



ARTICLE

<https://doi.org/10.1057/s41599-025-05466-8>

OPEN



Re-examining second language acquisition of English reflexives: new evidence for lexical learning driven process and against first language Transfer

Li Zeng  ¹✉ & Fei Gao  ²

This study re-examines second language (L2) acquisition of English reflexives by testing 98 first language (L1)-Chinese learners of L2 English with different proficiency levels and 12 native English speakers as controls. Using a truth-value judgment task, we systematically tapped the learners' judgments of various types of antecedents including long-distance objects. The results show that L2 English learners' errors in referring English reflexives to long-distance antecedents cannot be due to L1 transfer of Chinese reflexive referential pattern. Instead, these errors align with those documented in the literature on native English children's acquisition of reflexives. Moreover, as L1-Chinese learners' English proficiency improved, most of them unlearned the errors, and performed similarly to native English adult controls. This developmental trajectory recapitulates the pattern seen in native English children's acquisition of reflexives. These findings cast doubt on the view of L1 Chinese transfer and provide support for the Lexical Learning Hypothesis.

¹School of Education & Institute of Language Sciences, Shanghai International Studies University, Shanghai, China. ²Institute of Modern Languages and Linguistics, Fudan University, Shanghai, China. ✉email: lizeng@shisu.edu.cn; feigao@fudan.edu.cn

Introduction

Cross-linguistically, reflexives differ as to how far they can refer back to a previously mentioned word (hereafter referred to as the “antecedent”) within a sentence. In many languages including English, reflexives that require the antecedent to be present within the same clause (hereafter, “local antecedent”). For example, in sentence (a), the English reflexive *himself* can only refer to the local antecedent *Peter*.¹ However, reflexives in several non-Indo-European languages, such as Chinese, Japanese, and Korean, reflexives, can also refer to an antecedent outside the local clause (hereafter, “long-distance antecedent”). For example, in Chinese sentence (b), the reflexive *ziji* (“自己”) can refer to both the long-distance subject antecedent *John* and the local antecedent *Peter*. It is important to note that neither long-distance reflexives like the Chinese *ziji* nor local reflexives like the English *himself* can refer to a long-distance object antecedent, e.g., *Tom* in these examples. This restriction is consistent with *Universal Grammar* (UG), a theory hypothesizing that all natural languages share a set of linguistic principles and constraints.

a. John_i told Tom_j that Peter_k trust himself_{i/*j/k}. (English)

b. 约翰 告诉 汤姆 皮特 相信 自己。 (Chinese)

John_i gaosu Tom_j Peter_k xiangxin ziji_{i/*j/k}

John_i told Tom that Peter trusts himself/him_i.

For L2 learners, determining which antecedent(s) a reflexive can refer to in a sentence is subtle and cannot be directly deduced from language input. Research on the acquisition of antecedents for reflexives gives us a window to peek into the mechanism underlying the grammatical development. Besides, the L2 reflexive referential pattern may be similar to or different from that in the learners’ L1. Studies on reflexives continue to serve as a key domain for examining the role of L1 transfer in L2 acquisition.

Some previous studies (e.g., Akiyama, 2002; Jiang, 2009; Lakshmanan and Teranishi, 1994; Wu et al., 2020; Yuan, 1994) found that L2 English learners whose L1 has long-distance reflexives make errors of referring English reflexives to long-distance antecedents. Such errors are attributed to the effect of L1 transfer (e.g., Felser et al., 2009; O’Grady, 2013; Sperlich, 2020; Yuan, 1994). Moreover, these errors are argued to be within UG-sanctioned domain (Eckman, 1994; Finer, 1991; Jiang, 2009; MacLaughlin, 1998; Wakabayashi, 1996; Wu et al., 2020; Yip and Tang, 1998). However, these studies did not examine the learners’ judgments of long-distance object antecedents to English reflexives, a reading which is not possible for their L1 reflexive or sanctioned by UG.

On the other hand, previous studies focusing on L2 acquisition of Chinese reflexives have yielded more varied and even conflicting findings regarding the role of L1 transfer. Yuan (1998) and Sperlich (2013, 2017) found that L1-Japanese and L1-Korean learners of L2 Chinese outperformed L1-English learners of L2 Chinese. This may be because Korean and Japanese reflexive referential patterns are similar to Chinese while English reflexive referential pattern is different from Chinese. However, also comparing learners from diverse L1 backgrounds, Chen (1995) found that neither L1-English nor L1-French learners of L2 Chinese acquired long-distance antecedents to the Chinese reflexive, even though French has a long-distance reflexive like Chinese. Moreover, when L1-English learners and L1-Korean learners were matched for their L2 Chinese proficiency, Chen and Ionin (2023) found no L1 transfer effect in L2 acquisition. Furthermore, replicating Yuan’s study with different groups,

Dugarova (2007) revealed that L1-English learners of L2 Chinese acquired long-distance antecedents better than L1-Russian learners of L2 Chinese though neither English nor Russian has long-distance reflexives. The findings suggest that the role of L1 transfer in L2 acquisition of reflexives is not as transparent as it seems to be.

Even in the related L2 study of referring pronouns to antecedents, recent studies have detected learners’ errors in L2 as a consequence of L1 influence (Chen and Ionin, 2023; Kim, 2019, 2023). Pronoun-antecedent dependency is important because readers need to identify the antecedent accurately in order to construct a coherent representation of the text (van Gompel and Liversedge, 2003). Besides, according to UG, pronoun-antecedent dependency is universal and is thought to operate in the same way across languages (Chomsky, 1981). Therefore, there should be no cross-linguistic interference in the L2 acquisition of this dependency. For example, research on English has found no differences between L2 English learners and native speakers in interpreting pronouns (Contemori et al., 2019). However, errors in pronoun-antecedent reference shown in L1-Korean learners of L2 English (Kim, 2019, 2023) and L1-English and L1-Korean learners of L2 Chinese (Chen and Ionin, 2023) have been attributed to L1 transfer. This also provides an example of the controversial role of L1 transfer in L2 acquisition of noun/reflexive-antecedent dependency.

The current study addresses the issue of L1 transfer by systematically tapping how L1-Chinese learners of L2 English judge various types of antecedents for English reflexives. In particular, we test their judgment of long-distance object antecedent to English reflexives. This reading provides crucial evidence for determining whether L2 learners transfer their L1 reflexive referential patterns to L2 English.

As illustrated in Fig. 1, there are two possible uses of the reflexive *himself* in L2 English. One is the Chinese *ziji*-like use, where L1-Chinese learners transfer the referential patterns of the Chinese *ziji* to *himself*. Under this pattern, learners would accept local and long-distance subject antecedents for *himself*, and reject long-distance object antecedents. The other is the free use of *himself*, a pattern observed in native English children during their

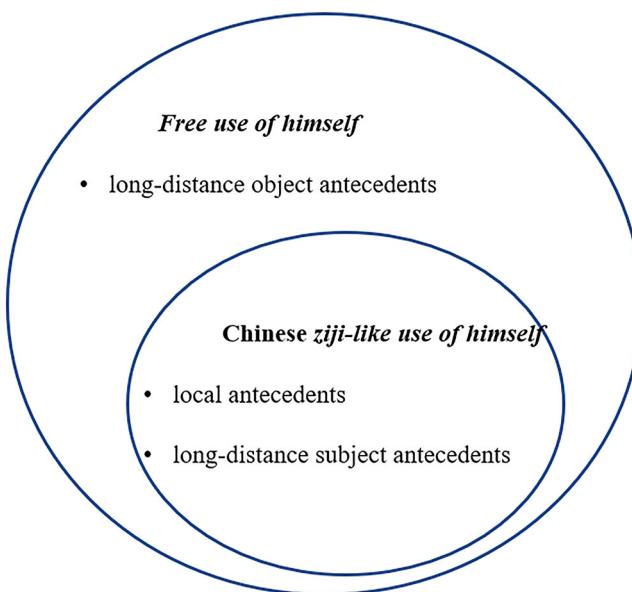


Fig. 1 Schematic demonstration of two different uses of the L2 English reflexive *himself*. L1-Chinese learners of L2 English can have a free use of *himself*, which is a superset of the Chinese *ziji*-like use of *himself*.

acquisition of reflexives. Research shows that native English children go through a developmental stage where they refer English reflexives to antecedents in a random and unsystematic manner before mastering correct usage (McDaniel et al., 1990; Wexler and Chien, 1985). For the free use of *himself*, not only local and long-distance subject antecedents, but also UG-unsanctioned long-distance object antecedents are acceptable. To determine whether L1-Chinese learners of L2 English transfer the Chinese *ziji*-like pattern to L2 *himself* or adopt the free-use pattern, it is essential to test whether they permit long-distance object antecedents for *himself*.

