THE ACQUISITION OF RECURSIVE MODIFICATION IN NPS

Ana T. Pérez-Leroux — *University of Toronto*
Tyler Peterson — *Arizona State University*
Anny Castilla-Earls — *University of Houston*
Susana Béjar — *University of Toronto*
Diane Massam — *University of Toronto*
Yves Roberge — *University of Toronto*

Despite sensitivity to the contextual demands of modification, children struggle with the production of complex NPs. What syntactic or semantic properties of NP embedding specifically introduce complexity? We compare production of definite descriptions with two modifiers that contrast in the attachment of the second modifier: sequential vs. recursive modification. Children ($n = 71$) produced overall fewer targets than adults ($n = 13$), but both groups found double nonrecursive modification (e.g. *the plate with oranges under the table*) much easier than recursive modification (e.g. *the bird on the alligator in the water*). We conclude that each embedding step introduces complexity beyond the elements and operations employed in the semantic composition of the structure, or the cyclic syntax that generates it.*

Keywords: complex NPs, embedding, modification, recursion, child language acquisition, syntax-semantics interface, PPs

1. Introduction. The growth of linguistic competence, from telegraphic speech to full adult competence, involves the production of longer, increasingly complex utterances. It seems natural to assume that the complexity of a given structure is the same whether it is generated by the grammar of a child or an adult. However, it is not clear whether sentences containing more elaborated structure are more difficult for speakers, and whether difficulties arise to the same degree in children and adult speakers. Making clear predictions is hindered in part because the field lacks a coherent understanding of or consensus on what constitutes complexity in grammar (see e.g. McWhorter 2011, Culicover 2013, Newmeyer & Preston 2014, Roeper & Speas 2014, Trotzke & Bayer 2015). Despite the heterogeneity of perspectives, most discussions of grammatical complexity assume that structural elaboration in general, and embedding specifically, introduces complexity (Culicover & Jackendoff 2006, Givón 2009). In this article we seek to better understand the effects of structural elaboration in grammar by isolating the degree of embedding and studying how it affects the performance of children and adults.

Our focus is the production of complex noun phrases (NPs) containing recursive prepositional phrase (PP) modifiers.[1] Modification is one of the most basic forms of NP elaboration. Under one view, its use in natural language is regulated by the Gricean maxim of quantity: speakers provide just enough information to identify a referent, but no more than is needed. Speakers make choices about the quantity of descriptive content to be expressed when labeling a referent, and these choices are conditioned by discourse and con-

* This research was supported by a grant from the Social Sciences and Humanities Research Council of Canada to A. T. Pérez-Leroux and Y. Roberge (SSHRC 435-2014-2000, 'Development of NP complexity in children'). We thank Tom Roeper, Petra Schulz, Jacqueline van Kampen, and Ian Roberts for helpful discussion, and our superb team of graduate assistants Erin Hall, Erin Pettibone, and Gabrielle Klassen. We are also grateful to Grant Goodall, Megan Crowhurst, and Lisa Pearl for their insightful suggestions and questions in their roles as editors and external referees.

[1] In this article the term 'complex NP' is used to refer to a modified NP, not necessarily to an NP whose head N is modified by a clause, as in traditional grammar or early generative grammar work (e.g. Ross 1967). Under various generative analyses, the distinction is superficial since NP-internal modifiers are thought to derive by ellipsis from relative clauses (although Ross does not specifically claim this).

text (Tanenhaus et al. 1995, Sedivy 2003, Davies & Katsos 2013, Heller & Chambers 2014). Our understanding of how children make choices to elaborate an NP, however, is less clear. The acquisition literature contains two seemingly conflicting observations about the referential skills of children. On the one hand, experimental results show that five-year-olds are highly sensitive to context in their production of modified NPs. They use adjectives (e.g. *the **small** glass*) only when a competing referent is present in the context (e.g. *a **large** glass*), and only when this competing referent is accessible to their interlocutor (Nadig & Sedivy 2002). On the other hand, there appears to be a productivity gap in children's production of complex NPs, as most of the nouns they produce spontaneously are unmodified nominals. Children's use of modification seems more limited for embedded PP modifiers than for adjectives. Recursively modified NPs are particularly challenging (Roeper 2011, Pérez-Leroux, Castilla-Earls, Béjar, & Massam 2012). This opens up the possibility that deployment of children's referential abilities is constrained by properties of the structures themselves. The goal of this study is to explore the source of children's difficulty with recursive modification, and to investigate whether such difficulties remain to a certain extent in adults. We seek to tease apart the basis for the difficulty arising from this type of embedding, in order to ascertain whether it is best described in syntactic or semantic terms, and in derivational or representational terms.

To do so, we investigate the production of two types of doubly modified definite descriptions. The two cases differ minimally with respect to the attachment of the second modifier. Consider the scenarios in Figures 1 and 2, which serve as visual context for a question requiring the identification of a unique referent.

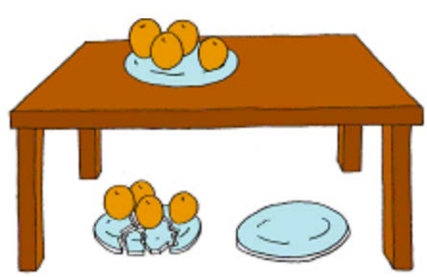


FIGURE 1. Which plate got broken?

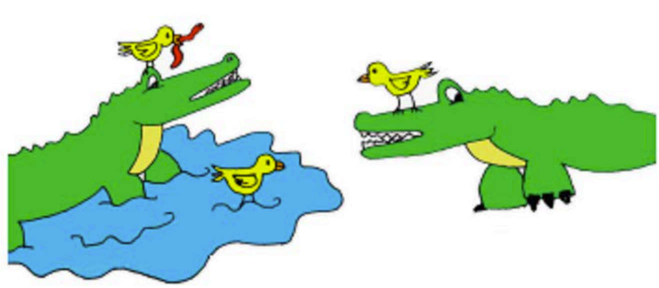


FIGURE 2. Which bird got the worm?

