Nominal Reference, Modification, and the Acquisition of Complex NPs

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September 19, 2015

1 Introduction

Modification introduces complexity in the syntax and the semantics of noun phrases. Its use in natural language is regulated by the Maxim of Quantity: speakers provide just enough information to identify a referent, but no more than is needed. Adult speakers make choices about the quantity of descriptive content to be expressed when labeling a referent, and these choices are intricately conditioned by discourse and context (Heller and Chambers 2014; Sedivy 2003; Davies and Katsos 2013; Tanenhaus et al. 1995). The acquisition literature contains two contrasting pieces of evidence in regards to the referential behavior of children. On the one hand, five-year olds are fully sensitive to context in their production of modified NPs, using adjectives (*the small glass*) only when a competing referent was present in the context (i.e., a large glass), and only when relevant from the perspective of their conversation partner (Nadig and Sedivy 2002). On the other hand, there seems to be a productivity gap in children's production of complex NPs, as most of the nouns they produce spontaneously are simple DPs with no modification. Recursive modification, in particular, seems heavily constrained in the speech of children. What is the source of children's difficulty in this domain?

We explore whether the complexity introduced by NP modification relates to the task of restriction and the processing of descriptive content, or whether the syntax and semantics of NP embedding specifically introduces complexity in acquisition.

We compare production of two types of doubly-modified definite descriptions. These cases differ minimally with respect to the attachment of the second modifier. Consider the following two figures, each of which includes the task of identifying a unique referent in the given visual contexts.

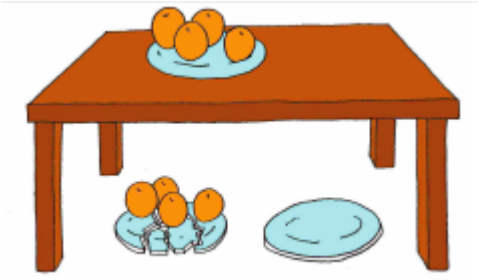


Figure 1: Which plate got broken?

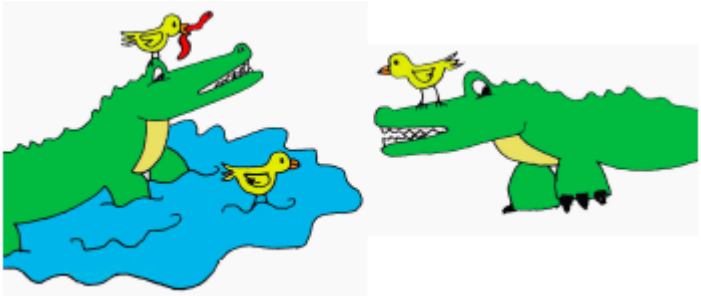


Figure 2: Which bird got the worm?

The correct response to Figure 1 involves simple modification: the same (highest) referring NP is sequentially modified by two independent restrictive PPs, as shown in the bracketing in (1). The response to Figure 2 also involves two modifiers, but they are recursive: the second modifier restricts the referent contained in the first PP modifier, as shown in (2):

(1) The plate [under the table] [with oranges]

(2) The bird [on the alligator [in the water]]

These two NP types constitute a minimal pair which allows us to tease apart quantity of descriptive content from level of embedding.

In this paper we present an elicited production study of these two types of complex NPs. Section 2 reviews evidence on children's difficulties with modification in general, and specifically with recursion. Section 3 presents the basic semantics and syntax of modification, as well as a recent proposal about the interactions between hierarchical structure and semantic relations between phases. Section 4 presents data from children and adults, which shows that level of embedding introduces a particular form of complexity. Children produce complex DPs at half the rates of adults, and have qualitative differences in their patterns of production. Section 5 explores the limitations of a purely syntactic or semantic approach to complexity.

2 NP modification in child language

Traditional accounts of the timing of acquisition of a given grammatical structure in children are generally based on external factors, such as frequency in the available input, maturational factors, or the timing of related conceptual developments. In some cases, timing is often explained by invoking poorly understood properties of the structure itself, including formal complexity and/or transparency of the form-meaning associations. In the case of noun modification, children exhibit difficulties that appear to go beyond the basic elements involved. Children learn the basic syntactic and semantic ingredients of nominal modification quite early, but, as we will see in this section, their production remains constrained until much later in development. Let us consider first the acquisition of the functional elements and relations that can be used to build complex nominal structures. Possession, modification and location are thought to be among the first semantic primitives identifiable in children's speech (Bloom et al. 1975). While the actual structural analysis of early word combinations is a matter of debate, it seems clear that children's initial two word utterances include sequences that serve to identify or restrict a referent, including adjective-noun, noun-noun and noun-location, as in these examples from Adam (Brown 1973) and Allison (Bloom 1973) in the CHILDES database (MacWhinney 2000).

(3) Adjective + Noun
CHILD: Green cup. (Allison 1;10)
CHILD: Big drum. (Adam 2;03)

Noun + Noun
CHILD: Puppy dog. (Adam 2;04)
CHILD: Baby doll. (Allison 1;08)

Noun + Locatives
CHILD: Diaper out. (Allison 1;10)
CHILD: Adam a [?] home (Adam 2;03)
CHILD: Bear dere [: there] right in here. (Adam 2;03) (Brown 1973)

Although these basic components emerge early in children's grammars, it takes a couple of years before children can use them in the production of complex NPs. Most forms of NP elaboration are under-produced by preschoolers and kindergarteners when compared to older children. PPs and adjectives are common in predicative contexts, but rare NP-internally. Eisenberg et al. (2008) found that most NPs present in the narrative of five year olds consist of unmodified nouns. Prenominal adjectives (e.g. *the yellow ball*) were observed in the narratives of 80% of the five-year-olds in their study, but less than two thirds of English-speaking five-year-olds produced any instance of PP or relative clause modification (e.g. *aliens with legs*, *a girl named Amanda*). Double adjectival modification (e.g. big yellow thing) is even rarer: only 25% of the five-year olds studied produced them. NP complexity in narrative samples increases during the school years. By the age of 11 most children include some PP modifiers and about half of the children include double adjectival modifiers in their narratives. In the referential literature, it is often pointed that children avoid producing complex referential expressions, often erring on the side of under-informativeness (Matthews et al. 2007; Davies and Katsos 2010).

Furthermore, complex NPs are less frequent in children than one might expect on the basis of other language abilities. Crucially, output constraints do not easily explain the low productivity of complex NPs. Most five-year-olds have mean lengths of utterance (MLU) that approximate the adult range (Brown 1973), but do not produce the same range of nominal structures as adults. This suggests that, although MLU continues to be used as a standard measure of complexity in children in the child language field, utterance length fundamentally fails to capture some dimensions of the development of grammatical complexity. Some investigators go as far as to argue that MLU is more reflective of talkativeness or lexical development than of syntactic development (Dethorne et al. 2005; Pérez-Leroux et al. 2012b; Dixon and Marchman 2007).

