

**Relative gradable adjective recursion such as *small small big mushrooms* is more challenging for children than possessive recursion such as *the deer's friend's sister's mushrooms***

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**Abstract.** Our experiment investigates whether children handle recursive possessives (R-Poss) in a more adult-like manner than recursive relative gradable adjectives (R-RGA). While the abstract notion of indirect recursion underlies both categories, we ask whether individual syntactic-semantic properties determine different acquisition paths in English for R-Poss and R-RGA at the 2-Level (*the deer's friend's mushrooms, small big mushrooms*) and at the 3-Level (*the deer's friend's sister's mushrooms, small small big mushrooms*). The results indicate that older children perform better than younger children on 2- and 3-Level R-Poss. However, this trend is not observed for R-RGA where both age groups perform similarly, successfully handling 2- but not 3-Level R-RGA. Analysis of individual results reveal that children who are successful with comprehension and production at 3-Level R-RGA are also successful with 3-Level R-Poss, but not the other way around. We conclude that 3-Level R-RGA is more challenging than 3-Level R-Poss, arguing that this difficulty arises from R-RGA syntax-semantics which involves a set-subset relation and gradability relative to comparative scales.

**Keywords.** language acquisition; English L1; adjectives; possessives; recursion; gradability; set; subset; syntax-semantics interface

**1. Introduction.** In the current paper, we investigate experimentally how younger ( $\leq 6$ ) and older ( $\geq 7$ ) English-speaking children handle recursive structures involving possessives such as those in (1) and structures involving relative gradable adjectives such as those in (2). Both are examples of 2-Level recursion:

- (1) Chippie's dad's mushrooms                      (2) small big mushrooms

For consistency, we refer to structures like (1) as *recursive possessives* (R-Poss) and to structures like (2) as *recursive relative gradable adjectives* (R-RGA). Importantly, in (1), the possessive *Chippie's* is embedded within another possessive *Chippie's dad's*, with the second possessive marker *-s* attaching itself to *Chippie's dad* (see 3).

- (3) [[Chippie's dad]'s] mushrooms

In (2), the adjective *big* modifies the noun *mushrooms*, thus identifying the set of *big mushrooms*, while the adjective *small* further narrows this set, picking out the subset of *small mushrooms* within the set of *big mushrooms* (see 4).

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(4) [small [big mushrooms]]

Both structures in (1) and (2) involve multiple embeddings, thus differing from coordinated possessives and adjectives structures such as (5) and (6):

(5) Chippie's and dad's mushrooms          (6) small and big mushrooms

Testing how children interpret structures such as (1) and (2) can shed light on children's capacity to handle multiple syntactic and semantic embeddings, and, importantly, it can inform us on whether their capacity holds to an equal measure across different categories and why (not).

The paper is structured as follows: in Section 2, we elaborate on the notion of *recursion* and present previous research on recursive possessives and recursive adjectives, also pointing to some possibly relevant differences between R-Poss and R-RGA. In Section 3, we present the experiment we conducted, providing details on the participants, materials, procedure, and results. In Section 4, we discuss the experimental findings and our conclusions, namely, that children are less adult-like with R-RGA than with R-Poss for 3-Level structures, and we put forth some possible explanations for why this occurs.

**2. Recursive possessives and recursive adjectives in language acquisition.** We start from the assumption that children develop language through principles and parameters of Universal Grammar, an innate faculty of the mind (Chomsky 2007). One of the most important properties of UG is recursion (Roeper 2011), a property which is unique to human language (Hauser et al. 2002) and which is responsible for the generation of an infinite number of complex sentences. Importantly, recursion relies on the operation of Merge, which makes hierarchical structure-building possible (Roeper 2011). Merge is combining two elements together. If we consider the labels on these elements, they could be different or alike. If they are different, the object {A, B} created by merging A and B can further combine with C, thus leading to {{A, B}, C}. If they are identical, you have category recursion, a special case of Merge. The object {A, B} further merges with another object B, thus creating the object {{A, B}, B} (Chomsky 1995) -see below for examples (7). If Merge is applied indefinitely, this will lead to an infinite number of objects in the language.

