin are contradictory. The Noun Phrase Accessibility Hierarchy and the structure-based account predict a universal preference for subject RCs, while the linear distance-based, usage-based and expectation-based accounts suggest an object RC advantage in Mandarin.

Using the character-sentence matching task, we have investigated the comprehension of Mandarin subject and object RCs by Mandarin-English heritage bilingual children and their vocabulary-matched monolingual peers. The results confirm the subject RC advantage previously reported for Mandarin using the character-sentence matching task (e.g., Hu et al., 2016; Hu & Guasti, 2017; Tsoi et al., 2019), providing stronger support for theoritcal accounts that predict a universal preference for subject RCs.

On the other hand, the error analyses confirm that the subject RC advantage was caused by the fact that both bilingual and their vocabulary-matched monolingual children made significantly more Head Errors for object RCs than for subject RCs in Mandarin. More

specifically, children tended to misinterpret the RC-internal noun phrase, which comes first in the sentence, as the head noun for object RCs. Therefore, similar to Tsoi et al. (2019), we suggest that in the character-sentence matching task, the similarity between Mandarin object RCs and Mandarin SVO transitives is likely to interfere with children's correct interpretation of Mandarin object RCs. The error analyses provide support for the usage-based and expectation-based account, indicating that children rely on the canonical simple transitives they have already acquired to guide their comprehension of RCs. This reliance causes more errors in children's comprehension of object RCs, which could be partially attributed to the fact that comprehension studies, including this one, did not use the object RCs that children encounter in everyday speech. If comprehension studies used object RCs with inanimate head nouns and pronominal RC-internal subjects that children encounter in everyday speech, the results might change (e.g., Brandt et al., 2009; Kidd et al., 2007; Macdonald et al., 2020).

Furthermore, the study extends the subject RC advantage in Mandarin to subject and object RCs with omitted head nouns. The results clearly indicate that the omission of head nouns did not influence either monolingual or bilingual children's comprehension of subject RCs and object RCs differently. It suggests that once the linguistic and visual context is provided, children as young as four years can identify most of the omitted head nouns from the context and, therefore can comprehend Mandarin RCs with omitted head nouns as accurately as those with overt head nouns. Our results are consistent with those reported in previous studies (e.g., Huang, 2011), in which both Mandarin-speaking monolinguals and Mandarin-English bilinguals between the ages of 2 and 3 years were able to use overt and omitted subject and object arguments pragmatically appropriately in their spontaneous speech.

7.2 Cross-linguistic Influence

Following Hulk and Müller (2000)'s hypothesis, Mandarin object RCs that structurally overlap with simple SVO transitives in both Mandarin and English are expected to be a candidate case for cross-linguistic influence. However, previous studies such as in Tsoi et al. (2019) showed that this structural overlap alone did not lead to cross-linguistic influence, while the interaction between structural overlap and language dominance did. Specifically, bilingual children performed similarly with their vocabulary-matched monolingual peers in the comprehension of Mandarin object RCs at the group level, while bilingual children who were more English dominant comprehended Mandarin object RCs less accurately at the individual level.

In the current study, Mandarin-English bilingual children were also on par with their vocabulary-matched monolinguals in their comprehension of object RCs. However, bilingual children were more accurate in their comprehension of Mandarin subject RCs than their monolingual peers, which is inconsistent with the results found in Tsoi et al. (2019). We suggest that the participant recruitment could partially explain the inconsistent results. Instead of collecting data in one Chinese school like Tsoi et al. (2019), the heritage bilingual children in this study were recruited online across the UK. Parents who wanted their children to be involved might focus more on their children's Mandarin language development, and therefore their children were more likely to acquire and maintain Mandarin better (e.g., Daller & Ongun, 2017; Zhang & Slaughter-Defoe, 2009). However, as bilingual children only performed better in their comprehension of subject RCs rather than object RCs, it indirectly provides evidence that bilingual children may have some difficulty in comprehending Mandarin object RCs accurately. On the other hand, our results clearly indicate that the interaction between structural overlap and language dominance caused cross-linguistic influence. Bilingual children who were more English dominant made more Head Errors for

Mandarin object RCs. This finding also lends support for the usage-based and expectation-based account, indicating that children's comprehension of RCs is not only affected by their experience with the related structures within Mandarin, but also the related structures across languages (i.e., simple SVO transitives in both Mandarin and English).

