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The judgment and interpretation of Mandarin relative clauses by heritage speakers and second language learners

Chung-yu Chen & Tania Ionin[*]

Abstract. This article examines the judgment and interpretation of Mandarin relative clauses (RCs) by heritage speakers (HSs) and second language learners (L2ers) of Mandarin, using an acceptability judgment task (AJT) and a picture-based truth-value judgment task (TVJT), in order to examine whether there is dominant language transfer in this domain, and whether HSs and/or L2ers exhibit a subject-extracted RC (SRC) advantage. The HSs and L2ers were both English-dominant and matched on Mandarin proficiency. The AJT tested whether participants knew that Mandarin RCs are head-final, unlike head-initial English RCs. The TVJT tested whether participants correctly interpreted Mandarin RCs with two animate nouns. In the AJT, both HSs and L2ers rated head-final RCs significantly above head-initial RCs, overcoming English transfer of RC headedness with increased proficiency. In the TVJT, HSs performed similarly to L2ers; neither group showed a clear SRC advantage, contrary to the predictions of the Noun Phrase Accessibility Hierarchy (NPAH) (Keenan & Comrie 1977). Compared to HSs/L2ers of Korean (O'Grady et al. 2001), HSs/L2ers of Mandarin in the present study acquire RCs more successfully, possibly due to high Mandarin proficiency, task format, and/or the lack of case markers in Mandarin RCs. While there was a slight HS advantage over L2ers in the AJT, there was no HS advantage in the TVJT, suggesting that Mandarin word order is not particularly difficult for either group, in contrast to case marking in Korean.

Keywords. Mandarin; relative clauses; subject-object asymmetry; heritage speakers; second language learners

1. Introduction. In the past two decades, heritage languages have received much attention within linguistics, partly due to the potential to re-examine language acquisition theories with a new population (e.g., Benmamoun et al. 2013; Polinsky 2018; Polinsky & Scontras 2020; Montrul & Polinsky 2021). The term *heritage speakers* (HSs) refers to speakers who were exposed to an ethnic or immigrant language from their parents since birth at home, but typically become dominant in the majority language (e.g., English in the US). An example of HSs is children of Mandarin-speaking immigrants in the US who speak or hear Mandarin as their heritage (home) language. Even though the heritage language is their first language (L1), HSs often do not reach the same level of attainment in their heritage language as in their dominant language. Yet, in many aspects, HSs are often found to be more target-like than late learners of a second language (L2ers), who acquire the target language after puberty, typically in a classroom setting (for discussion on comparing HSs and L2ers, see, e.g., Montrul 2008, 2016).

Many studies have been conducted to compare HSs and L2ers in a variety of languages and across many different linguistic phenomena in order to examine (i) whether HSs have an advantage over L2ers due to early age of acquisition and (ii) whether both groups are (equally) subject to dominant language transfer. While previous studies have often found HSs to have a selective advantage over L2ers on phonology, results are less clear with regard to morphosyntactic phenomena (for reviews, see Montrul 2008, 2016). One of the morphosyntactic phenomena on which HSs have been tested, in several languages, is relative clauses (RCs).

While both English and Russian have head-initial RCs (the head of the RC comes before the RC), Mandarin and Korean have head-final RCs. Additionally, different types of RCs involve different case markers in Russian and Korean, but differ only with regard to word order in such languages as English and Mandarin. As pointed out in Comrie (2007: 302), there has been "surprisingly little transfer" in the acquisition of head-final RCs in languages such as Japanese and Korean. O'Grady & Kim (2022: 89) also noted that English and Korean are so dissimilar that "there are relatively few opportunities for direct or indirect similarity-motivated transfer." However, some studies have indeed found dominant language transfer. For example, adult HSs and L2ers of Korean in O'Grady et al. (2001, 2003) misanalyzed the first noun inside the RC as the head due to English transfer. In Mandarin, head errors have been reported in English-Mandarin bilingual children or child HSs (Tsoi et al. 2019; Zhang 2022). To date, very few L2 studies have directly examined possible English transfer of headedness in Mandarin, with a few notable exceptions like Hu & Liu (2007); even fewer (if any) have done so with adults HSs (for child HSs, see Jia & Paradis 2020).

Moreover, results from Mandarin regarding a subject-object asymmetry in RC extraction are mixed. Cross-linguistically, subject-extracted RCs (SRCs) are often found to be acquired earlier, and read/processed faster, and with higher accuracy, than object-extracted RCs (ORCs) (see Table 1 in the next section for examples of SRCs and ORCs). In the literature, this phenomenon is often referred to as an SRC advantage or SRC preference (for a recent review, see Lau & Tanaka 2021). For example, in Korean, O'Grady et al. (2001) found that both HSs and L2ers performed significantly better on SRCs than ORCs, without a HS advantage. In heritage Russian, Polinsky (2011) also found that adult HSs performed significantly better on SRCs than ORCs. While the subject-object asymmetry in Mandarin RCs has been examined with monolingual children (e.g., Hu et al. 2016a) and adult L2ers (e.g., Dai 2023), and recently with bilingual children and child HSs (e.g., Jia & Paradis 2020), it has rarely (if ever) been investigated with adults HSs of Mandarin, let alone in comparison with proficiency-matched adult L2ers. This gap is surprising given that a much-debated question in language acquisition (and processing) is whether there is an SRC advantage in the acquisition of Mandarin, as in many other languages (e.g., Tsoi et al. 2019; Tanaka & Cherici 2023), or whether Mandarin presents a unique acquisition pattern (e.g., Chen & Shirai 2015; Chang 2023). The present study is, to the best of our knowledge, the first one to conduct a HS/L2 comparison on the acquisition of Mandarin RCs, and to separately examine whether (i) the learners are aware that Mandarin RCs are head-final and (ii) there is a subject-object asymmetry in the acquisition of Mandarin.

As mentioned before, there are mixed results as to whether HSs have an advantage over L2ers on morphosyntax; one possible explanation is task effects. Based on prior studies, Orfitelli & Polinsky (2017) argue that grammaticality judgment tests might not be ideal in assessing the grammatical knowledge of HSs and L2ers (due to processing and metalinguistic demands). Specifically, they report data from studies where Russian HSs were native-like on SRCs (but not ORCs) in a comprehension task (an auditory sentence-picture matching task), but were not

native-like in a written acceptability judgment task (AJT), over-accepting ungrammatical SRCs with incorrect case marking (ORCs were not tested here). However, Ionin (2021) cautions that their claim requires more empirical support and gives examples from other research where learners performed better in judgments than in comprehension. To examine both (un)grammaticality and interpretation of Mandarin RCs, in the present study, we include an AJT and a TVJT to test both judgments of RC headedness and RC interpretation by proficiency-matched Mandarin HSs and L2ers.