The correct answer to the question in Fig. 1 involves simple modification: the highest NP is sequentially modified by two independent restrictive PPs, as shown in the bracketing analysis in 1. The response to the prompt in Fig. 2 also involves two restrictive 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, SEQUENTIAL DOUBLE MODIFICATION (SDM) and RECURSIVE DOUBLE MODIFICATION (RDM), constitute a minimal pair distinguished only by level of embedding. Comparing the two allows us to tease apart quantity of descriptive content (e.g. number of modifiers) from level of embedding.

This article presents an elicited production study of children's and adults' production of the two types of complex NPs described above. We first discuss (§2) the basic semantic and syntactic properties of modification, leading to the formulation of a null hypothesis: that SDM and RDM should pattern alike. This null hypothesis is then considered in light of a recent proposal about the consequences of embedding for semantic interpretation, and an alternative hypothesis is formulated. We then summarize the literature on children's difficulties with modification in general, and specifically with recursive structures (§3). Section 4 presents our study and the results, pointing to the need to reject the null hypothesis. The limitations of a purely syntactic or semantic approach to characterizing our results are explored in §5, and we propose some alternative ways of analyzing the contrasts revealed therein.

2. SYNTAX AND SEMANTICS OF NOMINAL MODIFICATION. In this section we examine specific differences in the syntactic and semantic representations of the two types of complex nominals (SDMs and RDMs). We first examine some basic formal assumptions about the internal structure and interpretation of modified DPs and consider their derivational properties in light of phase theory.

2.1. THE FORMAL INGREDIENTS OF MODIFICATION. Our first observation is that SDM and RDM structures are syntactically identical with respect to the inventory of individual syntactic elements and steps or operations involved in combining them. If we take each step in their syntactic derivation to be an instance of the Merge operation, the two kinds of expressions contain the same number of iterations of Merge.[2] In terms of Merge, the only difference between the structures is whether the second PP modifier is merged higher (SDM) or lower (RDM). There is no a priori reason to think that any given instance of Merge, higher or lower, is somehow more difficult than another. Nor is there any a priori reason to think that merging a more complex PP (as in RDM) should be more difficult than merging a simpler one (as in SDM). This is particularly so in a phase-based model (Chomsky 2001), where at each cycle the lower structure becomes impenetrable and inaccessible to subsequent computations. In sum, from a syntactic point of view, there should, in principle, be no difference in complexity between SDM and RDM.[3]

[2] Merge, in contemporary generative grammar, is the basic structure-building operation that combines two syntactic objects to form a new constituent. For the sake of completeness, the syntactic derivation corresponding to 1 proceeds as follows: *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 with *under* [merge 4], the result of which then adjoins to *plate* [adjoin 2]. Then the structure *plate under the table with oranges* merges with *the* [merge 5]. In the derivation in 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]. Finally, *the* merges to form *the bird on the alligator in the water* [merge 5].

[3] Throughout this article we use the term 'complexity' in a pretheoretical sense. We do not elaborate on the potential connection between what is difficult and what is complex. What interests us here is to determine whether SDMs and RDMs are difficult for speakers to the same degree, and in a similar way for children and

A similar conclusion can be reached regarding the semantics of SDM and RDM structures. Nominal expressions map onto entities or set-denoting predicates, depending on the type of noun (e.g. *Lily*, *dog*) and the presence or absence of determiners (e.g. *the dog*, *dog*). Languages vary as to the presence of determiners, with consequences for the semantic mapping of NPs (Chierchia 1998, Partee 2002). The semantic type of a nominal expression is also partially determined by its syntactic position, as shown in the contrast between referential and predicative uses of DPs (***a dog*** *barked* vs. *Lily is* ***a dog***). The type of a constituent shifts as the constituent is subsequently merged with additional constituents to build higher extended projections. In textbook analyses of simple phrases such as 3, the NP denotes a predicate, and the determiner phrase (DP) denotes an entity (cf. Heim & Kratzer 1998).

(3) $[_{DP}$ the $[_{NP}$ table]]

Prepositions generally express a two-place relation between entities. When combined with a nominal constituent, the preposition shifts the type of the constituent from entity to predicate. This is evidenced by the use of PPs in copular constructions, as in 4, or in restrictive NP modification, as in 5.

(4) The vase is $[_{PP}$ on $[_{DP}$ the table]].
(5) $[_{DP}$ the vase $[_{PP}$ on $[_{DP}$ the table]]]

One consequence of embedding is that the embedded nominal expression no longer functions as a referring expression, but as a descriptor (e.g. a predicate) of the nominal it modifies (Arsenijević & Hinzen 2012). In 5, the lowest DP expression (*the table*), now a constituent of the PP modifier, provides additional descriptive content to *the vase*. The complex DP denotes an entity that both is a vase and is located on the table.

We can now consider what happens with DPs with sequential modification, as in 1, and compare them to those that have recursive modification, as in 2. The logical representations help us to pinpoint precisely what is different between these two types of complex nominals. The DPs given in 1 and 2 are the corresponding fragments that can be given in response to the scenarios in Figs. 1 and 2 (e.g. *the plate with oranges under the table* ~~*got broken*~~, and *the bird on the alligator in the water* ~~*got the worm*~~). Taking these visual scenarios as models, we can provide truth conditions for the corresponding propositions. The truth conditions for 1 are given in 6.[4] Here we have two PP predicates that simultaneously restrict the iota operator which picks out the (unique) plate x such that x has oranges and x is under the table.

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

In 7 we describe the truth conditions for 2.

(7) 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:
$$got.worm(\iota x(bird(x) \wedge \iota y((alligator(y) \wedge on(xy)) \wedge \iota z(water(z) \wedge in(yz)))))$$

Whereas in 6 the two PP predicates are commutative, in 7 they are not. This is what 7a shows: the bird x that got the worm is the x such that x is both on the alligator and in

adults. Whether an observed difficulty with a structure means that this structure is more complex is left for further research; see Béjar et al. 2017 for discussion.