Complexity in the acquisition of relative clauses has been studied in various languages, with a primary focus on the relative difficulty of the various types

of relative clauses according to position/function of the relative clause and the extraction site (Friedmann et al. 2009; Friedmann and Costa 2010; Guasti et al. 2012). While some structural factors determine complexity; the various studies suggest that the relevant factors are the same for children and adults. For instance, McDaniel et al. (2010) found a strong correspondence between children and adults responses to extraction site (object/subject) and depth of embedding of the relative clause (simple relative vs. recursive relative). Children often pause or restart around the onset of the most embedded clause, and frequently fail to prosodically or discursively integrate it within the initial utterance. McDaniel and colleagues concluded that children perform sentence planning more often and over shorter spans than adults, while relying on the same processes.

The acquisition of recursive modification has been explored in a number of studies in the last decade. Many of these were motivated by the controversial claim of Hauser et al. (2002) that recursion is the fundamental property of the human language faculty, in the narrow sense (Evans and Levinson 2009; Nevins et al. 2009; Moro 2011). These studies concur that recursive possession and recursive PP modification are exceptionally rare in the spontaneous speech of children (Roeper and Snyder 2005). The analysis of the CHILDES database also shows children have some difficulties understanding parental use of recursive DPs (Roeper and Snyder 2005). In the following dialogue, the parent invites the child to repeat a recursive locative phrase:

(4) Father: Very good. Up in the shelf in the closet in the kitchen, can you say that? Child: yeah. Up in the # up in the # what

(Gu 2008, cited in Roeper 2011)

Subsequent comprehension studies also indicate difficulties. Limbach and Adone (2010) found that preschool-aged children gave non-target interpretations to recursive possessives (*Mary's father's bike*), frequently choosing reduced ('Mary's bike') or coordinated interpretations ('the bike jointly owned by Mary and her father').

As a preliminary summary, we see that utterance length is only indirectly linked to development of grammatical complexity in children. Embedding introduces complexity, for children, but it is not clear why. Intuitively, speakers perceive a coordinated phrase, such as *a boy and a dog*, as less complex than a comparable modified NP *the boy with a dog*. Elicited production data confirms this intuition. Children avoid embedded NPs but produced coordinated NPs of comparable length without difficulty. Using an elicitation task, Pérez-Leroux

et al. (2012a) compared English-speaking preschoolers' ability to produce coordinated and recursive DPs. Three coordinated nouns (*a bicycle, a ball, and a doll*) were produced almost as frequently by children as by adults, but children had substantial difficulties with recursive possessives (5) and with recursive prepositional modifiers (6):

(5) Elmo's sister's ball

(6) The girl with the dog with the hat.

Two thirds of the children under five only produced simple, unmodified DP responses. Of the remaining children, several managed to produce one level of possessive or prepositional embedding. Recursive NPs were virtually absent (only 2 of the 32 younger children produced any instances of either recursive possessives or recursive PPs). The performance of older children was better. Most of the five-year-olds produced first-level nominal modification, and two fifths produced recursive structures, with recursive PPs being more prevalent. The ease with which they produce coordinated NPs suggests that children have no problem producing multiple NPs, but with integrating these into complex descriptions.

Assuming the standard endocentric analysis of coordination, the difference between coordination and subordination cannot be expressed in syntactic terms (Munn 1993; Progovac 1998). The contrast with subordination is best stated in semantic terms. The individual referents of coordinated DPs do not interact, but in NP modification, the most embedded DP contributes to the description of the referent described by the higher DP. Our goal is to disentangle what exactly about the syntax, semantics or pragmatics of embedded modification presents a problem for children. Pérez-Leroux et al. (2012a) noted responses such as (7), which provide a complete characterization of the target referent without syntactic integration.

(7) Question: Which girl is eating ice cream?
Response: She looks like, um, the dog has the hat . . . (TRB 4;06)
Target: 'The girl with the dog with the hat.'

These type of examples were interpreted to indicate that children can meet the demands of the referential task, while still demonstrating specific difficulties with embedded syntax. This fits with traditional lines of thought suggesting that children start with parataxis and eventually shift to hypotactic representations

(Lebeaux 2000; Givón 2009).[1] However, one can see how characterizing the developmental problem in purely syntactic terms has inherent problems. Embedding is just one of the applications of merge: If children have the basic constituents, and the merge operation, why should they not be able to apply it successively? Recursion is one of the fundamental operations in language (Hauser et al. 2002; Moro 2011). All evidence indicates that recursive merge is a property of children's earliest grammar Hunsicker and Goldin-Meadow (2013); Takahashi (2009). However, we lack an explanation for why children have to acquire the specific form of representational recursion, such as the type we see in the iterative embedding of phrasal categories of the same type.

One possibility, suggested at times for various acquisition phenomena (see McKee and McDaniel 2004 for a critique) is to claim that pragmatic difficulties can mask extant syntactic abilities. Children may avoid complex NPs because they are simply not aware that they need to use them. Research on children's referential behavior does not support this type of pragmatic deficits. Nadig and Sedivy's (2002) study demonstrates that five-year-olds show effects of common ground in comprehension, and that these effects appear early in their sentence processing.[2] Children in their study also tailored their use of modifications to both visual context and interlocutor perspective. When asked to identify an object for a listener, five-year-olds produced adjectives (*the small glass*) only when a related object (i.e., a large glass) was present in the context. Adjectives were produced less when the object of the same kind was not in the visual field of their interlocutor. This suggests that by the age of 5, children are not egocentric, and they know they have to adjust their use of adjectives according to the referential perspective of their conversation partner.[3] There is one systematic pattern of referential fail-

[1]The results are also congruent with evidence from the psycholinguistic literature that children have difficulty using multiple cues to generate an embedded (low attachment) interpretation of PPs (Trueswell et al. 1999; Kidd et al. 2009). However, this experimental work focuses the online integration of lexical, contextual and syntactic information. As such, this evidence is not interpreted in structural terms (but see Maia et al. to appear).

[2]Nadig and Sedivy's (2002) treatment of the common ground, which is the norm within this experimental literature, rests on the assumption that propositions can be added to the common ground through extralinguistic means, such as gesturing or drawing attention towards an object in the physical context, or the act of showing a picture.

