Mandarin speakers undergoing attrition produce more explicit referring expressions[1]

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Abstract: Continuous immersion in a second language causes speakers' first language to change, a phenomenon known as L1 attrition. We explored (1) whether bilingual native Mandarin speakers display attrition-related changes in their use of referring expressions in Mandarin after exposure to English, and (2) whether the severity of attrition is affected by the amount of exposure to both Mandarin (L1) and English (L2) and English proficiency. All participants completed a questionnaire to assess their language experience, and a picture description task in spoken Mandarin. The results show that where more-monolingual Mandarin speakers preferred null pronouns, bilingual speakers tended to use overt pronouns, suggesting attrition-related changes in their native language which favoured explicitness. Our study also shows that decreased use of L1 coupled with increased use of L2 and higher L2 proficiency are likely to result in a greater degree of attrition, although such an association is statistically unreliable in some models.

Keywords: L1 attrition, Mandarin Chinese, Referring expressions, Production

1. Introduction

L1 attrition refers to a process where the native language (L1) of bilinguals undergoes gradual changes due to continuous immersion in a second language (L2) environment and reduced use of their L1. Traditionally, attrition has been viewed as language loss or gradual erosion over time (Seliger & Vago, 2010). However, more recent research suggests that attrition may be an adaptive restructuring in response to a changed linguistic environment (e.g., Hicks & Domínguez, 2020; Laméris et al., 2024). Under this view, syntactic attrition is understood as change in linguistic preferences and processing strategies; for instance, at the syntax-pragmatics interface in pronominal use (our focus in this paper), bilingual speakers of pro-drop languages (e.g., Italian, Spanish) undergoing L1 attrition do not lose the ability to use null pronouns but rather develop a stronger preference for overt pronouns in contexts where monolingual speakers would typically omit them (Martin-Villena, 2023; Tsimpli et al., 2004).

Previous research has generally assumed that the effects of attrition emerge gradually over time and, as a result, has primarily focused on bilingual speakers who immigrated after puberty to a country where their L2 is the dominant language and lived there for years. However, studies on lexical attrition show that even brief L2 immersion can affect L1 lexical retrieval (six months in Baus, et al., 2013; three months in Linck et al., 2009). These studies suggest that L1 attrition may begin sooner than previously thought. While attrition at the syntax-pragmatics interface appears to emerge more slowly, it remains unclear how early such changes can begin.

In this paper we explore referent production in L1 Mandarin L2 English speakers. Many Chinese people now live abroad and may experience attrition. Despite this, L1 attrition in Mandarin Chinese have not been adequately explored, specifically regarding referring

expressions. Mandarin permits both subject and object drop and is distinct from often closely related Indo-European languages like Spanish and Italian that have been the focus of many studies on attrition. Investigating L1 attrition in Mandarin can reveal whether attrition phenomena reported in the literature are specific to certain languages or reflects a wider cross-linguistic phenomena. Speakers in our two experimental groups had resided in the UK for up to 12 months and at least 33 months, respectively. This notably shorter L2 residence than in previous research allows us to observe how early syntactic attrition might emerge.

In the sections that follow we review the literature on reference comprehension and production in monolinguals (section 1.1) and individuals undergoing attrition (section 1.2); since there is no literature on reference in Mandarin Chinese attriters, in section 1.3 we review the most relevant available evidence, from L2 learners of Mandarin. The general picture from this literature review is that speakers undergoing attrition in their L1 (and L2 learners) prefer more explicit forms relative to monolingual speakers. In section 1.4 we review the various theories proposed to account for attrition effects, before turning to our own study of attrition effects in L1 Mandarin L2 English individuals in sections 2-3.

1.1 Reference comprehension and production across languages

Here we review cross-linguistic similarities and differences in reference comprehension and production among Mandarin, English, Italian, and Spanish.

Languages can be broadly classified as pro-drop and non-pro-drop based on whether subjects (and, to a limited extent, objects) can be omitted. English, for instance, is a non-pro-drop language that generally requires overt subjects (1b). Mandarin, Italian, and Spanish are pro-

drop languages with a similar inventory of pronouns (i.e., null and overt pronouns) but differing licensing conditions and distributions of these forms.

Italian and Spanish primarily allow subject omission (1c and 1d), while object omission is more restricted. Their morphology allows omitted referents to be partially tracked through verb inflection; for example, the Italian past participle *partito* indicates a masculine singular subject. In contrast, Mandarin Chinese omits both subject and object flexibly (1a). With minimal verbal morphology, it relies more on discourse context for recovering omitted referents, and is thus classified as a radical pro-drop language, distinguishing it from agreement-based pro-drop languages like Italian and Spanish.

(1) a. **Null arguments in Mandarin**

A: Zhangsan kanjian Lisi le ma?
Zhangsan see Lisi LE[1] Q
'Did Zhangsan see Lisi?'
B: *e* kaijian *e* le.
[He] saw [him]. (Huang, 1984, p. 533)

b. **Overt subject in English**

Susan gave Betsy a pet hamster.
Susan/She reminded her such hamsters were quite shy. (Gorden et al. 1993, p.313)

c. **Null subject in Italian**

E' partito
Is-3s gone-M
'He left.' (Tsimpli et al., 2004, p259)

d. **Null subject in Spanish**

Pedro/*pro* salió del restaurante.

[1] LE: the marker for perfective or inchoative aspect (Huang, 1984).

Pedro/*pro* left of+the restaurant.
'(Peter) left the restaurant.' (Chamorro, 2018, p2)

Comprehension

Accessibility Theory (Ariel, 1990) posits that the appropriateness of a referring expression is associated with the referent's accessibility in the speaker's mental representation. Accessibility is influenced by multiple factors, with topicality being one of them. Discourse topics are often grammatical subjects. Therefore, antecedents in the subject/topic position have higher accessibility and are more likely to be referred to with reduced expressions (e.g., overt or null pronouns). NPs and (in pro-drop languages) overt pronouns often indicate lower accessibility (referents in non-subject/topic position) or topic shift (Chamorro, 2018).

Interpretational biases of Mandarin, English, Italian, and Spanish pronouns generally align with Accessibility Theory. However, each language follows its own syntactic and pragmatic rules. English pronouns are typically interpreted as referring to prominent discourse topics in subject position, indicating a strong subject bias (Garrod & Sanford, 1982; Gordon et al., 1993). Italian exhibits a clear division of labour: null pronouns refer to subjects and overt pronouns to objects (as shown in 2), known as the Position of Antecedent Strategy (Carminati, 2002). Spanish null pronouns also prefer subject antecedents, but overt pronouns are roughly equally likely to refer to subjects and objects (Filiaci et al., 2014).

(2). Marta$_i$ scriveva frequentemente a Piera$_j$ quando Ø$_i$/lei$_j$ era negli Stati Uniti.
'Marta$_i$ wrote frequently to Piera$_j$ when Ø$_i$/she$_j$ was in the United States.'

In Mandarin Chinese, both null and overt pronouns tend to refer to subject referents, i.e. both display a subject bias similar to English (Yang et al., 1999). However, Zhang and Kwon (2022) found a subtle distinction in Mandarin sentences like that shown in (3); null pronouns exhibit an even stronger subject bias than overt pronouns.

(3). Li Gang$_{male}$ gei Wang Qiang$_{male}$ da dianhua deshihou, **Ø/ta**$_{male}$ haizai bangongshi**.**

'When Li Gang$_{male}$ called Wang Qiang$_{male,}$ (he) was in the office.'

Production

Existing research on reference production in Mandarin, Italian, and Spanish uses various experimental paradigms, such as picture description and storytelling. Despite methodological differences, reference use follows a general pattern: null pronouns are consistently used to refer to highly prominent antecedent in subject/topic position, and NPs are preferred for less prominent, non-subject/topic referents. The use of overt pronouns may vary depending on task, but studies consistently find they are used least by monolingual speakers, leading to an alternation of null pronouns and NPs (Contemori et al., 2023; Montrul, 2004; Wu, 2020; Belletti et al., 2007). This seems to contrast with the comprehension preferences reviewed above, where overt pronouns tend to refer to less prominent antecedents. This asymmetry between comprehension and production suggests different underlying mechanisms.

Many studies have explored mechanisms underlying reference production. Two of these, conducted in Mandarin Chinese and English, respectively, are particularly relevant to the current research. Hwang (2021) examined written and spoken Mandarin. In the written system, third-person singular pronouns "他 (he)" and "她 (she)" are distinct, whereas in speech, they share the same pronunciation and are therefore gender-neutral. In a story-continuation task, participants read a sentence and then continued the story. Prompts involved either one character (5a) or two characters with the same (5b) or different (5c) genders. In the two-character condition, participants continued the story with either subject or non-subject

antecedents. They were also instructed to avoid using null pronouns as these can be ungrammatical in written Mandarin, though acceptable in spoken Mandarin.

