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The Acquisition of de: Investigating Recursive Possession in Mandarin-Speaking Kids

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ABSTRACT

Recursive grammar is the sole cognitive mechanism unique to human languages. This study investigates three aspects of the acquisition of the recursive possessive marker *de* by Mandarin-speaking children: the feasibility of recursive possessive (RP) levels, performance in both cognition and competence, and the age at which these abilities emerge. Following a development theory of recursive possessives in language acquisition, we conducted two tasks—comprehension and production—each comprising 12 questions. The comprehension task involved a truth-value judgment, while the production task consisted of a question-and-answer session. Forty-eight preschoolers, aged three to five, were recruited from a kindergarten and divided into three age groups. Additionally, 16 adults were randomly recruited to serve as a baseline for comparison. The results revealed that significant effects of levels of recursive possessiveness were observed only in five-year-old Mandarin-speaking children, not in their three- and four-year-old counterparts. The comprehension task was significantly easier for all participants compared to the production task, suggesting that understanding the material was not challenging for any group, with no substantial differences noted among them. The results demonstrated that age effects were critical for younger children in adopting RPs. Specifically, three- and four-year-old Mandarin-speaking children demonstrated the ability to comprehend multiple levels of RP but struggled to produce them. In contrast, five-year-olds exhibited adult-like comprehension and the ability to produce Level 1 RP.

Keywords: Recursive possession; De; Age; Task; Mandarin; L1

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1. Introduction

One of the faculties in the communication system of mankind is recursion, which is not known in other species. Recursive grammar is the sole cognitive mechanism unique to human languages (Hauser, Chomsky and Fitch, 2002). Recursion involves the self-embedding of a linguistic object (Huybregts, 2019). It can be applied to numerous syntactic structures, such as nominal possessives (as in (1)), relative clauses[①] (as in (2)), or even sentences embedded within another sentence (as in (3)), thereby enabling the creation of potentially endless sentences:

(1) Mama **de** pengyou **de** maozi
mommy PM[②] friend PM hat
'Mommy's friend's hat'

(2) The man **who** saw the cat **which** chased the rat is my uncle.

(3) Eric thought **that** Tom said **that** he would come.

Expressing possession is one of the most fundamental aspects of human language and cognition (Aikhenvald, 2013). Therefore, among the aforementioned types of recursion, a nominal possessive may be acquired earliest by native speakers. This is because possessiveness in language denotes the relation between the possessor and possessed, a situation that younger children often encounter in daily life conversations. To express possession, possessive markers are often adopted as a means to bridge connections. For instance, English uses possessive markers like *'s* and *of* (as shown in (4)), whereas Mandarin Chinese uses only *de* (as illustrated in (5)):

(4) the swimming pool **of** Mary**'s** friend**'s** house

(5) Xiaoming **de** pengyou **de** fangzi **de** wuding
Xiaoming PM friend PM house PM roof
'the roof of Xiaoming's friend's house'

However, there is no difference between English, as shown in (6a), and Mandarin Chinese, as illustrated in (6b), when there is 1-level possession:

(6) a. Mommy**'s** hat
b. Mama **de** maozi
mommy PM hat

For 2-level possession or above, as possession recurs, it becomes more challenging. English-speaking children may adopt either *'s + of* or *'s + 's,* while Mandarin-speaking children can only use *de* twice. The requirement of adding another grammatical morpheme(s) may lead to errors. For example, younger children may simply utter a 2-level RP sentence like (7a), use telegraphic speech as in (7b), or employ a conjunction as in (7c):

(7) a. Lilie **de** linju **de** chezi hen da.
Lilie PM neighbor PM car very big
'Lilie's neighbor's car is very big.'
b. *Lilie (+) linju (+) chezi hen da.
Lilie PM neighbor PM car very big
c. *Lilie **de** linju **han** chezi hen da.
Lilie PM neighbor and car very big

The situation in (7b), involving the deletion of the *de* marker, is supported by empirical studies. Brow and Kohut (2020) demonstrated that 25% deletion occurred among 4-year-old Mandarin-speaking children, with a reduction to 9.17% for 6-year-olds. Similarly, Franich, Iserman and Iserman (2010) found that deletion was a common strategy employed by young children. For instance, Franich, Iserman and Iserman (2010) found that 3-year-old English-speaking children exhibited a 19% middle drop (i.e., the deletion of the second *'s* marker) and a 6% first drop (i.e., the deletion of the first *'s*), while 4-year-olds showed 4% for both middle and first drops.

In addition to deletion, children may often make errors with conjunctions (i.e., *and* in English or *han* in Mandarin) instead of the possessive marker *de,* as seen in (7c). This suggests that conjunctions (i.e., direct recursion as defined by Roeper (2011) emerge in the first stage of each recursive structure. For instance, in Gentile (2003), one third of three- to four-year-old children chose the picture of Cookie Monster and his sister when they were asked, "Can you show me *Cookie Monster's sister's* picture?" A conjunctive reading was obtained, indicating that young children mistakenly replaced one of the two *'s* markers with a conjunction in a 2-level recursive possessive phrase. For Chinese, Brow and Kohut

① The relative clauses in English differ from the *de* structure in Chinese; however, they both express the concept of recursion.
② PM = possessive marker

(2020) observed that the type of conjunction error for 4-year-old Mandarin-speaking children was 11.67% and for 6-year-olds, it was 16%. Therefore, both the deletion and conjunction strategies seem universal, as they occur in the production data of both Mandarin-speaking and English-speaking children.

The discrepancy between children's comprehension and production is a heated issue in the literature (Clark and Hecht, 1982; Clark and Bernicot, 2008; Flynn and Masur, 2007; Hendrilks and Koster, 2010). Comprehension precedes production (Clark, 2016). In theory, a native speaker should develop competence in their mother tongue and mature to produce the outcome of their comprehension (Clark, 2016). Based on sufficient stimuli and monitoring, children are able to utter their first words and two-word phrases or sentences.