[3]Nadig and Sedivy (2002) also report that children used color adjectives in the absence of a competing referent, but scalar adjectives only when required by the situation. This can be interpreted as further evidence of pragmatic ability; adults also produce descriptions that point to perceptually salient characteristics of objects even in the absence of contrasting referents. Such non-contrastive descriptive material is thought to be helpful rather than redundant.

ure: children in their study consistently failed to provide descriptions in terms of locative PPs even when required by the context and perspective. These authors conclude that children understand the contextual requirements of modification, but at times fail to incorporate "common-ground information (or any potentially constraining information) [...] because of its complexity" (Nadig and Sedivy 2002, p. 335).

Subsequent work on children's referential behavior provides support for both the delay in production of referential elaboration, and for the notion that children are sensitive to informativeness. According to Davies and Katsos (2010), children aged 4-6 often produce under-informative descriptions in the presence of a contrastive set, but never over-specify in their production of referential expressions. In comprehension, however, children at that same age react like adults to under-informative descriptions, judging them as inappropriate. The same children also judge over-informative descriptions ('the big star', when only one star is present in the context) as degraded, provided that the experimental task allows for graded acceptability (Davies and Katsos 2010).

Studies measuring online processing of reference provide converging evidence on this issue. Sensitivity to quantity would predict that when confronted with over-informative descriptions, such as "Find the cat with a tail" in contexts where only one cat is present, comprehenders should be slowed down because they would assume that the speaker is implying the presence of a contrastive element. Analyzing reaction times and gaze direction, Morisseau et al. (2013) find that five-year-olds, but not three-year-olds are delayed in such scenarios, in comparison to instances where expressions are used with the appropriate quantity of descriptive material.

The literature on acquisition of the semantics of definite descriptions suggests a great degree of semantic competence. For example, children understand how definite descriptions can be used to restrict the domain of quantifiers. While not quite adult-like at the outset, young children demonstrate awareness of the maximality restriction on plural definites and free relatives (*the things on this plate/what is on this plate*) (Munn et al. 2006; Caponigro et al. 2012). Children also possess sophisticated intuitions about the interactions between definite descriptions and the semantics of adjectival modification. Syrett et al. (2010) presented children with a game where they had to decide whether they could give a puppet what he asked for based on the form of his request, and what was available in the context. This task assessed their intuitions of the felicitousness of various descriptions (*Give me the full one/the tall one*), given a context that either met, or failed to meet the conditions of existence and uniqueness. Three-year olds rejected definite phrases in violation of these presuppositions (Syrett et al. 2010,

p.27), and also demonstrated sensitivity to adjective type. With relative adjectives, which are used for referents only in comparison to other elements in a context, children were able to shift the standard of comparison according to context, without over-extending context-sensitivity to absolute adjectives. In other words, children know that *a full jar* is full no matter what else is there, but *a long stick* can describe a short stick, provided an even shorter stick is present in the context. This shows that children can already make sophisticated distinctions between types of modifiers. While more willing than adults to tolerate imprecision, children reject sentences on the conditions under presupposition failure, but accommodate them where appropriate, according to context and type of adjective.

In sum, the consensus from the semantic and pragmatic literature is that children can navigate meaning, context and perspective in their interpretation of nominal modification. As a consequence, it is difficult to explain the productivity gap in children's use of complex nominals in purely pragmatic or semantic terms. We will argue that that this also the case of syntax. The one promising line of inquiry starts from the observation by Nadig and Sedivy (2002) that some forms of nominal modification are more accessible than others, namely adjectival modification in comparison to PP modification. To examine whether embedding itself determines complexity, we need to isolate it. So the next step is to consider the semantics and the syntax of PP modification, with special attention to complex NPs that differ minimally in the degree of embedding.

3 Semantics and syntax of nominal modification

3.1 The formal ingredients of double modification

Nominal expressions map into entities or set-denoting predicates, depending on the type of noun (*Lily*, *dog*), and the presence or absence of determiners (*dog*, *the dog*). There is some variation across languages in regards to the availability of determiners, and the consequences for the semantic mapping of NPs (Chierchia 1998). The semantic type of a nominal expression is also partially determined by syntactic position, as shown in the contrast between referential and predicative uses of DPs (*a dog barked*/*Lily is a dog*). The type assigned to a constituent is not absolute in the sense that the interpretation shifts as the derivation progresses and a constituent integrates into higher structure. In the standard analysis of (8) the NP denotes a predicate, and the DP denotes an entity:

(8) $[_{\text{DP}}$ the $[_{\text{NP}}$ table]]

Prepositions, generally considered to be a two-place relation between entities, can further compose with the nominal constituent. At this point, the nominal expression becomes part of a predicate, as evidenced by their use in copular constructions, as in (9), or in restrictive NP modification, as in (10):

(9) The vase is $[_{\text{PP}}$ on $[_{\text{DP}}$ the table $]]$

(10) $[_{\text{DP}}$ The vase $[_{\text{PP}}$ on $[_{\text{DP}}$ the table $]]]$

The lowest nominal expression in (10) is now part of a modifier.

Let us now consider what happens with recursive and non-recursive modification, as in (1) and (2). Consider how the descriptions given as responses in (1) and (2) interact with the accompanying visual context. The logical representations can precisely pinpoint what is different between these two types of complex nominals. The truth conditions for of these sentence fragments associated to (1) and (2) are given in (11) and (12):[4]

(11) $broken(\iota x(plate(x) \wedge \iota y(table(y) \wedge under(xy)) \wedge \iota z(oranges(z) \wedge with(xz))))$

(12) a. FALSE:
$got.worm(\iota x(bird(x) \wedge \iota y(alligator(y) \wedge on(xy)) \wedge \iota z(water(z) \wedge in(xz))))$

b. TRUE:
$got.worm(\iota x(bird(x) \wedge \iota y((alligator(y) \wedge on(xy)) \wedge \iota z(water(z) \wedge in(yz)))))$

In the truth-conditions for (1), given in (11), the two PP predicates both restrict the iota operator that picks out the (unique) x such that x is a plate and x got broken. However, the truth conditions for (2) do not have this commutativity, as (12a) shows: the x such that x is a bird that got the worm is not both on the alligator and in the water. Rather, in (12b) the PP modifiers of *the bird* are recursively embedded and contain their own definite descriptions, the semantic values (i.e. the references) of which determine the semantic value of the bird that got the worm. Crucially, the iota operator binding the alligator variable (y) must take scope over its occurrence of being in the water ($in(yz)$).

[4]For brevity we are using the iota operator for definite descriptions in (1) and (2). As such, we adopt the standard assumption that the iota operator, alongside the predicate variable it binds, is a singular term, such that $Q(\iota x Px) \Leftrightarrow \exists x(Px \wedge \forall y(Py \rightarrow x = y) \wedge Qx)$. Also, we are not concerned with the definite description in the nuclear scope of *The bird on the alligator in the water got the worm*. Thus, *got the worm* is simply treated as an intransitive predicate.