Given that the difficulty facing English-dominant learners in acquiring RCs involves case marking in Korean (O'Grady et al. 2001) and Russian (Orfitelli & Polinsky 2017), it is illuminating to see whether English-dominant Mandarin HSs and L2ers have difficulty with Mandarin RCs, which differ from English only in word order (RC head direction and the position of the relativizer or so-called complementizer). Moreover, while no HS advantage over L2ers was found with Korean RCs (O'Grady et al. 2001), it remains to be seen whether an HS advantage would be found in Mandarin RCs. The present study examines whether (a) HSs and L2ers show English transfer in Mandarin RCs, (b) there is an SRC/ORC asymmetry in the acquisition of Mandarin, and (c) HSs have an advantage over L2ers on Mandarin RCs.

The paper is structured as follows. Section 2 introduces the properties of Mandarin RCs and the acquisition literature before posing the research questions. The overall methodology and participants are presented in section 3. The design of and results from the AJT and the TVJT are presented in sections 4 and 5, respectively. Section 6 offers a general discussion, and section 7 concludes the paper and addresses some limitations.

2. The morphosyntax and acquisition of relative clauses. In an English complex NP like *the boy who eats an apple*, *boy* is the head noun of the RC *who eats an apple.* (A "head noun" is the "head" of the NP that is modified by an adjective or a RC.) Unlike English, where the head noun precedes the RC, in Mandarin the head noun follows the RC.[1] Thus, English RCs are head-initial, while Mandarin RCs are head-final. The present study focuses on two common types of extraction: SRCs and ORCs; see Table 1. In terms of word order, English SRCs exhibit Subject-Verb-Object (SVO) word order, but in Mandarin, it is ORCs that exhibit SVO word order.

	SRC			ORC		
English	The **boy** [who __ eats an apple]			The **apple** [which the boy eats __]		
	Subject	Verb	Object	Object	Subject	Verb
Mandarin	[__ chī píngguǒ *de*] **nánhái**			[nánhái chī __ *de*] **píngguǒ**		
	[__ eat apple *de*] **boy**			[boy eat __ *de*] **apple**		
	Verb	Object	Subject	Subject	Verb	Object

Table 1. English and Mandarin RCs (*de* is the Mandarin RC marker)

As mentioned above, cross-linguistically SRCs are often found to be easier to acquire (and process) than ORCs (see Lau & Tanaka 2021 for a recent review). Below, we discuss several hypotheses that are commonly used to explain this asymmetry.[2] We first discuss the Noun Phrase Accessibility Hierarchy (NPAH), in which the availability of SRCs is higher than that of ORCs

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[1] While Mandarin RCs are head-final, head-initial Mandarin RCs have occasionally been mentioned in the literature. They are rare ("non-canonical") and mostly used as "afterthoughts" (Wang & Wu 2020).

[2] While these hypotheses were not originally used to explain heritage and L2 acquisition, they have been used to explain L2 performance (e.g., O'Grady et al. 2003; O'Grady & Kim 2022).

with direct objects, which in turn is higher than other types of RCs cross-linguistically. While the NPAH was originally proposed as a typological universal which may reflect "psychological ease of comprehension" (Keenan & Comrie 1977: 88), it has become the most tested proposal in the acquisition research of RCs. Simply put, the NPAH predicts that a subject is easier to relativize cross-linguistically than other types of RC extraction, resulting in an SRC advantage.

Two other hypotheses commonly used to explain the RC asymmetry address the structural distance vs. linear distance between the head noun and the gap (or the embedded verb). The first is the Structural Distance Hypothesis (SDH) (O'Grady 1997, among others), while the second is the Linear Distance Hypothesis (LDH) (Gibson 1998, among others). In all languages, the structural (hierarchical) distance between the head noun and the gap/verb is shorter in SRCs than in ORCs, resulting in an SRC advantage. This is similar to the proposal in Polinsky & Scontras (2020), who termed HSs' difficulty with ORCs, relative to SRCs, as "the distance problem" because of the longer structural distance between the head and the gap/verb in ORCs. In contrast, the LDH makes different predictions for English and Mandarin RCs: the LDH predicts an SRC advantage in English (since the linear distance between the head noun and the gap/verb is shorter in SRCs than in ORCs), but an ORC advantage in Mandarin (since the linear distance is shorter in ORCs than in SRCs; see Table 1). Yet another hypothesis that makes opposing predictions for English and Mandarin RCs is the canonical word order hypothesis (WOH) (e.g., Diessel & Tomasello 2005, cited in O'Grady & Kim 2022): the WOH predicts an SRC advantage in English (since English SRCs resemble the canonical SVO word order), but an ORC advantage in Mandarin (since Mandarin ORCs resemble the canonical SVO word order).

2.1. ACQUISITION OF MANDARIN RELATIVE CLAUSES. We discuss L1, second language (L2), and heritage language acquisition studies, in that order. We focus on offline behavioral studies, as online processing studies often have temporary ambiguity/garden-path problems that are not an issue in offline studies like ours.

Studies have shown that Mandarin-speaking children are quite accurate in producing Mandarin RCs by age 5 (e.g., Hsu 2014, 2023) or 6 (e.g., Hu et al. 2016b), though the children in Hu et al. (2016a) were not adult-like in a comprehension task until age eight. In terms of subject-object asymmetry in L1 acquisition of Mandarin, the SRC advantage (e.g., Hsu et al. 2009; Hsu 2014, 2023; Hu et al. 2016a,b; Tsoi et al. 2019) seems to be better supported than the ORC advantage (e.g., Chen & Shirai 2015; He et al. 2017) (for comprehensive reviews, see Lau & Tanaka 2021; Hsu 2023).

Turning to L2-Mandarin, we focus on L1-transfer of RC headedness before discussing subject-object asymmetry. Hu & Liu (2007) tested the role of L1-transfer using a written grammaticality judgment test, and found that L1-English L2ers outperformed L1-Korean L2ers in rejecting the ungrammatical forms (including head-initial Mandarin RCs), showing that L1-English L2ers were able to overcome L1-English transfer. Chang (2017) found head errors produced by L2ers from L1s with both head-initial and head-final RCs. Given that the participant samples from different L1s were not comparable, the author did not strongly argue for L1 transfer.