(5) a. Xiaohong$_{female}$ xiangqu chaoshi.

'Xiaohong$_{female}$ wants to go to a supermarket.'

b. Xiaohong$_{female}$ xianggen Xiaoli$_{female}$ quchaoshi.

'Xiaohong$_{female}$ wants to go to a supermarket with Xiaoli$_{female}$.'

c. Xiaohong$_{female}$ xianggen Xiaogang$_{male}$ quchaoshi.

'Xiaohong$_{female}$ wants to go to a supermarket with Xiaogang$_{male}$.'

Consistent with findings for a similar task in English (Arnold & Griffin, 2007), Hwang's participants used more NPs (i.e., proper names) in the two-character than the one-character condition. In the written task, speakers produced more pronouns in different-gender than same-gender contexts, while this difference was absent in the spoken task. Mandarin speakers' pronoun usage appears influenced by referential ambiguity, indicating a preference for avoiding potentially ambiguous expressions. However, this strategy does not fully explain the notable reduction in pronouns (and preference for NPs) in different-gender contexts of the written task, where using pronouns is not inherently ambiguous. Arnold and Griffin (2007) proposed that reduced pronoun use in the two-character condition is driven by semantic competition, where two referents compete for attention. This implies that reference production is constrained by speaker-internal cognitive pressures such as attention, as well as partner-directed factors such as potential ambiguity; overall, the process of reference production might involve an interplay of different strategies.

1.2 L1 attrition at the syntax-pragmatics interface

Attrition is not a deterministic process, and its effect may vary across individuals: not all bilinguals exhibit the same level or overt signs of attrition, making it a dynamic process, with individual differences in the degree and rate of attrition (Opitz, 2019). However, consistent patterns emerge at the group level, such as the general preference toward over-explicitness in reference reviewed below.

Notably, syntactic attrition is selective, insofar as certain linguistic structures are more easily affected by attrition than others (Chamorro & Sorace, 2019; Gürel, 2004). The Interface Hypothesis (Sorace & Filiaci, 2006) predicts that structures involving syntax and other cognitive domains, such as pragmatics, are more susceptible to change. This susceptibility arises from the need for speakers to have both (1) "knowledge of the structure and of the mapping conditions that operate within interface components" and (2) "the processing principles that apply in the real-time integration of information from different domains" (Sorace, 2011, p.12). In cases where speakers are inefficient in integrating these interface properties, the use of grammar becomes more vulnerable, manifesting as "emerging optionality" in L1 attrition (Sorace, 2011, p.5). Therefore, attrition impacts bilinguals' real-time language processing rather than their underlying representational knowledge.

Effects of attrition on comprehension

Pronominal structure in null-subject languages serves as a testbed for studying attrition, due to its reliance on both syntactic knowledge and pragmatic constraints. The Interface Hypothesis predicts that while null pronouns remain relatively stable in bilinguals, overt pronouns are likely to undergo change as their antecedent preferences are more flexible. For instance, Italian monolinguals are more likely to use an overt pronoun for a subject referent in sentence 6 (a), where no ambiguity exists, than in sentence 6 (b), where two equally possible

antecedents can cause ambiguity (Sorace, 2011). Additionally, as previously discussed, variation among pro-drop languages is primarily limited to the constraints of overt pronouns, whereas null pronouns consistently refer to the subject or topic referents.

6 (a) Paolo ha detto che pro/lui andra al matrimonio si Maria.

'Paolo has said that ∅/he will go to the wedding of Maria.

6 (b) Marta scriveva spesso ad Anna quando pro / lei era in vacanza.

'Marta wrote frequently to Anna when ∅/she was on holiday.'

This prediction is supported by studies exploring the interpretation of null and overt pronouns in potentially attrited speakers. Tsimpli et al. (2004) found that while monolingual Italian speakers tended to coreference overt pronouns with object referents in sentences similar to 6(b) (as in Carminati, 2002), their English-proficient Italian speakers (presumably undergoing attrition) tended to interpret overt pronouns as referring to subject referents, suggesting that L1 attrition affects pronoun interpretation, and that attrited speakers have a preference for more explicit forms of reference (i.e. using an overt pronoun for a subject referent is more explicit than the alternative null pronoun).

Chamorro et al. (2016) conducted a similar experiment exploring attrition in Spanish. The experiment consisted of two tasks, covering both online processing (via eye-tracking) and offline interpretation (via acceptability judgements) of Spanish null and overt pronouns in forward anaphoric sentences similar to Tsimpli et al. (2004). While the offline acceptability judgement task showed no difference between groups, the eye-tracking data revealed, in the attrited group only, a lack of sensitivity to a pronoun mismatch condition where an overt pronoun is coreferential with a subject referent. These findings are consistent

with a greater acceptance of explicit reference (i.e. use of overt rather than null pronouns) in speakers undergoing attrition. Chamorro et al. (2016) also found that re-immersion to the L1 can partially reverse the process of L1 attrition, supporting the view that L1 attrition reflects dynamic changes in processing strategies as an adaptation to different linguistic environments rather than permanent language loss or irreversible changes in mental representations.

Effects of attrition on production

The literature on attrition effects in production is relatively limited and presents mixed results. Martin-Villena (2023) explored the distribution of referring expressions in Spanish with a group of monolinguals and two groups of L1 Spanish L2 English bilinguals (advanced instructed bilinguals in Spain and immersed bilinguals in the UK) on two corpus-based video-retelling tasks. The bilingual groups showed a tendency toward over-explicitness, which is considered a sign of attrition-related changes. Both groups of bilingual speakers produced more overt pronouns than L1 Spanish monolinguals, and immersed bilinguals produced significantly more NPs than both monolinguals and instructed bilinguals in contexts of topic continuity, indicating an even stronger preference for explicit forms. While the Interface Hypothesis predicts pronominal preference in comprehension, it does not account for NP overuse in production. However, its principles may still provide insight into this pattern, as attrition-related processing difficulties could lead to a preference for more explicit referential forms, such as NPs. We will also explore alternative explanations for the overuse of NPs later, such as ambiguity avoidance. In contrast, Giannakou (2018) found no significant differences between Greek monolinguals and L1 Greek-L2 Spanish speakers in their use of lexical subjects, null subjects, and overt subject pronouns in a storytelling task. The differing results between the two studies may be partly explained by differences in their methodology. Compared to a large sample with a narrow age range in Martin-Villena (2020),

Giannakou's (2018) sample was small, with a wide age range, which could have reduced statistical power and introduced greater variability. Additionally, since attrition does not manifest uniformly, in some cases, subtle effects may remain unnoticed in explicit, behavioural tasks but can still be revealed through implicit, real-time processing measures (e.g., Chamorro et al., 2016). This emphasizes the importance of methodological diversity to capture the subtle effects of attrition.

1.3 The syntax-pragmatics interface in Mandarin Chinese in L2 Mandarin speakers

No research to date has looked at L1 attrition effects on pronoun comprehension and production in Mandarin Chinese. The most relevant studies we are aware of are those on L2 learners (Slabakova et al., 2024; Zhao, 2014), child bilinguals (Zhou et al., 2022), and heritage speakers (Jia & Paradis, 2015; Wu, 2020). As reviewed below, these studies suggest that referential over-explicitness is not consistently observed in all bilingual populations or linguistic contexts, likely because the use of reference is highly influenced by contextual factors.

Comprehension

To our knowledge, studies on comprehension of Mandarin anaphoric expressions in L2 Mandarin speakers do not use sentence stimuli comparable to those in typical attrition studies (e.g., Tsimpli et al., 2004: two possible referents were mentioned in the preceding context, causing ambiguity or competition for attention). For instance, Zhao (2014) used forward anaphora sentences, as shown in (6), where only one referent was mentioned in the preceding clause, reducing potential ambiguity in reference. Their L1 English L2 Mandarin learners did not differ from native Mandarin speakers, consistently interpreting null pronouns as referring to subject referents and also allowing overt pronouns to be coreferential with subject referents

(albeit with indeterminacy). This is perhaps not surprising given that both null and overt pronouns in Mandarin are strongly subject-biased (also see footnote four for a discussion on when-clauses in Mandarin Chinese).

(6) Xiao Zhang$_i$ chi fan de shihou, e$_i$/ta$_{i/j}$ dai zhe yi tiao haokan de xianglian.
'When Xiao Zhang is eating, he is wearing a pretty necklace.'

Slabakova et al. (2024) used resultative constructions, as illustrated in (7). In this structure, the null element refers to the matrix subject, whereas the overt pronoun has to refer to someone else in the discourse, creating a clear division of labour. This constraint arises because the coreferential reading of *ta* is argued to be ruled out by Binding Principle B, which states that a pronoun cannot refer to an antecedent within the same local domain (Huang J., 1992; Huang Y., 1994). They found that L2 learners more frequently corefer overt pronouns with subject referents than native speakers.