Many studies (Crain, Koring and Thornton, 2017; Brown and Dailey, 2019; Brow and Kohut, 2020; Limbach, Maxi and Adone, 2010; Matthei, 1982; Pérez-Leoroux et al., 2012; Roeper, 2007, 2011) have observed that age effects are a critical factor in the acquisition of recursive phrases (RPs). Crain (1991) observed that Sesotho-speaking children grasp the use of full passives similar to English by age 3, particularly in situations of limited input (Demuth, 1989). According to Roeper, the performance difference between 3- and 4-year-olds is minimal, involving the substitution of English possessives with *no* in Japanese. Recently, some have found that 4 years old is a likely age for children to adopt recursive possessives, whether in Mandarin, English, or Japanese. For example, Brow and Kohut (2020) demonstrated that 4-year-old Mandarin-speaking children can comprehend 2-level RP. However, others have suggested other ages of development. Yang (2014) contended that children cannot comprehend and produce 2-level RP structures until they are 8 years old. Hence, age is a potential factor influencing the constraints in recursive possessives, and a focus of the present study. Based on the foregoing discussion, the complete developmental pathways for both comprehension and production are the focal points of this study.

2. Empirical studies of first language acquisition of recursive possessive

In this section, empirical studies of the first language acquisition of recursive possessives are reviewed with regard to hierarchical structure, recursive level, and age.

2.1 Hierarchical structure

The hierarchical structure in language acquisition is essential for understanding how children process and produce complex linguistic forms. Shi and Zhou (2018) revealed that 4-year-old Mandarin-speaking children showed a strong preference for the de-possessive construction over noun-noun compounds, indicating an advanced understanding of hierarchical possessive structures. This suggests that by age four, children start to grasp the layered nature of language, where possessive relationships are nested within each other. On the other hand, 3-year-olds preferred simpler noun-noun compounds, reflecting a developmental stage where simpler, linear constructions are easier to process.

Brown and Dailey (2019) provided a different perspective, arguing that recursive possessives do not necessarily follow a gradual, hierarchical learning path but emerge more spontaneously. Their analysis of Mandarin corpora showed that recursive possessives are rare in natural speech, suggesting that such hierarchical structures might not be frequently encountered or needed in everyday communication. This rarity could mean that hierarchical possessive structures might be less about natural language use and more about the specific contexts in which they are taught or studied.

Dionne and Covas (2021) proposed that hierarchical structure in possessives should be viewed as a matter of structural substitution rather than strict self-embedding. Their corpus analysis showed that Mandarin allows for more flexible hierarchical relationships between N1 and N2 positions, where nouns can be substituted bidirectionally. This flexibility contrasts with the more rigid hierarchical structures seen in English possessives. Such findings suggest

that the hierarchical nature of possessive constructions can vary significantly across languages, influenced by their syntactic norms and usage patterns.

Pérez-Leroux et al. (2022) found that structural diversity in possessive constructions does not significantly affect the acquisition of recursion in German. Children were able to understand and produce recursive possessive structures regardless of the variability in possessive forms. Their findings challenge the notion that structural diversity in a language's grammar hinders the acquisition of recursive syntax. This supports the view that the ability to acquire recursive structures is a robust aspect of language development, relatively independent of specific linguistic environments.

Li and Schuler (2023) added to this discussion by demonstrating that learners can use distributional information to determine recursive embedding through an artificial language learning paradigm. This research highlights that understanding hierarchical structures can be facilitated by exposure to distributional cues, emphasizing the importance of input in acquiring complex linguistic forms.

2.2 Recursive level

Understanding recursion levels in language acquisition is crucial for analyzing how children deal with increasingly complex linguistic forms. Shi and Zhou (2018) found that 3-year-olds were still developing their understanding of recursive possessives, with only 56% accuracy, compared to 82% in 4-year-olds. This developmental gap highlights that younger children find it challenging to handle multiple layers of possession, suggesting a developmental trajectory where the ability to process recursive structures improves with age and experience.

Brown and Dailey (2019) challenged the traditional view of a gradual emergence of recursion by showing that children as young as four could spontaneously generate Level 2 genitives in both English and Mandarin. This finding suggests that the ability to understand and produce recursive structures might be an innate feature of the human language faculty, emerging naturally without the need for a specific transitional phase. This perspective implies that recursion is a fundamental aspect of language that children can grasp earlier than previously thought.

Brow and Kohut (2020) provided further insights by analyzing errors in recursive possessive tasks. They observed that as recursion levels increased, older children (6-year-olds) made more conjunction errors, indicating that higher levels of recursion pose significant challenges even for older children. The fluctuating error rates between 2-level and 3-level recursions suggest that there are specific thresholds of complexity that children struggle with, necessitating further investigation into how children manage these increasingly complex structures. This points to a nuanced understanding of recursion, where children's ability to handle recursive levels can vary based on the specific linguistic and cognitive demands of the task.

Li and Schuler (2023) expanded on this by showing that children can use distributional cues to acquire recursive structures, suggesting that the input they receive plays a crucial role in understanding recursion. This finding underscores the importance of the learning environment in facilitating the acquisition of complex recursive levels.

2.3 Age

Age is a pivotal factor in language acquisition, significantly affecting how children learn and use possessive constructions. Shi and Zhou (2018) demonstrated that 4-year-olds performed much better than 3-year-olds in producing de-possessive constructions, with accuracy rates of 82% and 56%, respectively. This difference underscores that as children grow older, their cognitive and linguistic abilities improve, enabling them to handle more complex language structures. The developmental stage of 3-year-olds shows a preference for simpler constructions, indicating that younger children are still building foundational linguistic skills.