Two types of categorical recursion have been distinguished: *direct recursion*, when a syntactic category merges with an identical syntactic category, and thus generates itself (as in DP-coordination, for instance-see 7a) or *indirect recursion*, when a syntactic category is embedded through an intermediate category (see 7b for an example where recursive possessives are embedded by adding the Possessive marker 's to a DP):

(7) a. the penguin and the horse and the bunny  
b. Tom's brother's penguin

Indirect recursion has been investigated for possessives (Gentile 2003, Limbach & Adone 2010, Roeper et al. 2012), prepositional phrases (Sevcenco et al. 2017, Sevcenco & Avram 2018, Bleotu 2021), adjectives (Matthei 1982, Bryant 2006, Gu 2008, Bleotu & Roeper 2021a, b), sentential complements (Hollebrandse et al. 2008, Hollebrandse & Roeper 2014), and even for verbal compounds (Hiraga 2010). The general finding is that children tend to initially treat indirect recursion as coordination (direct recursion).

Our study focuses on two types of indirect recursive structures: possessive phrases and adjectival phrases, asking whether children 6 and younger and children 7 and older can successfully handle comprehension and production tasks for both types and if there are age related differences. An important question we are interested in is whether different types of recursive

structures emerge at the same time or if it is a gradual developmental process. For example, if a child instantiates the arguably innate abstract representation of recursion (8), then the same loop may characterize various types of recursion (i.e., both possessives and adjectives, etc) and may facilitate recognition of further instances.

- (8)  $XP \Rightarrow X \ YP$   
 $YP \Rightarrow Y \ XP$

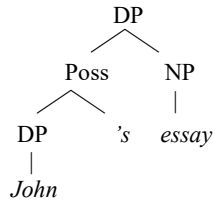
A second question is whether other factors such as the semantics [set/subset] determine the order of realization. An empirical dimension exists as well: will the recursive forms arise automatically or do they need to be in the environment of children directly? In order to better understand these structures, we take a look at their acquisition and at possible differences between them.

2.1. RECURSIVES POSSESSIVES IN LANGUAGE ACQUISITION. Although possession is an extremely complex concept, it is one of the first children engage with at one- and two-word stages. As discussed in Roeper (2007), language corpuses are rich with examples of children pointing to an object and uttering the name of the owner: *dada*, for instance, for a hat which belongs to the father. Double-embedded possessives such as *Anne's Mum's dolly* occur in the speech of 2-year-olds. Despite this early engagement with possessive recursion, children have many difficulties accurately using it (Roeper 2011). For example, 3-, 4- and 5-year-olds tend to misunderstand recursive possessives. They either fail to compute the structure altogether, misidentifying the referent of a phrase such as *Daddy's Daddy's name*, or they drop one or more possessives, simply removing *Daddy* from *Bam Bam's Daddy's name*, or reducing *Tom's friend's bike* to *friend's bike* (see further examples in Roeper 2011).

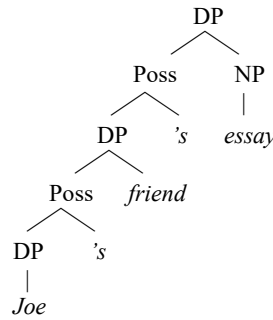
Experimental language acquisition studies (Gentile 2003, Limbach & Adone 2010, Fujimura 2010, Roeper 2011, Pérez-Leroux et al. 2012, Amaral & Leandro 2013, 2015, Hollebrandse & Roeper 2014) also support the findings based on longitudinal production data, suggesting that children tend to avoid recursive possessives. In comprehension, a common 'mistake' on the part of children seems to be to interpret indirect recursion as coordination (direct recursion): children often understand *Cookie Monster's sister's picture* as *Cookie Monster's and sister's picture*. Such non-adult-like interpretations may even linger until age 7, as shown by a study of Wapichana-Portuguese bilingual children by Amaral & Leandro (2013). In production (Pérez-Leroux et al. 2012), 3-, 4- and 5-year-old children are at ease with single possessives, but they avoid producing recursive possessives, opting instead for single possessives or nouns with modifiers.

In their development, children speaking English, German, Dutch, and other related languages go from a single possessive stage (9a) to a recursive possessive stage (9b) through the application of the rules shown in (10) (Roeper 2011, Hollebrandse & Roeper 2014). The rule shows that the determiner is replaced with a possessive, thus making recursive possessives possible.

(9) a. Single possessives



b. Recursive possessives (double-embedded example)



- (10) DP → Determiner & NP  
 Determiner → {Article, Possessive}  
 Possessive → DP & 's

Interestingly, the transition from single possessives to recursive possessives is gradual. On one hand, 6-year-olds perform better with recursive possessives than 4-year-olds (Li et al 2021). On the other hand, the number of embedded possessives matters. A study by Li et al. (2021) suggests that double-embedded possessives are easier for children than triple-embedded possessives, and Gentile (2003) and Terunuma & Nakato (2012) even argue that recursive possession is only in place when children master triple-embedded possessives, bringing evidence that children mastering double-embedded possessives do not necessarily master triple-embedded possessives. However, see Lakshmanan 2021 for an exception to this trend from child Tamil.