(7) Daxiang$_i$ change-de Ø$_{i/*j}$/ta$_{i/j}$/Little Monday$_j$ ku qilai le.
'Big Elephant sang, and as a result he began to cry.'

Production

Studies comparing reference production in Mandarin between L1 and L2 Mandarin speakers have presented mixed findings. For instance, Wu (2020) investigated the acquisition of Mandarin pronouns among two groups of L1 English L2 Mandarin learners with low and high Mandarin proficiency and two corresponding groups of heritage speakers in an oral narration task of picture sequences. Production patterns of highly proficient L2 learners and heritage speakers were in line with native speakers, having comparable use of NPs and both

overt and null pronouns when maintaining previously mentioned referents. Conversely, L2 learners and heritage speakers of low Mandarin proficiency diverged from native speakers in two ways: L2 learners used more overt pronouns, while heritage speakers used more NPs. This study did not explicitly differentiate referring expressions used for subject referents and those for non-subject referents; further in-depth analysis may therefore reveal variations in the distribution of the three reference types.

1.4 The causes of bilingual over-explicitness in reference

The role of language exposure and proficiency

What are the causes of L1 attrition? Researchers often consider factors such as exposure to and use of L1 as key predictors of attrition effects. The Activation Threshold Hypothesis (Paradis, 1993) proposes that each language has an activation threshold and a linguistic element in one language may fall below this threshold if it is not frequently used; attrition occurs when an element in the L1 is not used frequently enough and competes with a corresponding element in the L2 that is used more often. This hypothesis is supported by Chamorro et al. (2016) suggesting an inverse relationship between L1 exposure and the severity of attrition. Similarly, Martin-Villena (2023) attributed the stronger tendency toward over-explicitness in the immersed bilingual group in the UK, compared to the instructed bilingual group in Spain, partly to differences in language experience: the former reported even less frequent and recent use of L1 in English immersion contexts. Other studies have also observed a higher attrition level in participants experiencing diminishing exposure to their L1 (Bergmann et al., 2016; Flores, 2012; Kasparian et al., 2017; Opitz, 2013; Schmid & Yılmaz, 2018). However, some studies did not find a reliable relationship between L1 use and attrition effects (e.g., Jarvis, 2003; Schmid & Jarvis, 2014).

These divergent outcomes may arise from the inherent difficulty in quantifying the amount of language use and exposure (Schmid, 2007). For instance, the decrease in L1 exposure typically aligns with an increase in L2 exposure among bilinguals, thus making it difficult to disentangle these two intertwined processes (Schmid & Yılmaz, 2018). The intricate nature of these challenges pinpoints the importance of considering the dynamic relationship between L1 and L2 exposure in understanding the process of L1 attrition.

To further explore these relationships, Schmid and Yilmaz (2018) conducted a Principal Component Analysis examining correlations among several variables of L1 attrition and found that less frequent L1 use correlated with higher L2 proficiency. L2 proficiency itself has long been considered another key predictor of attrition (Yazawa et al., 2024). Early research often focused on individuals with high L2 proficiency, particularly those at a near-native level, and attrition appeared more pronounced in this group (e.g., De Leeuw et al., 2010; Flege, 1987; Mayr et al., 2012; Tsimpli et al., 2004). However, subsequent studies have shown that L2 proficiency is not always a robust predictor of attrition, with some reporting a non-significant relationship between the two (e.g., Schmid & Jarvis, 2014). In sum, while both language use and proficiency are frequently implicated in L1 attrition, their individual contributions remain difficult to isolate.

Crosslinguistic interference

In studies exploring L1 attrition in pronominal structure, where participants' L2 is a non-null-subject language, such as English, the preference for a more explicit form of reference is often attributed to crosslinguistic interference – the transfer effect of L2 on L1 (Tsimpli et al., 2004). For instance, the extension/overuse of overt pronouns is understood to be influenced

by English, which has only one pronominal option in the specific discourse context examined in those studies.

The Attrition via Acquisition model proposed by Hicks and Domínguez (2020), adapted from the L1 acquisition model in Lidz and Gagliardi (2015), conceptualises grammatical attrition as active restructuring driven by resolving conflicts between L1 grammar and extensive L2 input and, crucially, successful internalization of new input (intake), rather than passive loss. For adults with a stable L1 grammar, the inference engine for grammar adjustment based on new input typically becomes dormant. However, in an L2-dominant environment, substantial L2 input may trigger mismatches with the existing L1 grammar, reactivating the inference engine to resolve them. Consequently, grammatical attrition may occur, leading to modifications in the L1 that may cause it to resemble the L2.

However, these accounts may over-predict attrition effects. For instance, the model attributes grammatical attrition to the active resolution of mismatches between existing L1 knowledge and new L2 input; if this were the case, any L1 structures that conflict with L2 could undergo change. However, numerous studies suggest that attrition is selective and not always directly tied to specific L1-L2 structural contrasts (Sorace, 2019). Additionally, crosslinguistic interference alone may not fully explain attrition effects. Studies on child bilinguals (Sorace et al., 2009) and L2 learners[2] (e.g., Spanish and Italian: Belletti et al., 2007; Margaza & Bel, 2006; Spanish and Greek: Lozano, 2018) of two null-subject languages also reported the same over-extension of overt pronouns. However, interference between two null-subject

[2] Etxebarria and Montrul (2025) found that Basque-Spanish bilinguals used more null pronouns in Spanish than Spanish monolinguals, a pattern likely driven by the transfer effect of Basque on Spanish. This contrasts with most bilingual studies reporting an overuse of overt pronouns and/or NPs.

languages would not be expected to lead to a preference for overt pronouns under these accounts emphasising mismatches between the grammars of L2 and L1.

Glodstaf and Montrul (2025) extends the Attrition via Acquisition model by incorporating the Activation Threshold Hypothesis (Paradis, 1993). In this hybrid account, only certain L1 features (and only in some speakers) may fall below the activation threshold, reducing accessibility and leading to attrition. Individuals may vary both in how easily certain features are accessed and how much those features are affected by language input, depending on their linguistic experiences. This perspective helps account for both the selectivity of L1 attrition and why previous studies have reported inconsistent findings.

Overall, the crosslinguistic interference account offers a compelling explanation for some attrition patterns (particularly in contexts involving typological contrasts), but it has its limitations. Researchers have proposed alternative or complementary models to capture the complex mechanisms underlying attrition. Yet, no single account appears sufficient to fully explain this phenomenon.

A preference for redundancy

Lozano (2016, 2018) proposed the Pragmatic Principles Violation Hypothesis, which explains L2 learners' overuse of overt pronouns/NPs as driven by general principles of pragmatic economy, where learners would rather be redundant than ambiguous. This hypothesis has also been applied to explain similar tendencies in L1 Spanish attriters (Martin-Villena, 2023). While there is little direct evidence supporting this hypothesis in the literature, the contrast between the one-character and two-character conditions in our experiment speaks to this issue, which we return to in the discussion.

2. The current study

Here we report an experiment investigating the use of three referential forms (null and overt pronouns, and NPs) in spoken Mandarin through a picture description task. To explore the effects of reduced L1 exposure / increased L2 exposure, we tested three groups of speakers: a control group consisting of more monolingual speakers based in China, and two experimental groups of more-bilingual speakers were resident in the UK. We address two research questions: (1) Do L1 Mandarin-L2 English bilingual speakers show signs of attrition-related changes in referential production in their L1 Mandarin (i.e. a tendency toward more explicit forms), as seen in L2 Mandarin and in attrition in L1 Italian and Spanish? (2) If so, is there a correlation between their attrition-related changes and their usage of L1 and L2 in their daily lives or their L2 proficiency?

2.1 Methods

Participants completed a questionnaire adapted from the Language and Social Background questionnaire (Anderson et al., 2017), to assess their use of and exposure to Chinese and English, then completed an experiment consisting of a picture description task in spoken Mandarin, adapted from Arnold and Griffin (2007) and Hwang (2021).

Participants

We recruited participants for two experimental groups and a control group. The Control group included 31 mainland Chinese PhD researchers who had not travelled abroad (age 22-31, Mean: 26.87, SD: 2.23). The Short-English Exposure group consisted of 35 UK-based Masters students (age 20-29, Mean: 23.43, SD: 1.79) who had resided in the UK for 1 to 12 months (Mean 7.31 months, SD: 3.12). The Long-Term English Exposure group comprised

35 UK-based PhD researchers who were either studying or had completed their PhD program in the UK (age 22-37, Mean: 28.6, SD: 3.34) and had spent between 33 and 131 months in the UK (Mean: 60.57 months, SD: 23.39). The three groups did not differ substantially in their age of English acquisition, with most participants beginning to learn English in primary school: the age range was 5-13 years for the Control group (Mean: 8.35, SD: 2.30), and 3-12 for both the Short-Term (Mean: 6.63, SD: 6.63) and Long-Term English Exposure groups (Mean: 6.94, SD: 2.17; see also Section 3.1 and 3.2 for a more detailed analysis of language proficiency and use). Participant were paid £5 each.