Additionally, this study will compare the errors and developmental trajectories of L2 English reflexive acquisition to those observed in native English children's L1 acquisition. Native English children's L1 acquisition is UG-constrained and lexical learning driven (as discussed in more details in the next section). Through this comparison, we aim to deepen our understanding of the nature of L2 English reflexive development.

Background

Theoretical accounts and lexical learning-driven acquisition. The UG theory, a concept proposed by generative linguist Noam Chomsky in 1950s, hypothesizes that a set of linguistic principles and constraints are shared by all natural languages for structures. And these principles and constraints are considered to be innate. One of such linguistic principles is Chomsky's (1981) *Binding Principles*, which regulates the reference of noun phrases, such as reflexives, pronouns and other referential expressions. While the original proposal of the Binding Principles was mainly based on Western languages like English, Chinese grammar rules, as discussed in Peverelli (2015), have been greatly influenced by Western grammar. Indeed, the past 40 years has seen many fruitful generative works to reconcile the different referential patterns between the Chinese reflexive *ziji* and English reflexives.

Earlier theoretical accounts (e.g., Battistella, 1989; Cole et al., 1990; Huang and Tang, 1991; Progovac, 1992, 1993) claimed that the different referential patterns between the Chinese and English reflexives were due to the reflexive words' distinct morphological complexity. To be specific, the Chinese *ziji* is monomorphemic while the English *himself* is bimorphemic. However, more recent theoretical works tend to hold that Chinese *ziji* is actually bimorphemic (e.g., Cheng, 2004; Chien, 1998; Liu, 2016; Reuland et al., 2020; Wong, 2021; Everaert and Reuland, 2024). The broad idea is that the Chinese *ziji* consists of *zi*, a reflexive morpheme, and *ji*, the pronominal morpheme. In particular, the reflexive feature of *zi* enables *ziji* to refer to local antecedents in line with the Binding Principle A, and the pronominal feature of *ji* gives rise to the long-distance reference of *ziji* in accordance with the Binding Principle B.² Importantly, the fusion between *zi* and *ji* is low in degree, primarily serving to meet phonological requirements in the historical development of the Chinese language (Cheng, 2004; Dong, 2002). Thus, each morpheme plays a visible and distinct role in the overall interpretation of the compound *ziji*.³ Contrary to the loose association between the two subparts of Chinese compound *ziji*, nevertheless, the English *himself* is known as a fused reflexive (Levinson, 1991). In other words, *himself* can only be interpreted as a whole, with the interpretation determined by the reflexive morpheme *self*, giving rise to strict local reference of *himself*.⁴

As such, the differences in referential patterns of Chinese and English reflexives are attributed to how the subparts of the reflexive words are configured. Then, the acquisition of referential patterns is reduced to learning the lexical properties of reflexives, which in turn, can occur naturally through learners' exposure to the target language based on morphological or semantic cues

(Chomsky, 1995; Hicks, 2009). The idea that the acquisition of referential patterns of reflexives is accomplished through learning reflexive words was first proposed in Wexler and Chien's (1985) Lexical Learning Hypothesis. According to this hypothesis, child L1 learners are born with knowledge of the Binding Principles and only need to identify the reflexive word in a given language to demonstrate the proper referential patterns. Before recognizing reflexives, children assign antecedents in a non-systematic, free manner. Importantly, the Lexical Learning Hypothesis has been borne out by a series of studies on L1 acquisition of English reflexives (Lidz et al., 2021; McDaniel et al., 1990; Wexler and Chien, 1985), and has been corroborated by L1 reflexive acquisition research on other languages, such as Chinese (Chien and Wexler, 1987; Chien, Wexler, and Chang, 1993; see also Chien and Lust, 2006 for a review), Italian (McKee, 1992), Norwegian (Hestvik and Philip, 2000), and French (Emond and Shi, 2024).

To acquire the referential patterns of English reflexives, native English children start out by referring *himself* to either local or long-distance antecedents, or even antecedents outside the sentences, showing non-systematic, free reference of *himself*. Nevertheless, they gradually learn to correctly choose antecedents and, by the age of four to six years old, they can restrict *himself* to local antecedents (McDaniel et al., 1990; Wexler and Chien, 1985).⁵ Prior to arriving at adult-like grammar, some children tend to refer *himself* to long-distance antecedents in non-finite clauses though not in finite clauses, exhibiting finite/non-finite asymmetry in long-distance reference. McDaniel et al. (1990) and Solan (1987) attributed this type of error to the fact that non-finite clauses involve additional processing load as compared to finite ones. The error is eventually self-corrected since children are better able to deal with processing difficulties as they mature.

While the Lexical Learning Hypothesis has been well-established in L1 acquisition of reflexives, to the best of our knowledge, no L2 study has adopted this theoretical perspective to examine L2 learners' data. The current study seeks to fill this gap, using this perspective to investigate how L2 learners develop reflexive reference. The research could provide insights into whether the lexical learning mechanism observed in L1 acquisition also influence L2 reflexive acquisition.

Conducting research on L2 acquisition of reflexives involves comprehension tasks that assess learners' knowledge of reflexive reference. The multiple-choice task, which requires participants to select one or more antecedents for the reflexive from a possible set, was quite commonly used in early L2 research. However, it was soon noticed that the multiple-choice task tends to underestimate the grammatical representations of participants. This is because the multiple-choice task is more likely to elicit the participants' preferential antecedents instead of all possible ones which are permissible in their grammar (e.g., Lakshmanan and Teranishi, 1994; Thomas, 1993; White et al., 1997). Then, the story-based truth-value judgment task started to gain a popularity in L2 research, in which participants firstly read a story and then judge whether a reflexive sentence can match the story or not. As such, the reference of the reflexive is implicitly and naturally tested. And only one possible reference of the reflexive is tested each time. This task provides an approach for assessing every possible reference of the reflexive, remaining a widely used method in L2 research on reflexives and/or pronouns (e.g., Chen and Ionin, 2023; Kim, 2023; Wu et al., 2020).

Previous studies on the L2 acquisition of English reflexives. There has been a large body of studies on L2 acquisition of English reflexives. Researchers (e.g., Akiyama, 2002; Domínguez et al., 2012; Eckman, 1994; Finer, 1991; Jiang, 2009; MacLaughlin,

1998; Wakabayashi, 1996; Wu et al., 2020; Yip and Tang, 1998) have generally agreed that UG is accessible (or accessible via L1 transfer) to L2 learners. It has been argued that both errors and correct uses of L2 reflexives lie within the UG-sanctioned domain. Studies involving learners from a L1 Chinese, Japanese, or Korean background (e.g., Domínguez et al., 2012; Lakshmanan and Teranishi, 1994; Yuan, 1994) suggest that learners can ultimately achieve correct use of *himself* due to L1 transfer, with the idea that learners identify *himself* with the local reflexive in their L1. If this were true, one may wonder why learners fail to do so at the initial stage of L2 acquisition, given that L1 transfer is typically strongest at the beginning of language acquisition. Additionally, Lakshmanan and Teranishi (1994) and Yuan (1994) claimed that errors in long-distance reference of *himself* in L2 English were also due to L1 transfer. A key issue of this claim is that the UG-unsanctioned reading—i.e., referring *himself* to long-distance object antecedents—was not examined in these studies. If the learners did permit long-distance object antecedents for *himself*, the claim that they transferred the referential properties of L1 long-distance reflexives to L2 English would have to be refuted. And we would require an alternative explanation for the maintenance of UG accessibility in L2 acquisition. This problem was considered when we devised the test for the current study.