In addition to Mandarin object RCs, we also expected that Mandarin headless (subject and object) RCs would lead to cross-linguistic influence. That is, bilingual children who were more English dominant would have more difficulty recovering omitted head nouns, and therefore would make more Head Errors by taking the RC-internal subject (the only noun phrase in the RC) as the head noun. However, the results show that bilingual children did not make more Head Errors for headless RCs with their increasing English dominance. It suggests the possibility that bilingual children, even those with greater English dominance, are already sensitive to discourse-pragmatic cues in their comprehension of Mandarin RCs. However, the design of the current study also provided visual context (i.e., listener's visual access to referents). Therefore, we cannot deny the possibility that children could comprehend RCs with omitted head nouns simply dependent on the remaining structure with the support of the visual context. In order to test children's sensitivity towards discourse-pragmatic cues, further studies would need to be conducted to test whether using different types of contexts (e.g., only provide visual context) would lead to the same result.

In addition, further studies could conduct a more fine-grained assessment when recruiting heritage bilingual participants, and implement a more objective measure of their language dominance (e.g., standardized language measures for both languages). Unlike typical classroom second language learners, heritage bilingual acquisition occurs early in the home setting. Heritage bilingual children can vary significantly in their language proficiency due to factors such as input quantity and quality (e.g., De Houwer, 2007; Jia & Fuse, 2007; Sun et al., 2020). A detailed assessment should be adopted to categorize or filter heritage

bilingual participants to account for individual differences on the study results (De Bruin, 2019). For example, the presence of older siblings should be recorded, as older siblings might have more exposure to the majority language and tend to use the majority language to talk with their younger siblings at home (e.g., Rojas et al., 2016; Shin, 2002).

Data Availability Statement

The datasets generated and analyzed during the current study are available in the Open Science Framework repository, https://osf.io/r6bt3/.

Reference

Abbot-Smith, K., & Behrens, H. (2006). How known constructions influence the acquisition of other constructions: The German passive and future constructions. *Cognitive Science*, *30*(6), 995-1026.

Adani, F. (2011). Rethinking the acquisition of relative clauses in Italian: towards a grammatically based account. *Journal of Child Language*, *38*, 141-165.

Adani, F., Van der Lely, H. K., Forgiarini, M., & Guasti, M. T. (2010). Grammatical feature dissimilarities make relative clauses easier: A comprehension study with Italian children. *Lingua*, *120*(9), 2148-2166.

Ambridge, B., Kidd, E., Rowland, C. F., & Theakston, A. L. (2015). The ubiquity of frequency effects in first language acquisition. *Journal of Child Language*, *42*(2), 239-273.

Baayen, R. H. (2008). *Analyzing Linguistic data: A Practical Introduction to Statistics Using R.* Cambridge University Press.

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software*, *67(1),* 1-48.

Brandt, S., Kidd, E., Lieven, E., & Tomasello, M. (2009). The discourse bases of relativization: An investigation of young German and English-speaking children's comprehension of relative clauses. *Cognitive Linguistics*, *20*(3), 539-570.

Brandt, S., Li, H., & Chan, A. (2023). 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. *Cognitive Linguistics, 34*(1), 99-132.

Chan, A., Chen, S., Matthews, S., & Yip, V. (2017). Comprehension of subject and object relative clauses in a trilingual acquisition context. *Frontiers in Psychology*, *8*, 1641.

Chen, J., & Shirai, Y. (2015). The acquisition of relative clauses in spontaneous child speech in Mandarin Chinese. *Journal of Child Language*, *42*(2), 394-422.

Daller, M., & Ongun, Z. (2017). The threshold hypothesis revisited: Bilingual lexical knowledge and non-verbal IQ development. *International Journal of Bilingualism*, *22*(6), 675-694.

De Bruin, A. (2019). Not all bilinguals are the same: A call for more detailed assessments and descriptions of bilingual experiences. *Behavioral Sciences*, *9*(3), 33.