Stimuli

In the picture description task[3], we used a sentence structure similar to Hwang (2021)[4]. The task was built using JsPsych (De Leeuw et al., 2023) to elicit spoken production from participants in response to images, audio descriptions, and text. We designed images depicting a total of 224 scenarios, comprising 128 scenarios for the critical two-character condition, 64 for the one-character condition and 32 filler scenarios, adapted from Zhang and Kwon (2022) and Hwang (2021). These scenarios were constructed around four referents, including two female characters (Xiaozi "Little Purple" and Xiaohong "Little Red") and two male characters (Xiaolan "Little Blue" and Xiaohuang "Little Yellow"). The color of their hair and clothes matches their name, making it easier for participants to remember them.

[3] To access the full list of sentence and image stimuli, please go to the Stimuli folder via the link: https://osf.io/q2ev3/?view_only=d83cee3363ec4c1a91dfb2298dd402be

[4] We used a sentence structure similar to Hwang (2021) instead of the extensively-examined *when*-clause in L1 attrition studies (e.g., Tsimpli et al., 2004) and in Zhang and Kwon (2022). This is because in the "when" temporal clause in Mandarin, where the pronoun is null, the sentence entails an adverbial clause inserted inside the matrix one; whereas in the case of the overt pronoun, this is the structure in which the adverbial clause precedes the matrix one (Yan, 2022). So, in principle, these two sentences are structurally different, thus naturally leading to different results.

Each scenario consisted of two actions, illustrated in two separate images – the context image and the target image (see Figure 1). In the critical two-character condition, the context image featured two animate referents of either the same or different genders, and the target image featured one of them (either the subject or non-subject referent from the context image). We constructed trials around 16 pairs of verbs (one for the context image, one for the target image; e.g. the context verb in the scenario in Figure 1 is "greeted", the target verb is "picked up"); for each verb pair, we created 4 same-gender and 4 different-gender combinations, featuring different assignments of characters to the various roles in the context and target events, yielding an inventory of 128 possible two-character trials.

Scenarios in the one-character condition were adapted from the two-character condition, but the context image featured only one referent who reappeared in the target image. Each of the 16 verb pairs used for the two-character condition provided four possible one-character scenarios which differed only in the character involved, providing an inventory of 64 one-character items.

In filler scenarios, two animate referents, either two humans (e.g., "Xiaozi and Xiaohong") or one human and one animal (e.g., "Xiaozi and the little bunny"), are depicted performing actions together in both context and target images, thereby forming a compound subject within a coordinative structure. Target image descriptions on these filler trials featured neither the NPs nor the pronoun forms we were interested in in the critical trials (e.g., a target description in a filler trial might be "Xiaozi and the little bunny took a nap together. *They* felt hungry afterwards.").

We generated 16 experimental lists using the Latin Square method. Each list has 64 trials, including one variation of each of the 16 verb pairs from both the two-character and one-character conditions, alongside 32 fillers. Each referent appears an equal number of times within each list and across lists. Each variation of the 16 verb pairs in both conditions was equally distributed across the lists. The presentation order of trials within each list was randomised, starting with two filler trials, and then following the pattern of filler trial – one-character trial – filler trial – two-character trial throughout the task. Each list was divided into two blocks (32 trials each); to avoid potential priming effects between two-character and one-character trials, if a two-character scenario featuring a particular verb pair appeared in the first block, its corresponding one-character version would not be presented in the same block.

Figure 1: An example of image stimuli used in the picture description task. In this given example, the audio description says "Xiaozi [Little Purple] greeted Xiaohong [Little Red]". Participants are prompted to "Please repeat what you heard and then complete the story", and provided with a prompt word, in this example meaning "picked up". In this scenario, in the subject continuity condition, we expected the participant to say (in Chinese)

something like “Xiaozi greeted Xiaohong, then null/she/ Xiaozi [Little Purple] picked up the backpack”; in the shift condition we expected something like “Xiaozi greeted Xiaohong, then null/she/Xiaohong [Little Red] picked up the backpack”.

Procedure

All control participants in mainland China completed the experiment online via a Zoom or Tencent (a widely used online meeting platform in mainland China) session, sharing their screens with the researcher. We adopted this supervised procedure after finding in a pilot experiment that unsupervised remote participation resulted in very low-quality production data. UK-based participants were offered the flexibility to take part in the experiment either online (via Zoom or Teams, following the same screen-sharing procedure) or in person at the University lab.

Participants first completed the questionnaire, followed by the picture description task. During the task, the context image was displayed for 5 seconds, along with an audio description of the image. The target image then appeared with a prompt word (a verb) above and a microphone icon below. Participants repeated the description of the context image and then described the target image using the provided prompt word. Participants clicked the microphone icon to start and stop recording their verbal responses.

2.2 Predictions

We aim to address two primary research questions. First, we ask whether L1 Mandarin-L2 English bilinguals exhibit attrition effects in their L1in their choice of referential forms. As reviewed above, attrited speakers generally show a preference for the more explicit referential choice (e.g., Tsimpli et al., 2004). Accordingly, if speakers in our experimental groups are undergoing attrition, we expect them to use more explicit referring expressions

than our control speakers. However, exactly how this preference will manifest itself in Mandarin Chinese is unclear a priori. Increased explicitness could be achieved by using overt pronouns rather than null pronouns (as seen in L1 Italian or Spanish speakers undergoing attrition), or full NPs rather than pronouns. Various language-specific factors in Mandarin suggest the latter might be more likely. Overt pronouns in spoken Mandarin are gender-neutral, and therefore inherently ambiguous in the two-character condition; indeed they might be more ambiguous in practice than null pronouns, which have a stronger subject bias (Zhang & Kwon, 2022). Moreover, the Interface Hypothesis prediction regarding overt pronouns is based on pro-drop languages like Italian, where null and overt pronouns exhibit a clear division of labour in the two-character condition. In Mandarin, by contrast, both forms are strongly subject-biased. This prediction of NP over-explicitness is clearest for our Long-Term English Exposure group; the potential differences between the Control and the Short-Term English Exposure groups remains uncertain due to that group's shorter stay in the UK.

We expected minimal distinctions among the three groups in the one-character condition (as shown in Zhao, 2014), as the single referent in the context eliminates any ambiguity/competition introduced by an additional character and both pronoun types strongly favour the subject, making overt and null pronouns equally effective.

The second research question concerns the role of exposure to L1 and L2 as well as L2 proficiency in attrition effects. As discussed earlier, findings on these factors have been mixed. Given this lack of clarity, we aim to test whether more English exposure (less Mandarin exposure) and/or higher English proficiency are associated with more severe attrition in bilinguals' reference production, i.e. a stronger preference for more explicit forms. If so, this pattern should show up in a coarse-grained fashion by comparing across our three

groups but can also be assessed in a more fine-grained way by correlating our questionnaire data with participants' explicitness in the production task.

2.3 Data Analysis[5]

We focused on participants' production of three referential forms, namely NPs (which were always proper names in the context of our experiment), overt pronouns and null pronouns, in the two conditions of the picture description task. We analysed the referential forms that speakers used in their first complete sentence when mentioning the target referent. Empty responses and responses containing plural forms (such as "Xiaozi and Xiaohong", or "They") or possessive forms (such as "Her hands") were excluded from data analysis. We also excluded responses where participants reversed the order of the context and target images and provided descriptions accordingly (e.g., "Xiaohong picked up a backpack and greeted Xiaolan") or where a topic shift occurred before speakers described the target referent in the topic-continuity context of the two-character condition (e.g., "Little Red met Little Blue on the campus. Little Blue is Little Red's enemy, so Little Red was particularly unhappy.")

Consequently, a total of 1515 trials in the two-character condition and a total of 1551 trials in the one-character condition were analysed using Bayesian ordinal logistic regression, specifically the adjacent category model, with the brms package (Bürkner, 2017) in R (R Core Team, 2023). Since the three referential forms produced by speakers can be conceptualized along a continuum of increasing explicitness, the adjacent category model allows for a comparison of differences between adjacent categories (i.e. null to overt pronouns, overt pronouns to NPs) across groups. The probability of direction (pd) was

[5] The full analysis can be accessed in the Acat Analysis folder via this link: https://osf.io/q2ev3/?view_only=d83cee3363ec4c1a91dfb2298dd402be

obtained accordingly using the function pd() from the bayestestR package (Makowski et al., 2019). For each model, we used weakly informative priors with mean 0 and standard deviation 1.5 (log-odds) for both the intercept and the other effects (corresponding to a 95% Credible Interval between -3 and + 3 log-odds, equal to almost 0 to 100% probability). Four MCMC chains of 4000 iterations each were executed and the first 1000 iterations were warmup.