On the other hand, Jiang (2009), MacLaughlin (1998), and Wu et al. (2020) found that some L1-Chinese learners of L2 English demonstrated finite/non-finite asymmetric errors in long-distance reference of *himself*. As Chinese lacks finite/non-finite distinction (Hu et al. 2006), the errors cannot be attributed to L1 transfer of Chinese. Jiang (2009) and MacLaughlin (1998) attributed the errors to learners' initial mis-analysis of *himself* as monomorphemic Icelandic-like reflexive. Later, they re-analysed *himself* as bimorphemic, triggered by transparent evidence from the morphological composition of *himself*. As such, one might wonder what prevents learners from becoming attuned to the morphological evidence of *himself* at the very beginning. It is worth noting that the finite/non-finite asymmetric errors in long-distance reference of *himself* also occurs in native English children's L1 acquisition. Just as native English children need time to master non-finite clauses before they exhibit strict local reference of *himself*, L1-Chinese learners of L2 English may also need to acquire English non-finite clauses before they show correct reference of *himself*.

Overall, the nature of errors and the mechanism underlying the transition from errors to successful L2 English reflexive acquisition remain unclear. The issue concerns the role of L1 transfer and the mechanism driving the development of L2 reflexive reference. The current study aims to advance our understanding by conducting a cross-sectional analysis of L1-Chinese learners' acquisition of English reflexives. Specifically, we will test learners' judgments of various antecedents, including the UG-illicit long-distance object antecedent. Additionally, we will compare the current L2 acquisition with native English children's L1 acquisition of reflexives, which has been shown to be driven by lexical learning. Drawing on these analyses, we attempt to shed new light on the role of L1 transfer and the mechanism underlying L2 acquisition.

This study

Specifically, this study aims to answer the following research questions: How would L1-Chinese learners of L2 English develop English reflexive reference? Will they be guided by L1 transfer or be driven by lexical learning?

In view of what we have reviewed above, there are two potential ways for L1-Chinese learners of L2 English to develop English reflexive reference. The first possibility is that the

acquisition process is influenced by L1 transfer from Chinese. Learners treat the English *himself* as their L1 Chinese *ziji*, as they “initially perceive [L2 lexical] items in terms of the featural composition of their ‘closet’ morpholexical equivalents in the L1” (Lardiere, 2009)⁶. Adopting this line of reasoning, the following results are expected: learners would initially accept local and long-distance subject antecedents for *himself*, treating the English *himself* as if it were their L1 Chinese *ziji*. However, they would reject references to long-distance objects, as this reading is not possible for the Chinese reflexive *ziji*, nor sanctioned by UG. Furthermore, because the English language does not provide negative evidence to indicate the incorrectness of long-distance subject antecedents for *himself*, the learners would be stuck with this error.

By contrast, the second possibility is that L1-Chinese learners of L2 English may be free from L1 transfer influence in acquiring the English reflexive. Instead, L2 learners would follow a developmental path similar to that of native English children in their L1 acquisition of English reflexives, in line with the Lexical Learning Hypothesis. More specifically, L2 learners would initially make errors similar to those of native English children, showing unsystematic, free reference for *himself*, as they have not yet recognized (the features of) the reflexive. Other developmental errors, such as the finite/non-finite asymmetry in long-distance reference of *himself*, may also occur due to the additional processing cost of non-finite clauses. However, these errors would mainly be seen in L2 learners with lower English proficiency and should gradually be unlearned. Once the features of the reflexive are recognized, learners would show strict local reference, which should be evident in higher proficiency learners' performance.

Methods

Participants. We recruited 98 Chinese native speakers (age range: 15–29 years, 49 females) who studied English as an L2. They were senior high school students or university students in mainland China and started their English learning at ages of 7–13. By the time of the experiment, they had received English classroom teaching for at least 3 years and none of them reported to have ever studied abroad or lived in English-speaking communities. Their English proficiency was measured using the Oxford Placement Test (Allan, 2004), with results showing an average score of 132 ± 21 . Additionally, 12 native English adults (age range: 20–29 years, 6 females) were included as the control group. All participants signed on the informed consent form before the formal test. Research protocol and materials were approved by the Institutional Review Board of the local institute.

Design and materials. As we are interested to probe the full range of referential patterns of reflexives allowed by L2 learners, we employed the story-based truth-value judgment task to elicit their judgments. In the task, the participants would first read a story (Fig. 2) and then encounter a test sentence containing English reflexives. Each story was illustrated with 2 to 3 pictures of black-white drawings and each picture was captioned with 1 to 2 English sentences. Corresponding to these stories, meanwhile, four test sentence types were carefully constructed (Table 1) to manifest various antecedents for English reflexives. More specifically, we tested local antecedents for English reflexives (LOC, 4 sentences), long-distance subject antecedents outside finite clauses (LDS_F, 4 sentences), long-distance subject antecedents outside non-finite clauses (LDS_N, 4 sentences), and long-distance object antecedents (LDO, 3 sentences). Note that we examined the participants' judgments of long-distance subject antecedents in different sentence structures, for L2 English

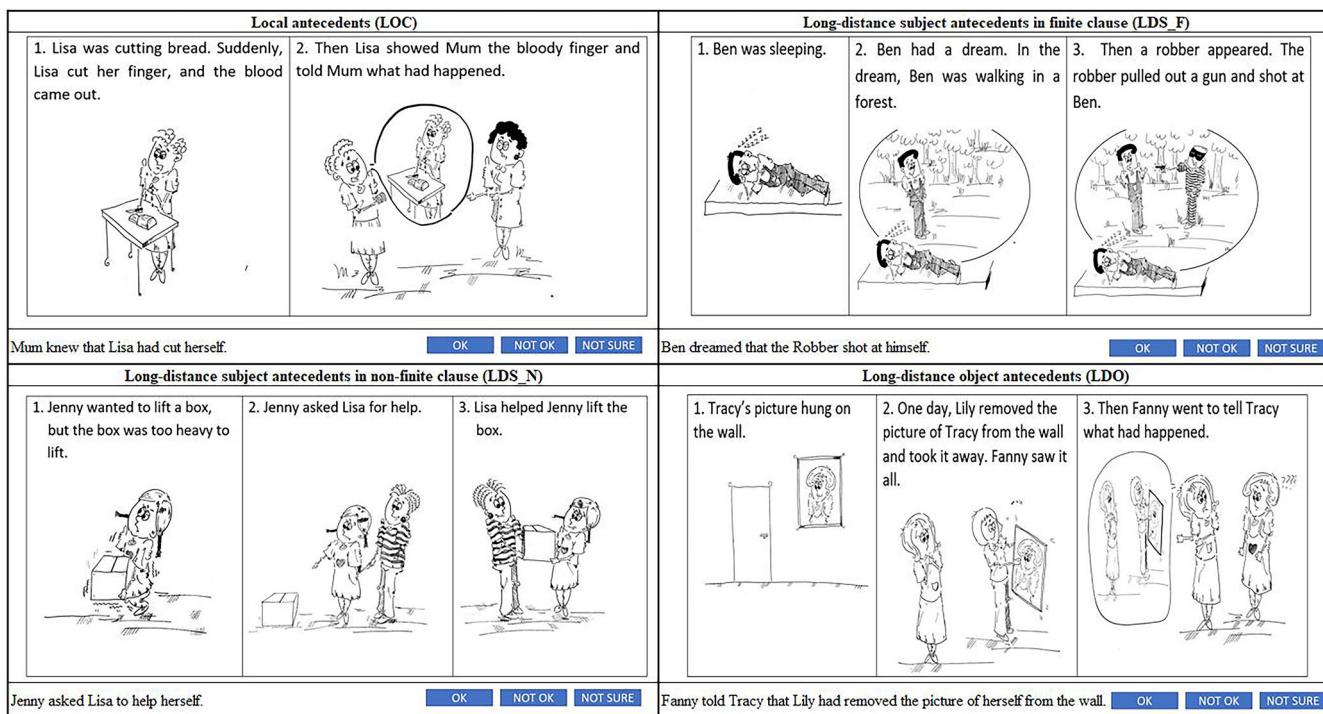


Fig. 2 Exemplar illustrations of the story-based truth-value judgment task. The illustrations correspond to the story context of four types of test sentences (i.e., LOC, LDS_F, LDS_N, and LDO).

Table 1 Four types of the test sentences following the story reading.

Local antecedents (LOC)

1. Jessica hoped that **Lily** could dress *herself* quickly.
2. Ken's father told **Ken** to control *himself*.
3. Mum asked **Jenny** to wash *herself*.
4. Mum knew that **Lisa** had cut *herself*.