Brown and Dailey (2019) found that children as young as four could generate recursive possessives, challenging the idea that these structures require a specific transitional phase. This finding aligns with

the notion that certain linguistic abilities may emerge earlier than traditionally expected, suggesting that the capacity for recursion might be an inherent aspect of language acquisition. The early emergence of recursive abilities indicates that age-related developmental stages might be more about refining and expanding existing capabilities rather than acquiring entirely new ones.

Brow and Kohut (2020) noted that while there was no significant age effect in their pre-task phase, older children (6-year-olds) exhibited more conjunction errors with increasing recursion levels. This indicates that while older children might have a better grasp of basic recursive structures, they still face challenges as the complexity of the recursion increases. The increased rate of reduction errors among younger children (4-year-olds) suggests that they are still developing the ability to manage complex hierarchical relationships. This highlights that age plays a crucial role in language acquisition, but the specific nature of linguistic tasks and the levels of complexity involved also significantly influence performance.

Dionne and Covas (2021) further investigated the role of distributional learning in acquiring recursive structures, emphasizing that exposure to structured linguistic input can aid in overcoming age-related limitations. This research suggests that targeted linguistic experiences can help younger children develop the ability to handle complex recursive structures, bridging the gap observed in earlier studies.

To sum up, the studies reviewed above provide a comprehensive understanding of how hierarchical structures, recursive levels, and age impact the acquisition of possessive constructions in children. Shi and Zhou (2018) highlighted that older children (4-year-olds) show a better grasp of hierarchical and recursive possessive constructions compared to younger children (3-year-olds), indicating a developmental trajectory in linguistic capabilities. Brown and Dailey (2019) challenged traditional views by showing that recursion might emerge spontaneously and earlier than previously thought, with children as young as four demonstrating the ability to generate recursive structures. Brow and Kohut (2020) and Dionne and Covas (2021) emphasized the role of distributional learning in acquiring these complex structures, suggesting that targeted linguistic input can facilitate the understanding and production of recursive possessives. Overall, the findings underscore the importance of age, linguistic input, and the complexity of the task in language acquisition, providing valuable insights into how children develop advanced linguistic skills.

To investigate how Mandarin-speaking children acquire the recursive possessive marker *de*, we consider the following research questions:

1) How do Mandarin-speaking children perform on different recursive levels of Mandarin possessives?
2) Do Mandarin-speaking children correctly comprehend and produce recursive possessives?
3) Is age a crucial factor affecting the acquisition of the recursive levels in Mandarin possessives?

Therefore, the present study aims to advance the understanding of language acquisition, specifically the development of recursive grammar in Mandarin-speaking children. It highlights the age at which children demonstrate adult-like comprehension and production of recursive structures, contributing to linguistics and cognitive science. The findings can inform early childhood education strategies, helping educators design age-appropriate curricula. Knowing that five-year-olds show significant comprehension and production of recursive possessive structures aids speech-language pathologists in diagnosing and creating interventions for children with language delays, allowing for more targeted therapies.

3. Research design

3.1 Participants

Numerous studies have shown that children aged three to eight years old are capable of comprehending and producing multiple levels of recursive possessives (hence RPs) (Brown and Dailey, 2019; Brow and Kohut, 2020; Shi and Zhou, 2018). However, Roeper (2007) noted that English-speaking children

could not produce RPs to yield 2 or 3 levels of RP or even 4 levels (Fujimuri, 2010) until they were 6 years old (LaMendola and Scott, 2017). Moreover, while some studies have focused on levels of RPs, others have examined the age effect, and some may have only included comprehension or production tasks, leading to different results for the same questions. As a result, there may be potential gaps among the recursive levels, ages, and task effects.

In the present study, forty-eight participants were divided into three experimental groups, each consisting of 16 children. Additionally, G4, which also comprised 16 participants, served as the adult group. The age range of the experimental groups was 3 to 6 years old, while the adult group consisted of university students aged 23 to 30. **Table 1** presents the participants' background information:

Table 1. Demographic details of participants.

Group	Age Range	Mean Age	Number
Group 1	3–4	3.5	16
Group 2	4–5	4.6	16
Group 3	5–6	5.5	16
Group 4 (native adults)	23–30	25.8	16

The younger participants were preschoolers from a non-profit kindergarten. Participants in G1 through G3 received instruction in Mandarin Chinese and had weekly English classes, each lasting 30 minutes. All participants were from middle-class socioeconomic backgrounds. Since this study focused on first language acquisition research, Mandarin Chinese was the mother tongue of all participants. Additionally, none of the participants had a history of speaking or hearing difficulties or cognitive impairments. Their language learning experiences/ backgrounds were consistent, with exposure primarily to Mandarin Chinese and limited, structured exposure to English. IQ scores for all participants were within the average range, ensuring no significant cognitive differences that might affect the study's outcomes.

3.2 Materials and methods

This study examines the ability of participants of different ages and levels to interpret and perform linguistic structures, using a quantitative cross-sectional approach instead of a qualitative longitudinal method due to its wider generalizability and objective validation (Larsen-Freeman and Long, 1991; Reichardt and Cook, 1979). Additionally, while previous research explored recursive types, task effects, and age effects, it did not comprehensively address these questions, and the results were inconsistent. To overcome the difficulties in collecting natural data on recursive possessives, we used a comprehension-focused methodology. This involved truth-value judgment (TVJ) and question-and-answer (Q&A) tasks, designed with scenarios to evaluate and elicit the target structure in children's comprehension and production of Mandarin.

Brow and Kohut (2020) observed that Mandarin-speaking children in China often use conjunction structures or deletion instead of recursive possessives (RPs) in Level 2–3 recursion comprehension tasks, but did not explore their actual production of such phrases. Similarly, Fujimori's (2010, Unpublished) pilot study on 4-level recursive possessives, with its limited scope of only 10 questions, could not definitively describe Japanese-speaking children's ability with 4-level recursion. Addressing these research gaps, this study introduces tasks that cover both comprehension and production, including 4-level recursion, to determine whether children in Taiwan exhibit similar capabilities, as shown in **Table 2**, with a comprehension and a production task section.