[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 $Q(\iota xPx) \Leftrightarrow \exists x(Px \wedge \forall y(Py \rightarrow x = y) \wedge Qx)$. Also, we are not concerned with the definite description in the nuclear scope of the sentence (e.g. *the worm*). Thus, *got the worm* is simply treated as an intransitive predicate.

the water. By contrast, in 7b the PP modifiers of *the bird* are recursively embedded and contain their own definite descriptions, whose references determine the identification 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 ($in(yz)$). To put this in plain English, only the alligator is in the water, not the bird.

These truth conditions can be straightforwardly derived with nothing but the standard semantic types. Nouns and PPs are predicates (type $\langle e, t\rangle$). By extension we assume that prepositions are of type $\langle e,\langle et\rangle\rangle$: 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 definite article *the* in 8, which takes a predicate and returns an entity.[5]

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

The next step is to characterize, for the nominal predicates found in the doubly modified DPs, the combinations of PP modification and their resulting definite descriptions. To begin with, modification of the kind relevant here is achieved through the rule of PREDICATE MODIFICATION (e.g. Heim & Kratzer 1998:63–73), shown in 9.

(9) 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 $[\![\alpha]\!] = \lambda x \in D_e \,.\, [\![\beta]\!](x) = [\![\gamma]\!](x) = 1$.

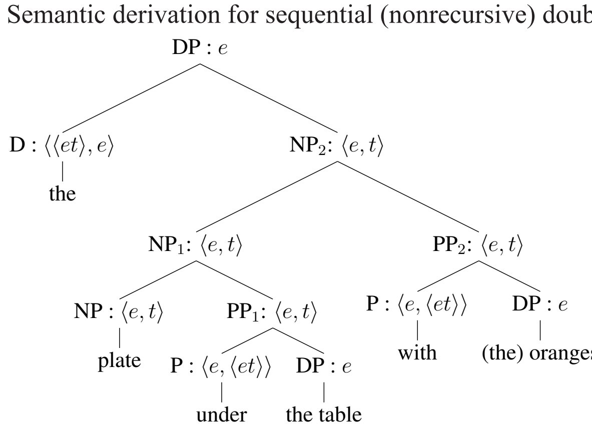
Predicate modification forms a complex predicate that defines the intersection of the things that have the property set by the head noun and the property or properties defined by the PPs. The expression in 10 represents the first level of embedding, and the one in 11, two instances of first-level embedding (SDM).

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

(11) Sequential (nonrecursive) 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 is argument to the definite determiner. The semantic derivation is shown in 12.

(12) Semantic derivation for sequential (nonrecursive) double modification



[5] In the given scenarios, the presupposition of existence of the various definite descriptions is satisfied (cf. Russell 1905, Strawson 1950, etc.).

Since sequential PP modification is commutative, the two PP modifiers of *plate* can be freely reordered, as in 13, with no effect on the truth conditions.

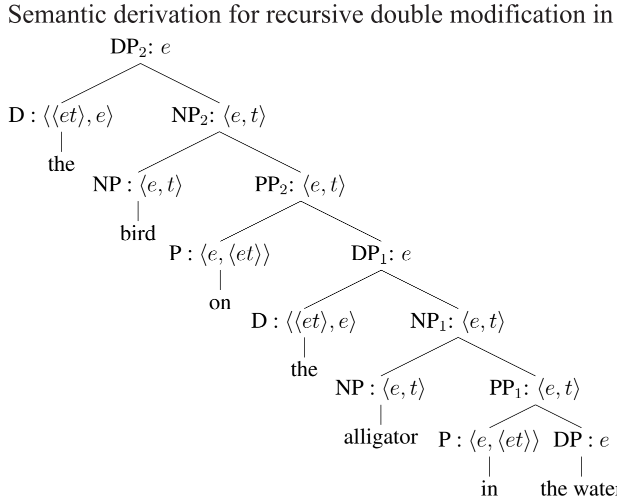
(13) a. the plate under the table with oranges
b. the plate with oranges under the table

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 14 against the set-up in Fig. 2.

(14) Recursive modification
a. ⟦bird on the alligator in the water⟧ $\in D_{\langle e,t \rangle}$
b. FALSE (two iterations of level 1 sequential modification):
λ*x* . *x* is a bird and *x* is on the alligator and *x* is in the water.
c. TRUE (level 2 recursive embedding):
λ*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 14b, with the three predicates directly combined via predicate modification, incorrectly predicts that this expression can apply to a context where the bird is both in the water and on the alligator. The expression in 14c provides 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 predicative content inside it (the property of 'being in the water') is no longer accessible to the referent described by the higher NP. This is the relevant difference between the sequential and recursive structures. The complete derivation is provided in 15.

(15) Semantic derivation for recursive double modification in 2



To summarize, DPs with double modification, in both the recursive and the sequential cases, are derived by the same number of iterations of predicate modification. This means that they are identical with respect to the individual steps or operations involved in building the semantic structure. We saw above that the same was true for the syntactic derivation of these structures. Although SDM structures contain additional depth and a more elaborate form, there is no difference between SDM and RDM in terms of the length of the derivational process in either syntax or semantics. Consequently, we can expect recursively modified and sequentially modified NPs to behave the same during the acquisition process. This is thus the null hypothesis: no differences between the structures.

If, however, acquisitional differences exist between SDM and RDM, the differences cannot be described in terms of derivational steps (in either the syntactic or the semantic derivations) but rather in terms of the resulting structural representation, which for RDM yields additional structural depth and a more elaborate logical form. Some possibilities along these lines are laid out in the next section.