Long-distance subject antecedents in finite clause (LDS_F)

1. ***John** told Mum that Harry had hit *himself* with the ball.
2. ***Ben** dreamed that the Robber shot at *himself*.
3. ***Jessica** heard that Lily had blamed *herself*.
4. ***Cathy** knew that Linda had rescued *herself*.

Long-distance subject antecedents in non-finite clause (LDS_N)

1. ***Jenny** wanted Sally to believe *herself*.
2. ***Jenny** asked Lisa to help *herself*.
3. ***John** wanted the policeman to protect *himself*.
4. ***Jack** asked Peter to trust *himself*.

Long-distance object antecedents (LDO)

1. *Fanny told **Tracy** that Lily had removed the picture of *herself* from the wall.
2. *Peter told **Jimmy's father** that Jimmy tore the picture of *himself*.
3. *Lisa told **Grandma** that the doctor had rescued *herself*.

*Those sentences were illegal once "herself/himself" take the **antecedent in bold**.

learners may show asymmetrical acceptance of this reading across finite and non-finite clauses, as shown in the literature.

In addition to the 15 critical stories and their corresponding test sentences, we also included 11 fillers to avoid the participants' strategic responses. These 11 stories were followed by 4 sentences including a single antecedent (e.g., "Mum looked at the hat-wearing *herself* in the mirror."), 4 sentences with a subject-oriented antecedent (e.g., "David told Mrs. White something about *himself*."), and 3 with an object-oriented antecedent (e.g., "The interviewer asked Sharon some questions about *herself*.").

All the involved words in the stories and test sentences from both critical stimuli and the fillers were extracted from the high-frequency vocabulary of the high-school English textbooks, whose familiarity among students was verified by their instructors. To enhance the validity of the test, especially to avoid unintended pragmatic bias or semantic ambiguity for the critical stimuli, the naturalness of all critical sentences was assessed and agreed upon by two English linguists. The correctness of all critical sentences (Table 1) was further verified by two English native speakers, who independently assessed them as "correct" or "incorrect" based on the story context, achieving 100% inter-rater consistency.

Procedures. The participants were given the test materials in booklets. Two versions of the booklets were used, containing the same test items but in different, randomized order to minimize the order effect. In the test, the participants were required to read the story and then judge the acceptability of test sentence containing English reflexives by circling OK or NOT OK. If they could not make a judgment, they were allowed to choose the NOT SURE option. Instructions were given in the L2 participants' native language Chinese. Before the test, the participants were trained with two sample items to ensure that they understood what to do in the actual test. They were allowed to ask the meanings of words they did not understand. The test was self-paced, and the participants were instructed to trust their intuition and not go back to change their answers. After the test, the participants completed the Oxford Placement Test for their English proficiency assessment and filled out a questionnaire about their background information.

Results

All participants reported perfect familiarity with the test materials during and after the test, showing their good engagement with the task. All the missing or NOT SURE responses ($n = 25$, constituting 1.52% of all responses) were excluded from data analyses. Participants' acceptance and rejection responses to

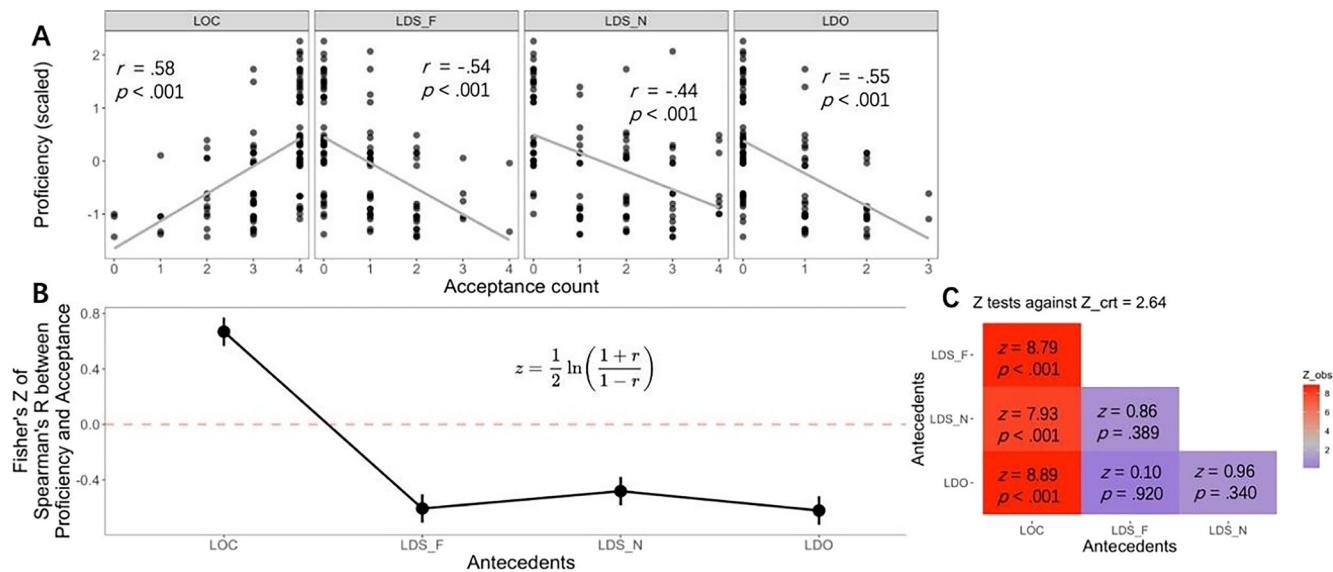


Fig. 3 The correlation between participants' acceptance of different antecedent types and English proficiency. **A** Scatter plots illustrate the correlation between the acceptance count for each antecedent type and English proficiency (scaled). The gray line is the regression line, indicating the increase or decrease of the acceptance count for each antecedent type as English proficiency increases. **B** The line plot illustrates the Fisher's Z of Spearman's rho between English proficiency and the acceptance count of each antecedent type. The dashed line indicates zero correlation. **C** The color map illustrates pairwise comparisons between antecedent types. Z-tests were conducted with Bonferroni corrections for multiple comparisons (the corrected alpha level of $0.05/6 = 0.008$, and the corresponding critical value of $z = 2.64$). At the color bar's midpoint, $z = 2.64$. Red indicates a significant difference, while blue indicates an insignificant difference.

antecedents of English reflexives were coded as "1" and "0", respectively. The acceptance count for each antecedent type was then calculated. The acceptance count refers to the times a specific antecedent type has been accepted out of a total four or three test tokens. This way, the native English controls accepted local antecedents ($M = 3.9, SD = 0.3$) while rejected long-distance subjects in finite clauses ($M = 0, SD = 0$), long-distance subject antecedents in non-finite clauses ($M = 0.2, SD = 0.4$), and long-distance objects ($M = 0, SD = 0$). The L2 learners generally preferred local antecedents ($M = 3.2, SD = 1.0$) to other types of antecedents, namely, long-distance subjects in finite clauses ($M = 1.0, SD = 1.0$), long-distance subjects in non-finite clauses ($M = 1.4, SD = 1.3$), and long-distance objects ($M = 0.6, SD = 0.8$).

To examine whether learners' acceptance counts are related to English proficiency, Spearman's correlation analysis between the acceptance count (treated as ordinal data) for each antecedent type and English proficiency (i.e., the Oxford Placement Test score, scaled) was conducted.⁷ The correlation coefficients were then transformed to Fisher's Z to facilitate comparisons among antecedent types. For pairwise comparisons between antecedent types, Fisher's Z tests were conducted with Bonferroni corrections for multiple comparisons.

The correlational results (Fig. 3) showed that with the increase of English proficiency, the learners' acceptance count for local antecedents also increased. By contrast, their acceptance counts for long-distance subject antecedents in finite clauses, long-distance subject antecedents in non-finite clauses, and long-distance objects all decreased (Fig. 3A). There was a significant correlation between proficiency and the acceptance count for each antecedent type (Fig. 3A). The acceptance count for local antecedents was positively correlated with English proficiency, and the acceptance counts for long-distance subject antecedents in finite clauses, long-distance subject antecedents in non-finite clauses, and long-distance object antecedents were all negatively correlated with English proficiency (Fig. 3B). Pairwise comparisons between antecedent types revealed that the correlation

between the acceptance count for local antecedents and proficiency was significantly more positive than the correlation between the acceptance count for long-distance subject antecedents in finite clauses and proficiency. The correlation between the acceptance count for local antecedents and proficiency was also significantly more positive than the correlation between the acceptance count for long-distance subject antecedents in non-finite clauses and proficiency, and significantly more positive than the correlation between the acceptance count for long-distance object antecedents and proficiency. No other significant results were identified (Fig. 3C).