3. Results

We begin this section by summarising participants' questionnaire responses on their language proficiency and use. Next, we present the statistical results on reference production in the picture description task, comparing across groups. Finally, we analyse how language proficiency and use relate to referential explicitness.

3.1 Language proficiency and use

Figure 2[6] illustrates the mean proficiency of English and Mandarin in listening, speaking, reading, and writing across groups, self-reported on a scale of 0-10. The Long-Term English Exposure group reported the highest English proficiency in all four skills. All speakers reported the highest proficiency in Mandarin Chinese, with the two bilingual groups slightly surpassing the Control group.

Figure 3 depicts mean proportions of English and Mandarin use in the four skills by group. Figure 4 shows the proportion of English use in 12 specific daily situations by group. Of 20 contexts in the questionnaire, only 12 were included ("at school", "with roommates", "with

[6] We also asked participants about their use of regional varieties of Chinese, including e.g., Cantonese and Wu. Figure 1-2 in Supplementary Materials provide descriptive statistics on these responses.

neighbours", "with friends", "social events", "activities", "shopping", "reading", "emails", "texting", "on social media", "watching shows"), because all three groups reported using over 90% of Chinese in six contexts related to communication with family members at home, and two contexts related to communication with colleagues at work were not applicable to speakers in the Short-Term English Exposure group. As expected, the Long-Term English Exposure group reported the highest percentage of English use across skills and daily contexts, whereas the Control group reported the lowest.

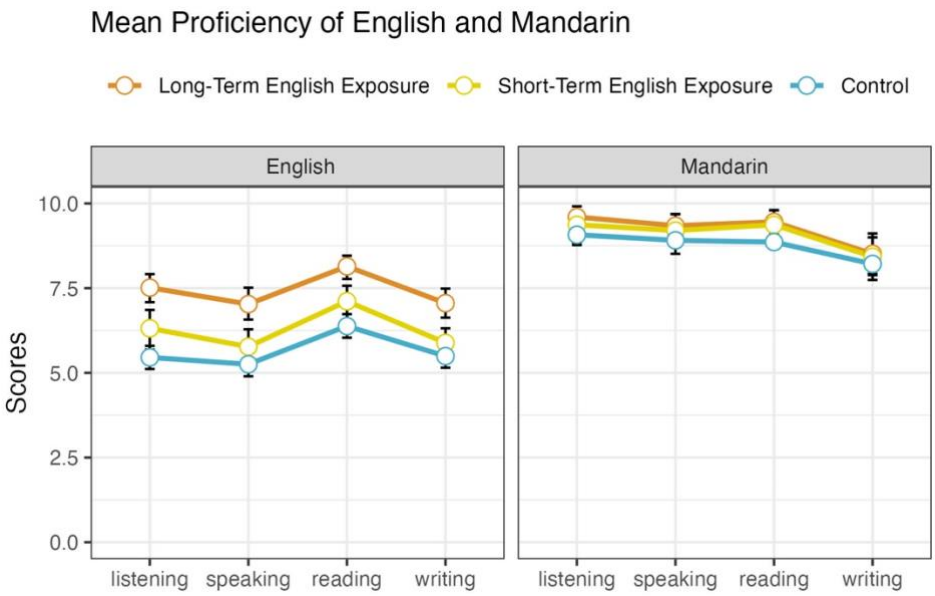

Figure 2: The mean proficiency scores in English and Mandarin across our three groups. Error bars show bootstrapped 95% confidence intervals of the mean.

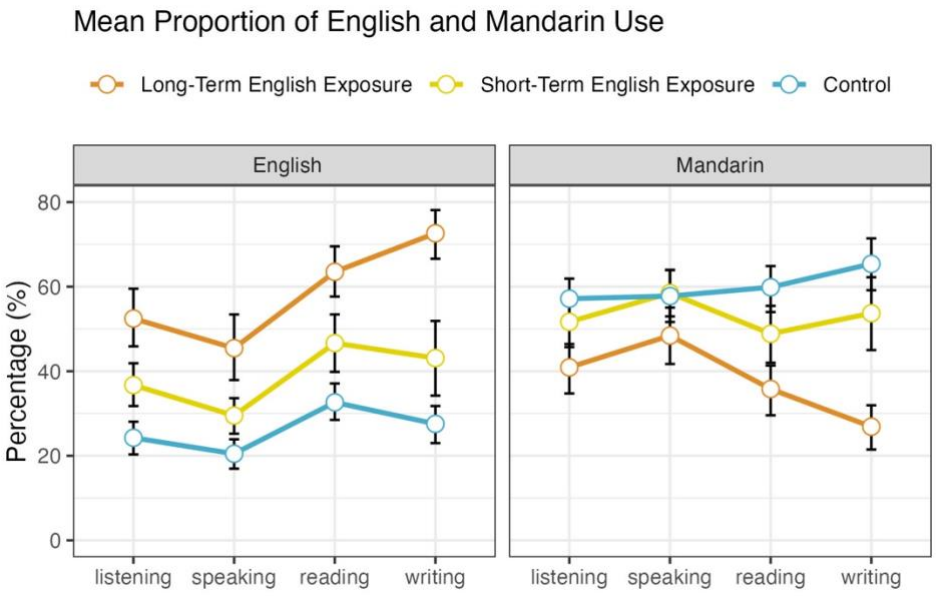

Figure 3: The mean percentage of language use in English and Mandarin in the respective four skills across groups. Plotting conventions as in Figure 2. Use of Chinese dialects are not shown and make up the remaining percentages.

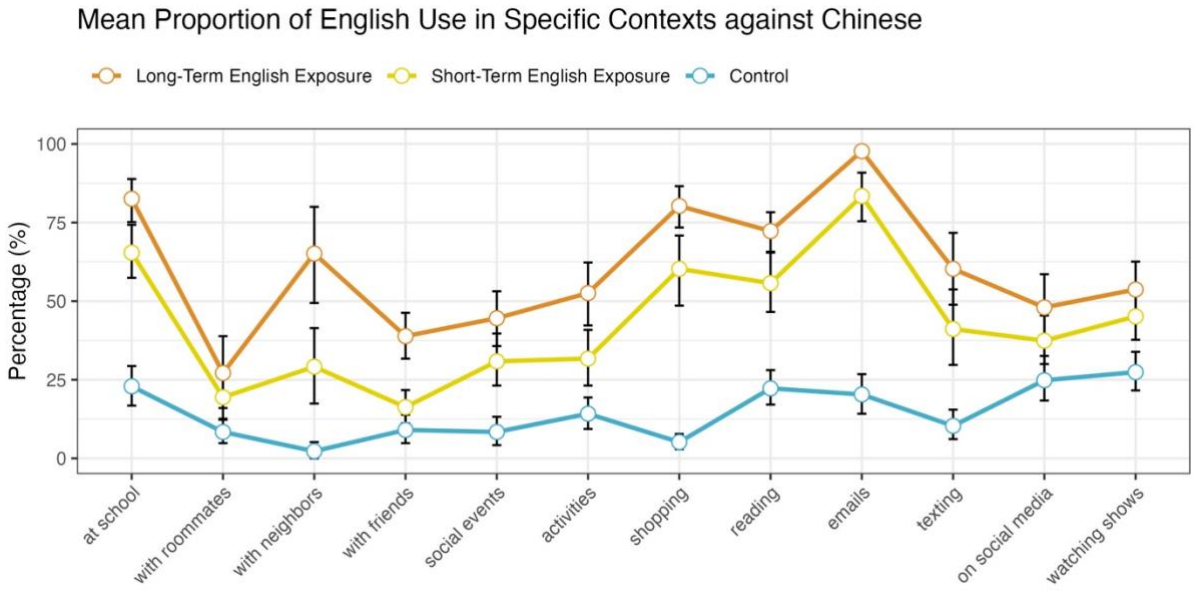

Figure 4: The mean percentage of language use in English in 12 specific daily situations. Plotting conventions as in Figure 2 and 3.

3.2 Reference production

The questionnaire responses reveal the expected group differences in self-reported English proficiency and language use. Next we analyse whether the three groups show different

preferences in reference production. Figure 5 and Figure 6 show the distribution of the three referential forms in the two-character condition and one-character condition, respectively.