De Houwer, A. (2007). Parental language input patterns and children's bilingual use. *Applied Psycholinguistics*, *28*(3), 411-424.

Diessel, H., & Tomasello, M. (2000). The development of relative clauses in spontaneous child speech. *Cognitive Linguistics, 11,* 131-151.

Diessel, H., & Tomasello, M. (2005). A new look at the acquisition of relative clauses. *Language*, *81*(4), 882-906.

Dryer, M. S. (2013a). Order of relative clause and noun. In Dryer, M. S., & Haspelmath, M. (Eds.), *The world atlas of language structures online*. Max Planck Institute for Evolutionary Anthropology.

Dryer, M. S. (2013b). Order of subject, object and verb. In Dryer, M. S., & Haspelmath, M. (Eds.), *The world atlas of language structures online*. Max Planck Institute for Evolutionary Anthropology.

Dunn, L. M., Dunn, D. M., & NFER. (2009). *The British Picture Vocabulary Scale - Third Edition.* GL Assessment.

Fox, B. A., & Thompson, S. A. (1990). A discourse explanation of the grammar of relative clauses in English conversation. *Language*, 297-316.

Gibson, E. (1998). Linguistic complexity: Locality of syntactic dependencies. *Cognition*, *68*(1), 1-76.

Gibson, E. (2000). Dependency locality theory: A distance-based theory of linguistic complexity. In Marantz, A., Miyashita, Y., & O'Neil, W. (Eds.), *Image, Language, Brain: Papers from the First Mind Articulation Project Symposium* (pp. 95-126). MIT Press.

Hale, J. (2006). Uncertainty about the rest of the sentence. *Cognitive Science*, *30*(4), 643-672.

Hawkins, J. A. (1999). Processing complexity and filler-gap dependencies across grammars. *Language*, 244-285.

Hawkins, J. A. (2004). *Efficiency and Complexity in Grammars*. Oxford University Press.

Hawkins, J.A. (2007). Acquisition of relative clauses in relation to language universals. *Studies in Second Language Acquisition, 29*(2), 337-344.

Hsiao, Y., Gao, Y., & MacDonald, M. C. (2014). Agent-patient similarity affects sentence structure in language production: Evidence from subject omissions in Mandarin. *Frontiers in Psychology*, *5*, 104735.

Hu, S., Gavarró, A., Vernice, M., & Guasti, M. T. (2016). The acquisition of Chinese relative clauses: contrasting two theoretical approaches. *Journal of Child Language*, *43*(1), 1-21.

Hu, S., & Guasti, M. (2017). Complexity in the acquisition of Relative Clauses: Evidence from school-age sequential Mandarin-Italian bilingual children. *Journal of International Chinese Education*, *2*, 121-156.

Huang, C. C. (2011). Referential choice in Mandarin child language: A discourse-pragmatic perspective. *Journal of Pragmatics*, *43*(7), 2057-2080.

Huang, N., & Phillips, C. (2021). When missing NPs make double center-embedding sentences acceptable. *Glossa: a journal of general linguistics, 6*(1), 1-28.

Hulk, A., & Müller, N. (2000). Bilingual first language acquisition at the interface between syntax and pragmatics. *Bilingualism: Language and Cognition*, *3*(3), 227-244.

Hsu, C. C. (2014). The Role of Age in Mandarin-Speaking Children. *Concentric: Studies in Linguistics*, *40*(2), 29-54.

Jia, G., & Fuse, A. (2007). Acquisition of English grammatical morphology by native Mandarin-speaking children and adolescents: Age-related differences. *Journal of Speech, Language, and Hearing Research*, *50*(5), 1280-1299.

Keenan, E. & Comrie, B. (1977). Noun phrase accessibility and Universal Grammar. *Linguistic Inquiry, 8*(1), 63–99.

Kidd, E., Brandt, S., Lieven, E., & Tomasello, M. (2007). Object relatives made easy: A cross-linguistic comparison of the constraints influencing young children's processing of relative clauses. *Language and Cognitive Processes*, *22*(6), 860-897.