A mixed-effects logistic regression model with crossed random effects for subjects and items was conducted using the *lme4* package (version 1.1-31; Bates, et al., 2015) in R (version 4.2.2; R Core Team, 2022). The fixed effects included three planned comparisons between the local antecedents (LOC) and each of the three long-distance antecedents (LDS_F, LD_N, and LDO), proficiency, and the interactions between proficiency and each comparison. These interactions were tested to examine whether increasing proficiency influenced learners' tendency to select more local antecedents than long-distance ones, thereby addressing whether proficiency modulates sensitivity to strict local reference of English reflexives.

The three comparisons were structured and coded following Schad et al. (2020): condition 1 compared LOC (coded as -1) with LDS_F (coded as 1); condition 2 compared LOC (coded as -1) with LDS_N (coded as 1); and condition 3 compared LOC (coded as -1) with LDO (coded as 1). Proficiency was treated as a continuous covariate and z-standardized to improve interpretability of coefficients and interactions in the model.

Models fitting was performed using maximum likelihood estimation to ensure robust parameter estimation. The initial full model had a maximal random effects structure, as justified by the experimental design (Barr et al. 2013; Yi et al. 2017).⁸ Specifically, the model included random intercepts for subjects and items to account for baseline variability, by-subject random slopes for the three comparisons (i.e., 'condition1', 'condition2', and 'condition3')

Table 2 Generalized linear mixed-effects model results.

Parameters	Fixed effects				Random effects			
					By subject		By item	
	Estimate	SE	z	p	Variance	SD	Variance	SD
Intercept	-0.52	0.12	-4.31	<0.001	0.41	0.64	0.05	0.23
Condition 1 (LDS_F vs LOC)	-3.41	0.29	-11.7	<0.001	-	-	-	-
Condition 2 (LDS_N vs LOC)	-2.61	0.27	-9.48	<0.001	-	-	-	-
Condition 3 (LDO vs LOC)	-3.71	0.33	-11.33	<0.001	-	-	-	-
Proficiency	-0.45	0.12	-3.88	<0.001	-	-	-	-
Condition 1 × Proficiency	-2.18	0.26	-8.40	<0.001	-	-	-	-
Condition 2 × Proficiency	-2.06	0.24	-8.51	<0.001	-	-	-	-
Condition 3 × Proficiency	-2.46	0.3	-8.21	<0.001	-	-	-	-

There are 1449 observations, where one observation is equal to a trial where a participant was presented with an antecedent type and had to respond. Model formula: RESPONSE - condition1 + condition2 + condition3 + proficiency.z + condition1:proficiency.z + condition2:proficiency.z + condition3:proficiency.z + (1 | Subj) + (1|TEST.ITEM). Conditions: Condition 1: LDS_F (Long-Distance Subject, Finite) vs LOC (Local Antecedent); Condition 2: LDS_N (Long-Distance Subject, Non-Finite) vs LOC; Condition 3: LDO (Long-Distance Object) vs LOC.

to allow these effects to vary across participants. By-item random slopes for the three comparisons ('condition1', 'condition2', and 'condition3'), z-standardized proficiency ('proficiency.z'), and the interactions between proficiency and each comparison were also included to account for variability across test items. As the full model failed to converge, we applied a stepwise model reduction procedure. Slopes with high correlations (i.e., exceeding 0.8) were removed iteratively, and the model was refitted until convergence was achieved (Bates et al., 2015; Matuschek et al., 2017; Singmann and Kellen, 2019). This process yielded a parsimonious model with improved AIC/BIC values, retaining only significant predictors and enhancing convergence stability and generalizability. The final model results are reported below.

Table 2 presents the fixed and random effects of the final model. L2 learners showed a significant preference for local antecedents over long-distance antecedents. Specifically, long-distance subjects in finite clauses (LDS_F) were less likely to be selected than local antecedents (estimate = -3.41, SE = 0.29, $z = -11.7$, $p < 0.001$), and long-distance objects (LDO) were also less selected compared to local antecedents (estimate = -3.71, SE = 0.33, $z = -11.33$, $p < 0.001$). Similarly, the comparison between long-distance subjects in non-finite clauses (LDS_N) and local antecedents was significant (estimate = -2.61, SE = 0.27, $z = -9.48$, $p < 0.001$).

English proficiency was a significant predictor of antecedent selection. As proficiency increased, learners became more likely to select local antecedents over long-distance ones. The main effect of proficiency was significant (estimate = -0.45, SE = 0.12, $z = -3.88$, $p < 0.001$), indicating that higher proficiency was associated with a stronger preference for local antecedents over long-distance ones.

There were also significant interactions between proficiency and differences between antecedent types. As proficiency increased, the preference for local antecedents over long-distance subjects in finite clauses (LDS_F) became stronger (estimate = -2.18, SE = 0.26, $z = -8.39$, $p < 0.001$). Similarly, proficiency modulated the preference for local antecedents over long-distance subjects in non-finite clauses (LDS_N) (estimate = -2.06, SE = 0.24, $z = -8.51$, $p < 0.001$) and long-distance objects (LDO) (estimate = -2.46, SE = 0.30, $z = -8.21$, $p < 0.001$). These interactions suggest that as learners' proficiency in English improves, their preference for local antecedents over various types of long-distance antecedents increases.

Regarding the co-acquisition of various antecedent types for English reflexives, we also examined contingent knowledge of the properties in individual grammars. We categorized participants

according to the following English reflexive patterns: transferring the Chinese *ziji*, showing unsystematic and free reference, exhibiting finite/non-finite asymmetry in long-distance reference, or exhibiting target-like performance.

Except for unsystematic and free reference, only participants who evidenced a fair number of consistent responses were reported. To define consistent responses, we followed Eckman (1994), Thomas (1991), White et al. (1997), and White (2003), setting the criteria as at least three acceptance counts out of a total of four options, or at least two out of a total of three options. For consistent rejection responses, the acceptance count for a certain antecedent type had to be one or fewer out of four or three options. For participants transferring the Chinese *ziji* to English reflexives, local antecedents, long-distance subject antecedents in finite clauses, long-distance subject antecedents in non-finite clauses were consistently accepted, while long-distance object antecedents were consistently rejected. For those exhibiting finite/non-finite asymmetry in long-distance reference, local antecedents and long-distance subject antecedents in non-finite clauses were consistently accepted, while long-distance subject antecedents in finite clauses and long-distance object antecedents were consistently rejected. For target-like performance, local antecedents were consistently accepted, while long-distance subject antecedents in both finite and non-finite clauses and long-distance object antecedents were consistently rejected. Participants who did not fall into any of these patterns were classified as showing unsystematic and free reference.

To chart the development of acquisition across proficiency, cut-off points of the 33rd percentile and the 67th percentile of the distribution of proficiency scores were used to divide the L2 learner participants into low, middle, and high proficiency groups (Lee and Lardiere, 2019). This method ensured balanced group sizes, $\chi^2(2) = 1.73$, $p = 0.420$. A significant difference in proficiency scores was also attested among the three proficiency groups, $F(2, 873) = 2871.16$, $p < 0.001$.

On the criteria, as shown in Table 3, the great majority of low-proficiency learners demonstrated unsystematic and free reference of English reflexives, while a few made errors in long-distance reference in finite clauses though not in non-finite clauses. None of the low-proficiency learners showed target-like reference of English reflexives. Among the middle-proficiency learners, fewer than half exhibited unsystematic and free reference. A few showed errors in finite/non-finite asymmetric long-distance reference. And half attained target-like performance. For the high-proficiency learners, the percentage of error-making

Table 3 Results on the referential pattern for English reflexives across different proficiency levels.