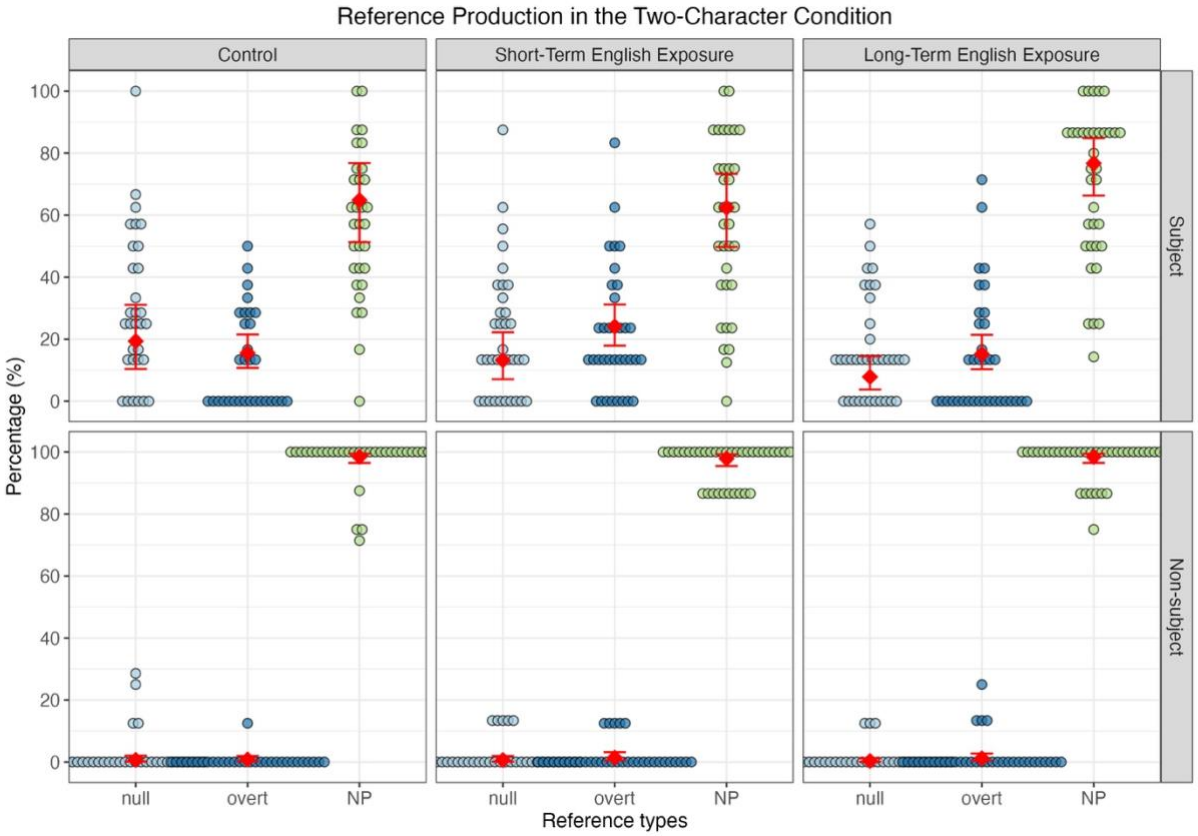

Figure 5: Production of three referential forms in the two-character condition across groups, with the target referent being either the subject or non-subject of the previous context. Each dot corresponds to one participant's data. The diamond shape represents the estimated mean, with error bars showing 95% credible intervals, both derived from the Bayesian model.

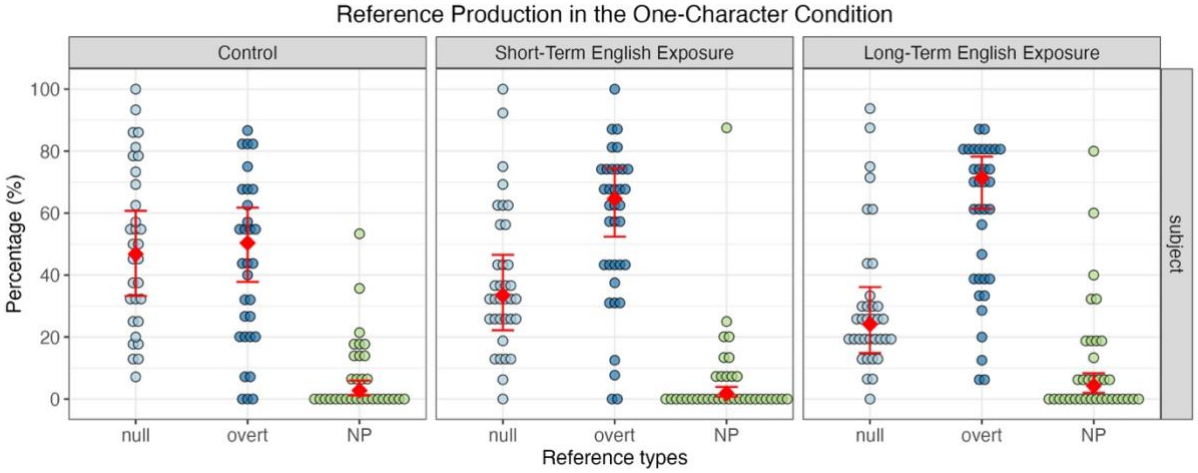

Figure 6: Production of three referential forms in the one-character condition, with only one referent in context. Plotting conventions as in Figure 5.

Our analysis of referring expressions for two-character scenes included fixed effects of the referent role (subject or non-subject of the context sentence), group (Control, Short-Term English Exposure, Long-Term English Exposure), and their interaction. The model also included by-participant and by-item random intercepts and slopes for referent role. We used the default treatment contrast for both Role and Group, with the Subject role and the Control group set as reference levels for Role and Group, respectively. This produces two Group fixed effects: one which compares the Short-Term English Exposure group against the Control group, and a second which compares the Long-Term English Exposure group against the Control group. The adjacent category model with category-specific effects allows us to specifically compare group differences across two referential contrasts, i.e. overt versus null pronouns; NPs versus overt pronouns. Table 1 in the Appendix provides the results of the Bayesian model in the two-character condition.

Looking first at the Control group, the analysis reveals no clear preference between null and overt pronouns, for both subject and non-subject referents, as indicated by the wide range of credible intervals that include both negative and positive values (intercept, indicating subject role: b = 0.21, CrI = [-0.36, 0.75], pd = 77%; effect of non-subject role: b = 0.42, CrI = [-0.86, 1.79], pd =73%). The control speakers used more NPs than overt pronouns for subject referents (b = -1.43, CrI = [-1.94, -0.93], pd = 100%), and this preference for NPs was even stronger for non-subject referents (b = 3.40, CrI = [2.42, 4.48], pd = 100%).

In terms of group comparison, both Short-Term and Long-Term English Exposure groups preferred overt pronouns over null pronouns more than the Control group (Short-Term vs Control: b = 0.82, CrI = [0.15, 1.48], pd = 99%; Long-Term vs Control: b = 0.88, CrI = [0.17,

1.61], pd = 99%); although the wide range of credible intervals suggests some uncertainty about the magnitude of these effects (that is, this effect could be very small or large).

Neither of the bilingual groups preferred NPs over overt pronouns compared to the Control group, as suggested by the credible intervals spanning both negative and positive values, indicating substantial uncertainty regarding the directionality and magnitude of these effects (Short-Term vs Control: b = -0.48, CrI = [-1.08, 0.13], pd = 94%; Long-Term vs Control: b = 0.19, CrI = [-0.43, 0.81], pd = 73%). All interaction terms have credible intervals that encompass a wide range of both negative and positive values, suggesting considerable uncertainty about the direction and magnitude of these effects; as can be seen from Figure 5, reference to non-subjects in all 3 groups is dominated by the use of NPs.

We also analysed reference production in the one-character condition. Since this condition features a single referent, the model contained only a fixed effect of Group (Control, Short-Term English Exposure, Long-Term English Exposure, coded as before), with by-participant and by-item random intercepts. Model results are presented in Table 2 in the Appendix.

The model indicates that speakers in the Control group had no clear preference between null and overt pronouns (b = -0.07, CrI = [-0.62, 0.47], pd =61 %) but they strongly favoured overt pronouns over NPs (b = 2.91, CrI = [2.27, 3.57], pd = 100%). The Short-Term English Exposure group tended to prefer overt pronouns over null pronouns more than the Control group; however, the directionality and magnitude of the effect remain uncertain, as the credible intervals include both negative and positive values (b = 0.58, CrI = [-0.10, 1.25], pd = 96%). The Long-Term English Exposure group showed a stronger and clearer preference for overt over null pronouns than the Control group (b = 1.01, CrI = [0.34, 1.70], pd = 100%),

although again the wide credible interval indicates this difference could be quite small or large. No differences were observed between either of the bilingual groups and the Control group when comparing NPs and overt pronouns (Short-Term vs Control: b = -0.66, CrI = [-1.51, 0.15], pd = 94%; Long-Term vs Control: b = 0.09, CrI = [-0.71, 0.77], pd = 59%).