Overall, recursive possessives represent an interesting challenge for children, and investigating it can provide important insights into children's capacity to refer to Possessors and link them to Possesseees linguistically.

2.2. RECURSIVE ADJECTIVES IN LANGUAGE ACQUISITION. As far as recursive adjectives are concerned, in production, children first use adjectives in coordination ([Adam 2;3]: *I funny little boy*), while they use recursive adjectives later ([Adam 3; 4]: *he got a little big trailer*) (Gu 2008). In comprehension, they exhibit a similar tendency to prefer coordination over recursion. Experimental work by Matthei (1982) shows that 4-year-olds interpret recursive structures such as *the second green ball* as 'the second and the green ball' rather than 'the second of the green balls', while Bryant (2006) shows that they understand *big black balls* as 'big and black balls' and not as 'the big of the black balls'. Recent work by Bleotu & Roeper (2021a, b) further supports these findings: in an experiment on Romanian 5-year-olds, they showed that, in production, children generally avoid producing recursive structures, preferring simpler one adjective forms over multiple adjective forms. In contrast, when asked to produce coordinative adjective structures, children almost always succeed. Moreover, in comprehension, children tend to reduce recursion to coordination, which seems to function as a default interpretation in acquisition. Thus, when asked to indicate the object named by the expression in (11 a), children often interpret the adjectives as conjoined (11 b):

- (11) a. flori mici mari  
 flowers small big  
 'big small flowers'
- b. flori mici și mari  
 flowers small and big  
 'small and big flowers'

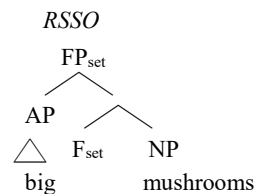
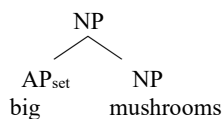
Bleotu & Roeper (2021a, b) have argued that recursive adjectival structures are syntactically more complex than coordinative adjectives structures, especially in Romanian, where recursive adjectives occur in a mirror order compared to English, and more complicated movement operations may be argued to give rise to such an effect (see the discussion about Roll-Up Movement in Bleotu & Roeper 2021a, b).

Interestingly, most of the literature on multiple adjectives has focused on cognitive adjective ordering restrictions (AORs) that order adjectives depending on the cognitive dimension they specify. One example of AOR, as shown in (12), is Quality > Size > Shape > Color > Provenance (Sproat & Shih 1991), but see Dixon 1982, Scott 2002, Scontras et al. 2017 for other proposals along these lines.

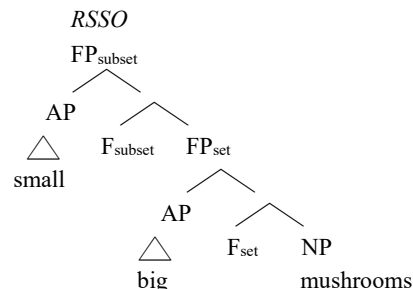
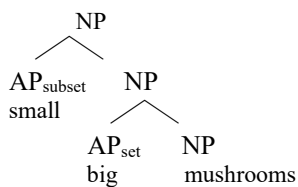
(12) the beautiful big round brown French mushrooms

Such ordering preferences have even been argued to be part of the innate hierarchy of projections in UG (Cinque 1994, 2005, 2010). However, the proposal made by the cartographic approach is undermined by evidence for freer AORs coming from other languages such as Greek or Romanian (Cornilescu & Nicolae 2016, Leivada & Westergaard 2019), as well as by evidence from language acquisition that English children do not initially order adjectives according to a fixed hierarchy (Lee et al. 2018). Bleotu & Roeper (2022) and Bleotu, Foucault, & Roeper (Forthcoming) argue that AORs based on semantic properties are cognitive in nature. They propose instead a stronger grammatical principle which guides the ordering of adjectives in UG, namely the Recursive Set Subset Ordering Constraint (RSSO). According to the RSSO, adjectives referring to sets are merged to the noun first and then the adjectives referring to subsets. Importantly, in a context where one has to refer to the subset of green leaves out of a set of long leaves, both Romanian adults and children prefer to name them *frunzele lungi verzi* ‘the green long leaves’ rather than *frunzele verzi lungi* ‘the long green leaves’, which would have corresponded to the cognitive AOR. The RSSO is particularly useful for the syntactic representation of R-RGA such as *small big (mushrooms)*. Here, children go from an initial Set Stage where they identify a set by picking out the mushrooms with the property *big* to a Recursive Stage where they are able to pick out a subset of mushrooms that are small with respect to the set of *big mushrooms*. The Set Stage is represented syntactically in (13a), while the Recursive Stage is represented syntactically in (13b) either through an adjunction analysis (Abels & Neeleman 2010) or through a Cinque-like cartographic analysis which postulates distinct projections for Set and Subset adjectives.