These truth conditions can be straightforwardly derived with nothing but the standard types. Nouns and prepositional phrases are predicates (type $\langle e, t\rangle$). By extension we assume that prepositions are of type $\langle e, \langle e, t\rangle\rangle$: essentially a transitive relation between entities. The definite article picks a unique individual that fits the descriptive content of the predicate it takes as argument. As such, we adopt the standard lexical entry for *the* in (13), which takes a predicate and returns an entity.[5]

(13) $[\![\text{the}]\!] = \lambda P_{\langle e,t\rangle} \,.\, \iota x[P(x)]$
$[\![\text{the plate}]\!] = \iota x[plate(x)]$

The next step is to characterize the combinations of PP modification of the nominal predicates found in the doubly-modified DPs, and their resulting definite descriptions. To begin with, modification of the kind relevant here is achieved through the rule of Predicate Modification (Heim and Kratzer 1998, p.63-73), shown in (14):

(14) *Predicate Modification*
If α is a branching node, where $\{\beta, \gamma\}$ is the set of α's daughters, and $[\![\beta]\!]$ and $[\![\gamma]\!]$ are both $D_{\langle e,t\rangle}$, then $[\![\alpha]\!] = \lambda x \in D_e \,.\, [\![\beta]\!](x) = [\![\gamma]\!](x) = 1$

The complex predicate formed by PM defines the intersection of the things that have the property defined by the head noun and the one defined by the PPs. The expression in (15) represents the first level of embedding, and the one in (16), two instances of first level embedding.

(15) Simple modification
$[\![\text{plate under the table}]\!] = \lambda x \,.\, [\![\text{plate}]\!](x) = [\![\text{under the table}]\!](x) = 1$

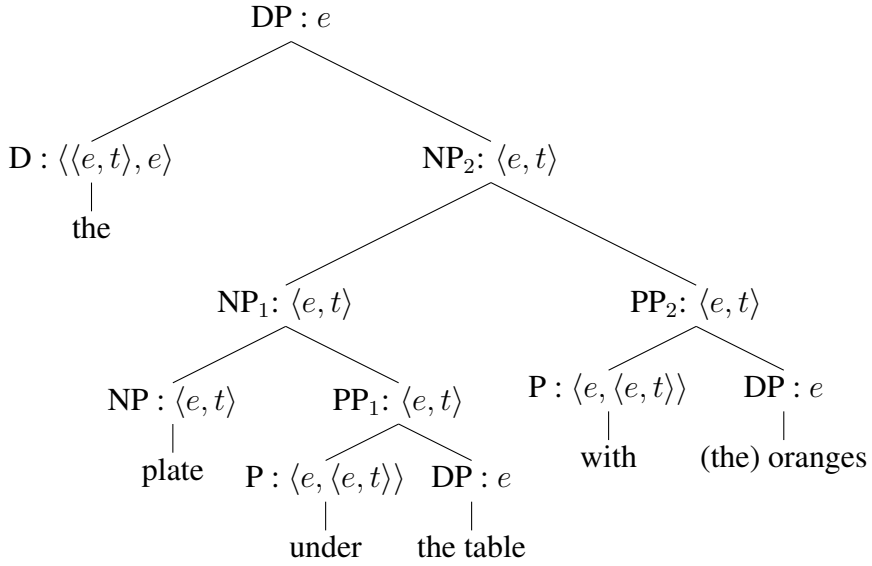
(16) Non-recursive double modification

a. $\lambda x \,.\, [\![\text{plate under the table}]\!](x) = [\![\text{with oranges}]\!](x) = 1$

b. $\lambda x \,.\, x$ is a plate and x is under the table and x is with (the) oranges

The resulting complex predicate *plate under the table with oranges* is a suitable argument for the definite determiner. The following tree shows the derivation for (1):

[5] We also assume the presupposed existence conditions of the various definite descriptions are satisfied by the images depicted in the pictures (Russell 1905; Strawson 1950, etc.)



Recall that non-recursive PP modification is commutative, so that the two PP modifiers of plate, can be freely reordered as in (17), with no effect on the truth conditions.

(17) a. the plate under the table with oranges

b. the plate with oranges under the table

The recursive DP *the bird on the alligator* in the water has similar components, but combined in a way that yields crucially different expressions. This becomes evident when we compare the two sets of truth conditions in (18), and apply them to the scene in Figure 2:

(18) Recursive

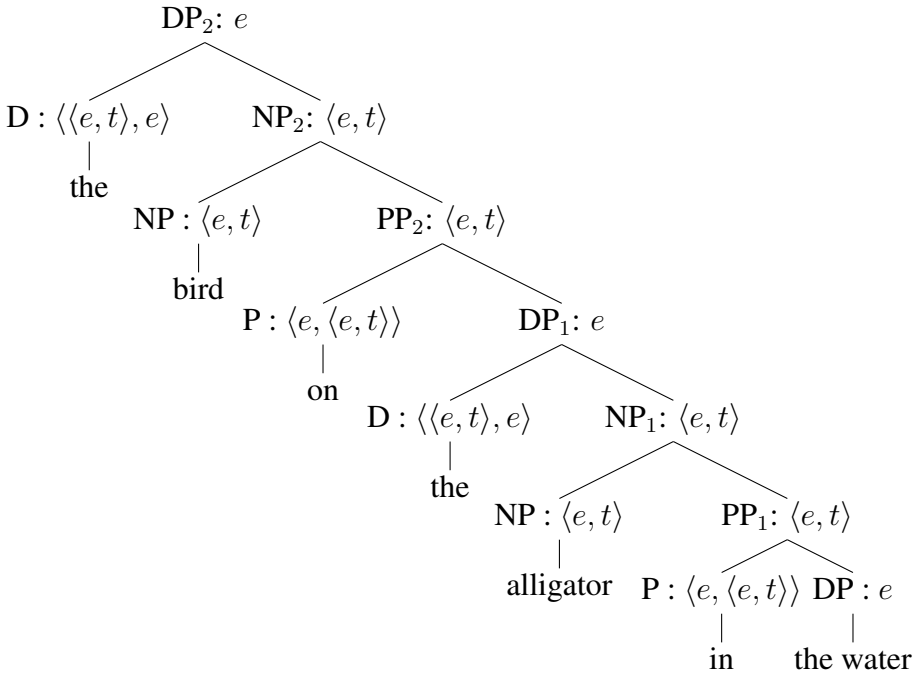
a. $[\![\text{bird on the alligator in the water}]\!] \in D_{\langle e,t\rangle}$

b. FALSE (two iterations of level 1 recursive embedding):
$\lambda x\,.\,x$ is a bird and x is on the alligator and x is in the water

c. TRUE (level 2 recursive embedding):
$\lambda x\,.\,x$ is a bird and x is on the unique y such that y is an alligator and y is in the water