2.2. BEYOND NARROW SYNTAX. The minimalist framework distinguishes between narrow syntax, which simply consists of a sequence of applications of Merge, and interfaces, where the syntactic objects generated by Merge are cyclically spelled out for phonetic and logical interpretation (Chomsky 2007, Sauerland & Gärtner 2007). Sentences thus correspond to a layered system of phases or subderivations, each layer being quite simple (Trotzke & Zwart 2014). This distinction leads to a paradoxical insight: while embedded structures obviously result from the structure-building process, any difficulty they may introduce might not form part of narrow syntax. One consequence of the cyclic organization of phases is that embedded constituents exhibit dual referential behaviors. This is the point behind Arsenijević and Hinzen's (2012) claim that syntactic embedding induces intensionality effects. For instance, regarding clauses, we know that propositional complements of belief predicates are not asserted by the speaker of the sentence; they are opaque. There is one exception to this opacity effect, namely, when the proposition itself is not syntactically embedded to the epistemic verb, as witnessed by the contrast in 16.

(16) a. Bob believes Mary is wrong.
b. Mary is wrong, and Bob believes so.

This shows that referential opacity arises from a structural rather than a merely lexical property. Arsenijević and Hinzen argue that a comparable effect is present also in the case of DPs: an embedded nominal expression cannot be directly predicated of, as shown in 17a. In contrast, a similar nominal coordinated or paratactically adjoined is accessible to modification by the copular predicate, as in 17b (Arsenijević & Hinzen 2012:430).

(17) a. The vase on the table was/*were green.
b. The vase, the table, were/*was green.

The lower nominal expression in 17a is interpreted first in order to determine a discourse referent (e.g. the unique, familiar table). As discussed in the previous section, the DP is rendered predicative again by the preposition, and 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).

This cyclic property of phases may lead us to conclude (prematurely) that the internal hierarchical structure of modified constituents is immaterial, since at the point of computation of a higher head, all of the content from lower phases has already become inaccessible in the syntax and is nonreferential in interpretation. However, combining a phasal analysis with the logical form at the interface highlights one property of embedded structures: that they force speakers to keep multiple cycles of reference simultaneously active. Applying this insight concretely to example 2, the right alligator must be chosen at the same time as the right bird. This is the essence of what is formalized in the representation in 14b.

Under this view, the derivation of RDM adds additional structural depth and results in a more elaborate logical form. This is despite our observation that doubly modified DPs are derived by the same number of iterations of semantic steps (predicate modification) and syntactic steps (Merge) in both the recursive and the sequential cases. In light of this, we see an alternative to the null hypothesis articulated above. Whereas the null hypothesis takes the two structures to be equally difficult, the alternative is that RDMs are more complex than SDMs, in which case children (and possibly adults too) will have difficulties with RDMs but not with SDMs. In sum, if children exhibit the same level of difficulty with RDMs and SDMs, then we can take the two structure types to be equally challenging. Otherwise, we must consider the alternative hypothesis, that RDMs result in a more challenging representation than SDMs.

We emphasize that even if our results support the alternative hypothesis and indicate added difficulty in RDMs, under our view the difficulty cannot arise from any individual component or step in acquiring the syntax or the semantics of RDMs for the reasons just established. The alternative hypothesis posits that the added difficulty of RDMs would have to be attributed to other factors, and the explanation would have to be built on the insight that RDM requires keeping multiple constituents open and multiple referents active. The alternative hypothesis switches the explanatory burden to the interface of structure and interpretation and/or the processes involved in sentence production and comprehension of complex NPs.

Other possible accounts of the difference between SDMs and RDMs include non-domain-specific issues, such as information-processing failure relating to the various sources of information present in the referential context that must be assembled to properly point to the appropriate referent. It is not outside the realm of possibilities that this is the type of ability that develops over time in children. Other processing considerations might also be at play, hindering the deployment in real time of the target structures. Finally, it is even conceivable that a contrast in the level of difficulty between RDMs and SDMs arises from the different descriptive conditions involved.

We return to this in §5 using the results of our experiment, which is presented in §4. Next, however, we consider previous literature on how children learn to use complex NPs.

3. NP modification in child language. Traditional explanations for the timing of the acquisition of grammatical structures in children include frequency of the required input (Yang 2004), maturational factors (Chien & Wexler 1990), and the timing of associated conceptual developments (Johnston 1985, Pérez-Leroux 1998). In other cases, researchers explain difficulties in the acquisition of a form by appealing to certain structural properties. Complexity in these cases is articulated in configurational terms (Jakubowicz & Nash 2002, Jakubowicz & Strik 2008, Friedmann et al. 2009, Friedmann & Costa 2010).

In the case of noun modification, children seem to exhibit difficulties that go beyond the properties of the basic grammatical ingredients involved. The functional elements and relations needed to build complex nominal structures enter children's language quite early. According to Bloom and colleagues (1975), possession, modification, and location are among the first semantic primitives identifiable in children's speech. These uses are evident even at the onset of grammatical combinations. Two-word utterances frequently include combinations such as adjective-noun, noun-noun, and noun-location. The following examples of child utterances from the CHILDES database clearly illustrate how these are employed to identify or restrict a referent (MacWhinney 2000).

(18) a. Adjective + noun
Green cup. (Allison 1;10)
Big drum. (Adam 2;03)
b. Noun + noun
Puppy dog. (Adam 2;04)
Baby doll. (Allison 1;08)

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

Despite the early appearance of these functions, for the first few years, children produce primarily simple NPs. PPs and adjectives are common in predicative contexts, but are used much less frequently in NP-internal position. Eisenberg and colleagues (2008) found that the narrative samples of five-year-olds contain mostly unmodified nouns. About 20% of the five-year-olds in their study used no prenominal adjectives at all (e.g. *the* ***yellow*** *ball*). Twice as many children produced no instances of PPs 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 produced them. No instances of double PPs or relative clauses were reported. In contrast, most of the narratives from eleven-year-olds include some use of PP modification, and about half of the children are shown to use double adjectival modifiers in their narratives. NP elaboration in narrative samples increases drastically during the school years.