(13) a. *Adjunction*



b. *Adjunction*



Investigating children’s acquisition of recursive adjectives can thus shed light on important syntactic and semantic properties of adjectives, helping us understand how children construct sets and subsets.

2.3. RECURSIVE POSSESSIVES (R-Poss) *versus* RECURSIVE RELATIVE GRADABLE ADJECTIVES (R-RGA). While recursion characterizes both R-Poss and R-RGA, there are important syntactic and semantic differences between the two structures (see Table 1).

R-POSS	R-RGA
SYNTACTIC DIFFERENCES	
The Possessor and the Possessee are independent syntactic objects which then undergo merge	The Subset object is dependent on the Set object, with which it merges.
There are possessive markers which can act as a recursion cues.	No extra recursion cue
SEMANTIC DIFFERENCES	
The Possessor and the Possessee are independent semantic objects with distinct reference.	The Subset adjective operates a change in reference on the Set object.
R-Poss expresses a relation of possession.	R-RGA expresses a Set-Subset relation.
Lack of gradability	Gradability

Table 1. Differences between R-Poss and R-RGA

Syntactically, R-Poss differs from R-RGA with respect to the order of merging objects. While, in R-Poss, the independent objects Possessor and the Possessee are first created and then undergo Merge, in R-RGA, the Subset is created by merging the Subset adjective to the Set object, which, in turn, is created by merging the Set adjective to the head noun. Thus, adjectives are composed inside the NP, while the Possessive is composed outside N. The syntactic dependence of the Subset with respect to the Set can lead to challenges in the acquisition of R-RGA, while the syntactic independence of the Possessor with respect to the Possessee may make the acquisition of R-Poss easier for children. Importantly, possession is marked syntactically through specific elements such as the genitive case inflection *-s* or the genitive preposition *of*, which may also act as helpful cues for the acquisition of R-Poss, while R-RGA is not marked through any cues. However, it is possible that the challenges involved with R-RGA (*vis-a-vis* R-Poss) may also be a function of the level of recursion.

In terms of semantics, in R-Poss the Possessor and the Possessee each have a different reference, while in R-RGA the Subset picks out its reference by narrowing down the reference of the Set in a dynamic manner. Moreover, the Set-Subset relation may be more challenging semantically than the Possession relation. Another important difference between R-RGA and R-Poss is gradability. In order to pick out the small mushrooms out of the set of big mushrooms, children have to change the domain of evaluation for the property at issue. That is to say, children must evaluate the size property of mushrooms with respect to the domain of big mushrooms, not with respect to the domain of mushrooms in general. While children seem to be able to handle gradable adjectives contextually (Ebeling & Gelman 1994, Syrett et al. 2010), computing antonymic adjectives in a recursive sequence such as *small big mushrooms* might prove more challenging, leading to a potential contradiction. Interpreting these adjectives as a coordination, which represents the default reading of recursion, can result in a contradiction (‘small and big’). This can make children reconsider their initial interpretation and assume instead a recursive reading.

However, children who have a strong preference for coordination over recursion might feel confused and instead opt for interpreting *small big mushrooms* as naming two separate groups (a group of small mushrooms and a group of big mushrooms).

Given these considerations, we expect children to generally have more difficulties with the acquisition of R-RGA than with the acquisition of R-Poss.

**3. Experiment.** In this exploratory study, we investigate children’s comprehension and production of 2- and 3-Level R-RGA such as *small<sup>3</sup> small<sup>2</sup> big<sup>1</sup> mushrooms*, where big is the 1-Level *Set* and subsequent R-RGAs are the 2- and 3- *Subset* Levels, alongside R-Poss such as *the deer’s mushroom’s circle* to determine whether the evidence supports a difference in development for possessives and adjectives. Considering the syntactic and semantic differences discussed in 2.3, we hypothesize that R-Poss will be easier for children to acquire than R-RGA.