The logical form in (18b), with the three predicates directly combined via predicate modification, incorrectly predicts that this expression can apply to a

context where the bird was both in the water and on the alligator. The expression in (18c) does provide the right conditions, by establishing reference to an intermediate definite description 'the unique y such that y is an alligator and y is in the water'. This definite description is opaque, in the sense that the predicate inside it (the property of 'being in the water') is no longer accessible to the referent targeted by the higher description. This is the crucial difference between the non-recursive and recursive cases. In other words, predicate modification applies once in the non-recursive condition (two iterations of level 1 embedding) and twice in the recursive condition (level 2 embedding). The complete derivation is provided in the following tree:



To summarize, complex DPs, recursive or non-recursive, are derived by iterations of predicate modification, so they are identical with respect to the individual steps or semantic operations involved in building the structure. Syntactically, the two kinds of expressions contain the same number of elements and even of steps.[6]

[6]In Figure 1 'the' merges with 'oranges' [merge 1], then the result merges with 'with' [merge 2]. This is then adjoined to 'plate under the table' [adjoin 1]. 'Plate under the table' is itself formed by merge of 'the' with 'table' [merge 3], followed by merge of 'under' [merge 4], the result of which then adjoins to 'plate' [adjoin 2]. Then the structure 'plate under the table with

At each moment in the derivation we are undertaking either an operation of Merge or Adjoin. There is no *a priori* reason to think that any given instance of Merge or Adjoin is more complex than another. In a phase-based model, at each cycle the lower structure becomes impenetrable, inaccessible to subsequent computations. So, from a syntactic point of view, there should, in principle, be no difference between merging a simple or a complex PP modifier.

3.2 Recursion and phases

Arsenijevic and Hinzen (2012) argue that syntactic embedding induces intensionality effects. In the case of clauses, this means that a proposition that serves as complement of a belief predicate is not asserted by the speaker of the sentence, but only if truly syntactically embedded, as witnessed by the contrast in (19)

(19) a. Bob believes Mary is wrong.

b. Mary is wrong, and Bob believes so.

In the case of DPs, they propose that an embedded nominal expression cannot be predicated of, as shown in (20). Equivalent content, if paratactically adjoined, rather than embedded, is accessible to modification by the copular predicate (Arsenijevic and Hinzen 2012, p.430).

(20) The vase on the table (was/*were) green.
The vase, the table, (were/*was) green.

Arsenijevic and Hinzen (2012) explain these semantic effects in terms of the organization of phases in the grammar. Phases are thought to be both cycles of computation and points of transfer to semantic interpretation (Chomsky 2001, 2008). Such a system requires that an embedded constituent be interpreted twice. The lower nominal head is interpreted first to determine a discourse referent (i.e., the unique, familiar table); later, rendered predicative again by the preposition, it is no longer referential. While occurring embedded in the matrix D, *the table* merely functions as a descriptive condition used to identify the referent of the higher nominal head (*the vase on the table*). Note that phases do not directly

oranges' merges with 'the' [merge 5]. In Figure 2 'the' merges with 'water' [merge 1], then the result merges with 'in' [merge 2]. This is then adjoined to 'alligator' [adjoin 1] and then 'alligator in the water' merges with 'the' [merge 3]. Then 'on' merges [merge 4] and the resulting PP 'on the alligator in the water' adjoins with 'bird' [adjoin 2]. Then 'the' merges to form 'the bird on the alligator in the water' [merge 5].

address why recursive and non-recursive DPs will differ in complexity, since at the point of computation of a higher head, all the content from lower phases has already become inaccessible in the syntax, and to interpretation. But combining a phasal perspective with syntactic derivation highlights one property of embedded structures: that they force speakers to keep multiple domains of reference simultaneously active. To put it in a concrete reference to (12), the right alligator is being selected at the same time the right bird is, as implied by (18c).

If the recursive structure is more complex than the non-recursive structure, complexity must arise from the whole, not from any individual step in the syntax or the semantics. Complexity is the result of the particular order in which the operations are combined, which can only be determined at the end of the derivation.

4 Study

4.1 Goals of the study

The goal of the present study was to determine whether the operation of modification is the sole determinant of children's difficulty with complex DPs, or whether embedding plays a specific role. Our purpose was to examine, at the age in which children acquire recursive nominals, i) whether they are sensitive to the distinction between recursively and non-recursively modified DPs, and ii) whether they differ from adults in this regard.

4.2 Method

4.2.1 Participants

Fifty monolingual English-speaking children were recruited in preschools in upstate New York. Ages ranged between 4;00 and 5;11, with a mean age of 4;11 (*SD* = 5.8 months). All children were developing typically, demonstrating language scores within normal limits in the Clinical Evaluation of Language Fundamentals Preschool 2 (CELF-P2; Wiig et al. 2004) and typical scores for the Non-Verbal Scale of the Kaufman Assessment Battery for Children Second Edition (KABC-II; Kaufman and Kaufman 2004). Thirteen monolingual English-speaking adults from the same area served as control participants.

4.2.2 Materials

A referential elicitation task targeting descriptions of complex noun phrases, was developed using a similar strategy as employed in Pérez-Leroux et al. (2012a). In this task, a brief narrative accompanied by a picture was used to introduce various competing referents, and the relevant vocabulary items. The scenarios were designed so two different modifier PPs were required to uniquely describe the target. Children were then presented a question of the form which *x* ... *?*, to prompted them to produce the target description.

The recursive conditions were structured as in (2) *the bird on the crocodile in the water*, where the PP modifying the head noun is itself recursively modified by another PP. In the non-recursive conditions, as in (1) *the plate on the floor with oranges*, the head noun was directly modified by two PPs unrelated to each other. The narratives below accompanied the corresponding scenarios presented in the introduction

(21) *Non-recursive Narrative:* Mary had many oranges (POINT TO ALL ORANGES), so, she puts them in different plates (POINT TO PLATES). Somebody threw a rock in the kitchen and broke one of the plates. Look! (POINT TO BROKEN PLATE) Which plate got broken?

(22) *Recursive Narrative:* This little worm is afraid of the birds. The birds (POINT TO EACH) are afraid of the two crocodiles (POINT TO CROCODILES). One of the crocodiles is in the water, one is on land. But look, somebody caught the worm! (POINT TO WORM) Which bird caught the worm?

The materials contained six stories per condition. For the non-recursive trials, half the trials contained two locative modifiers (i.e. *the books in the box under the table*), while the other half combined locative and comitative (*with*) modifiers (as in *the plate with oranges under the table*). The latter type could be in principle ambiguous in these contexts: a recursive interpretation would be possible but not necessary because both the box and the books are under the table.