Each section contained eight questions, covering recursion levels 1 to 4 for both tasks, with two questions at each recursion level, evenly distributed. Participants were required to respond to the comprehension task by indicating a designated color as the token of their answer. Additionally, there were four distractors for each task, with a filler question placed after every two consecutive questions, to assess the participants' cognition.

Table 2. Types of recursive possessives in the two tasks.

Type	Example(s)	Comprehension Task		Production Task	
		No.	Q No.	No.	Q No.
Level 1	*Xiaomei de pengyou* 'Xiaomei's friend'	2	CQs1, 2	2	PQs1, 2
Level 2	*Xiaomei de pengyou de gou* 'Xiaomei's friend' dog'	2	CQs4, 5	2	PQs4, 5
Level 3	*Xiaomei de pengyou de gou de qiu* 'Xiaomei's friend's dog's ball'	2	CQs7, 8	2	PQs7, 8
Level 4	*Xiaomei de pengyou de pengyou de fangzi de youyongchi* 'the swimming pool of Xiaomei's friend's friend's swimming pool'	2	CQs10, 11	2	PQs10, 11
Distractor	*Qing wen zhe shi yi ge pingguo ma?* 'Is this an apple?'	4	CQs, 3, 6, 9, 12	4	PQs3, 6, 9, 12
Total		12		12	

Note: CQ: comprehension Questions; PQ: production questions.

Comprehension task: truth-value judgement task

The comprehension of one's own language is often referred to as data on learners' competence (Fraser, Rintell and Walters, 1980), while others define it as metalinguistic judgment data (Chaudron, 1983). Younger children first comprehend the utterances around them, and then, after the maturation of both their cognition and physical abilities, start to produce language and interact with their surroundings. Therefore, a comprehension task involving truth-value judgment was the first step of the present study to test at what ages and to what extent younger Mandarin-speaking children in Taiwan were able to understand recursive possessives③.

As shown in **Table 3**, participants were asked questions such as "*Xiaoming de mingpai de daizi shi lanshede, dui bu dui?"* (Is it correct that Xiaoming's name card strap is blue?).

Participants were expected to answer with "Yes" or "No," or they could simply nod or shake their head to indicate their comprehension of the experimenter's interpretation of the target picture.

Production task: question-and-answer task

Conducting a question-and-answer session with stimuli is a common method for eliciting language acquisition data (Larsen-Freeman and Long, 1991) that aligns with the requirements of the present study. In theory, researchers who prefer quantitative methods would opt to use instruments in their studies (Larsen-Freeman and Long, 1991) rather than relying solely on spontaneous or natural data. Additionally, learners inherently impose limitations on the data (Corder, 1981), making it preferable to design specific aspects of linguistic performance to immerse participants in relevant circumstances rather than expecting target linguistic structures to emerge in all settings.

For the production task, participants were presented with a picture featuring two main roles, each with identical items but in different colors. They were then asked questions as outlined in **Table 4** to elicit the recursive possessive *de* structure.

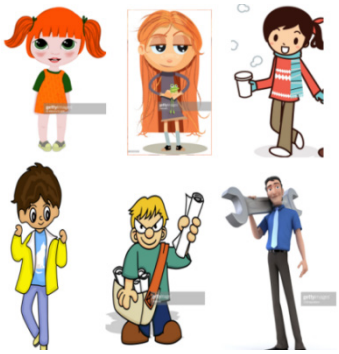
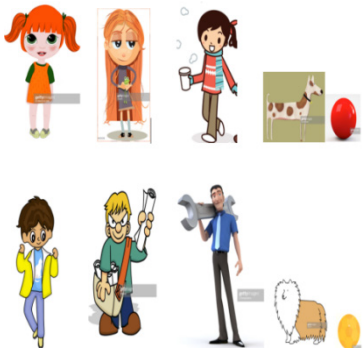
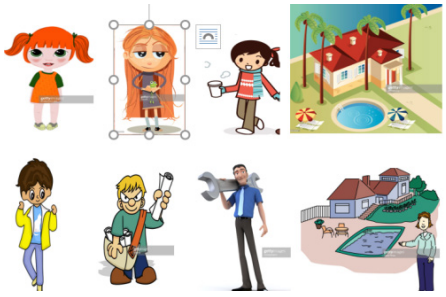
Participants were expected to clarify the possession of the target item, as both roles possessed the same items but in distinct colors.

③ We agree with one of the reviewers that it would be beneficial for our comprehension task (TVJ task) to request participants to explain why they believed certain statements were false. However, given that the children involved in this study were between the ages of 3 and 6, it was challenging to ask them to provide such explanations. We have acknowledged this as a limitation of the study.

Table 3. An example of Level 2 recursive possessives for the TVJ task.

The Participant Saw	The Participant Heard
	*Zhe shi Xiaoming. Zhexie shi tade shubao, mingpai, shuihu, qiuxie, gen qianbihe. Tade mingpai de daizi shi lansede, dui bu dui?* 'This is Xiaoming. These are his schoolbag, name card, water bottle, sneakers, and pencil box. The strap of his name card is blue. Is it true?'

Table 4. An example of Level 2 recursive possessives for the Q&A task.