3.1. PARTICIPANTS. 47 TD English-speaking children (Age range: 4-12, Mean age: 7;3), of which 26 were monolingual, and 21 were simultaneous bilinguals - all with English as their stronger language except for one child. The younger children ranged in age from 4-6 and their Mean age was 5;4. The older children ranged in age from 7-12 with a Mean age of 8;9. There were 10 adult-controls who participated in a pilot experiment.

3.2. PROCEDURE AND MATERIALS. The story-based task was conducted online via Zoom where children had to help *the deer, the deer’s friend, and the deer’s friend’s sister* pick various sized (R-RGA) groups of mushrooms (Figure 1), put them in trucks of various (R-RGA) sizes (Figure 2) and then go to the market to sell them to three squirrels, i.e., Chippie, Chippie’s father, Chippie’s father’s friend (Figure 3). For comprehension, children drew circles around objects (mushrooms/trucks) and drew arrows between groups of objects or animals to identify R-RGA, R-Poss, and coordinative controls.

We used R-RGA denoting the same dimension (Size) rather than R-RGA specifying different dimensions (like Size or Color). While (R-RGA) specifying different dimensions (like Size or Color) can be understood both coordinatively and recursively, those denoting the same dimension (Size) are more likely to receive a recursive interpretation of Set/Subsets. The coordination reading of *small big mushrooms* would lead to a contradiction (‘small and big’), unless the properties were evaluated against different standards (‘small wrt A’, ‘big wrt B’). As such, we tested both 1-, 2- and 3-Level adjectives (Table 2) and 1-, 2- and 3-Level possessives (Table 3) alongside control coordinative phrases for both comprehension and production.



Figure 1. Picking mushrooms

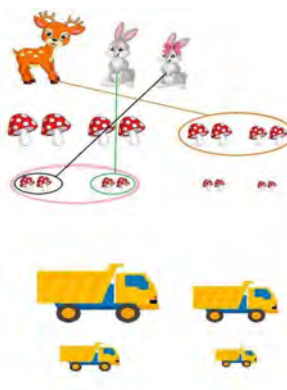


Figure 2. Carrying the mushrooms in trucks



Figure 3. Selling the mushrooms to squirrels

ADJECTIVES	Comprehension		Production	
	Recursion	Coordination	Recursion	Coordination
1-Level Adjective	big mushrooms small mushrooms	...the big mushrooms and...the small mushrooms	The big mushrooms are on top The small mushrooms are on the bottom	the yellow and green boxes are part of the big group.
2-Level Adjectives	small big mushrooms big small mushrooms big small truck small big truck small small truck		small big mushrooms big small mushrooms small big truck small small truck	
3-Level Adjectives	big small big mushrooms small big small mushrooms big big small mushrooms		small small big mushrooms big small big mushrooms	

Table 2. Materials used in the testing of R-RGA

POSSESSIVES	Comprehension		Production	
	Recursion	Coordination	Recursion	Coordination
1-Level Possessive	the deer's friend Chippie's father	the deer's and the deer's friend's mushrooms	the deer's friend Chippie's mushrooms	Chippie's and Chippie's father's mushrooms
2-Level Possessives	the deer's friend's sister the deer's mushroom's circle the deer's friend's mushrooms Chippie's father's friend	the deer's friend's and the deer's friend's sister's mushrooms	Chippie's father's mushrooms the deer's friend's sister	Chippie's father's mushrooms and Chippie's father's friend's mushrooms
3-Level Possessives	the deer's friend's mushrooms' circle the deer's friend's sister's mushrooms Chippie's father's friend's mushrooms		Chippie's father's friend's mushrooms Chippie's father's mushrooms' circle	

Table 3. Materials used in the testing of R-Poss

As can be seen in examples 14 through 17 taken from the protocol, all the test questions containing recursive phrases were carefully introduced to the participants:

(14) R-RGA COMPREHENSION (2-Level): “Now let’s look at the group of small mushrooms. These small mushrooms (on the left, pointing out with mouse) are bigger than these small mushrooms (on the right, pointing out with mouse). If this is the SMALL SMALL mushroom group, which ones do you think are the BIG SMALL mushrooms?”

Great! Now, the BIG BIG mushrooms are too big for the animals' bellies, so they cannot eat those. Let's leave them alone for now. And the SMALL SMALL mushrooms are too small – the animals will still be hungry! Let's leave them alone for now too.