Findings regarding the subject-object asymmetry in L2-Mandarin are mixed as well.[3] We focus on studies with L1-English L2-Mandarin learners. Testing L1-English L2ers, Xu (2013a,

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[3] Additionally, in Mandarin, a determiner-classifier phrase (such as *nà-ge*, roughly 'that') can precede or follow a Mandarin RC, so both *nà-ge [RC … de] head* or *[RC … de] nà-ge head* are grammatical in Mandarin. The positions of

2014) and Tanaka & Cherici (2023) found an SRC advantage, while Wang & Feng (2014) found an ORC advantage. Dai (2023) found an ORC advantage in production, but not in comprehension. Testing L2ers from various L1 backgrounds (mostly English and Korean), Cui (2013) found an ORC advantage using a multiple-choice questionnaire (asking "who helped whom?"), but data from self-paced reading were mixed. Moreover, it is possible that some L2ers in Cui (2013) were able to answer Mandarin ORCs (i.e., [subject-verb *de*] object) correctly by utilizing SVO order, without fully acquiring Mandarin RCs. Examining written compositions, Chang (2017) found both L1-English and L1-Japanese L2-Mandarin learners produced more ORCs than SRCs, but the trend was reversed for L1-English L2ers with higher proficiency. In a follow-up study, Chang (2023) included L2ers from six L1s, but the finding regarding L1-English L2ers was largely replicated. Chang (2023) reasons that because ORCs resemble canonical word order in Mandarin, learners initially produced ORCs with greater ease. As their proficiency increases, they approach native-like patterns and produce more SRCs than ORCs.

Turning to heritage language acquisition, we are unaware of any published studies on the acquisition of Mandarin RCs by English-dominant adult HSs. We review several studies that examined Mandarin with English-Mandarin child bilinguals or English-dominant child HSs in predominantly English-speaking environments. Several studies have found English-to-Mandarin transfer of RC headedness, in child HSs in Canada (Jia & Paradis 2020) and the UK (Zhang 2022) and in bilingual children in Australia (Tsoi et al. 2019).

We discuss Jia & Paradis (2020) in more detail, as they directly examined possible English transfer of RC headedness in the acquisition of Mandarin RCs. Overall, Jia & Paradis (2020) found that child HSs in Canada patterned like monolingual Mandarin-speaking children in China in comprehension but not in production. In production, some child HSs (10 out of 29 children, but only 8% out of all utterances) incorrectly produced head-initial Mandarin RCs (i.e., head-RC-*de*), showing English transfer. One unusual feature of this study is that participants were asked to comprehend grammatical head-final and ungrammatical head-initial Mandarin RCs in an audio picture-selection task (termed "a timed offline decision task" by the authors). Interestingly, with ungrammatical head-initial Mandarin RCs, both groups were more accurate in SRCs (i.e., head $_{RC}$[verb-object-*de*]) than ORCs (i.e., head $_{RC}$[subject-verb-*de*]), probably because head-initial Mandarin SRCs have a SVO word order that helps children to comprehend who did what to whom, even though it is ungrammatical (Jia & Paradis 2020: 171). In terms of response times, both groups patterned similarly, except that monolingual children took longer than child HSs to process head-initial Mandarin ORCs. Jia & Paradis (2020: 171) speculate that child HSs have an advantage in processing head-initial Mandarin ORCs because they used "an English RC parsing strategy". In other comprehension studies, English-dominant English-Mandarin bilingual children or child HSs were found to misidentify the subjects in ORCs as the heads in referent selection tasks (Tsoi et al. 2019; Zhang 2022).

In terms of the subject-object asymmetry in bilingual children or child HSs, Tsoi et al. (2019) found an SRC advantage in comprehension with Mandarin-English bilingual children, similar to child HSs in Zhang (2022). However, in production, Zhang (2022) found that child HSs produced proportionally more ORCs than SRCs relative to monolingual children and argued that acquisition of Mandarin ORCs is facilitated by SVO word order in both Mandarin and English.

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such phrases tend to be different with SRCs vs. ORCs, which may be one of the explanations for the prior mixed results (for L2-Mandarin studies that examined such phrases in RCs, see e.g., Xu 2013b; Wu et al. 2021).

A note on the methodology in studying RC comprehension is in order. While studies such as Cui (2013) compared different L1-groups when examining subject-object asymmetry, it is unclear whether they excluded participants who made RC head errors before comparing SRCs vs. ORCs. Thus, the present study examines whether participants know that Mandarin RCs are head-final before examining whether they show a subject-object asymmetry in comprehension. Additionally, while several L1-Mandarin studies use picture-based comprehension tasks to study RCs, very few L2-Mandarin studies have used such tasks. The present study adopted a picture-based TVJT so that participants can judge one sentence-context mapping at a time.

To examine whether English-dominant HSs and L2ers of Mandarin can overcome English transfer and interpret SRCs/ORCs correctly, the present study tests both the grammaticality and the interpretations of Mandarin RCs. Furthermore, by examining both SRCs and ORCs, this paper contributes to the debate concerning an SRC/ORC advantage with new HS and L2 Mandarin data.

2.2. RESEARCH QUESTIONS AND HYPOTHESES. The research questions (RQs) are listed below:

1. Is English transfer of RC headedness attested in judgments of Mandarin RCs by HSs and L2ers?
2. Is there an SRC/ORC asymmetry in comprehension of RCs by Mandarin HSs and L2ers?
3. Do HSs have an advantage over L2ers in Mandarin RCs in judgments and/or in comprehension, when proficiency is controlled for?

In response to the first RQ, we hypothesize that under English transfer, some HSs and L2ers might over-accept head-initial RCs and under-accept head-final RCs, or simply rely on SVO word order to parse the sentences. In response to the second RQ, both the NPAH and the SDH predict an SRC advantage, while the LDH and the WOH predict an ORC advantage. Turning to RQ3, given that RCs are acquired relatively late in child language acquisition (age 5 or 6; Hsu 2014; Hu et al. 2016b) and that no HS advantage has been found with Korean RCs (O'Grady et al. 2001), it is possible that Mandarin HSs would not exhibit an advantage over L2ers in this domain.

3. Overall methodology. To answer the above research questions, two offline tasks were conducted. The AJT tested whether participants knew that Mandarin RCs are head-final and the TVJT tested whether the same participants interpreted Mandarin RCs correctly. Both SRCs and ORCs were tested to examine whether there is an SRC/ORC asymmetry. A proficiency test was used in order to check for any improvement with proficiency, as well as to control for proficiency levels of the L2 and HS groups.