	L1 transfer conditioned	Lexical learning driven			
		Transfer of <i>ziji</i>	Unsystematic or free choice	Finite/non-finite asymmetric long-distance reference	Target-like
Low (n = 24)	0%	87.50%	(21)	12.50%	0%
(0)	(0)	(3)	(0)	(0)	(0)
Middle (n = 30)	0%	40%	(12)	10%	50%
(0)	(0)	(3)	(15)	(15)	(15)
High (n = 27)	0%	14.80%	(4)	3.70%	81.50%
(0)	(0)	(1)	(22)	(22)	(22)
English Controls (n = 10)	0%	0%	(0)	0%	100%
(0)	(0)	(0)	(0)	(0)	(10)

Percentages were calculated horizontally for each participant group (e.g., the percent number of all elementary learners can be seen in the first row). The numbers in parentheses refer to the number of participants per category.

further decreased, with a great majority achieving target-like performance, similar to native English controls. Notably, none of the L2 learners, regardless of proficiency, transferred the Chinese *ziji* patterns to English reflexives.

Discussion

The objective of the current study was to examine whether L2 learners' acquisition of English reflexive reference is driven by L1 transfer or lexical learning. Based on our data, the performance of L1-Chinese learners does not bear out the predictions of the L1 transfer hypothesis. Specifically, we found that L1-Chinese learners, across all proficiency levels, did not carry over L1 grammatical rules concerning the Chinese *ziji* to the English *himself*, contrary to previous L2 research (e.g., Jiang, 2009; Yuan, 1994). Earlier studies claiming that L1-Chinese learners transferred the long-distance reference of the Chinese reflexive *ziji* to English reflexives did not consider their judgments of long-distance object antecedents. This is crucial, as the reference to long-distance object antecedents distinguishes the two uses of English reflexives: the free use and the Chinese *ziji*-like use.

As illustrated in Fig. 1, the fact that L1-Chinese learners of L2 English accepted both local and long-distance subject antecedents for *himself* does not necessarily indicate that they were transferring the rules concerning the Chinese *ziji* to the L2. Alternatively, they could be adopting the free use of *himself*. We can only be certain that learners are transferring *ziji*-like patterns to *himself* if they accept both local and long-distance subject antecedents while rejecting long-distance object antecedents. The current study considered learners' judgments of long-distance object antecedents and found that those who accepted both local and long-distance subject antecedents for *himself* also accepted long-distance object antecedents. Thus, none of the L1-Chinese learners, at any proficiency level, adopted the Chinese *ziji*-like grammar in their judgments of *himself*.

Importantly, our results suggest that the L2 acquisition of English reflexive reference conforms with the Lexical Learning Hypothesis. First, the mass analysis results indicated a developmental pattern where L1-Chinese learners of English approximated target-like performance as their L2 proficiency increased. Specifically, learners' correct acceptance of local antecedents steadily improved, while their choices of incorrect long-distance antecedents decreased with proficiency. This pattern is in accordance with the Lexical Learning Hypothesis (Wexler and Chien, 1985), whereby learners go through an initial period of unsystematic and free use of English reflexives and other developmental errors before achieving target-like performance.

In particular, the majority of low-proficiency learners exhibited unsystematic and free references for English reflexives, also consistent with previous research (e.g., Wu et al., 2020) which shows that many low proficiency learners fail to select antecedents for English reflexives consistently. Another developmental error observed was finite/non-finite asymmetry in long-distance reference to subject antecedents, which was primarily seen in a few low- and middle-proficiency learners. This asymmetry may stem from difficulties with non-finite clauses and improves with increased L2 proficiency (Wu et al., 2020). Indeed, this error was gradually unlearned as proficiency increased. Notably, as developmental errors decreased, correct local reference for English reflexives steadily increased, and the majority of high-proficiency learners achieved target-like performance.

As we have seen, L1-Chinese learners' performance on the reference of L2 English reflexives steadily improved with increasing English proficiency. According to the Lexical Learning Hypothesis, they are learning the reflexive word and mastering the non-finite structure as their proficiency grows. Similarly, for native English children's L1 reflexive development, age plays a crucial role in their ability to correctly assign reference to reflexives, as children's L1 proficiency increases with age. While L2 learners' performance is influenced by proficiency and native children's by age, a comparison of the developmental stages of L2 English reflexive reference and native English children's L1 development reveals similar errors and developmental trajectories (see Table 4).

Overall, the L1-Chinese learners' L2 acquisition of English reflexive reference recapitulated the L1 acquisition trajectories of native English children. The L2 acquisition is more closely tied to the lexical properties of English reflexives than to the learners' prior knowledge of reflexives in Chinese. In particular, while L2 learners differ from L1 learners in terms of linguistic and cognitive backgrounds, previous research suggests that L2 acquisition of reflexive referential pattern can have the same profile as L1 acquisition (Thomas, 1991:172). This is supported by the view that "the essential language faculty involved in L1 acquisition is also involved in adult L2 acquisition" (Flynn, 1996, pp. 150–151). Therefore, certain linguistic properties of L2 acquisition have been shown to be fully constrained by language universals and unaffected by L1 transfer (e.g., White et al., 1992; Ionin et al., 2008). Reflexive referential pattern, being a core property of UG, can unsurprisingly fall into this category.

Meanwhile, input frequency and explicit instruction does not seem relevant for the developmental patterns observed in reflexive referential patterns. The rules for selecting correct antecedents for English reflexives are not made explicit in the instructional materials, and our interviews with the participants'

Table 4 A Comparison of the L2 and L1 development of English Reflexive Reference.

Chinese-speaking L2 learners' development of English reflexive reference	Native English children's development of English reflexive reference (Chien and Lust, 2006; McDaniel et al., 1990; Wexler and Chien, 1985)
<ul style="list-style-type: none"> ● The vast majority of low-proficiency learners showed unsystematic and free use of <i>himself</i>; ● A few L2 learners exhibited finite and non-finite discrepancy with regard to the long-distance reference to subject antecedents; ● Half of the middle-proficiency learners and a great majority of the high-proficiency learners referred <i>himself</i> to local antecedents only, attaining target-like performance. 	<ul style="list-style-type: none"> ● Children younger than 4 years and 6 months old had unsystematic and free use of <i>himself</i>; ● Some children exhibited finite and non-finite discrepancy with regard to the long-distance reference to subject antecedents; ● Children starting from the age of 4 years and 6 months old were able to refer <i>himself</i> to local antecedents, and attained target-like performance by the age of 6 years and 6 months old.

English teachers confirmed the absence of targeted instruction on this topic. Furthermore, while learners may infer from context that local antecedents are possible, there is a lack of negative evidence indicating long-distance antecedents are ungrammatical for English reflexives (Jiang, 2009). As such, the acquisition of reflexive referential pattern is underdetermined by input alone—whether in an L1 or L2 context. Although L1 learners benefit from intensive language exposure, and L2 learners typically receive more limited input, the difference in input quantity between L1 and L2 learners may affect the rate of acquisition rather than the underlying developmental trajectory.

Finally, the role of L1 transfer has been explicitly examined in our study as one of the research questions. The experimental results suggest that Chinese-speaking learners were not transferring their L1 grammar of reflexives to L2 English. One might wonder why L1 transfer seems not to play a role in the L2 acquisition of reflexive reference. Eubank's (1993) weak transfer view provides a possible explanation, suggesting that morphology-driven features do not transfer between languages.

However, there are several limitations that warrant discussion. The participants in this study had already acquired some English proficiency, having received English classroom teaching for at least three years by the time of testing. Thus, they might have passed through an initial stage of L2 learning where L1 transfer might influence acquisition. The lack of evidence for L1 transfer in this study does not rule out its potential role, especially at earlier stage of learning. Besides, the current study focused on the referential distance of L2 English reflexives, leaving open the question of whether other properties of English reflexives—such as antecedent orientation or c-commanding conditions—are unaffected by L1 transfer. Future research could explore these properties and include participants in the early stage of L2 learning to further investigate the role of L1 transfer.

Additionally, we acknowledge that L2 learners are not a homogeneous group. Individual differences such as working memory capacity, amount and quality of exposure to English, and processing speed can also influence L2 acquisition outcomes. While our study has investigated the influence of proficiency in the acquisition of reflexive referential pattern, we did not measure other variables related to individual differences. This constitutes a limitation of this study. Future research should incorporate measures of learners' individual differences in order to explore how such factors influence the acquisition of reflexives, and whether they modulate sensitivity to universal constraints across different learners.