Separate analyses were conducted to directly compare the Short-Term and Long-Term English Exposure groups (the same statistical model with the Short-Term English Exposure as the reference level). Results are provided in Table 3 and 4 in Appendix. In the two-character condition, the Long-Term English Exposure group showed a stronger preference for NPs over overt pronouns than the Short-Term English Exposure group (b = 0.63, CrI = [0.05, 1.21], pd = 98%), whereas the two groups did not differ in their use of overt relative to null pronouns (b = 0.10, CrI = [-0.56, 1.21], pd = 61%). In the one-character condition, no robust difference emerged for either overt versus null pronouns (b = 0.38, CrI = [-0.28, 1.03], pd = 88%) or NP versus overt pronouns (b = 0.59, CrI = [-0.19, 1.36], pd = 93%).

In summary, in both conditions, we found that our bilingual groups showed a preference for more explicit forms (specifically, overt rather than null pronouns), relative to the control group, consistent with attrition effects shown for Italian and Spanish. Additionally, the Long-Term English Exposure group used more NPs than the Short-Term English Exposure group in the two-character condition.

3.3 Over-explicitness and L2 proficiency and use

The previous analyses look at the effect of group (Control, Short-Term English Exposure, Long-Term English Exposure) on referential choices. Here we conduct three additional sets of analyses, each using a continuous predictor from participants' questionnaire responses to

predict referential choices: (1) English proficiency, (2) English use in four skills (listening, speaking, reading, and writing), and (3) English use in specific contexts. These analyses address our second question in a fine-grained manner: whether increased L2 (English) proficiency or use correlates with a preference for more explicit forms of reference. For each participant, we computed (1) the average score of English proficiency in the 4 skills of listening, speaking, reading, and writing; (2) the average percentage of English use for each participant in the 4 skills; and (3) the average self-reported percentage of English use in 12 specific contexts. To ensure consistency, we scaled and centred all continuous predictors in the models. Results are summarised in Table 1 to 6 in Supplementary Materials.

English proficiency in the four skills

Recall that in the two-character condition, the group-based analysis found that our bilingual groups had a stronger preference for overt over null pronouns than the less English-proficient Control group, and the Long-Term English Exposure group used more NPs than the Short-Term English Exposure group. In the analysis using self-reported English proficiency, the association between increased English proficiency and the preference for overt pronouns over null pronouns was in the expected direction, but not reliable (b = 0.20, CrI = [-0.11, 0.51], pd = 90%); for NPs over overt pronouns the directionality of the effect is unclear (b = -0.06, CrI = [-0.32, 0.20], pd = 67%). In the one-character condition, our group-based analysis again showed that our bilingual groups preferred overt over null pronouns relative to the Control group; as expected, increased self-reported English proficiency was positively associated with the preference for overt pronouns over null pronouns (b = 0.38, CrI = [0.10, 0.68], pd = 99%), although the wide range of credible intervals indicate that this effect might be small. There was no clear effect of English proficiency on the use of NPs over overt pronouns (b =

0.26, CrI = [-0.09, 0.61], pd = 92%), consistent with the absence of those effects in the group-based analysis.

English use in the four skills

In the two-character condition, the association between increased English use in the four skills and the preference for overt pronouns over null pronouns was in the expected direction, but not reliable (b = 0.20, CrI = [-0.10, 0.52], pd = 91%); similarly for NPs over overt pronouns (b = 0.15, CrI = [-0.10, 0.41], pd = 89%). The first interaction term, which compares overt to null pronouns, indicates a potential (albeit weak) positive association between the English use in four skills and the preference of the more explicit form, i.e. overt pronouns, for the non-subject referents (b = 0.88, CrI = [-0.04, 1.87], pd = 97%), but the direction and magnitude of this effect remain uncertain as the credible intervals include zero. The second interaction term comparing NPs to overt pronouns showed substantial uncertainty of directionality and magnitude (b = -0.29, CrI = [-0.87, 0.31], pd = 83%).

In the one-character condition, consistent with the group-based analysis, more English use in the four skills was likely associated with the use of overt pronouns rather than null pronouns, but this association could be very small or negative (b = 0.28, CrI = [-0.02, 0.57], pd = 97%). Increased English use in the four skills also predicted a preference for NPs over overt pronouns (b=0.36, CrI = [0.03, 0.71, pd = 98%), an effect not seen in the group-based analysis, although this effect could be very small.

English use in the daily contexts

In the two-character condition, increased English use in daily contexts was associated with a preference for overt pronouns over null pronouns (b = 0.40, CrI = [0.11, 0.71], pd = 100%),

consistent with the group-based analysis. This association was not seen in the contrast of NPs versus overt pronouns (b = 0.05, CrI = [-0.19, 0.31], pd = 66%). In the one-character condition, increased English use in daily contexts was also positively associated with the use of overt rather than null pronouns (b = 0.46, CrI = [0.18, 0.75], pd = 100%), but not with the use of NPs over overt pronouns (b = 0.18, CrI = [-0.18, 0.53], pd = 85%).

In general[7], the relationship between continuous measures of English use/proficiency and referential explicitness is more pronounced in the use of overt pronouns over null pronouns in the one-character condition. However, in the two-character condition, these associations are less clear than in the group-based analysis, except for a reliable link between English use in daily contexts and a preference for overt pronouns over null pronouns.

4. Discussion

Our findings partially align with our predictions. Consistent with previous studies on reference production (Arnold & Griffin, 2007; Hwang, 2021), all speakers, irrespective of their L2 proficiency, used more NPs than pronouns in the two-character condition. Our bilingual speakers prefer more explicit forms than their more monolingual peers, indicating potential attrition in their L1 in the form of changes in referential preferences. Our data also indicate attrition-related change even after a relatively short period of L2 immersion, i.e., no more than 12 months, as seen in the Short-Term English Exposure group. Our findings align with the Interface Hypothesis and its specific predictions for L1 attrition (Sorace, 2011) and the results reported by Martin-Villena (2023) with L1 Spanish L2 English speakers. In the two-character condition we found that both Short-Term and Long-Term English Exposure

[7] We compared models with the three continuous predictors and found no reliable differences in their predictive strength for referential over-explicitness (Table 7, Supplementary Materials).

groups tended to use more overt pronouns than Control speakers. The Long-Term English Exposure group also preferred NPs over overt pronouns relative to the Short-Term English Exposure group. This suggests that while the Short-Term English Exposure group made a strong shift toward overt pronouns, the Long-Term English Exposure group did not further reinforce this tendency but instead relied more on NPs, possibly to mitigate the potential ambiguity in the two-character condition. In the one-character condition, most participants used pronouns rather than NPs, as expected, but again we see a preference for more explicit referential forms (more overt than null pronouns) in our bilingual groups relative to the Control group, with this effect being clearest in the Long-Term English Exposure group.

While our findings suggest a general preference for more explicit referential forms among our bilingual groups, the magnitude of this effect remains variable. This variability likely reflects individual differences in language use, suggesting that attrition may occur along a continuum, with general patterns emerging at the group level. As shown in Figure 5 and 6, individual variability exists in all groups. In spoken Mandarin, both null and overt pronouns are grammatically licensed and pragmatically felicitous when referring to subject referents, as each shows a strong subject bias. This makes the reference choice in these anaphoric contexts flexible and driven by individual preference. Nevertheless, a substantially larger proportion of speakers (although not all) in both the Short-Term and Long-Term English Exposure groups underuse null pronouns compared to Control speakers (see Table 5 in Appendix). As discussed earlier, attrition may not always manifest overtly in all bilinguals; instead, it may reflect reduced accessibility of certain linguistic features when their activation falls below a threshold (e.g., Chamorro et al., 2016; Glodstaf & Montrul, 2025; Paradis, 1993), potentially leading to a stronger preference for specific patterns of use. This threshold is likely

influenced by individual differences in language experience (such as language proficiency and use), as further discussed below.

Our experiment involved self-reports regarding speakers' language proficiency and use in both Mandarin and English. When asking speakers to assess their language exposure, we took into consideration the dynamic change between L1 and L2, reflecting decreased L1 coupled with increased L2. Speakers assessed their language exposure through two lenses: (1) general language skills (listening, speaking, reading, and writing), and (2) language use in more specific contexts (e.g., communicating with friends, shopping, and social events). This approach provided a more comprehensive picture of speakers' language use across various aspects of their daily routines and interactions. Our results show that using more L2 (English) and less L1 (Mandarin), as well as higher L2 proficiency, are likely to deepen the attrition process, specifically a stronger preference for overt pronouns over null pronouns, particularly clear in the one-character condition. This association is consistent with previous studies on the role of language exposure (e.g., Chamorro et al., 2016) and the role of L2 proficiency (e.g., Tsimpli et al., 2004) in the attrition process. In contrast, the two-character condition, while these associations are broadly in line with the group-based analysis, the direction and strength of the associations are inconsistent across models, with a reliable effect only observed for English use in the four general skills. The extent to which language proficiency and use drives this shift therefore appears to depend on contexts. As suggested by Arnold and Griffin (2007) and Hwang (2021), referential choice in the two-character condition is much more complex and can be influenced by an interplay of multiple factors (e.g., speaker-internal cognitive pressure and partner-directed factors such as ambiguity avoidance), compared to the much simpler, less ambiguous one-character condition.