RP Level	The Participant Saw	The Participant Heard
Level 1		*Zhe shi Xiaomei, Xiaoming han tamende xiezi. Zhe zhang tu li you shenme dongxi shi baishede?* 'Here are Xiaomei, Xiaoming, and their shoes. Is there anything white in this picture?' Expected answer: *Xiaomei* ***de*** *xiezi 'Xiaomei's shoes'*
Level 2		*Zhe shi Xiaomei, Xiaoming, han tamende pengyou. Zhe zhang tu li sheide shou shang you beizi?* 'Here are Xiaomei, Xiaoming, and their friends. Who is holding a cup in this picture?' Expected answer: *Xiaomei* ***de*** *pengyou* ***de*** *pengyou* 'Xiaomei's friend's friend'
Level 3		*Zhe shi Xiaomei, Xiaoming, tamende pengyou, han tamende gou. Zhe zhang tu li na zhi gou you hongsede qiu?* 'Here are Xiaomei, Xiaoming, their friends, and their dogs. Which dog has a red ball in this picture?' Expected answer: *Xiaomei* ***de*** *pengyou* ***de*** *pengyou* ***de*** *gou* 'Xiaomei's friend's fiend's dog'
Level 4		*Zhe shi Xiaomei, Xiaoming, tamende pengyou, han tamende fangzi. Zhe zhang tu li yousheme shi yi ge da yuanxingde?* 'Here are Xiaomei, Xiaoming, their friends, and their houses. Which picture has a big circle?' Expected answer: *Xiaomei* ***de*** *pengyou* ***de*** *pengyou* ***de*** *fangzi* ***de*** *youyongchi* 'Xiaomei's friend's friend's house's swimming pool'

3.3 Procedures

Participants' parents completed a consent form in advance to inform them of the study's goals, task materials, and expected results. After receiving all consent forms, the Q&A task was conducted first, followed by the TVJ task in a quiet, separate room to minimize interruptions to the experiment. In the Q&A task, the focus was on how participants used the *de* marker in recursive possessives. Its omission was evaluated as incorrect or incomplete, as shown in **Table 4**. The complete use of the *de* marker(s) was scored as 1, with zero adoption of *de* receiving the lowest score of 0. Omissions were scored at 0.5; for example, one or two omissions of *de* in a 3-level recursive possessive received a score of 0.5 each, while one, two, or three omissions in a 4-level recursive possessive were scored accordingly.

Table 5. Scoring on the Q&A task.

Example	Participant's Answer	Score	Note
1-level RP *Xiaomei **de** xiezi* 'Xiaomei**'s** shoes'	*Xiaomei **de** xiezi*	1	correct
	*Xiaomei **ø** xiezi*	0	1 *de* omission
2-level RP *Xiaomei **de** pengyou **de** pengyou* 'Xiaomei**'s** friend**'s** friend'	*Xiaomei **de** pengyou **de** pengyou*	1	correct
	*Xiaomei **ø** pengyou **de** pengyou* *Xiaomei **de** pengyou **ø** pengyou*	0.5	1 *de* omission
	*Xiaomei **ø** pengyou **ø** pengyou*	0	2 *de* omissions
3-level RP *Xiaomei **de** pengyou **de** pengyou **de** gou* 'Xiaomei**'s** friend**'s** friend**'s** dog'	*Xiaomei **de** pengyou **de** pengyou **de** gou*	1	correct
	*Xiaomei **ø** pengyou **de** pengyou **de** gou*	0.5	1 *de* omission
	*Xiaomei **ø** pengyou **ø** pengyou **de** gou*	0	2 *de* omissions
4-level RP *Xiaomei **de** pengyou **de** pengyou **de** fangzi **de** youyongchi* 'Xiaomei**'s** friend**'s** friend**'s** house**'s** swimming pool'	*Xiaomei **de** pengyou **de** pengyou **de** fangzi **de** youyongchi*	1	correct
	*Xiaomei **ø** pengyou **de** pengyou **de** fangzi **de** youyongchi*	0.5	1 *de* omission
	*Xiaomei **ø** pengyou **de** pengyou **de** fangzi **ø** youyongchi*	0	2 *de* omission

Answers to questions in the TVJ task were designed to be either "Yes" or "No," with scores of 1 or 0 assigned accordingly. For instance, when participants were asked "*Xiaoming de mingpai de daizi shi hongse, dui bu dui?*" ('Is it true that the strap of Xiaoming's name card is red?') as shown in Table 2, they received a score of 1 for the correct answer "No," or 0 for the incorrect answer "Yes," since the strap of Xiaoming's name card was blue.

After scoring the participants' responses, statistical analysis was conducted using R software. Means were calculated to examine the average scores achieved by participants on both the Q&A and TVJ tasks. Additionally, a two-way ANOVA was performed to explore potential interactions between task type (Q&A *vs.* TVJ) and participant characteristics, providing insights into any significant differences in performance based on these factors.

4. Results and discussion

4.1 Recursive levels

The first research question focuses on examining the performance of Mandarin-speaking children across different recursive levels of nominal possessives. Previous studies have predominantly investigated Level 2 recursive possessives methodologically.

Table 6 shows that the means of each level in the experimental groups exhibited a pattern where Level 1 > Level 2 = Level 3 = Level 4. By contrast, there appeared to be no significant difference in the adult group, with Level 1 = Level 2 = Level 3 = Level 4. This trend suggests that as the complexity

of the recursive levels increased, participants in the experimental groups experienced a decrease in performance, whereas performance remained consistent across all levels in the adult group.

The developmental path of the acquisition of levels in Mandarin recursive possessives (RP) appears to be divided into two sections: Level 1 and levels beyond Level 1 (i.e., Levels 2, 3, and 4 in the present study). This conclusion is drawn from the observation that the only significant difference was found between Level 1 and Level 2 (0.61 vs. 0.53), while no significant differences were observed between Level 2 and Level 3 (0.53 vs. 0.52), Level 2 and Level 4 (0.53 vs. 0.50), or Level 3 and Level 4 (0.52 vs. 0.50). By contrast, the control group, with proficiency in the target language, showed no significant differences, with scores close to full accuracy across all levels. Detailed statistics including means scores, standard deviations (SDs), and *p*-values for each level in the groups are listed in **Table 7** below.

Table 6. Participants' overall performance on the distinctive levels of RPs.