Kidd, E., Chan, A., & Chiu, J. (2015). Cross-linguistic influence in simultaneous Cantonese–English bilingual children's comprehension of relative clauses. *Bilingualism: Language and Cognition*, *18*(3), 438-452.

Lau, E., & Tanaka, N. (2021). The subject advantage in relative clauses: A review. *Glossa: a journal of general linguistics*, *6*(1).

Lee, J. N., & Naigles, L. R. (2005). The input to verb learning in Mandarin Chinese: a role for syntactic bootstrapping. *Developmental Psychology*, *41*(3), 529.

Levy, R. (2008). Expectation-based syntactic comprehension. *Cognition*, *106*(3), 1126-1177.

Lin, C. J. C., & Bever, T. G. (2006). Subject preference in the processing of relative clauses in Chinese. In Baumer, D., Montero, D., & Scanlon, M. (Eds.), *Proceedings of the 25th West Coast Conference on Formal Linguistics* (pp. 254-260). Cascadilla Proceedings Project.

Lin, C. J. C., & Bever, T. G. (2010). Garden path and the comprehension of head-final relative clauses. In Yamashita, H., Hirose, Y., & Packard, J. L. (Eds.), *Processing and Producing Head-Final Structures* (pp. 277-297), Springer Science & Business Media.

Liu, Z. J. (2015). *The development of noun-modifying constructions in child Mandarin* [Doctoral dissertation, Hong Kong Polytechnic University].

Macdonald, R., Brandt, S., Theakston, A., Lieven, E., & Serratrice, L. (2020). The role of animacy in children's interpretation of relative clauses in English: Evidence from sentence–picture matching and eye movements. *Cognitive Science*, *44*(8), e12874.

MacDonald, M.C. & Christiansen, M.H. (2002). Reassessing working memory: A comment on Just & Carpenter (1992) and Waters & Caplan (1996). *Psychological Review*, *109*, 35-54.

Mak, W. M., Vonk, W., & Schriefers, H. (2006). Animacy in processing relative clauses: The hikers that rocks crush. *Journal of Memory and Language*, *54*(4), 466-490.

Mak, W. M., Vonk, W., & Schriefers, H. (2008). Discourse structure and relative clause processing. *Memory & Cognition*, *36*, 170-181.

O'Grady, W. (1997). *Syntactic Development*. University of Chicago Press.

Reali, F., & Christiansen, M. H. (2007). Processing of relative clauses is made easier by frequency of occurrence. *Journal of Memory and Language*, *57*(1), 1-23.

Rojas, R., Iglesias, A., Bunta, F., Goldstein, B., Goldenberg, C., & Reese, L. (2016). Interlocutor differential effects on the expressive language skills of Spanish-speaking English learners. *International Journal of Speech-Language Pathology*, *18*(2), 166-177.

Roland, D., Dick, F., & Elman, J. L. (2007). Frequency of basic English grammatical structures: A corpus analysis. *Journal of Memory and Language*, *57*(3), 348-379.

Rowland, C.F., Noble, C.H., & Chan, A. (2014). Competition all the way down: how children learn word order cues to sentence meaning. In MacWhinney, B., Malchukov, A., & Moravcsik, E. (Eds)., *Competing Motivations in Grammar and Usage* (pp.127-143), Oxford University Press.

Shin, S. J. (2002). Birth order and the language experience of bilingual children. *Tesol Quarterly*, *36*(1), 103-113.

Sun, C. F., & Givón, T. (1985). On the so-called SOV word order in Mandarin Chinese: A quantified text study and its implications. *Language*, 329-351.

Sun, H., Ng, S., O'Brien, B., and Fritschke, T. (2020). Child, family, and school factors in bilingual preschoolers' vocabulary development in heritage languages. *Journal of Child Language*, *47*(4), 817-843.

Tanaka, N., Lau, E., & Lee, A. L. (2024). On the universality of the subject preference in the acquisition of relative clauses across languages. *First Language*, 01427237241226734.

Tsoi, E. Y. L., Yang, W., Chan, A., & Kidd, E. (2019). Mandarin–English speaking bilingual and Mandarin speaking monolingual children's comprehension of relative clauses. *Applied Psycholinguistics*, *40*(4), 933-964.