4.2.3 Procedures

Participants were interviewed individually, in a school setting. Graduate students experienced in language assessment administered the tasks. In addition to the referential tasks, children were administered three standardized tests (CELF-P2, KABC-II, and Peabody Picture Vocabulary 4; Dunn and Dunn 2007), and a standard non-word repetition task (Dollaghan and Campbell 1998). The order of the

various tasks was randomized to avoid practice effects. In addition to the recursive and the non-recursive conditions, the referential elicitation task contained three other referential conditions, not reported here, and 12 distractor items of different types, for a total of 42 test items. To mitigate potential ordering effects the referential task was presented with 3 different orders of presentation across participants. Participant completed the whole battery of tests in two or three sessions.

In the referential task, if a given trial was not responded to, the experimenter repeated up to three times (initial presentation plus two extra attempts). Incomplete responses (i.e., "the bird") were followed up with an additional prompt ("but which one?"). Pointing and gestural responses were discouraged; the children who produced them were invited to produce verbal responses ("...can you tell me with words?").

4.2.4 Coding

The data was analyzed using two independent coding systems, one to describe the syntax of the responses, the other to describe their referential properties. In the syntactic coding, we classified both level of embedding, and linking strategy. According to the syntactic coding, shown in (21), recursive modification is classified as second level of embedding. Children often produce simpler responses, consisting of either single NPs, or a head noun and a single PP modifier. Non-embedded double modification was described as two instances of Level 1 embedding, as shown in (23c).

(23) Syntactic coding: Levels of Embedding

a.	Single NP:	[$_{NP}$ the bird]		
b.	Level 1:	[$_{NP}$ the bird	[$_{PP}$ on the alligator]]	
c.	2 Level 1:	[$_{NP}$ the plate	[$_{PP}$ with oranges]	[$_{PP}$ under the table]]
d.	Level 2:	[$_{NP}$ the bird	[$_{PP}$ on the alligator	[$_{PP}$ in the water]]]]

Linking strategies included: prepositional modification (PP), relative clauses (RC), which is a possible but presumably more complex alternative to PP modification, and possessor genitives (POSS). There were also linking strategies that do not entail embedding, such as clausal relations, parataxis, and coordination. We illustrate with simple examples in (24).

(24) Syntactic coding: linking strategy
[$_{NP}$ the bird [$_{PP}$ on the alligator]] (PP)

[$_{NP}$ the bird [$_{CP}$ that is sitting [$_{PP}$ on the alligator]]] (RC)
[$_{NP}$ [$_{GENP}$ the alligator's] bird] (POSS)

The data was independently coded with a second classification system, based on descriptive content. That is, depending on whether and how the target referential expressions were used (i.e., 'plate', 'oranges' and 'table', and 'bird', 'alligator' and 'water', for (1) and (2), respectively). This referential coding had four categories:

(25) Referential coding

a. Incomplete descriptions: These were incomplete responses consisting of simpler NPs that made reference to one or two but not all three of the target referents (the bird, that one, the plates with oranges).

b. Alternative responses: These consisted of simple descriptions, often stated on spatial terms, which identified the referent correctly but not on the basis of the target PPs (the one on the left, the higher one).

c. Descriptively complete but non-target responses. These were responses that contained the three target nouns but lacked the target configuration.

d. Target.

Only descriptions that were i) coded as descriptively complete, and ii) had the relevant syntax of embedding (Level 2 for recursive modification, 2 Level 1 for non-recursive double modification) were classified as target. This leaves out responses that achieve pragmatic success by other lexical means (i.e., Alternative). These are correct but not useful for the purpose of our investigation. We also did not count as successful fully informative but pragmatically infelicitous clausal responses, such as in (26a):

(26) Which bird got the worm?

a. The bird is on the alligator in the water. (True but infelicitous)

b. The bird on the alligator in the water ~~got the worm~~. (True and felicitous)

The statement in (26a) is true within the context model, but does not answer the question under discussion, which (26b) does.

4.3 Results

4.3.1 Adult responses

Given the inherently open nature of this type of referential task, and the complexity of the scenario, it is not surprising that adults produced a range of responses, in addition to the target doubly-modified complex NPs. As shown in Table 1, 64% (50 out of 78) of the responses integrated the target expression into the same NP for non-recursive items. For recursive items, the percentage is much lower (36%, or 28 out of 78) consisted of recursively modified DPs.

	Recursive condition		Non-recursive condition	
Incomplete	25	(32%)	21	(27%)
Alternative	13	(17%)	3	(4%)
Complete non-target	12	(15%)	4	(5%)
Target	28	(36%)	50	(64%)
Total	78		78	

Table 1: Counts and percentages of responses to each condition given by adults, classified according to the referential coding

For these participants, the most common non-target response was incomplete descriptions, as in (27). These constitute almost one third of the total number of responses in each condition.

(27) Descriptively incomplete responses given by adults

a. The crocodile in the water

b. The alligator with the bird on his head

c. The plate under the table

On conversations after the task, some adult speakers who provided incomplete answers explained they had not noticed one of the competing referents (i.e., "Oh. I didn't see the other plate"). A single participant failed to produce targets in either condition, producing instead mostly incomplete responses. Another speaker gave all incomplete and alternative responses in the recursive condition, but produced targets in the non-recursive conditions.

Adults also produced alternative responses, as in (28), and descriptively complete non-target responses, as in (29). The latter type consisted primarily of clausal

responses (29a), and complete DPs with reordered modifiers. Example (29b) was produced in lieu of *the toothbrush in the cup on the shelf*, which contrasted with the toothbrush on the shelf.

(28) Alternative responses given by adults

a. The one on the left.

b. The one near the nearest tree.

(29) Complete non-target responses given by adults

a. The big toothbrush is in the cup on the shelf.

b. The one on the orange shelf in the cup

These two types of responses were more frequent in the recursive conditions, where relatively few targets were produced.

4.3.2 Children's responses

Children frequently had difficulties producing doubly modified DPs. In fact, 20 out of 50 participants produced no targets in either condition. An additional 12 children produced target structures in trials involving non-recursive modification. Four additional children produced target responses exclusively to recursive trials. The remaining fourteen children produced target responses to both types of NPs.

Children in this study were between the ages of 4 and 5, the period in which DP recursion is beginning to emerge, according to Pérez-Leroux et al. (2012a). Within this narrow age range, there was little correlation between age and production of recursive NPs. A Kendall's Tau rank correlation analysis showed small, non-significant associations between age (in months) and number of target recursive NPs (Tau=0.19, p=.09), and between age and target non-recursive NPs (Tau=.15, p=.16).

Table 2 shows that children's data shares some commonalities with those of adults. Children produce twice as many target responses to the non-recursive condition than to the recursive condition. Like in the case of adults, although at different magnitude, the primary non-target response was descriptively incomplete descriptions. There were also differences. The overall counts of target responses were much lower than adults. Children produce more descriptively complete but syntactically unintegrated responses. These were more common than the target responses.