Level / Group	Level 1		Level 2		Level 3		Level 4	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Experimental	0.61	0.21	0.53	0.14	0.52	0.14	0.50	0.13
Adult	1.00	0.00	1.00	0.00	0.98	0.05	0.98	0.05

Table 7. Mean scores of each group on different Levels of RPs.

Level / Group	Level 1		Level 2		Level 3		Level 4		*p*-value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
G1	0.42	0.18	0.39	0.13	0.40	0.14	0.36	0.13	0.9106
G2	0.50	0.26	0.46	0.13	0.48	0.13	0.46	0.11	0.9685
G3	0.90	0.20	0.73	0.17	0.67	0.15	0.69	0.14	0.0004
Adult	1.00	0.00	1.00	0.00	0.98	0.05	0.98	0.05	0.1053

The data in **Table 7** shows that RP levels were not significant for 3-year-old, 4-year-old Mandarin-speaking children, and Adults ($p > 0.05$). Only the 5-year-old group (G3) had significant results ($p < 0.01$), indicating a difference between levels. For G1 and G2, levels were not significant, suggesting they were at the same cognitive development stage. G3 showed differences between levels, with Level 1 being different from Levels 2, 3, and 4 ($p < 0.05$ and $p < 0.01$). G3 had similar availability degrees for Levels 2, 3, and 4.

Our analysis employed a two-way ANOVA with participants' overall correct responses as the dependent variable, and Age Group (G1, G2, G3, G4) and Levels (Levels 1–4) as factors. Results revealed a significant main effect of Age Group ($F(3, 993) = 96.4647$, $p < 2.22e\text{-}16$***), indicating variations in performance across different age groups. Additionally, there was a significant main effect of Levels ($F(3, 993) = 7.5392$, $p < 5.4498e\text{-}05$***), suggesting differences in performance across the four recursive levels. However, the interaction between Age Group and Levels was not found to be significant ($F(9, 993) = 1.3605$, $p = 0.20162$), indicating that the relationship between age group and performance did not vary significantly across different recursive levels.

The levels of recursive possessives (RP) showed no significance for Mandarin-speaking children younger than 5 in the present study, which is consistent with previous research suggesting that children comprehend and produce Level 2 or higher at a later stage in their language development (Brown and Dailey, 2019; Matthei, 1982; Pérez-Leroux et al., 2012; Roeper, 2007, 2011). Despite there being four levels in the task, it appears that there were only two segments: Level 1 and levels beyond Level 1 (i.e., Levels 2, 3, and 4). This result also aligns with previous studies indicating that younger children's performance on different levels of RP is good at when comprehending and producing one level (Brown, 1973), but two or three levels of RP present difficulties (Roeper, 2011), and achieving all four levels is even rarer. Roeper suggested that the time-course of each form of recursion may be influenced by the

amount of exposure involved, as well as the nature of derivation and its intersection with morphology (Roeper, 2011). Furthermore, the age of five was proposed as an important threshold between Level 1 and Level 2 for Mandarin-speaking children, suggesting that 5-year-olds overcome the gap between these levels, enabling them to handle hierarchical structures rather than flat structures.

Nevertheless, the present study found that levels were significant for 5-year-old Mandarin-speaking children, which differs from previous studies suggesting that Level 2 could be produced by four-year-olds (Brown and Dailey, 2019; Brow and Kohut, 2020; Shi and Zhou, 2018). This discrepancy may be attributed to the ease or complexity of the task design employed. For example, Brown and Dailey (2019) used a storytelling task where a role in the story provided a hint with the target *de* marker in a complete sentence to participants, allowing them to imitate the whole sentence by changing one of the noun phrases to obtain the correct target structure. Meanwhile, in the present study, there were no such prompts, and the questions were open-ended.

In conclusion, our findings shed light on the developmental trajectory of the Chinese recursive possessive *de* in Mandarin-speaking children. While younger children demonstrate proficiency primarily at Level 1 of recursive processing, older children exhibit greater competence in handling more complex hierarchical structures. The discrepancies observed between this study and previous research underscore the influence of task design on children's performance and emphasize the need for further investigation into the factors affecting the acquisition of the recursive possessive marker.

4.2 Task effect

The second research question explored whether Mandarin-speaking children could both understand and produce RP accurately. The comprehensive results presented in **Table 8** below unequivocally illustrates that participants excelled more in comprehension than in production tasks, with mean scores of 0.87 and 0.20, respectively.

Performances on both tasks exhibited significant differences, as indicated by $p < 0.01$ for the experimental group. Furthermore, the adult group also demonstrated a significant disparity in task performance, with $p = 0.01308$ (below the 0.05 threshold). This suggests that the abilities of younger Mandarin-speaking children were notably better on the comprehension task than the production task. This finding echoes the notion of comprehension preceding production (Clark, 2016), indicating that comprehension not only precedes production but also exceeds it asymmetrically. Language speakers may comprehend rare structures, but may produce them only rarely or perhaps never (Clark, 2016). This explains why Mandarin-speaking children as young as three years old were able to comprehend Level 4 RP but were unable to produce Level 1 RP, with such asymmetry.

After comparing the performances of children and adults, the results for each group on the comprehension task are presented in **Table 9**.

Table 8. Comparison of children and adults in the tasks.

Task / Group	Comprehension		Production		*p* -value
	Mean	SD	Mean	SD	
Experimental	0.87	0.15	0.20	0.15	< 2.22e-16***
Adults	1.00	0	0.98	0.03	0.01308

Table 9. Mean scores of each group on the comprehension task.