Conclusion

This study re-examines the judgments of L1-Chinese learners of L2 English regarding possible antecedents to English reflexives and presents new empirical evidence on reflexive reference in L2 English grammar. Importantly, it expands the descriptive database on L2 reflexive reference by examining developmental patterns across proficiency levels that have previously been

insufficiently explored. Moreover, this study goes beyond previous work by considering not only long-distance subject antecedents but also long-distance object antecedents to English reflexives.

In addition to this empirical contribution, the present work also contributes to the debate about factors affecting L2 speakers' grammar. It considers possible explanations for the patterns of reflexive reference at different proficiency levels, focusing on lexical learning explanations and the L1 transfer effect. The experimental results demonstrate that, for these and other L2 English learners, L2 English reflexive reference does not appear to be influenced by pre-existing L1 knowledge. Instead, it progresses gradually, similar to the process of native English children's L1 acquisition, conforming to the Lexical Learning Hypothesis.

Data availability

The data for this study are available on the Open Science Framework (OSF) at <https://osf.io/2vj9z/>.

Received: 13 April 2024; Accepted: 26 June 2025;

Published online: 09 July 2025

Notes

- 1 English reflexives have singular forms, i.e., *himself*, *herself*, *itself*, and plural forms *themselves*. In the actual experimental task, we tested on both *himself* and *herself*. In the paper, we used the singular form *himself* as the example of English reflexives for the sake of conciseness.
- 2 According to Chomsky (1981), a pronoun must not find its antecedent in the local clause in which the pronoun appears.
- 3 Cheng (2004) contended that *zi* and *ji*, the two free morphemes in Archaic Chinese, fused into the compound *ziji* by a long and gradual process, due to the concurrent process of Chinese words changing from predominantly monosyllabic to disyllabic in phonology.
- 4 In the English reflexive *himself*, the reflexive morpheme *self* serves as the head in accordance with William's (1981) righthand head rule; thus, the interpretation of *himself* is mainly determined by the head *self*, resulting in the strict local reference. And the morpheme *him* specifies the gender and number requirements for the antecedent (Cheng, 2004).
- 5 Employing the preferential looking paradigm which requires much less effort for children as compared to traditional L1 research methods like act-out and picture-identification tasks, Lidz et al. (2021) revealed that native English children as early as 30 months have already sorted out the English reflexive word and show correct referential patterns accordingly.
- 6 Yuan (1994) suggested that L1-Chinese learners of L2 English may later re-identify *himself* with the Chinese reflexive *taziji*, which is a local reflexive. However, this does not seem likely because, theoretically, the English *himself* and the Chinese *ziji* are both bi-morphemic, whereas the Chinese *taziji* has a more complicated structure (cf. Cheng, 2004; Reuland et al., 2020). In other words, the English *himself* shares morphological similarity with the Chinese *ziji*, rather than with the Chinese *taziji*. Empirically, L2 acquisition studies on L1-Chinese learners' acquisition of the English *himself* (e.g., Jiang, 2009) also indicated that they do not transfer *taziji* to *himself*.
- 7 Pearson correlation measures the linear relationship between two continuous variables that are normally distributed, while Spearman correlation does not assume normality and is often used with ordinal data or data that is not linearly related (Cohen et al., 2013; Gibbons and Chakraborti, 2010). In our study, as the acceptance count for each

antecedent might not be normally distributed, this factor was treated as ordinal data and thus Spearman correlation instead of Pearson correlation was conducted between the acceptance count and English proficiency.

8 Formula: RESPONSE ~ condition1 + condition2 + condition3 + proficiency.z + condition1:proficiency.z + condition2:proficiency.z + condition3:proficiency.z + (1 + condition1 + condition2 + condition3 | Sub) + (1 + condition1 + condition2 + condition3 + proficiency.z + condition1:proficiency.z + condition2:proficiency.z + condition3:proficiency.z | TEST.ITEM).

References

Akiyama Y (2002) Japanese adult learners' development of the locality condition on English reflexives. *Stud Second Lang Acquis* 24:27–54

Allan D (2004) Oxford placement test (2). Oxford University Press

Barr DJ, Levy R, Scheepers C, Tily HJ (2013) Random effects structure for confirmatory hypothesis testing: Keep it maximal. *Journal of Memory and J Mem Lang* 68(3):255–78

Bates D, Mächler M, Bolker B, Walker S (2015) Fitting linear mixed-effects models using lme4. *J Stat Softw* 67(1):1–48

Battistella E (1989) Chinese reflexivization: a movement to INFL approach. *Linguistics* 27(6):987–1012

Chen CY, Ionin T (2023) Interpretation of Mandarin pronouns and reflexives by L1-Korean and L1-English learners of Mandarin. *Second Lang Res* 39(4):941–968

Chen D (1995) Mandarin reflexive *ziji* in second language acquisition. *Univ Pa Working Pap Linguist* 2(2):37–52

Cheng G (2004) A minimalist approach to long-distance reflexives. Henan University Press

Chief LC (1998) Mandarin intransitive reflexive verbs and the unaccusative hypothesis (Mandarin intransitive reflexive verbs). In: Guo J, Lua KT, Xu J (eds.) *Proceedings of the 12th Pacific Asia conference on language, information and computation*. Singapore: Chinese and Oriental Languages Information Processing Society pp 48–59

Chien Y-C, Lust B (2006) Chinese children's knowledge of the Binding Principles. In: Li P, Tan LH, Bates E, Tzeng OJL (eds.) *Handbook of East Asian psycholinguistics*. Cambridge University Press pp 23–38

Chien Y-C Wexler K (1987) A comparison between Chinese-speaking and English-speaking children's acquisition of reflexives and pronouns. Paper presented at the 12th Annual Boston University Conference on Language Development, San Bernardino, CA: California State University

Chien Y-C, Wexler K Chang H-W (1993) Children's development of long-distance binding in Chinese. *Journal of East Asian Linguistics* 2:229–259

Chomsky N (1981) Lectures on government and binding. Foris, Dordrecht

Chomsky N (1995) The minimalist program. MIT Press

Cohen J, Cohen P, West SG, Aiken LS (2013) Applied multiple regression/correlation analysis for the behavioral sciences. Routledge

Cole P, Hermon G, Sung LM (1990) Principles and parameters of long-distance reflexives. *Linguistic Inq* 21(1):1–22

Contemori C, Asiri O, Perea Irigoyen ED (2019) Anaphora resolution in L2 English: an analysis of discourse complexity and cross-linguistic interference. *Stud Second Lang Acquis* 41(5):971–998

Domínguez L, Hicks G, Song H-J (2012) Untangling locality and orientation constraints in the L2 acquisition of anaphoric binding: a feature-based approach. *Lang Acquis* 19(4):266–300

Dong X (2002) *Zi* and *ji* in Classic Chinese: the source of Mandarin *ziji*. *Res Anc Chin Lang* 1:69–75

Dugarova E (2007) Acquisition of the Chinese reflexive 'ziji' by Russian and English speakers. In: Hilton N, Arscott R, Barden K, Krishna A, Shah S, Zellers M (eds.) *Proceedings of the fifth University of Cambridge postgraduate conference in language research*. CILR, pp 48–55

Eckman F (1994) Local and long-distance anaphora in second language acquisition. In: Tarone E, Gass S, Cohen AD (eds.) *Research methodology in second-language acquisition*. Erlbaum pp 207–225

Emond E, Shi R (2024) The knowledge of binding principles in early child grammar: experimental evidence from 30-month-old toddlers. *Lang Acquis* 32(3):1–29

Eubank L (1993) On the transfer of parametric values in L2 development. *Lang Acquis* 3(3):183–208

Everaert M, Reuland E (2024) (Under)specification counts: when nonlocal anaphors are not exempt. *Linguist Inq* 1–16

Felser C, Sato M, Bertenshaw N (2009) The on-line application of Binding Principle A in English as a second language. *Bilingualism: Lang Cognition* 12(4):485–502

Finer D (1991) Binding parameters in second language acquisition. In: Eubank L (ed.), *Point counterpoint: Universal Grammar in the second language*. John Benjamins, pp 351–374

Flynn S (1996) A parameter-setting approach to second language acquisition. In: Ritchie WC & Bhatia TK (eds.), *Handbook of second language acquisition*. San Diego, CA: Academic Press, pp 121–158

Gibbons JD, Chakraborti S (2010) *Nonparametric Statistical Inference* (5th ed.). Chapman and Hall/CRC

van Gompel RPG, Liversedge SP (2003) The influence of morphological information on cataphoric pronoun assignment. *J Exp Psychol Learn Mem Cogn* 29(1):128–139