Now we have two groups of mushrooms that are left. One group is from the big mushrooms, and the other is from the small mushrooms. Which group is the SMALL BIG mushrooms? Ok. Which group is the BIG SMALL mushrooms?"

(15) R-RGA PRODUCTION (3-Level): Let's look a bit at the mushrooms the deer has. Some of the SMALL BIG mushrooms are smaller, and some of the SMALL BIG mushrooms are bigger.

How could we call the SMALL BIG mushrooms that are smaller? (Answer: *SMALL SMALL BIG mushrooms*)

What about the SMALL BIG mushrooms that are bigger? (Answer: *BIG SMALL BIG mushrooms*)

(16) R-POSS COMPREHENSION (2-Level): Chippie's father's friend would like to buy the BIG, BIG SMALL mushrooms from the animals. Who should Chippie's father's friend buy the BIG, BIG SMALL mushrooms from? (Answer: *the deer's friend's sister*)

(17) R-POSS PRODUCTION (3-Level): Now whose are these mushrooms? (pointing to Chippie's father's friend's mushrooms) (Answer: *Chippie's father's friend's mushrooms*)

Each session was recorded and viewed independently by two researchers who coded the child's responses for accuracy. Specifically, a three-way categorization system was used (0=Incorrect; 1=Correct on first attempt; 2=Correct on the 2nd attempt (upon receiving feedback from the researcher). For the purpose of this paper, we focus on the results based on children responding correctly on the first attempt. As the number of trials varied across each recursive type, the percentage of the proportion of correct responses (for comprehension and production combined) for each recursive type (2-Level and 3-Level R-RGA and R-Poss) was computed for each child. Further analyses were conducted to determine the number of individuals within each age group who were successful on one recursive type but not the other, as well as those who were successful on both recursive types (R-RGA and R-Poss). The criterion for success in relation to overall accuracy was set at >70%. In addition, children's production alternatives were examined to compare the response patterns for R-RGA and R-Poss.

3.3. RESULTS. All children were successful with 1-Level adjective and possessive phrases (direct recursion). Table 4 presents the mean accuracy scores and standard deviation for 2-level and 3-level R-RGA and R-Poss by age group. The results indicate that older children equal to or older than 7 performed better than younger children on 2-level and 3-level R-Poss.

Age Group	2-Level R-Poss	2-Level R-RGA	3-Level R-Poss	3-Level R-RGA
Age <= 6 Range: 4-6 M=5;4 (N = 21)	M=58.16% SD=31.51%	M = 73.77% SD=17.46%	M = 68.64% SD = 35.36%	M = 56.64% SD= 29.67%
Age => 7 Range: 7-12 M: 8;9 (N = 26)	M=78.93% SD=20.70%	M=79.97% SD=20.14%	M = 89.13% SD = 14.95%	M = 65.13% SD= 24.08%

Table 4. Mean % Accuracy Scores for 2-Level and 3-Level R-Poss and R-RGA by Age Group

As shown in Table 4, the older children's mean scores for R-Poss were above 70% whereas the younger children's mean scores were below 70%. In contrast, both age groups performed similarly on 2-Level and 3-Level R-RGA. In the case of 2-Level R-RGA, the mean percentage scores for both groups were above 70%, with the older children receiving slightly higher scores. In contrast, in the case of 3-Level R-RGA, the mean percentage scores for both groups was below 70%, with the older children receiving slightly higher scores than the younger children. A Kruskal-Wallis test was used to determine whether there were significant differences across the two age groups' accuracy scores. The results revealed significant differences only in the case of 2-Level R-Poss ( $H(1) = 6.13, p = .013$  and 3-Level R-Poss,  $H(1) = 4.39, p = .036$ ), with older children performing better than younger children. In contrast, the differences in the groups' accuracy scores for 2-Level R-RGA ( $H(1) = 2.70, p = .100$ ), and 3-Level R-RGA ( $H(1) = 1.17, p = .279$ ), were non-significant, indicating that the younger and older children behaved similarly for R-RGA. Thus, the null hypothesis that the accuracy scores across the two age groups are the same was rejected only for R-Poss and not for R-RGA.