Group / Task	Level 1		Level 2		Level 3		Level 4		*p*-value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
G1	0.75	0.44	0.78	0.42	0.78	0.42	0.72	0.05	0.92839
G2	0.78	0.42	0.84	0.37	0.91	0.30	0.91	0.30	0.42386
G3	1.00	0.00	1.00	0.00	1.00	0.00	1.00	0.00	0.39531
Adults	1.00	0.00	1.00	0.00	1.00	0.00	1.00	0.00	0.395

G1 demonstrated competence on the comprehension task, even achieving a mean score of 0.72 for Level 4, the most challenging items in the task. Furthermore, G2 excelled with a remarkable score of 0.91 in Level 4, while G3 achieved perfect accuracy across all levels of the task, indicating that 5-year-old Mandarin-speaking children possess the ability to perform at an adult-like level in comprehending RP in Mandarin. Moreover, with all *p*-values > 0.05, our results suggest that younger Mandarin-speaking children exhibit proficiency in comprehending RP, as there were no significant differences observed.

Moreover, there was a high level of significance for each level among groups on the comprehension task, with all *p*-values < 0.01. This indicates substantial distinctions among groups at every individual level of the task, with Level 4 showing the most pronounced differences. Given the extreme significance observed at each individual level among groups on the comprehension task, it was found that regardless of the level examined in this task, there was consistently a *p*-value of 1 between G3 and G4. This suggests that 5-year-old Mandarin-speaking children may possess a level of proficiency similar to that of adults. Furthermore, although the *p*-value for the G1:G2 comparison in Level 1 showed no significant difference in comprehension between them (p = 0.7457, > 0.05), significance tended to increase as the levels progressed: p = 0.2157 (> 0.05) for Level 3, and notably, p = 0.027 (< 0.05) for Level 4. This indicates that Level 4 differentiated G2 comprehension ability from G1.

The performance on the production task, as shown in **Table 10** below, exhibited no significant differences for G1 (p = 0.0999035 (> 0.05)), G2 (p = 0.083879 (> 0.05)), and adults (p = 0.098822 (> 0.05)). However, our results suggested that the age of five (G3) was critical for Mandarin-speaking children in performing RP correctly, with a correctness rate of 0.78 for Level 1 and 0.45 for Level 2. For G1, they were barely able to produce RP with a mean correctness rate of 0.028 (averaging Levels 1 through 4) in the task. Although G2 performed better with a mean correctness rate of 0.22 in Level 1, there was not much difference between Levels 2 to 4. Therefore, Mandarin-speaking children younger than 5 years old were unable to produce RP orally. By contrast, at 5 they were able to produce Level 1 RP in Mandarin but struggled with Levels 2 through 4. The task result for Level 1 in G3 was better than for Levels 2, 3, and 4, with extreme significance (p = 0.00207 (< 0.01), p = 3.15e-05*** (< 0.01), and p = 1.15e-04*** (< 0.01), respectively).

The participants' overall performance on the production task exhibited significant results (p < 0.01) for each individual level across the groups, as shown below.

Table 10. Mean scores of each group on the production task.

Level / Group	Level 1		Level 2		Level 3		Level 4		*p*-value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
G1	0.09	0.30	0.00	0.00	0.02	0.09	0.00	0.00	0.099035
G2	0.22	0.42	0.08	0.18	0.05	0.15	0.02	0.09	0.083879
G3	0.78	0.42	0.45	0.39	0.34	0.35	0.38	0.29	1.0693e-05 ***
Adults	1.00	0.00	1.00	0.00	0.95	0.15	0.95	0.15	0.098822

The task results showed extreme significance for all *p*-values < 0.01 between groups of G4:G1, G4:G2, G1:G3, and G2:G3. G3 (5-year-old Mandarin-speaking children) performed better on Level 1, but not on Levels 2, 3, and 4, as observed by the degree of significance between G4:G3, where p = 0.0189 (< 0.05) for Level 1, but p = 2.52e-14, p = 6.53e-17, and p = 9.28e-20 (< 0.01) for Levels 2, 3, and 4, respectively. These figures indicate that their performance on Level 1 was far more distinctive than on Levels 2, 3, and 4. Moreover, the comparisons between G1 and G2 are also worth mentioning, as they show no significant distinction between the two groups, with p = 0.134, p = 0.1, p = 0.482, and

$p = 0.661$ (> 0.05) for Levels 1, 2, 3, and 4, respectively. This suggests that G1 and G2 exhibited a similar degree of unavailability when producing meta-levels of RP in Mandarin. That is to say, 3-year-old Mandarin-speaking children actually had a degree of comprehension ability similar to that of 4-year-olds, a result not clearly found in previous studies.

Analysis using a two-way ANOVA with the participants' overall correct responses as the dependent variable, and Age Group (G1, G2, G3, G4) and Tasks (comprehension and production) as factors, yielded several significant findings. There was a significant main effect of Age Group ($F(3, 1001) = 510.08$, $p < 0.001$), indicating differences across age groups. Additionally, there was a significant main effect of Tasks ($F(1, 1001) = 736.72$, $p < 0.001$), suggesting variations between comprehension and production tasks. Moreover, there was a notable interaction between the two factors ($F(3, 1001) = 190.08$, $p < 0.001$), indicating that the relationship between age group and task performance was not uniform across all groups.

Previous research suggested that four years old was a critical age for Level 2 comprehension (Brown and Dailey, 2019; Brow and Kohut, 2020; Shi and Zhou, 2018), but not for 3-year-olds. However, in the present study, G1 showed no significant distinction from G2 for Level 2 comprehension. Even for Level 3, there was still no significance shown between the 3-year-olds and the 4-year-olds.

In their ability to produce RPs in Mandarin, both 3- and 4-year-old Mandarin-speaking children seemed unable to produce meta-levels of RPs, a finding that differed from the findings of previous studies. Previous research indicated that 4-year-old children were able to produce Level 2 RPs (Brown and Dailey, 2019; Brow and Kohut, 2020; Shi and Zhou, 2018). However, our findings align with those of Roeper (2011) and Yang (2014), suggesting that children between six and eight years old are able to produce Level 2 RPs.