3.1. PROCEDURE. The entire experiment was administered on Qualtrics, a web-based survey tool. Participants completed a background questionnaire, a Mandarin proficiency test, two tasks testing their knowledge of tone in Mandarin (not reported here), the TVJT, and the AJT, in that order. All tasks were untimed. The TVJT preceded the AJT since the latter was more explicit. The Mandarin proficiency test was a multiple-choice test, consisting of 24 vocabulary items (participants chose one out of five English translations for each word) and 16 cloze items (participants chose one out of five Chinese words for each blank). For example, in one of the vocabulary items, participants had to choose among 'import,' 'export,' 'progress,' 'regress' or 'digest' as the translation for the Chinese word *jìnkǒu* 'import,' with a literal meaning of 'enter-mouth'. In a sample cloze test item, participants had to choose among five Chinese words to fill

a blank in a complex sentence that requires a causal transition; the correct choice was *suǒyǐ* 'so'. All of the questions came from an unused portion of a university Chinese placement test.[4]

As Chinese characters are non-alphabetic, many HSs have difficulty acquiring Chinese literacy, even if they are fluent in speaking (e.g., Xiao 2008). To minimize literacy issues, Romanization (Pinyin) was added to the AJT and TVJT for the HS and L2 groups. They could choose to read the characters (traditional or simplified Chinese) with or without Romanization for the AJT and the TVJT. They could also choose to read traditional or simplified Chinese characters for the proficiency test; however, we did not add Romanization to the proficiency test, a limitation that will be addressed in section 7. For all tasks, monolinguals were presented with traditional or simplified Chinese characters, depending on whether they were tested in Taiwan or in mainland China. For the proficiency test, monolinguals only completed the cloze portion, but not the vocabulary portion, which required knowledge of English.

	Monolinguals (*n*=62)	HSs (*n*=39)	L2ers (*n*=36)
Age of testing	Mean 22.2 (range 19-37)	Mean 20.9 (range 18-33)	Mean 27.6 (range 18-55)
Age of acquisition of Mandarin (in years)	at birth	at birth or age 1	3 at ages 8 through 12 10 at ages 13 through 17 23 at ages 18 and up
Age of acquisition of English (in years)	N/A	Mean: 1.4 (range 0-5; 2 did not respond)	at birth
Average years of Mandarin classes	N/A	Mean: 6 (range 0.3-14)	Mean: 3.6 (range 0.4-13)
Age of US arrival	N/A	26 born in the US and 4 in Canada; 9 came to the US before age 5	25 born in the US, but 1 grew up in the UK 11 born outside the US[a]
Proficiency test (max score = 40 for HSs and L2ers, but 16 for monolinguals)	Mean 15.9 (range 15-16)	Mean 27.7 (sd 9.1, range 11-40)	Mean 29.2 (sd 7.6, range 10-40)

Table 2. Information about the participants who completed the AJT

[a] 1 born in Australia; 1 born in Canada; 1 born in Bahamas, but grew up in Canada; 4 born in the UK; 1 born in India; 1 born in Saint Vincent and the Grenadines; 1 born in Germany to American parents, and moved to the US at age 6; 1 born in Honduras to American parents, and moved to the US at age 17.

3.2. PARTICIPANTS. The participants were 39 Mandarin HSs and 36 Mandarin L2ers, as well as a baseline comparison group of 62 (functionally) monolingual Mandarin speakers (*monolinguals* hereafter).[5] All of these 137 participants were included in the AJT analysis (see Table 2). For the

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[4] The questions were designed to be part of a Chinese placement test at UIUC but were not included as part of the actual placement test. The test developers first created a corpus from commonly used Chinese textbooks in the US and conducted vocabulary distribution analyses on the corpus (for more information, see Yan et al. 2023). Then they randomly selected the test words in each vocabulary level. We chose to test our participants with the unused test portion (provided to us by the test developers) rather than the actual placement test because some of the participants in the study had already taken the placement test.

[5] Thirteen additional HSs and L2ers were excluded from the analysis based on background variables (being bilingual or native in another language: Filipino, Korean, or a non-Mandarin Chinese language). Another 10 HSs/L2ers

TVJT analysis, five participants were excluded based on their non-target-like performance on the AJT, and four more were excluded based on poor performance on fillers in the TVJT (more in section 5.3); in the end, data from 62 monolinguals, 35 HSs and 31 L2ers were analyzed for the TVJT.

Table 2 summarizes the information about the 137 study participants, including their scores on the Mandarin proficiency test. Two t-tests were conducted to compare the scores on the Mandarin proficiency test by HSs and L2ers who were analyzed for the AJT, as well as the subset who were analyzed for the TVJT. The tests showed no significant differences between the two groups ($p > 0.05$). The monolingual participants were tested in mainland China or Taiwan in a private setting. All HSs and L2ers completed the study in the US or in Taiwan a private setting. The HSs tested in Taiwan had either grown up in the US or Canada but moved to Taiwan as adults, or else were visiting Taiwan at the time of testing.

4. Acceptability Judgment Task (AJT). The first and primary goal of the AJT was to identify whether participants knew that Mandarin RCs are head-final; it was also used to pre-screen participants for the TVJT. Thus, we discuss the AJT prior to the TVJT, even though it was administered last. The second goal is to examine whether there is evidence that participants use a SVO word order strategy to parse RCs (Jia & Paradis 2020; Zhang 2022).

4.1. AJT MATERIALS. Each item in the AJT was a single sentence which participants rated on 1-to-4 scale, where 1 stood for "completely unacceptable" and 4 for "completely acceptable". Four conditions were created in a 2 (RC TYPE) × 2 (RC HEADEDNESS) design, creating two grammatical conditions and two ungrammatical conditions: grammatical head-final SRC, grammatical head-final ORC, ungrammatical head-initial SRC, and ungrammatical head-initial ORC; see Table 3 for a sample token set.

Conditions	Examples
Head-final SRC: [RC VO *de*]S	[____ chī píngguǒ *de*] **nánhái** hěn gāo [____ eat apple *de*] **boy** is tall 'The **boy** [that eats the apple] is tall.'
Head-final ORC: [RC SV *de*]O	[nánhái chī ____ *de*] **píngguǒ** hěn tián [boy eat ____ *de*] **apple** is sweet 'The **apple** [that the boy eats] is sweet.'
*Head-initial SRC: S[RC VO *de*]	***nánhái** [____ chī píngguǒ *de*] hěn gāo **boy** [____ eat apple *de*] is tall Intended meaning: 'The **boy** [that eats an apple] is tall.'
*Head-initial ORC: O[RC SV *de*]	***píngguǒ** [nánhái chī ____ *de*] hěn tián **apple** [boy eat ____ *de*] is sweet Intended meaning: 'The **apple** [that the boy eats] is sweet.'