Complex NPs thus might seem less frequent in children than one might expect on the basis of other language abilities. What determines this apparent modification gap? Three obvious possibilities come to mind: (i) performance constraints that set limits on children's production of more difficult structures, (ii) pragmatic deficits that make children less aware of the contextual demands for modification, and (iii) incomplete competence of the syntax/semantics of nominal modification. Starting with the problem of performance, we can see that the initial low productivity of complex NPs cannot be fully accounted for in terms of simple output constraints. Most five-year-olds have mean lengths of utterance (MLUs) that approximate the adult range (Brown 1973). However, they do not produce the same range of nominal structures as older children or adults.[6] The literature on the acquisition of relative clauses has long established that children tend to underproduce complex NPs. Processing of relative clauses and the specific challenges of the various relative clause constructions are themes that figure in this literature (Friedmann et al. 2009, Friedmann & Costa 2010, Kidd et al. 2011, Guasti et al. 2012). One general observation from these studies is that the same factors that present difficulties in the acquisition of relative clauses also play a role in the adult processing of relative clauses (Moscati & Rizzi 2014). For instance, the McDaniel et al. 2010 study of production fluency noted a strong correspondence between how children and adults responded, depending on 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 the second relative clause within the initial utterance. McDaniel and colleagues concluded that while children conduct sentence planning more often and over shorter spans than adults, they rely on the same processes and sentence-formulation systems as adults. Despite the disparities in planning resources, children and adults react similarly to the same types of structural elaboration.

[6] Although MLU continues to be used as a standard measure of complexity in the developmental field, utterance length clearly fails to capture some fundamental dimensions of the development of grammatical complexity. Some argue that MLU is more reflective of talkativeness or lexical development than of syntactic development (Dethorne et al. 2005, Dixon & Marchman 2007, Pérez-Leroux, Castilla-Earls, & Brunner 2012).

The second possibility is that children's pragmatic limitations simply mask extant syntactic abilities.[7] Children may avoid complex NPs because they are simply not aware that they are supposed to use modification in a given context. In the referential-pragmatics literature, children's avoidance of complex nominals is described as underinformativeness (Matthews et al. 2007, Davies & Katsos 2010). The experimental evidence on children's referential behavior does not provide general support for a pragmatic deficit. In a study by Nadig and Sedivy (2002), five-year-olds show early sensitivity to common ground in sentence processing.[8] Children in their study carefully adjusted their use of modifications according to both visual context and interlocutor perspective. When asked to identify an object for a listener, five-year-olds produced adjectives (e.g. *the small glass*) only when a related object (e.g. *a large glass*) was present in the context. Adjectives were produced less when the object of the same kind was absent from the visual field of their interlocutor. The authors conclude that by the age of five, children are not egocentric, and they know they have to adjust their use of adjectives according to the referential perspective of their conversation partner.[9] Nonetheless, this study identified one systematic pattern of referential failure: 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 & Sedivy 2002:335, emphasis ours).

Subsequent work on children's referential behavior further confirms both sensitivity to informativeness and a lag in production. According to Davies and Katsos (2010), children between the ages of four and six often produce underinformative descriptions in the presence of a contrastive set, but never overspecify in their production of referential expressions. In comprehension, however, children at that same age react like adults to underinformative descriptions, judging them as inappropriate. The same children also judge overinformative descriptions (e.g. labeling a star as *the big star* when only one star is present in the context) as degraded, provided that the experimental task gives them an opportunity to express graded acceptability (Davies & Katsos 2010).

On-line studies contribute with compatible results. Sensitivity to quantity would predict that when confronted with overinformative descriptions, such as 'Find the cat with a tail' in contexts where only one cat is present, comprehension will slow down because the listener would assume that the speaker is implying the presence of a contrastive element. Analyzing reaction times and gaze direction, Morisseau and colleagues (2013) find that five-year-olds, but not three-year-olds, are delayed in overinformative scenarios, in comparison to appropriate uses.

An independent line of experimentation investigating children's sensitivity to the semantics of definite modified NPs also suggests a great degree of semantic and pragmatic

[7] McDaniel and McKee (2004) present an interesting critique of the overuse of pragmatic-deficit accounts in the child literature.

[8] 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 to an object in the physical context, or the act of showing a picture.

[9] Interestingly, 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 noncontrastive descriptive material is thought to be helpful rather than redundant.

competence in young children. Children understand how definite descriptions can be used to restrict the domain of quantifiers, demonstrating 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 and colleagues (2010) tested children's intuitions about the felicitousness of various descriptions (*Give me the full one*/*the tall one*), given contexts 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. 2010:27) and also demonstrated sensitivity to adjective type. With relative adjectives, which are used for establishing comparisons among elements in a context, children were able to shift the standard of comparison, without overextending 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, as long as an even shorter stick is present in the context. This shows that children can already make sophisticated distinctions between types of modifiers and are simultaneously able to detect presupposition failure, as well as accommodate other presuppositions when appropriate.

It seems then that the modification gap cannot be explained in terms of lack of sensitivity to pragmatics. Performance effects are likely implicated but cannot constitute the whole explanation. In fact, performance accounts make direct reference to some notion of complexity not fully defined. Let us now turn our attention to the question of structure itself. Adjectives appear to be used more freely in child language data than PP modifiers. Their formal properties also differ: AP modifiers are not considered phasal, but the DPs that provide the content for PP modifiers are; see Hinzen & Sheehan 2013:102. We thus propose to leave aside adjectival modification in order to concentrate on what is special about the self-embedding property of phrases. A few studies have examined the acquisition of recursive embedding within DPs, inspired in part by the claim in Hauser et al. 2002 that recursion is the fundamental property of the human language faculty, and the subsequent debates on the universality of recursion in natural language and its psycholinguistic nature (Evans & Levinson 2009, Nevins et al. 2009, Pallier et al. 2011, Maia et al. 2013). Roeper and Snyder (2005) examined recursive possessives and PPs across the CHILDES database and concluded that these structures are exceptionally rare in the spontaneous speech of children. They found parental use of recursive DPs and observed that children have difficulties understanding them (Roeper & Snyder 2005). The following dialogue, taken from Roeper 2011, shows that the child is unable to repeat a complex NP consisting of recursively embedded PP locatives.

(19) 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)

Other studies have tested children's comprehension of NPs. Limbach and Adone (2010) found that preschool-aged children gave nontarget 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').