Table 5 shows the number and percentage of the children in each age group who successfully met the criterion of greater than 70% accuracy on 2-Level R-RGA, 2-Level R-Poss, 3-Level R-RGA, and 3-Level R-Poss. Also shown in Table 5 is the number and percentage of children who were successful on *both* 2-Level R-RGA and R-Poss combined, and on *both* 3-Level R-RGA and R-Poss combined. Table 6 presents a comparison of the number and percentage of individuals across recursive category type within each recursive level by age group with a greater than 70% accuracy score. The crucial point here, based on the results shown in Tables 5 and 6, is that in the case of the older age group, all except one of the 14 children who got 3-Level R-RGA also got 3-Level R-Poss. In the younger age group, all 8 children who got 3-Level R-RGA (except two) also got 3-Level R-Poss. The reverse is not true: children who got 3-Level R-Poss did not typically get 3-Level R-RGA. Together, these results show that, from a developmental standpoint, success on 3-Level R-RGA is predictive of success on 3-Level R-Poss. However, a similar trend is not observed for the 2-Level Recursives for both age groups. Most of the younger children who got 2-Level R-RGA did not get 2-Level R-Poss, suggesting that success on 2-Level R-RGA is not predictive of success on 2-Level R-Poss. However, for the older children, success on 2-Level R-Poss and 2-Level R-RGA is bidirectionally predictive.

Age Group	2-Level R-Poss	2-Level R-RGA	3-Level R-Poss	3-Level R-RGA	Combined: Both 2-Level R-RGA and R-Poss	Combined: Both 3-Level R-RGA and R-Poss
Age <= 6 Range: 4-6 M=5.4 (N = 21)	6 (28.57%)	13 (61.90%)	13 (61.90)	8 (38.10)	3 (14.29%)	5 (23.81)
Age => 7 Range: 7-12 M: 8;9 (N = 26)	20 (76.92%)	22 (84.62%)	23 (88.46%)	14 (53.85%)	19 (73.08%)	13 (50.00%)

Table 5. Number of Children within Each Age Group with >70% Accuracy Score

Age Group	2-Level R-Poss <i>but not</i> 2-Level R-RGA	2-Level R-RGA <i>but not</i> 2-Level R-Poss	3-Level R-Poss <i>but not</i> 3-Level R-RGA	3-Level R-RGA <i>but not</i> 3-Level R-Poss	Combined: Both 2-Level R-RGA and R-Poss	Combined: Both 3-Level R-RGA and R-Poss
Age <= 6 Range: 4-6 M=5.4 (N = 21)	3/6 (50%)	10/13 (76.92%)	9/13 (69.23%)	2/8* (23%)	3/21 (14.29%)	5/21 (23.81%)
Age => 7 Range: 7-12 M: 8;9 (N = 26)	1/20 (5%)	3/22 (13.64%)	10/23 (43.48%)	1/14 (7.14%)	19/26 (73.08%)	13/26 (50%)

Table 6. Comparison of Number and Percentage of Individuals across Recursive Category Type (R-RGA versus R-Poss) within Each Recursive Level (Level-2 and -3 by Age Group with > 70% Accuracy Score

\*Note: There was missing value for 3-Level R-Poss for one child who got 3-Level R-RGA.

Analysis of the production alternatives (i.e, non-target responses) is currently underway. Preliminary findings indicate that the most frequent production alternatives for R-RGA were: deleting or inserting an adjective, as well as misordering. For R-Poss, the most frequent production alternative was genitive omission (dropping the 's marker), though there were instances of deleting a Possessor. Overall, children produced a greater variety of R-RGA production alternatives: deletion or insertion of an adjective, comparatives, superlatives, alternative adjectives or misordering of adjectives (see Table 7).

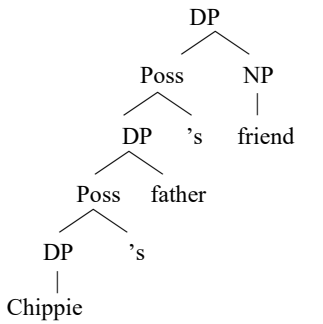
Alternative answer types	Expected answers	Actual answers
Deletion	small big mushrooms	big mushrooms/ small mushrooms
	big big small mushrooms	big small mushrooms
Insertion	small big mushrooms	big big small mushrooms
Comparative	small big mushrooms	smaller mushrooms
Superlative	big big mushrooms	biggest mushrooms
Alternative adjectives	small big mushrooms	medium mushrooms
Misordering of adjectives	small big mushrooms	big small mushrooms

Table 7. Examples of R-RGA Production Alternatives (non-target) Responses by Children

**4. Conclusion.** Despite the fact that recursion underlies both R-RGA and R-Poss, children converge earlier on 2- and 3-Level R-Poss and 2-Level R-RGA than on 3-Level R-RGA. Crucially, 3-Level recursive embedding is more difficult for R-RGA, which can be explained by the syntactic and semantic differences between R-RGA and R-Poss, as discussed in section 2.3.