Table 3. Sample token in the AJT (brackets and bold font were not in the actual test)

The RC always modified the matrix subject. Following standard procedures (Cowart 1997), 20 token sets were constructed and distributed across four lists in a Latin-square design, so that participants only saw one out of the four variants in a given token set; each list contained five tokens

per condition. In addition to the four conditions (20 tokens) testing RCs, each experimental list also included 16 conditions (80 tokens) testing aspect marking for a different experiment and 10 distractor conditions (50 tokens) without either RCs or aspect marking. In total, each participant read 150 sentences.

Items were blocked and randomized within each block. Each test page contained a single block, and participants could not return to the previous block to change their answers.

4.2. PREDICTIONS. Monolinguals were expected to give near-categorical judgments. For HSs and L2ers who are not target-like, there are two possible misanalyses. Under English transfer of RC headedness, HSs and L2ers may incorrectly accept head-initial Mandarin RCs and incorrectly reject head-final Mandarin RCs ("head error"). Alternatively, if learners rely on a SVO word order strategy to parse Mandarin RCs, they would consider head-initial SRCs and head-final ORCs grammatical, since both have a SVO sequence (ignoring the marker *de*). The predictions are summarized in Table 4.

Conditions	Target judgments	Judgments under transfer of RC headedness	Judgments under a SVO word order strategy
Head-final SRC: [RC VO *de*]S	✓	✗	✗
Head-final ORC: [RC SV *de*]O	✓	✗	✓
*Head-initial SRC: S[RC VO *de*]	✗	✓	✓
*Head-initial ORC: O[RC SV *de*]	✗	✓	✗

Table 4. Predictions for HSs and L2ers in the AJT (✓ = accepted; ✗ = rejected)

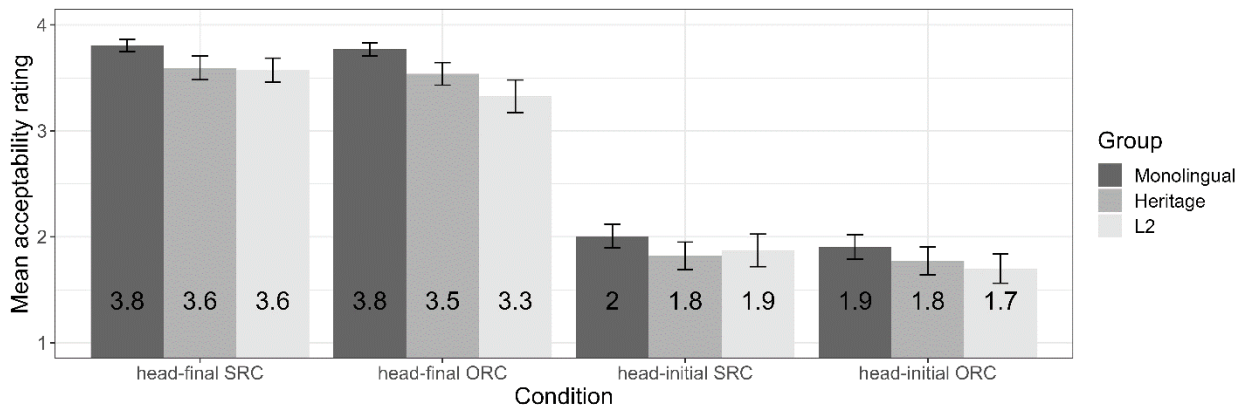4.3. RESULTS. The averaged ratings for the three groups are shown in Figure 1.

Figure 1. AJT results: Mean ratings (error bars show standard error)

All groups rated head-final RCs higher than head-initial RCs. The AJT results were analyzed with a cumulative link mixed model for ordinal data (Christensen 2023) using the *clmm* function in the ordinal package in R (R Core Team 2023). The dependent variable was the participants' ratings from 1 to 4. The fixed effects were RC HEADEDNESS (head-final vs. head-initial; reference level: head-final), RC TYPE (SRC vs. ORC; reference level: SRC), GROUP (monolinguals vs. HSs vs. L2ers; reference level: monolinguals), and their interactions; the random effects included

random intercepts for subjects and items. There was a main effect of RC headedness ($z = -20.270$, $p < 0.001$), indicating that participants made a distinction between head-final and head-initial RCs. There was also a main effect of group (monolinguals vs. HSs: $z = -2.792$, $p < 0.01$; monolinguals vs. L2ers: $z = -3.379$, $p < 0.001$), with monolinguals giving higher ratings overall than the other two groups. There was no effect of RC type ($z = -1.087$, $p = 0.3$), suggesting that participants did not make a distinction between SRCs and ORCs. RC type did not interact with RC headedness or group. The interaction between RC headedness and the HS group ($z = 1.24$, $p = 0.21$) was not significant, nor the interaction between RC headedness and the L2 group ($z = 1.864$, $p = 0.06$). To examine whether proficiency affects HSs and L2ers' judgments (and to check whether any differences between the two groups were due to proficiency), we excluded data from monolinguals and added proficiency scores (as a continuous variable) to the mixed-effects model as a fixed effect. There is a main effect of proficiency ($z = 3.939$, $p < 0.001$), suggesting that as proficiency increased, the ratings changed. There was no main effect of group ($z = -1.111$, $p = 0.3$), indicating that HSs and L2ers performed similarly overall. RC type remained non-significant ($z = 0.171$, $p = 0.9$), suggesting that participants did not make a distinction between SRCs and ORCs. While the main effect of RC headedness became non-significant ($z = -0.544$, $p = 0.6$), there was a significant two-way interaction between RC headedness and group ($z = 3.544$, $p < 0.001$), indicating that HSs made a greater distinction than L2ers between head-final and head-initial RCs. There was also a significant two-way interaction between RC headedness and proficiency ($z = -4.785$, $p < 0.001$), suggesting that as proficiency increased, the ratings changed depending on the headedness. There was also a significant three-way interaction among RC headedness, group and proficiency ($z = -3.198$, $p < 0.01$). In order to explore this interaction, we plotted it using the *emmip* function from the emmeans package. As shown in the visualization in Figure 2, more proficient HSs and L2ers make greater distinctions between grammatical and ungrammatical conditions relative to less proficient speakers; however, even low-proficient HSs gave low ratings to head-initial RCs, while low-proficient L2ers were unable to reject head-initial RCs. Thus, both proficiency and group (HS vs. L2) influence judgments of RC-headedness.
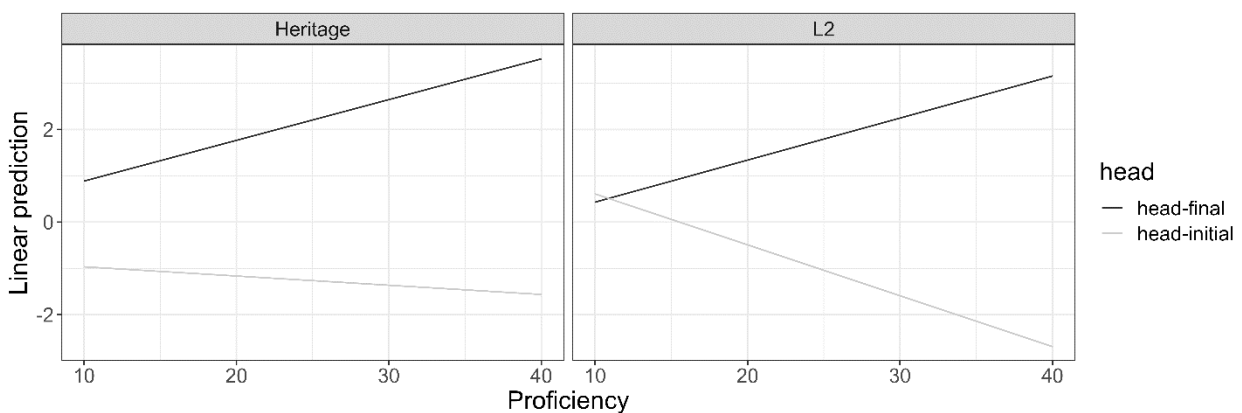