Hestvik A, Philip W (2000) Binding and coreference in Norwegian child language. *Lang Acquis* 8(3):171–235

Hicks G (2009) The derivation of anaphoric relations. Benjamins, Philadelphia

Hu J, Pan H, Xu L (2006) Is there a finite vs. nonfinite distinction. *Chin ? Linguis* 39(6):1117–1148

Huang C-TJ, Tang C-CJ (1991) The local nature of the long-distance reflexive in Chinese. In: J Koster J, Reuland E (eds.), *Long-distance anaphora*. Cambridge University Press, pp 263–282

Ionin T, Zubizarreta ML, Maldonado SB (2008) Sources of linguistic knowledge in the second language acquisition of English articles. *Lingua* 118(4):554–576

Jiang L (2009) A referential/quantified asymmetry in the second language acquisition of English reflexives by Chinese-speaking learners. *Second Lang Res* 25(4):469–491

Kim EH (2023) L1-transfer effects and the role of computational complexity in second language pronoun interpretation. *Second Lang Res* 40(3):1–27

Kim EH (2019) Interpretation and processing of overt pronouns in Korean, English and L2-acquisition. [Doctoral dissertation, University of Illinois at Urbana-Champaign]. IDEALS

Lakshmanan U, Teranishi K (1994) Preferences versus grammaticality judgments: some methodological issues concerning the governing category parameter in second-language acquisition. In: Tarone EE, Gass SM, & Cohen AD (eds.), *Research methodology in second-language acquisition*. Lawrence Erlbaum Associates, pp 185–206

Lardiere D (2009) Some thoughts on the contrastive analysis of features in second language acquisition. *Second Lang Res* 25(2):173–227

Lee E, Lardiere D (2019) Feature reassembly in the acquisition of plural marking by Korean and Indonesian bilinguals. *Linguistic Approaches Bilingualism* 9(1):73–119

Levinson SC (1991) Pragmatic reduction of the binding conditions revisited. *J Linguist* 27:107–161

Lidz J, Lukyanenko C, Sutton M (2021) The hunt for structure-dependent interpretation: the case of Principle C. *Cognition* 213:104676

Liu Y (2016) Chinese *zi*: Linking reflexivization and binding [Master's thesis, Utrecht University]. Utrecht University Student Theses Repository

MacLaughlin D (1998) The acquisition of the morphosyntax of English reflexives. In M.-L. Beck (ed.), *Morphology and its interfaces in second language knowledge* (pp. 195–226). Amsterdam/Philadelphia: John Benjamins Publishing Company

Matuschek H, Kliegl R, Vasisht S, Baayen H, Bates D (2017) Balancing Type I error and power in linear mixed models. *J Mem Lang* 94:305–315

McDaniel D, Cairns HS, Hsu JR (1990) Binding principles in the grammars of young children. *Lang Acquis* 1(1):121–139

McKee C (1992) A comparison of pronouns and anaphors in Italian and English acquisition. *Lang Acquis* 2(1):21–54

O'Grady W (2013) Reflexive pronouns in second language acquisition. *Second Lang* 12:5–18

Peverelli PJ (2015) The history of modern Chinese grammar studies. Springer

Progovac L (1992) Relativized SUBJECT: long-distance reflexives without movement. *Linguistic Inq* 23(4):671–680

Progovac L (1993) Long-distance reflexives: movement-to-Infl versus relativized SUBJECT. *Linguistic Inq* 24(4):755–772

R Core Team (2022) R: A language and environment for statistical computing (Version 4.2.2) [Computer software]. R Foundation for Statistical Computing. <https://www.R-project.org/>

Reuland E, Wong SC-H, Everaert M (2020) How the complexity of Mandarin *zi-ji* simplifies the grammar. *Linguistic Inq* 51(4):799–814

Schad DJ, Vasisht S, Hohenstein S, Kliegl R (2020) How to capitalise on a priori contrasts in linear (mixed) models: a tutorial. *J Mem Lang* 110:104038

Singmann H, Kellen D (2019) An introduction to mixed models for experimental psychology. In: Spieler D & Schumacher E (eds.), *New Methods in Cognitive Psychology*. Routledge, pp 4–31

Solan L (1987) Parameter setting and the development of pronouns and reflexives. In: Roepel T, & Williams E (eds.), *Parameter setting*. Reidel, pp 189–210

Sperlich D (2020) Reflexive pronouns: A theoretical and experimental synthesis. Springer

Sperlich D (2013) The acquisition of long-distance reflexives in Chinese as an interlanguage: an experimental study. University of Auckland

Sperlich D (2017) The instantiation of binding through pragmatic and syntactic processes. In: IKeckés I, Sun C (eds.) *Key issues in Chinese as a second language research*. Routledge, pp 188–213

Thomas M (1991) Universal grammar and knowledge of reflexives in a second language (Doctoral dissertation, Harvard University, Cambridge, MA)

Thomas M (1993) Knowledge of reflexives in a second language. Amsterdam: John Benjamins

Wakabayashi S (1996) The nature of interlanguage: SLA of English reflexives. *Second Lang Res* 12(3):266–303

Wexler K, Chien Y-C (1985) The development of lexical anaphors and pronouns. *Papers and Reports on Child Language Development* 24:138–149

White L (2003) Second language acquisition and universal grammar. Cambridge University Press

White L, Travis L, MacLachlan A (1992) The acquisition of wh-question formation by Malagasy learners of English: evidence for universal grammar. *Can J Linguist* 37:341–368

White L, Garavita JB, Kawasaki T, Pater J, Prévost P (1997) The researcher gave the subject a test about himself: problems of ambiguity and preference in the investigation of reflexive binding. *Lang Learn* 47(1):145–172

Wong SCH (2021) Reflexivization in Mandarin: The role of zi-ji and its components [Doctoral dissertation, Utrecht University]. Utrecht University Repository

Wu M, Zhang LJ, Wu D, Wang T (2020) Effects of the interface categories on the acquisition patterns of English reflexives among learners of English as a foreign language. *Int J Bilingualism* 24(4):651–671

Yi W, Lu S, Ma G (2017) Frequency, contingency and online processing of multiword sequences: an eye-tracking study. *Second Lang Res* 33(4):519–549

Yip V, Tang G (1998) Acquisition of English reflexive binding by Cantonese learners: testing the positive transfer hypothesis. In: M-L Beck (ed.), *Morphology and its interfaces in second language knowledge*. John Benjamins Publishing Company, pp 165–193

Yuan B (1994) Second language acquisition of reflexives revisited. *Language* 70(3):539–545

Yuan B (1998) Interpretation of binding and orientation of the Chinese reflexive ziji by English and Japanese speakers. *Second Lang Res* 14(4):324–340

Acknowledgements

We would like to thank Dr. Wenshuo Chang for his assistance with the data analysis in the study. This study is supported by Shanghai Pujiang Program (grant number: 23PJC005), Key Laboratory of Multilingual Education with AI of Shanghai International Studies University (grant number: B202207), and the Fundamental Research Funds for the Central Universities.

Author contributions

Conceptualizations—Li Zeng and Fei Gao. Methodology—Li Zeng. Validation and analysis—Li Zeng. Data collection and curation—Li Zeng. Writing original draft—Li Zeng. Writing, review and editing—Li Zeng and Fei Gao.

Competing interests

The authors declare no competing interests.

Ethical approval

All procedures conducted in the study involving human participants were in accordance with the 1964 Helsinki Declaration and its later amendments. Research protocol and materials of the study were approved by the Institutional Review Board of School of Education at Shanghai International Studies University (SISUGJ2024010) on 9/25/2023.

Informed consent

Written informed consent for participation, data use for research purposes and publication was obtained from all participants by the researcher at the beginning of the experiment, between October 10 and December 20, 2023. All participants were fully informed about the research purpose, data utilization, potential risks, and assured of complete anonymity throughout the study.

Additional information

Correspondence and requests for materials should be addressed to Li Zeng or Fei Gao.

Reprints and permission information is available at <http://www.nature.com/reprints>

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Open Access This article is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License, which permits any non-commercial use, sharing, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if you modified the licensed material. You do not have permission under this licence to share adapted material derived from this article or parts of it. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by-nc-nd/4.0/>.

© The Author(s) 2025