From a syntactic standpoint, in R-Poss, when merging nouns together to express possession, the Possessor is first created independently and then merged to the head noun denoting the Possessee (18). Composition of Possessors occurs outside the noun, and, importantly, it happens through the explicit possessive marker 's, which might be a helpful cue for recursion. In contrast, R-RGA is created through composition within the nominal domain, as in (19), by first merging the *Set* Adjective with the noun, and then the *Subset* Adjective with the object created from the *Set* Adjective and the noun. Importantly, R-RGA is not marked explicitly through any additional recursion cue. The recursive adjectival reading can only be reached by relying on adjectival order and context.

(18) Structure for R-POSS

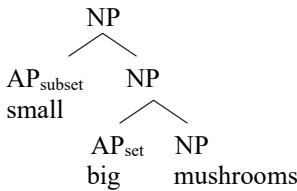


[[[Chippie's] father]'s friend]

Order of operations for R-POSS

- (i) Merge *Chippie* with *father* through the Possessive marker 's
- ⇒ [Chippie's] father
- (i) Merge [*Chippie's*] *father* with *friend* through the Possessive marker 's
- ⇒ [[[Chippie's] father]'s friend]

(19) Structure for R-RGA



Order of operations in R-RGA

- (i) Merge *big* with *mushrooms* to create the Set object
- ⇒ [big mushrooms]
- (ii) Merge *small* with *big mushrooms* to create the Subset object
- ⇒ [small [big mushrooms]]

From a semantic standpoint, in R-Poss, each possessor embedding is defined by the limits of each noun. It is a straightforward re-application of a single semantic rule expressing possession for each embedding. The reference of each noun is bounded and unaffected. Importantly, although our experiment made use of a relational noun like *friend*, this role was associated with only one character among the three characters in the story at each stage (*the deer's friend*, *Chippie's father's friend*). Hence, children could not get confused by associating the friend role with another character. In contrast, for R-RGA, the *Set* Adjective applies to the noun, but the *Subset* Adjective applies to the new object [Set adjective Noun]. The change of denotation in the domain of application of adjectival recursion leads to a change in reference, which is not the case for possessive embedding.

Meaning-wise, relating an entity to its Possessor might also be conceptually easier than ascribing properties to objects, as both the entity and its Possessor are distinct, while properties belong to objects, being in a sense indistinguishable from them.

Another semantic dimension which might make R-Poss easier and R-RGA more challenging is gradability. *Big big small mushrooms* could be more difficult for children because they have to sequentially evaluate the size property against a different domain for the same phrase: (i) first, they have to identify the set of *small mushrooms* among a larger group of mushrooms by evaluating their smallness, (ii) then, they have to identify the subset of *big small mushrooms* among the set of *small mushrooms* by evaluating their bigness and repeat for subsequent subsets. Given that the meaning of a gradable adjective changes with its domain, all gradable adjectives could independently complicate the computation (Weicker 2019). In our study, we used antonymic RGAs.

A question for future studies is whether antonyms heighten this effect. However, we know that children as young as 2 can handle gradable adjectives such as *small* and *big* in a relative manner, as *small/big for an entity of that sort* (Ebeling & Gelman 1994, Syrett et al. 2010). Moreover, in the current experimental set-up, we tried to introduce gradability by means of comparatives (20), thus trying to make children at ease with evaluating objects against different domains:

(20) These (point with cursor) big mushrooms are smaller than these (point with cursor) big mushrooms.

Of course, the notion of set/subset is relevant even if the adjectives are not gradable. A phrase such as *American softball players* denotes a subset of the *softball players*, but there is no gradability factor. Hence, given that gradability might complicate the computation beyond a set/subset relation, it may be useful to investigate whether a non-gradable set/subset relation would or would not be more complex than possessive recursion. We leave this for future studies.

Overall, differences in compositional syntax, recursion cues, referentiality and gradability make R-Poss easier to handle than R-RGA. In the current paper, we have brought experimental evidence that syntax-semantics mapping for 3-Level recursion is more challenging for R-RGA than R-Poss. In R-RGA syntax, computation is within the noun phrase, while, in R-Poss syntax, computation is within the possessive. Moreover, set/subset semantics is more difficult than possessive relational semantics, as it may be easier for children to relate two entities than to ascribe properties to subsets, with gradability of antonymic adjectives adding another complicating factor.

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