Why does attrition result in the particular pattern of reference use that we see here? We reviewed two theories from the literature in the introduction: crosslinguistic interference, and a more general preference for redundancy/clarity/ambiguity avoidance.

Our results are hard to reconcile with the latter explanation, because the clearest attrition effects we see (i.e. the strongest preference for more explicit referential forms) tend to be in the one-character condition, where there is little referential ambiguity introduced by using less explicit referential forms. While this does not rule out some preference for redundancy or ambiguity avoidance being the cause of these effects, we think it complicates this account.

Our data do not rule out a crosslinguistic interference account: one possibility is that the pronominal system in Mandarin for our bilingual speakers might simply be influenced by the English pronominal system, potentially resulting in increased usage of overt pronouns over null pronouns throughout. To delve deeper into the impact of cross-linguistic influence in the attrition process, we next plan to study late bilingual speakers whose two languages both permit subject drop, by testing native Mandarin speakers currently residing in Italy. Given that Italian and Mandarin are pro-drop languages, but with different distributions of null and overt pronouns, we are intrigued to see how Mandarin-Italian speakers make referential choices in those discourse contexts.

5. Conclusion

We investigated attrition effects on referential choice in Mandarin Chinese using a picture description task. Compared with more-monolinguals, L1 Mandarin L2 English bilinguals preferred overt over null pronouns across one- and two-character conditions, suggesting attrition-related changes in their L1, even after brief L2 immersion (as seen in the Short-Term

English Exposure group). This preference for over-explicitness correlated with L1/L2 exposure and L2 proficiency; this correlation was clearer in the one-character condition. However, the underlying mechanisms require further investigation, particularly to differentiate between cross-linguistic interference and other cognitive mechanisms.

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Appendix

Reference Production: Reference Level = Control Group

Table 1: The outputs of the Bayesian model for effects involving Role and Group in the two-character condition. For Intercept, positive values indicate a preference for the less explicit form (listed on the right), whereas negative values indicate a preference for the more explicit form (listed on the left). For the remaining effects, it is the opposite (positive values indicate a preference for the more explicit form, listed on the right). Role = Subject and Group = Control were set as reference levels, respectively; group is dummy coded.

Predictors	**Estimates**	**95% CrI**	**PD (%)**
Intercept, Overt vs Null (Control group, Role = Subject)	0.21	[-0.36, 0.75]	77
Intercept, NP vs Overt (Control group, Role = Subject)	**-1.43**	**[-1.94, -0.93]**	**100**
Role = Non-subject, Null vs Overt (Control group)	0.42	[-0.86, 1.79]	73
Role = Non-subject, Overt vs NP (Control group)	**3.40**	**[2.42, 4.48]**	**100**
Short-Term English Exposure vs Control, Null vs Overt (Role=Subject)	**0.82**	**[0.15, 1.48]**	**99**
Short-Term English Exposure vs Control, Overt vs NP (Role=Subject)	-0.48	[-1.08, 0.13]	94
Long-Term English Exposure vs Control, Null vs Overt (Role=Subject)	**0.88**	**[0.17, 1.61]**	**99**
Long-Term English Exposure vs Control, Overt vs NP (Role=Subject)	0.19	[-0.43, 0.81]	73
Role = Non-subject * Short-Term English Exposure, Null vs Overt	-0.18	[-1.71, 1.37]	59
Role = Non-subject * Short-Term English Exposure, Overt vs NP	-0.09	[-1.32, 1.17]	56
Role = Non-subject * Long-Term English Exposure, Null vs Overt	0.25	[-1.38, 1.95]	61
Role = Non-subject * Short-Term English Exposure, Overt vs NP	-0.59	[-1.84 0.71]	82

Table 2: The outputs of the Bayesian model for effects involving Group in the one-character condition. For Intercept, positive values indicate a preference for the less explicit form (listed on the right), whereas negative values indicate a preference for the more explicit form (listed on the left). For the remaining effects, it is the opposite (positive values indicate a preference for the more explicit form, listed on the right). Group = Control was set as the reference levels and was dummy coded.

Predictors	**Estimates**	**95% CrI**	**PD (%)**
Intercept Null vs Overt (Control group)	-0.07	[-0.62, 0.47]	61
Intercept Overt vs NP (Control group)	**2.91**	**[2.27, 3.57]**	**100**
Short-Term English Exposure vs Control, Overt vs Null	0.58	[-0.10, 1.25]	96
Short-Term English Exposure vs Control, NP vs Overt	-0.66	[-1.51, 0.15]	94
Long-Term English Exposure vs Control, Overt vs Null	**1.01**	**[0.34, 1.70]**	**100**
Long-Term English Exposure vs Control, NP vs Overt	0.09	[-0.71, 0.88]	59

Reference Production: Reference Level = Short-Term English Exposure

Table 3: The outputs of the Bayesian model for effects involving Role and Group in the two-character condition. For Intercept, positive values indicate a preference for the less explicit form (listed on the right), whereas negative values indicate a preference for the more explicit form (listed on the left). For the remaining effects, it is the opposite (positive values indicate a preference for the more explicit form, listed on the right). Role = Subject and **Group = Short-Term English Exposure group** were set as reference levels, respectively; group is dummy coded.

Predictors	**Estimates**	**95% CrI**	**PD (%)**
Intercept, Overt vs Null (Short-Term English Exposure group, Role = Subject)	**-0.59**	**[-1.12, -0.09]**	**99**
Intercept, NP vs Overt (Short-Term English Exposure group, Role = Subject)	**-0.97**	**[-1.42, -0.53]**	**100**
Role = Non-subject, Null vs Overt (Short-Term English Exposure)	0.36	[-0.82, 1.64]	72
Role = Non-subject, Overt vs NP (Short-Term English Exposure)	**3.10**	**[2.30, 4.00]**	**100**
Control vs Short-Term English Exposure, Null vs Overt (Role=Subject)	**-0.84**	**[-1.54, -0.16]**	**99**
Control vs Short-Term English Exposure, Overt vs NP (Role=Subject)	0.43	[-0.18, 1.04]	91
Long-Term English Exposure vs Short-Term English Exposure, Null vs Overt (Role=Subject)	0.10	[-0.56, 0.79]	61
Long-Term English Exposure vs Short-Term English Exposure, Overt vs NP (Role=Subject)	**0.63**	**[0.05, 1.21]**	**98**
Role = Non-subject * Short-Term English Exposure, Null vs Overt	-0.39	[-2.13, 1.32]	67
Role = Non-subject * Short-Term English Exposure, Overt vs NP	0.99	[-0.43, 2.55]	91
Role = Non-subject * Long-Term English Exposure, Null vs Overt	0.31	[-1.25, 1.98]	64
Role = Non-subject * Short-Term English Exposure, Overt vs NP	-0.28	[-1.41, 0.88]	69

Table 4: The outputs of the Bayesian model for effects involving Group in the one-character condition. For Intercept, positive values indicate a preference for the less explicit form (listed on the right), whereas negative values indicate a preference for the more explicit form (listed on the left). For the remaining effects, it is the opposite (positive values indicate a preference for the more explicit form, listed on the right). **Group = Short-Term English Exposure group** was set as the reference levels and was dummy coded.

Predictors	**Estimates**	**95% CrI**	**PD (%)**
Intercept, Overt vs Null (Short-Term English Exposure)	**-0.71**	**[-1.26, -0.20]**	**100**
Intercept NP vs Overt (Short-Term English Exposure)	**3.40**	**[2.68, 4.06]**	**100**
Control vs Short-Term English Exposure, Null vs Overt	**-0.73**	**[-1.40, -0.06]**	**98**
Control vs Short-Term English Exposure, Overt vs NP	0.35	[-0.45, 1.18]	80
Long-Term English Exposure vs Short-Term English Exposure, Null vs Overt	0.38	[-0.28, 1.03]	88
Long-Term English Exposure vs Short-Term English Exposure, Overt vs NP	0.59	[-0.19, 1.36]	93

Table 5: The proportion of speakers in each group whose use of null pronouns for subject referents falls below the posterior group mean of more-monolinguals estimated by the Bayesian models: 19.4% in the Two-Character Condition; 46.8% in the One-Character Condition.

Condition	**More-Monolingual**	**Short-Term English Exposure**	**Long-Term English Exposure**
Two-Character	39% (12/31)	57% (20/35)	71% (25/35)
One-Character	48% (15/31)	74% (26/35)	83% (29/35)