Figure 2. Interaction plot by HSs and L2ers (RC headedness × Group × Proficiency)

5. Truth-Value Judgment Task (TVJT). The goal of the TVJT was to determine whether participants have correct interpretations of Mandarin SRCs and ORCs. Crucially, the TVJT examines whether there is an SRC advantage (greater accuracy on SRCs than ORCs) in the acquisition of Mandarin by L2ers and HSs. Note that merely using the SVO word order cue is insufficient to answer all four conditions correctly (more below).

5.1. TVJT MATERIALS. Each picture-based TVJT item had a picture and a sentence underneath it. Participants had to choose TRUE if the picture and sentence matched and FALSE if the picture and sentence mismatched. The TVJT included four conditions testing RCs, as well as six conditions testing anaphors for a different study. With six tokens per condition, there were 24 sentences on RCs (12 target TRUE and 12 target FALSE), 36 on anaphors (24 target TRUE and 12 target FALSE), and 24 fillers (6 target TRUE and 18 target FALSE). The fillers consisted of 12 monoclausal sentences: e.g., a picture of a doctor using a computer with either the Mandarin translation of 'The doctor is using the computer' (TRUE) or 'The nurse is using the computer' (FALSE); and 12 bi-clausal sentences: e.g., a picture of Sean thinking Kate going to the cinema with either the Mandarin translation of 'Sean thinks Kate goes to the cinema' (TRUE) or 'Sean thinks Kate goes to the market' (FALSE). Unlike the target items, where mismatching pictures involved the grammar (wrong RC type), mismatching pictures for the filler items always involved an incorrect entity or an incorrect action in the picture. Participants needed to give correct responses to at least 20 of the 24 fillers in order to be included in the final analysis, to ensure that they were paying attention. There were two experimental lists.[6] Items were arranged into six blocks and pseudorandomized within each block, following standard procedure (Cowart 1997); no trials from a single condition occurred sequentially. The TVJT had four target conditions for RCs by crossing the factor RC TYPE (SRC vs. ORC) with the factor PICTURE TYPE (matching vs. mismatching). A sample token set is shown in Table 5. Participants saw one item at a time on a computer screen and could not return to the previous test item to change their answers.

		Picture A	Picture B
SRC		TRUE	FALSE
[zhǐzhe yīshēng de] hùshi méi dài yǎnjìng			
[point.at doctor de] nurse negation wear glasses			
'The nurse [who points at a doctor] does not wear glasses.'			
ORC		FALSE	TRUE
[yīshēng zhǐzhe de] hùshi méi dài yǎnjìng			
[doctor point.at de] nurse negation wear glasses			
'The nurse [who a doctor points at] does not wear glasses.'			

Table 5. Sample token set exemplifying the four TVJT conditions

Similar to the AJT, the TVJT tested RCs that modify the matrix subject. Unlike the AJT, which tested knowledge of RC headedness, the TVJT tested interpretation; the actions depicted in the TVJT were fully reversible, with two animate actors. As shown in Table 5, the target responses are two TRUE and two FALSE. Within each token set, Pictures A and B involve the

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[6] Under a full Latin-square design, there should be four lists of RCs. However, there are not many transitive verbs that are both picturable and likely to be familiar to HSs and L2ers. Moreover, the agents and patients need to be able to take reversible roles. Thus, after checking L2-Mandarin vocabulary lists, we came up with 12 predicates, resulting in only two lists. This meant that the same picture appeared twice in each list (but in different blocks), once with SRC and once with ORC sentences. Using only two lists might potentially give rise to priming/repetition effects; to lessen priming effects, the blocks were randomized for each participant.

same three characters: e.g., Picture A depicts a nurse (without glasses) pointing at a doctor, who in turn is pointing at another nurse (with glasses); Picture B depicts a nurse (with glasses) pointing at a doctor, who in turn is pointing at another nurse (without glasses). The action is reversible so that the nurse can be an agent (pointing at other people) or a patient (being pointed at). The only difference between the two pictures lies in the direction of the action. To achieve target performance on this design, participants need to know that Mandarin RCs are head-final and that the word orders inside the RCs are VO in SRCs and SV in ORCs. Crucially, unlike some previous studies, relying on linear word order or some other extra-syntactic strategy (e.g., animacy cues with non-reversible actions) would not yield the correct answer across all four conditions.

5.2. PREDICTIONS. Monolinguals were expected to perform at ceiling across conditions. For HSs and L2ers, an SRC advantage (greater accuracy with SRCs than ORCs, for both matching and mismatching pictures) was expected under the NPAH and the SDH, while an ORC advantage was expected under the LDH and the WOH (see section 2).

5.3. RESULTS. To correctly interpret SRCs and ORCs, participants need to have knowledge of both Mandarin RC headedness and word order inside RCs. Thus, before examining the TVJT results, we first excluded participants who incorrectly rejected head-final RCs or incorrectly accepted head-initial RCs in the AJT. For each individual, a mean rating for each of the four conditions in the AJT was calculated. Acceptance was defined as giving a mean rating above 3, while rejection was defined as giving a mean rating below 2. While no participant gave a mean rating below 2 to either head-final SRCs or head-final ORCs, five participants (three HSs and two L2ers) incorrectly accepted head-initial RCs and were excluded from the subsequent analysis of the TVJT. We furthermore excluded four participants (one HS and three L2ers) who scored below 20 out of the 24 filler sentences in the TVJT. In the end, TVJT data from the remaining 128 participants (62 monolinguals, 35 HSs, and 31 L2ers) were analyzed.