Speakers informally judge a coordinated NP, such as *a boy and a dog*, as less difficult than a comparable modified NP, *the boy with a dog*, which contains the same constituent NPs. Elicited production data from children confirm this intuition. Pérez-Leroux, Castilla-Earls, Béjar, and Massam (2012) compared English-speaking preschoolers' ability to produce coordinated and recursive DPs. Children were able to produce three coordinated nouns (*a bicycle, a ball, and a doll*) almost as frequently as adults. In contrast, few children managed to produce recursive possessives (as in 20) or recursive PP modifiers (as in 21).

(20) Elmo's sister's ball
(21) the girl with the dog with the hat

Approximately two thirds of the children between the ages of three and four were limited to producing simple, unmodified NPs. The remaining children managed to produce a single level of possessive or prepositional embedding, but structures such as 20 or 21 were virtually absent. Only two of the thirty-two younger children produced any instances of either recursive possessives or recursive PPs. It is only after the age of five that these complex NPs enter production. Two fifths of the five-year-olds produced recursive structures, with recursive PPs being more prevalent than possessives. This pattern of development, compared to the ease with which all children produce coordinated NPs, shows that there is no limitation on producing prosodically integrated multiple-constituent NPs. The challenge lies with integrating these various NPs into complex descriptions linked by embedding.[10]

Interestingly, some of the nontarget answers given by children in Pérez-Leroux, Castilla-Earls, Béjar, & Massam 2012 provide a complete characterization of the target referent, syntactically integrating the three NPs.

(22) 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 examples suggest that some children can manage to make reference to the target expression, while showing specific difficulties with embedded syntax. This is congruous with the traditional view that children start with parataxis and eventually shift to embedded representations (Lebeaux 2000, Givón 2009). Nonetheless, if the developmental problem is described in purely syntactic terms, we quickly run into explanatory problems. Embedding is simply one of the applications of Merge: if children have the basic constituents and the ability to merge syntactic elements, why should they not be able to apply it successively or recursively? All evidence from child language indicates that asymmetric hierarchical structure is a property of children's earliest productions (Takahashi 2009, Hunsicker & Goldin-Meadow 2012). Then there is the question of recursion. If children can produce complex NPs using a rule for embedding constituents once, why is there such a gap between this initial step (acquiring simple, first-level possession or PP modification) and the second step of applying the modification rule recursively? In other words, assuming embedding through Merge is one of the fundamental operations in language (Hauser et al. 2002, Moro 2011), why is recursive embedding such a challenge in acquisition?

To summarize, studies on semantic and pragmatic development provide clear evidence that children can navigate meaning, context, and perspective in their interpretation and use of nominal modification. Despite these abilities, there is a clear productivity gap in children's use of complex nominals. Attributing this gap to syntactic capacity raises

[10] Standard current analyses of coordination attribute endocentric structure to coordinate clauses, making coordination analogous to other forms of phrase structure building (Munn 1993, Progovac 1998; but see Cowart & McDaniel 2012 for a dissenting view). This makes it difficult to state the contrast between coordination and embedding in purely structural terms. The contrast between coordination and subordination then must be defined in terms of the semantic interface: 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, in the manner described in §2.

many questions in a generative framework. Even in usage-based models, which posit that complex structures are acquired in a piecemeal fashion by analogy to what children know about matrix clauses (Diessel & Tomasello 2001, 2005), the question of recursive embedding is left unanswered: how does an embedding strategy learned for one-level embedding generalize to additional levels of embedding?[11] Are these structures late because they are rare, or rare and late because they are complex? And beyond the developmental question, there is the structural question: what makes embedding more complex than other forms of structure?

We have hinted above at the path we plan to follow, which is to use what we can learn from children's acquisition patterns to tease apart the various dimensions of the problem of determining the level of difficulty emerging from structural elaboration. The most promising line of inquiry starts from the observation that the modification gap in children is uneven. From previous work, we note that some forms of nominal modification, namely adjectives, appear to be less constrained than PP or relative clause (RC) embedding (Nadig & Sedivy 2002:330, n. 1, Eisenberg et al. 2008). This categorial distinction aligns with the formal notion of phases as CPs and DPs (Hinzen & Sheehan 2013). Adjectival modification extends the nominal projection, but under the assumption that phasal status is linked to reference, adjectives do not introduce an additional phase.[12] In other words, we assume a distinction between adding a phase (as in PP and RC modification) and not adding a phase (adjectival modification). Treating embedding of lower phases separately from the function of modification may lead to a better understanding of children's modification gap.

4. Study. In order to test our null hypothesis and to understand how embedding may introduce complexity in grammar, we need to determine how degree of embedding affects the performance of children and adults. Our purpose is to examine, at the age at which children acquire recursive modification: (i) whether they are sensitive to the distinction between RDM and SDM DPs, and (ii) whether they differ from adults in this regard.

4.1. Method.

Participants. Participants were seventy-one monolingual English-speaking children recruited in preschools in upstate New York and Toronto. Ages ranged between 4;00 and 6;11 (years;months.days). These children included twenty-five four-year-olds (mean age = 4;06.3, median = 4;06, *SD* = 2.4 months), twenty-five five-year-olds (mean age = 5;04.3, median = 5;04, *SD* = 3.3 months), and twenty-one six-year-olds (mean age = 6;05.2, median 6;04, *SD* = 3.2 months). All children were developing typically, with 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 nonverbal scale of the Kaufman Assessment Battery for Children, 2nd edn. (KABC-II;

[11] It seems unclear that piecemeal analyses such as those provided by Diessel and Tomasello (2001) can contribute to the discussion here. For example, these authors explain the acquisitional difficulties of the various types of relatives by appealing to the numbers of referents expressed. Such metrics will not shed light on the contrast between coordination and embedding.

[12] What should count as a phase is an important point of theoretical discussion. Initial formalizations counted CP and vP as phasal (Chomsky 2001). We follow the ontological approach to phases, as articulated in Hinzen & Sheehan 2013, where phases are defined in terms of reference: clauses are mapped to propositions, verbal phrases to events, and nominal expressions to objects. Modifying adjectives are entered directly as properties and do not introduce new referents. While Bošković (2014) considers APs to be phases, his arguments extend only to APs in predicative position, not to modifiers.