Wang, Q., Lillo-Martin, D., Best, C. T., & Levitt, A. (1992). Null subject versus null object: Some evidence from the acquisition of Chinese and English. *Language Acquisition*, *2*(3), 221-254.

Xue, N., Jiang, Z., Zhong, X., Palmer, M., Xia, F., Chiou, F. D., & Chang, M. (2010). *Chinese Treebank 7.0 LDC2010T07*. Web Download. Linguistic Data Consortium.

Yang, W. (2019). *The acquisition and processing of relative clauses: experimental evidence from Mandarin* [Doctoral dissertation, Hong Kong Polytechnic University].

Zhang, S. (2022). *The acquisition and use of Mandarin relative clauses by monolingual and bilingual children and adults* [Doctoral dissertation, Lancaster University].

Zhang, D., & Slaughter-Defoe, D. T. (2009). Language attitudes and heritage language maintenance among Chinese immigrant families in the USA. *Language, Culture and Curriculum*, *22*(2), 77-93.

Zhu, J., & Gavarró, A. (2019). Testing language acquisition models: null and overt topics in Mandarin. *Journal of Child Language*, *46*(4), 707-732.

Appendix A

Test sentences, practice sentences and filler sentences for one experimental list

List 1	Sentences (before randomization)
Test sentence 1	抱小猪的小马在哪里？Where is the horse that is hugging the pig?
Test sentence 2	亲老虎的小象在哪里？Where is the elephant that is kissing the tiger?
Test sentence 3	喂小熊的小象在哪里？Where is the elephant that is feeding the bear?
Test sentence 4	推兔子的小羊在哪里？Where is the sheep that is pushing the rabbit?
Test sentence 5	现在推狮子的在哪里？Where is (the bear) that is pushing the lion now?
Test sentence 6	现在抱奶牛的在哪里？Where is (the giraffe) that is hugging the cow now?
Test sentence 7	现在亲猴子的在哪里？Where is (the cow) that is kissing the monkey now?
Test sentence 8	现在喂小猫的在哪里？Where is (the duck) that is feeding the cat now?
Test sentence 9	猴子喂的小狗在哪里？Where is the dog that the monkey is feeding?
Test sentence 10	老鼠推的鸭子在哪里？Where is the duck that the mouse is pushing?
Test sentence 11	小猫抱的小羊在哪里？Where is the sheep that the cat is hugging?
Test sentence 12	小猪亲的小狗在哪里？Where is the dog that the pig is kissing?
Test sentence 13	现在公鸡亲的在哪里？Where is (the mouse) that the chicken is kissing now?
Test sentence 14	现在兔子喂的在哪里？Where is (the chicken) that the rabbit is feeding now?
Test sentence 15	现在老虎推的在哪里？Where is (the horse) that the tiger is pushing now?
Test sentence 16	现在狮子抱的在哪里？Where is (the giraffe) that the lion is hugging now?
Practice sentence 1	大大的猴子在哪里？Where is the big monkey?
Practice sentence 2	小女孩的鱼在哪里？Where is the girl's fish?
Filler sentence 1	大大的鱼在哪里？ Where is the big fish?
Filler sentence 2	黄色的鸭子在哪里？ Where is the yellow duck?
Filler sentence 3	小小的蝴蝶在哪里？ Where is the small butterfly?
Filler sentence 4	胖胖的蜜蜂在哪里？ Where is the fat bee?
Filler sentence 5	短短的虫子在哪里？ Where is short caterpillar?
Filler sentence 6	红色的蜘蛛在哪里？ Where is the red spider?
Filler sentence 7	瘦瘦的老鼠在哪里？ Where is the thin mouse?
Filler sentence 8	长长的蛇在哪里？ Where is long snake?

Appendix B

The number of Head, Reverse and Other Errors made by monolingual and bilingual children for Mandarin subject and object RCs

		Subject RCs			Object RCs		
		Head	Reverse	Other	Head	Reverse	Other
Monolinguals	Younger	23	9	31	104	5	5
	Older	23	7	26	78	8	4
Bilinguals	Younger	9	6	15	87	9	4
	Older	22	4	8	82	9	1