For the TVJT, an accurate response was assigned a score of "1" and an inaccurate response a score of "0". The raw scores in each condition were averaged across the participants and converted to percentages. Figure 3 shows the mean accuracy on the TVJT.

The TVJT data were analyzed in a logistic mixed-effects model (Jaeger 2008) using the *glmer* function in the *lme4* package in R (R Core Team 2023). Response was modeled as the binary outcome. RC TYPE (SRC vs. SRC; reference level: SRC), PICTURE TYPE (matching vs. mismatching; reference level: matching), GROUP (monolinguals vs. HSs vs. L2ers; reference level: monolinguals), and their interactions were treated as fixed effects; the random effects included random intercepts for subjects and items. There was no main effect of RC type ($z = -0.943$, $p = 0.3$), indicating that participants performed similarly on both SRCs and ORCs. There was a main effect of group, but only between monolinguals and HSs ($z = -2.193$, $p = 0.03$), not between monolinguals and L2ers ($z = -1.255$, $p = 0.2$). There was no significant effect of picture type ($z = 1.769$, $p = 0.08$), meaning that participants did not perform differently on matching vs. mismatching RCs. The two-way interaction of picture type and the L2 group was significant ($z = -3.158$, $p < 0.05$), indicating that L2ers performed better on matching than mismatching RCs, with no corresponding difference for monolinguals. There was no significant interaction between picture type and the HS group ($z = -1.457$, $p = 0.15$). There was no significant interaction between RC type and the HS group ($z = -0.477$, $p = 0.63$), or between RC type and the L2 group ($z = -1.657$, $p = 0.1$), indicating that HSs and L2ers, like monolinguals, did not perform differently on SRCs and ORCs, even though numerically, L2ers performed better on SRCs than ORCs.
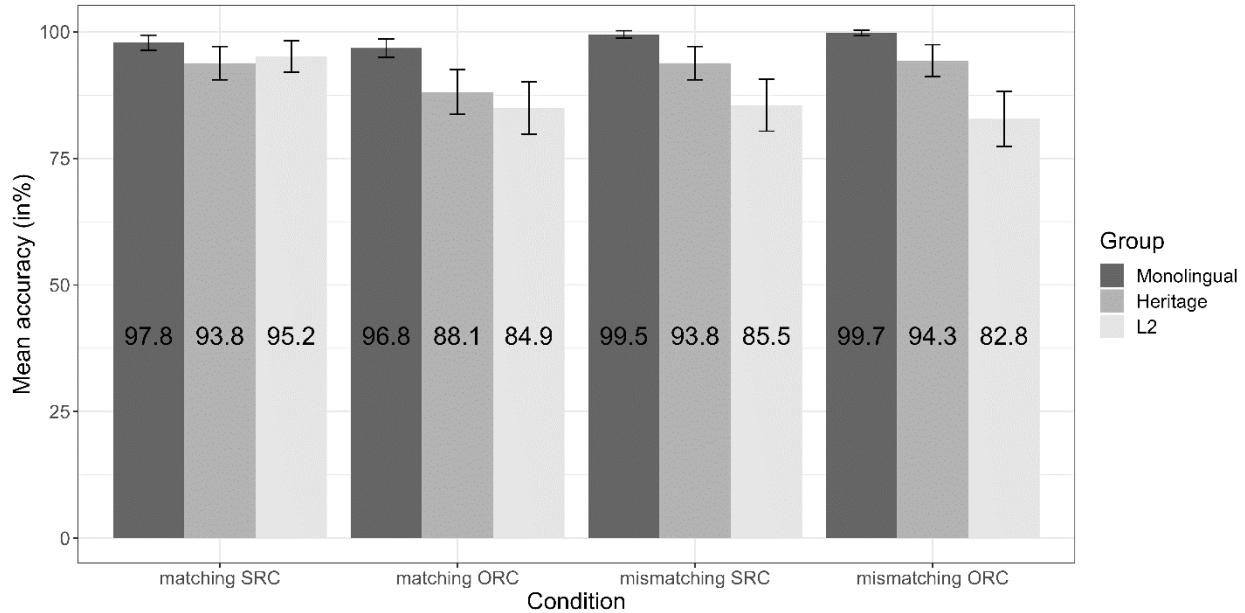
Figure 3. TVJT results: Mean accuracy (in %) (error bars show standard error)

To examine whether proficiency affects both HSs and L2ers, and whether group differences are due to proficiency, we excluded data from monolinguals and added proficiency scores (as a continuous variable) as a fixed effect to a logistic model (we removed random effects to solve a convergence issue). There was a significant main effect of proficiency ($z = 2.344$, $p < 0.05$), indicating that accuracy improved as proficiency increased. There was no main effect of group ($z = -1.488$, $p = 0.1$), indicating that HSs and L2ers performed similarly overall. There was no main effect of RC type ($z = -0.753$, $p = 0.5$) or picture type ($z = 0.614$, $p = 0.5$), suggesting that participants performed similarly on both SRCs and ORCs, as well as on matching and mismatching RCs. No two-, three- or four-way interactions were significant.

6. General discussion. Recall that the RQs, repeated below, investigated whether proficiency-matched HSs and L2ers correctly accept head-final (but not head-initial) Mandarin RCs and have the correct interpretations of head-final RCs. We also examined SRC/ORC asymmetry and conducted HS/L2 comparisons.

1. Is English transfer of RC headedness attested in judgments of Mandarin RCs by HSs and L2ers?
2. Is there an SRC/ORC asymmetry in comprehension of RCs by Mandarin HSs and L2ers?
3. Do HSs have an advantage over L2ers in Mandarin RCs in judgments and/or comprehension, when proficiency is controlled for?

6.1. TRANSFER FROM ENGLISH. In terms of dominant language transfer from English (RQ1), we found very similar patterns between monolinguals, HSs and L2ers in the AJT; at the group level, the HSs and L2ers did not appear to transfer RC-headedness from English, and correctly rated head-final RCs above head-initial ones. At the same time, an investigation of proficiency effects found that the differentiation between head-final and head-initial RCs became stronger with proficiency, and that lower-proficiency HSs made a fairly small distinction between head-final and head-initial RCs, while lower-proficiency L2ers made none at all (Figure 2).