In sum, our findings shed light on the nature of these developmental stages, particularly within Mandarin-speaking children. This underscores the necessity for ongoing exploration into the factors shaping language development across diverse age groups and linguistic environments.

4.3 Age effect

Previous research identified age 4 as a pivotal age for children in the initial acquisition of their first language, particularly for understanding RP (Brow and Kohut, 2020; Shi and Zhou, 2018). Several studies, such as Yang (2014), proposed that children at age 4 could comprehend and produce Level 1 recursive possessives, but achieving proficiency in Level 2 may not occur until age 8. However, few studies have systematically investigated the ages at which children acquire the comprehension and production skills for Level 1 through 4 RP. This study explores the age effect more deeply from two perspectives: the level and the task of RP. The age effect was found to be highly significant across all RP levels, with all *p*-values being less than 0.01 (*p*-values less than 2.22e-16 for Levels 1 & 2, 5.23e-14 for Level 3, and 7.14e-16 for Level 4). Additionally, while age impacts how Mandarin-speaking children perform across different RP levels, no significant differences were found when comparing different ages within the same level. For instance, the performances of G1 and G2 across all levels showed no significant differences, with all *p*-values greater than 0.05 ($p = 0.255$ for Level 1, $p = 0.399$ for Level 2, $p = 0.308$ for Level 3, and $p = 0.164$ for Level 4). Further, there was no significant difference between G3 and G4 at Level 1 RP, with a *p*-value of 0.223, indicating that 5-year-old Mandarin speakers are as proficient as adults in producing Level 1 RP. In conclusion, as outlined in **Table 11**, the data suggest that the age effect is a significant factor in both tasks and levels in the first language acquisition of RP among Mandarin Chinese speakers.

Table 11. Age effect on the two tasks.

Task \ Group	G1		G2		G3		G4		*p*-value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Comprehension	0.76	0.24	0.86	0.20	1.00	0.00	1.00	0.00	4.07e-14***
Production	0.03	0.08	0.09	0.11	0.49	0.26	0.98	0.03	< 2.22e-16***

Table 11 shows that there were highly significant differences ($p < 0.01$) for all group comparisons, except between G2 and G1, where the difference was significant but less so ($p < 0.05$). Regarding comprehension, children in G3 showed a mastery of understanding comparable to adults, as there was no significant difference ($p > 0.05$). However, the production abilities of 5-year-old children (likely G4) fell short of adult standards, marked by a highly significant difference ($p = 2.02e\text{-}38$) when compared to G3. These findings clearly indicate an age-related improvement in both comprehension and production of language among Mandarin-speaking children, emphasizing the significant role of age in language development.

At the age of 5, children begin to demonstrate adult-like comprehension and production of Level 1 recursive possessives (RP), which is slightly older than what several past studies have indicated. Previous research suggested that children as young as 4 may reach this level. Notably, Roeper (2007) found that English-speaking children do not fully master nominal recursive possessives until age 6. This aligns with the results of our pilot study, in which a child aged nearly 7 achieved 70% accuracy in tasks involving four levels of RP. Similarly, Pérez-Leroux et al. (2012) observed that 3–5-year-old English-speaking children struggled more with nominal RPs than with prepositional recursions (Shi et al., 2019), supporting the idea that the age of 5 is likely more important for mastering multiple RP levels than age 4.

These findings emphasize the need to acknowledge each child's unique developmental path and individual differences when assessing language development. The research indicates a consistent growth in language abilities between the ages of 4 and 6, rather than a sudden leap. This slow and steady improvement underscores the importance of adapting language learning challenges to match the cognitive developmental stages of children.

5. Conclusions

This research highlights three main areas concerning the acquisition of recursive possessive (RP) by Mandarin-speaking children: the levels of RP, the tasks involved, and the influence of age. First, a noticeable advancement in RP levels is evident only after the age of five, marking a pivotal developmental stage between Levels 1 and 2. Before this age, children seemed to manage all levels similarly. Second, both comprehension and production tasks showed significant results across all age groups, with comprehension consistently stronger than production. Third, age proved to be an important determinant, with older children (G3 and G4) achieving nearly adult levels of comprehension and only the children in the oldest group (G4) nearing adult production skills.

This study methodically identified obstacles and delineated pathways for improvement. For example, we acknowledge the limitations posed by the small sample size in our study. Due to logistical constraints and the availability of participants within the specified age range, we faced challenges in recruiting a larger cohort. Recruiting more child participants would be desirable. Additionally, we found that Mandarin-speaking children grappled with the production of four levels of RPs, indicating a developmental phase akin to Piaget's (1964) preoperational stage. This highlights the necessity for future investigations to tailor the complexity of RP levels to the linguistic development of these children, with recommendations leaning towards using two or three RP levels. Furthermore, this study underscored the significance

of exploring the RP acquisition process systematically by involving 6-year-old participants, potentially elucidating the developmental trajectory further. It is suggested to incorporate moderately complex tasks to elicit more responses and refine test questions to enhance authenticity.

Author Contributions

Conceptualization, Li-wen Joy Chien and Chun-yin Doris Chen; methodology, Li-wen Joy Chien and Chun-yin Doris Chen; software, Li-wen Joy Chien; validation, Chun-yin Doris Chen; formal analysis, Li-wen Joy Chien and Chun-yin Doris Chen; investigation, Li-wen Joy Chien; resources, Li-wen Joy Chien and Chun-yin Doris Chen; data curation, Li-wen Joy Chien; writing—original draft preparation, Li-wen Joy Chien; writing—review and editing, Chun-yin Doris Chen; visualization, Li-wen Joy Chien; supervision, Chun-yin Doris Chen; project administration, Chun-yin Doris Chen; funding acquisition, Chun-yin Doris Chen. Both authors have read and agreed to the published version of the manuscript.

Conflict of Interest

The Authors declare that there is no conflict of interest.

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