Kaufman & Kaufman 2004). Thirteen monolingual English-speaking adults from the same area served as control participants.

MATERIALS. We designed a referential elicitation task to target descriptions of complex NPs, following the elicitation strategy in Pérez-Leroux, Castilla-Earls, Béjar, & Massam 2012. Each trial started with a brief narrative, accompanied by pictures. The short story served to draw attention to the target referent and various competing referents, and to introduce the relevant vocabulary items. The target referent was similar enough to the competing referents so that a speaker would need to use two different modifier PPs in order to uniquely identify the target. For example, the recursive conditions required that the head noun be modified by a PP that had to be itself modified by another PP. In 2, *the bird on the alligator in the water*, the context shows two birds standing on different alligators, and a third standing in the water (see Fig. 2). In the nonrecursive conditions, as in 1, *the plate under the table with oranges*, there are three plates (see Fig. 1); the target can be distinguished with two independent modifiers. After the story, participants were prompted by means of simple referential questions (*Which x ... ?*). Examples of the narratives are given in 23 and 24.

(23) SEQUENTIAL MODIFICATION NARRATIVE: Mary had many oranges (POINT TO ALL ORANGES), so, she puts them on 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?

(24) RECURSIVE MODIFICATION NARRATIVE: This little worm is afraid of the birds. The birds (POINT TO EACH) are afraid of the two alligators (POINT TO ALLIGATORS). One of the alligators is in the water, one is on land. But look, somebody caught the worm! (POINT TO WORM) Which bird caught the worm?

These materials included six stories per condition. For the nonrecursive trials, half of the trials contained two locative modifiers (e.g. *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*). While both types of trials could in principle be ambiguous, the ambiguity becomes more salient in the two-locative contexts: a recursive interpretation is possible but not necessary because both the box and the books are under the table. For the recursive trials, there is no optionality and the context sets a requirement for low attachment of the second modifier.

PROCEDURES. All participants were tested individually, in a school setting. Graduate students experienced in language assessment administered the tasks. In addition to the referential tasks, children received three standardized tests: CELF-P2, KABC-II, Peabody Picture Vocabulary 4 (Dunn & Dunn 2007), and a standard nonword-repetition task (Dollaghan & Campbell 1998). The referential elicitation task contained a total of forty-two test items, which included the SDM and RDM conditions, three additional referential conditions investigating other structures (not reported here), and twelve distractor items. To mitigate potential ordering effects, the referential task was presented with three different semi-randomized orders, which were evenly distributed across participants. The entire battery of tests was administered in two or three sessions.

In the referential task, if a participant did not offer a response to a given trial, the experimenter followed up with two additional attempts. Incomplete responses (e.g. *the bird*) were followed up with an additional prompt ('But which one?'). Experimenters encouraged verbal responses; the children who pointed at the referent were asked: 'Can you tell me with words?'.

Coding. In this type of open-ended elicitation task, it is possible for speakers to be accurate in uniquely identifying the referent without using the complex NPs that are the focus of the study. For that reason, we analyzed the data according to two independent coding systems; the first aimed to describe the syntactic structure of the responses, and the other their referential properties. In the syntactic coding, we coded both level of embedding and type of linking strategy. Children often produce simpler responses, consisting of either single NPs (25a) or a head noun and a single PP modifier (25b). In our coding system, shown in 25, recursive modification is classified as a second level of embedding (25d), whereas for sequential modification, the target was two instances of level 1 embedding, as in 25c.

(25) Syntactic coding: levels of embedding

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

Linking strategies that result in embedding included prepositional modification (PP), relative clauses (RC), and possessor genitives (poss), given in 26. There were also linking strategies that do not entail embedding, as in the case of coordination, apposition, and linking via the predicate-argument relationships of a clause. These are illustrated in 27.

(26) Linking strategies that increase the level of embedding of the NP
- a. [$_{\text{NP}}$ the bird [$_{\text{PP}}$ on the alligator]] (PP)
- b. [$_{\text{NP}}$ the bird [$_{\text{CP}}$ that is sitting [$_{\text{PP}}$ on the alligator]]] (RC)
- c. [$_{\text{NP}}$ [$_{\text{GENP}}$ the alligator's] bird] (poss)

(27) Nonembedding linking strategies
- a. Coordination
  The bird **and** it's sitting on the crocodile in the water. (C309, 6;06)
- b. Apposition
  The birds that's on top of the crocodiles, the crocodiles that's in water. (C54, 4;06)
- c. Clausal
  The green **worm is in the** apple that is on the plate. (adult)

The data were independently coded in a system that integrated an evaluation of the descriptive content and referential behavior with degree of embedding. This system made reference to whether the target referential expressions (e.g. *plate*, *oranges*, and *table*, and *bird*, *alligator*, and *water*, for 1 and 2, respectively) were included in the response and how they were used. This referential coding had five categories.

(28) Referential coding
- a. Incomplete: These consisted of simpler or level 1 NP responses that made reference to one or two, but not all three, of the target referents.
  Examples: *The bird*. (C04, 5;04)
- b. Sequential: These were sequences of incomplete responses that, combined together, provided a full description, but were not integrated into a single utterance. They resulted either from the speaker pausing and then starting a new utterance incorporating new information, or from the use of a second or third prompt.
  Example: *That one with the orange. That … right there under the table.* (C025, 5;02)
- c. Alternative: These consisted of simple descriptions, often stated in spatial terms (e.g. *on the left*, *the highest one*), which identified the refer-

ent correctly but not on the basis of the target PPs. Using these alternative descriptions allowed speakers to attain referential success without articulating NPs at the level of structural elaboration investigated in this study.
Example: *The dog in the middle.* (C311, 6;04)

d. NONEMBEDDED: These were semantically complete descriptions, where the three referents were mentioned in a single utterance, but were not integrated syntactically by means of embedding strategies. In the case of the recursive condition, this might include reordering of the referents.
Example: *the worm that's on the plate, in the apple* (C318, 6;03)
(target: the worm in the apple on the plate) (reordering)
Example: *the one on the ground had the oranges on them* (C310, 6;03)
(target: the plate on the ground with oranges) (clausal strategy)

e. TARGET: Only responses that were (i) coded as descriptively complete, and (ii) had the relevant syntax of embedding (level 2 for recursive modification, 2 level 1 for nonrecursive double modification) were classified as target.