	Recursive condition		Non-recursive condition	
Incomplete	204	(68%)	182	(61%)
Alternative	25	(8%)	8	(3%)
Complete non-target	47	(16%)	61	(20%)
Target	24	(8%)	49	(16%)
Total	300		300	

Table 2: Number and percentages of responses to each condition given by children, classified by the referential coding

In general, children produced a wide variety of non-target responses. When producing complete but off target responses, adults produced clausal or reordered responses. As shown in (30), children did as well.

(30) Target: the toothbrush in the cup on the shelf. Competing referents in the model were 1) a toothbrush in another cup, not on the shelf, and 2) a toothbrush on the shelf but not in a cup.

a. Uh the one on top of the table in the cup (KP, 4;08) (reordered)

b. The one is up in the table (AG4;07) (clausal)

Children produced referentially complete descriptions linked by coordination, as shown in (31a), or parataxis, as in (31b). This was was also found in Pérez-Leroux et al. (2012a). Such responses did not appear in adult data.

(31) Descriptively complete, non-target

a. **Target:** The worm in the apple on the plate.
Response: The worm inside the apple and the apple is on the plate and the worm is green. (DA, 5;10) (coordination)

b. **Target:** the bird on the crocodile in the water
Response: The birds that's on top of the crocodiles the crocodiles that's in water (AL4, 5;04) (parataxis)

4.3.3 Comparisons of responses between the groups

The data clearly shows that producing recursively modified DPs is much more difficult than producing doubly modified, non-recursive DPs. This is true for both

children and adults. To test this observation, we entered the frequency of target responses into a mixed-effect, logistic regression analysis with group (adults vs. children) and conditions (recursive vs. non recursive condition) as fixed effects, and participants as a random effect. The analysis shows that there are significant differences in the frequency of target responses across groups ($\beta = 2.21, Z = 4.56, p < .001$) and across conditions ($\beta = 1.38, Z = 3.84, p < .001$). However, there was no interaction between the fixed effects ($\beta = 0.45, Z = 1.00, p = .310$).

These results suggest that the same things that are complex for adults are complex for children, with differences in the magnitude. There is only one asymmetry in the distribution of responses, and it emerges only when descriptively complete responses are considered. Once adults can incorporate the three relevant referential expressions, they are more likely to produce target than nonintegrated DPs, at a ratio of 7:3 for recursive DPs, and 8:1 for the non-recursive DPs. For children, the opposite is true. Targets are less frequent than nonintegrated DPs, in both the recursive (1:2), and the non-recursive condition (5:6). These asymmetries in the frequency of target vs. non-integrated in children vs. adults are highly significant for both conditions (recursive, $\chi^2 = 12.05, df = 1, p < .001$; non-recursive, $\chi^2 = 32.96, df = 1, p < .001$). This suggests that children have specific issues with the formal integration of the referential expressions.

4.3.4 Structural analysis

In Table 3 we compare structures used by children and adults. The syntactic analysis is congruent with the referential analysis: children favor the simpler structures, whereas adults favor the relevant complex forms. The general trends for levels of embedding are similar across conditions.[7]

The most prevalent linking strategy used by both children and adults is PP modification, with relative clauses a far second. Similarly, there seem to be no dif-

[7] Target structures in this table are indicated in bold. Note that percentages of level 2 responses given by children in Table 3 are higher than their overall target responses (according to the referential coding), as reported in Table 2. Children produced some recursively embedded DPs that failed to include the target referential expressions. Example (i) contains 'the plate' as the highest head noun, and the pronoun in the most embedded NP position; (ii) builds up structure on the basis of additional relational nouns (eye, top of) that do not add the information necessary to distinguish which alligator.

(i) The one [=plate] that there's an apple on it. (OT 4;02)

(ii) "That bird." (Which bird is that?) "The one that's on top of the alligator's eye." (JG 5;01)

	Adult		Children	
	Recursive	Non-Recursive	Recursive	Non-Recursive
Single	5 (6%)	3 (4%)	72 (25%)	71 (24%)
Level 1	29 (37%)	15 (19%)	143 (49%)	108 (37%)
2 Level 1	5 (6%)	**50 (64%)**	10 (3%)	**60 (20%)**
Level 2	**32 (41%)**	2 (3%)	**47 (16%)**	27 (9%)
Unembedded	7 (9%)	8 (10%)	21 (7%)	30 (10%)

Table 3: Frequency (and percentages) of responses classified as to level of embedding

ferences across conditions, or between groups in the overall distribution of linking strategies used (with all levels of embedding taken altogether). This is shown in Table 4:

	Recursive		Non-recursive	
	Adult	Child	Adult	Child
PP	84	211	98	244
RC	23	66	19	54

Table 4: Overall frequencies of the two primary linking strategies employed by children and adults across conditions

One intriguing fact emerges when one considers the linking strategies employed in the target complex responses. Doubly modified responses for both conditions were extracted and tabulated for whether they were linked by PPs (32a), by RCs (32b) or by a combination of both (32c).

(32) a. The one on the plate with the apple.
(LAR,5;10) [= in the apple on the plate] (PP)

b. The bird. [Which one?] The bird that's on the crocodile that's in the water. IR, 5,08 (RC)

c. The one on the one on the crocodile's eyes that was in the water (AG, 5;03) (MIX)

Table 5 shows a contrast between the successful responses to recursive and non-recursive trials. Speakers primarily produced sequences of two PPs in the

non-recursive condition. In the recursive condition, adults produced either PPs or a mix of PPs and RCs.

	Adult		Child	
	Recursive	Non-recursive	Recursive	Non-recursive
PP	8	29	3	32
RC	0	2	9	6
MIX	9	9	11	6

Table 5: Frequency of linking strategies combinations (PP only, RC only, both) among the target responses given by children and adults to each condition

One difference between children's and adults' responses to recursive trials stands out. In the recursive condition, children were more likely to provide the more elaborated RC or RC/PP mix responses than the structurally simpler PP responses. The ratio of pure PPs to responses containing relative clauses was of almost 1 to 7 for the recursive targets, compared to 8 to 3 for the non-recursive targets. This asymmetry in the distribution of linking types among children's responses to the two types of complex DPs is highly significant ($\chi^2 = 21.64, df = 2, p < .001$). In other words, despite the challenge involved in the production of recursively modified DPs, when children actually manage to compose these complex referential expressions, they produce more structure rather than less. This shows even more clearly that in the recursive conditions, children do not necessarily opt for the structurally and lexically simpler form. Instead of producing the simpler stacked NP/PP sequences – the target – they seem to favor forms that introduce additional structural distance between the relevant referential expressions, as schematized in the difference between (33a) and (33b):

(33) a. [$_{DP}$ N [$_{PP}$ P [$_{DP}$ N [$_{PP}$ P [$_{DP}$ N]]]

b. [$_{DP}$ N [$_{CP}$ C . . . [$_{PP}$ P [$_{DP}$ N [$_{CP}$ C . . . [$_{PP}$ P [$_{DP}$ N]]]]]]]

4.4 Summary

The data reveals a strong asymmetry between recursive and non-recursive double modification, but an asymmetry that does not necessarily have a specific developmental component. The statistical analysis shows both type of NP and group were significant effects, but there was no interaction between these fixed effects.