The lack of clear transfer effects at the group level in the present study is different from what was found in Mandarin child HSs or bilingual children (Tsoi et al. 2019; Jia & Paradis 2020; Zhang 2022) and adult heritage/L2 Korean learners (O'Grady et al. 2001); moreover, the relatively successful acquisition of RCs for both HSs and L2ers in the present study differs from studies on heritage/L2 Korean (e.g., O'Grady et al. 2001) and on heritage Russian (e.g., Polinsky 2011; Orfitelli & Polinsky 2017). There are at least three possible explanations: proficiency, task effect, and structural complexity. First, the present study likely had participants with a higher level of proficiency. For example, HSs and some L2ers in O'Grady et al. (2001) were just in second-semester Korean classes, while the HSs in the present study had taken an average of six years of Mandarin classes and the L2ers had taken an average of almost four years. Indeed, the finding of proficiency effects in our AJT data is consistent with the explanation that transfer effects at the group level were largely obscured by our participants' overall high proficiency.

The second possible explanation is task effects. The RC sentences were presented auditorily in Polinsky (2011) and O'Grady et al. (2001), but in written form (with Romanization) in the present study. Written tasks are arguably less demanding than tasks that include aural stimuli, since participants are able to reread the sentences. Third, Korean and Russian RCs may indeed be more challenging than Mandarin RCs for English speakers. To learn Mandarin RCs, English speakers only need to learn that Mandarin RCs are head-final, since the word order inside the RCs remains SVO (SV and VO). However, to learn Korean RCs, English speakers need to learn that they are head-final and that case marking is required to differentiate SRCs from ORCs. The fact that in Korean, both SRCs and ORCs begin with nouns might have led HSs and L2ers of Korean in prior studies to ignore the case markers and incorrectly assume that Korean RCs are head-initial like English. In Mandarin, however, SRCs are verb-initial, forcing HSs and L2ers to notice that Mandarin has head-final RCs. This may explain why HSs and L2ers in the present study (as well as L1-English L2ers in Hu & Liu 2007) were quite accurate in judging Mandarin RC headedness. English-dominant HSs and L2ers of Mandarin may indeed have a relatively easier time acquiring Mandarin RCs than their counterparts in acquiring Korean RCs because no case marking is involved. In a similar vein, while Russian HSs reported in Orfitelli & Polinsky (2017) over-accepted ungrammatical SRCs compared to monolinguals, HSs and L2ers in the present study did not. It is possible that rejecting ungrammatical Mandarin RCs (as in the present study) is easier than rejecting ungrammatical Russian RCs (as in Orfitelli & Polinsky 2017) because the former only involves incorrect word order, while the latter involves incorrect case marking.

6.2. SRC/ORC ASYMMETRY. Next, we discuss the SRC/ORC asymmetry (RQ2). We did not see a clear SRC advantage in the TVJT from HSs and L2ers, unlike the clear SRC advantage observed previously in comprehension by bilingual children or child HSs (Tsoi et al. 2019; Zhang 2022). Hence, we did not find clear support for the NPAH (Keenan & Comrie 1977) or the SDH (O'Grady 1997, among others). Given that the HSs and L2ers' overall accuracy was relatively high, they might have been too advanced to show any asymmetry.

Given that both SRC and ORC advantages have been reported in L1 and L2 Mandarin, it is possible that Mandarin indeed lacks a unique acquisition/processing preference. Some recent studies (e.g., L2-production: Xu 2013b) have concluded that multiple factors (structural distance, linear distance, etc.) play a role in RC acquisition. While multiple factors conspire in languages with head-initial RCs like English to make SRCs easier to acquire than ORCs, in languages with head-final RCs like Mandarin, different factors point in opposing directions and render an SRC

or ORC advantage sometimes undetectable. From a typological perspective, the fact that Mandarin has a rare combination of mixed headedness (SVO word order with head-final RCs; Comrie 2008) may explain why it lacks a clear SRC advantage.

6.3. HS/L2 COMPARISON. Turning to HS/L2 comparisons (RQ3), given that RCs are acquired in monolingual children by age 5 or 6 (Hsu 2014; Hu et al. 2016b), and given the lack of a clear HS advantage in Korean RCs (O'Grady et al. 2001), there was no reason to expect a HS advantage with Mandarin RCs. The results show that both groups largely accepted head-final RCs and rejected head-initial RCs in the AJT and largely had correct interpretations in the TVJT. In the AJT, proficiency contributed to the results independently of group: L2ers with lower proficiency failed to differentiate between head-final and head-initial RCs, unlike HSs with lower proficiency. In contrast, in the TVJT, there was an overall proficiency effect that affected HSs and L2ers equally. With regard to the AJT results, it is possible that HSs, even those with apparently lower proficiency, were able to retain some purely syntactic knowledge they had acquired as young children, while L2ers did not master this syntactic knowledge unless they were sufficiently advanced. Additionally, the proficiency test used in this study might have underestimated HSs' proficiency (more on this in section 7). Thus, the question of a HS advantage in this domain requires further research.

7. Conclusion, limitations, and future directions. The present study examined RCs in two tasks. First, the AJT examined if HSs and L2ers knew that Mandarin RCs are head-final, unlike head-initial English RCs. Secondly, the TVJT examined if they had correct interpretations of Mandarin RCs when SVO word order cues were insufficient to achieve the target interpretation. While not completely target-like, both HSs and L2ers overcame dominant language transfer from English in correctly rejecting head-initial RCs and were able to correctly interpret Mandarin head-final RCs most of the time. HSs were found to have an advantage over L2ers in the AJT when proficiency was taken into account; there was no corresponding advantage in the TVJT, where both groups were affected equally by proficiency.

One major limitation of the present study is that the proficiency measure adopted here might have put some HSs at a disadvantage, given that HSs tend to have more exposure to aural than to written language input, unlike L2ers (e.g., Montrul 2008). If Romanization had been added, the proficiency scores of HSs might have been higher (Zhang et al. 2019); thus, the proficiency of HSs in our study might have been underestimated. If the HSs in the present study were in fact more advanced than L2ers, the HS advantage observed in the AJT might not hold (i.e., it would be fully accounted for by their higher proficiency). More studies with comprehensive proficiency tests and carefully-designed experimental tasks are needed to examine whether an SRC advantage indeed exists in Mandarin and whether a HS advantage holds in this domain.

To sum up, the present study examined whether HSs and L2ers acquire the headedness and interpretations of Mandarin RCs, whether there is an SRC/ORC asymmetry, and whether HSs have an advantage over L2ers in this domain. The results show that both groups largely overcame English transfer of RC headedness and correctly interpreted Mandarin head-final RCs, but without a clear SRC advantage or a clear HS advantage. This study contributes to our understanding of Mandarin RC judgment and interpretation by HSs and L2ers and shows that the difficulty of interpreting RCs, especially ORCs, found in other languages might not be generalized to Mandarin. More studies in different languages are needed to pinpoint the sources of RC difficulty and whether there is a HS advantage in this domain.

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