Both children and adults produce non-recursive targets at twice the rate they produced target recursive NPs. There is only one potential point of evidence that non-recursive double modification might emerge earlier than recursive modification. Children who are able to produce non-recursive but failed to produce recursive structures outnumbered children who had the opposite production pattern by a ratio of 3:1. However, this may simply follow from the overall frequency differences in the productivity of the two.

In sum, children are comparable to adults in that they:

a. Find recursive modification more complex than non-recursive modification;

b. Often fail to notice the relevant two-way contrasts required by the visual contexts provided, and consequently fail to integrate all three referring expressions into their responses; and

c. Rely primarily on PP as the linking strategies between the relevant referents, as was intended in the design of the elicitation task. They also occasionally substitute a semantically equivalent but overtly more elaborate RC strategy.

Children also differed from adults in that they:

d. Produce complex structure much less frequently, at a ratio as low as 4:1 for the non-recursive condition and 9:2 for the recursive condition.

e. Can produce more descriptively complete but syntactically unintegrated responses than target responses, whereas adults, if they manage to produce the target referents, are more likely to produce a target response than not.

f. Produce more (overtly) over-elaborated responses than adults, on the average, and cluster these responses in the recursive condition.

5 Discussion

Acquisition data, messy as it can often be, can contribute to our understanding of why the system is the way it is. Our data introduces two novel observations about children's production of complex referential descriptions. The first observation is that children frequently fail to produce responses that meet the demand of the referential task. Because this difficulty goes beyond the demands of producing complex descriptions, we infer that children have a specific problem with integrating

the various referential expressions into a recursive structure. The paratactic and clausal strategies they often employ flatten the structure and reduce the number of nominal expressions dominating other nominal expressions. Undeniably, children's reliance on such structural alternatives relates to their propensity, in speech production, to conduct sentence planning over shorter spans, when compared to adults (McDaniel et al. 2010). However, the recursively modified DP targets in our study are not particularly long, nor are they longer than their non-recursive counterparts. Thus, phrasal length, in the traditional sense, cannot properly account for our results.

The second observation is that children tend to introduce relative clauses in the target responses to the recursive condition. Again, this points in the same direction as the previous observation. Children produce longer, more overtly elaborated description, which have the consequence of decreasing the structural proximity between referential expressions. At this point, it would be useful to consider this result in light of Arsenijevic and Hinzen's (2012) discussion of how the forms of recursion arise from the way in which narrow syntax and interpretation interlock, rather than from narrow syntax itself. These authors note that, in natural language, instances of a category X directly dominating other instances of X are exceedingly rare. The norm is that referential expressions and propositions (DPs and CPs) dominate others of the same type only indirectly, mediated by a rigid sequence of functional categories. This brings us to a speculation about recursion, and the different interface behaviors of embedded and embedding categories. The parataxis and relative clause effects observable in our results suggest that the faculty of language (as revealed through the process of acquisition) is set to maximize the structural contour existing between a higher referential expression from lower expressions embedded under its domain.

Complex NPs such as the ones examined in this study point to the limitations of syntax-only or semantics-only approaches to complexity. Structurally, these complex DPs involve identical parts, containing the same types (and number) of lexical-level categories, and the same types (and number) of maximal projections, and the same type of adjunction involved in integrating the parts. In compositional terms, we discussed how these structures involve the same semantic types and two applications of predicate modification. The components that enter the derivation (whether syntactic or semantic) step-wise do not help us articulate why there should be a difference in complexity. However, a difference does exist, as indicated by the magnitude of the observed asymmetry in productivity, for both adults and children. Standard assumptions about how phrases are generated by the syntax, and about how they are interpreted in a compositional semantic sys-

tem, do not lead to a characterization of this difference. What we do know is that the descriptive conditions associated with the recursive case are more complex. The referent identified by non-recursive double modification can be simply described as a Boolean intersection of three sets (denoted by the relevant predicates, 'plates', 'things with oranges on', 'things under the table'). The relation between the three set-denoting predicates in the recursive case ('bird', 'things on alligators', 'things standing on water') cannot be described by any simple intersection. Instead, in the task of contrastively describing the referent of a recursive description, speakers must represent an intermediate domain of reference (which we call, level 1, assuming a bottom up metaphor) within which the intermediate iota operator (which binds the "alligator" variable in the cases considered) must bind the first variable of the lowest relational predicate (i.e. the preposition). At a subsequent (higher) layer in a recursive structure, what we have called level 2, the variables in the lowest PP are already saturated. As a consequence, applying these operations recursively/cyclically isolates independent scopal domains. The order in which operations apply (modification, in semantic terms, or, embedding in syntactic terms), results in a more complex and descriptively rich expression. This approach can account for the observation, from the acquisition literature, that PP modifiers are produced less frequently than simple predicative adjectives. A modifying adjective restricts a referent without involving lower referential expressions that have to be type-shifted into predicates. PP modification, in contrast, entails additional layers of reference.

The cases examined here fall into a lacuna in the existing discussion on the syntax/semantics of embedding and of recursion. Arsenijevic and Hinzen (2012) differentiate embedded and embedding categories on the basis of the two potential denotations of a DP (referential and predicative). This two-way split does not illuminate the contrast between recursive and non-recursive modification. In either type, at the highest point of the derivation, all PP modifiers have become part of predicative content. While all the descriptive content in lower phases remains relevant at interface, the scopal possibilities (particularly, that of the intermediate iota operator) have become fixed by the derivational history. Thus, each step in embedding introduces a new layer of descriptive complexity. The reasons why are not evident within a framework in which earlier phases are rendered inert. The solution is to understand that inertness of the content of a phase refers exclusively to the syntactic computation.

What have we learned about how embedding introduces complexity for children? The results of our study support previous claims that what is difficult for adults is also difficult for children. Just more so. Enough, in fact, to account for

the general modification gap in found in production studies, and in spontaneous speech studies. The present study shows that recursive embedding introduces complexity that goes beyond the elements and operations used during the semantic composition of the structure, or the cyclic syntax that generates it.

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