Data were coded by one investigator and independently verified by a second coder. Concordance was high, and all discrepancies were collectively discussed and reconciled.

4.2. RESULTS.

OVERALL DISTRIBUTIONS OF RESPONSES. Table 1 classifies all responses given, grouped into age groups, for SDM and RDM. The total number of trials is 1,008, but six cases were lost due to experimenter error. Starting from the first column, we see that the most common response by younger children is to produce incomplete NPs. In both conditions, four- and five-year-olds produce around 60% incomplete responses. By the age of six, this percentage drops sharply, with both adults and six-year-olds producing between 22% and 32% incomplete responses. Sequential responses, where a cumulative aggregation of independent, simpler NPs complete the relevant description, are found primarily in the data of younger children. For four- and five-year-olds, these constitute about 20% of the responses to the SDM condition, and 11%–15% in the RDM condition. Alternative responses represent a small proportion of the data, but they increase slightly in the six-year-old group, perhaps reflecting greater mastery of the spatial vocabulary used in these responses (e.g. *the one in the middle*). We also note that alternative responses represent a higher proportion of children's responses in the RDM condition. Nonembedded responses are low in the SDM condition for all groups, and higher in the RDM condition, particularly for the six-year-old group. Finally, target responses are very low initially, and particularly so in the RDM condition. Target responses in both conditions increase drastically by the six-year-old group to adult levels.

CONDITION	AGE	INCOMPLETE	SEQUENTIAL	ALTERNATIVE	NONEMBED	TARGET
	4	86 (57%)	32 (21%)	11 (7%)	4 (3%)	17 (11%)
SEQUENTIAL	5	85 (57%)	27 (18%)	3 (2%)	3 (2%)	30 (21%)
(SDM)	6	34 (27%)	3 (2%)	10 (8%)	8 (6%)	71 (56%)
	Adults	17 (22%)	4 (5%)	9 (12%)	2 (3%)	46 (59%)
	4	97 (66%)	16 (11%)	18 (12%)	7 (5%)	10 (7%)
RECURSIVE	5	88 (60%)	23 (16%)	16 (11%)	10 (7%)	11 (7%)
(RDM)	6	29 (23%)	5 (4%)	36 (29%)	27 (21%)	29 (23%)
	Adults	25 (32%)	3 (4%)	11 (14%)	8 (10%)	31 (40%)

TABLE 1. Frequency of responses (with % in parentheses) classified according to the semantic coding, by condition and age groups.

For the adult participants in our study, the most common nontarget responses to both conditions are incomplete and alternative descriptions. Alternative responses are correct but uninformative about speakers' abilities. We were surprised to find that adults, too, produced incomplete responses, such as in 29.

(29) 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

In informal conversations after the task, some adult speakers explained they had not noticed or forgotten about one of the competing referents (e.g. 'Oh. I didn't see the other plate').

In what follows, we set aside all response types but the target responses and explore first the distribution of those target responses across age group and conditions. We then return to the other responses to examine the specific syntactic strategies employed by speakers in response to these tasks.

Analysis of target responses.

Children vs. adults. We first analyzed the differences in the distribution of target responses between all children taken as a group and adults, across conditions; see Figure 3.

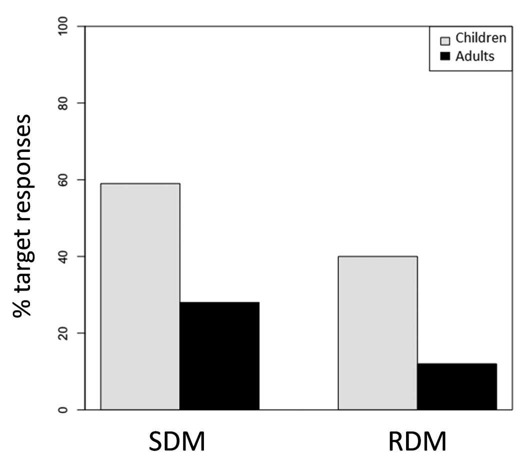


Figure 3. Percentage of target responses given by children and adults to the SDM and RDM trials.

To compare overall frequencies of target responses in children and adults, we fitted a generalized linear mixed-effects model using the maximum-likelihood method in R (Laplace approximation), using the binominal distribution. Following an incremental approach, we initially fitted the data with a minimal model, containing only the random effects (Participants and Items). This basic model was subsequently augmented by including Group and Condition as fixed effects. The results of this analysis revealed a highly significant difference between the groups as well as a significant effect of Condition. These results are reported in Table 2.

	est.	*SE*	*z*	*p*
(intercept)	−0.72	0.59	−1.24	0.217
Group : Child	−2.12	0.51	−4.19	< 0.001 ***
Condition : SDM	1.29	0.54	2.39	0.017 *

Table 2. Results of the model testing the effect of Group and Condition in the production of target responses. Formula: Target ~ Group + Condition + (1 | Participant) + (1 | Item).

A GLMER model (logit) was fit using maximum-likelihood estimation (Laplace) and included the random effects of Participant (variance = 2.18) and Item (variance = 0.76). This model was based on 1,008 observations from eighty-four participants and twelve items. The fit of this augmented model was better than that of the minimal model according to the Akaike information criterion (AIC): 911.9 vs. 895.1. This difference was statistically significant ($\chi^2 = 20.729$, $p < 0.001$).

A third model was generated to test for the interaction between Group and Condition. As shown in Table 3, this interaction was not significant.

	est.	*SE*	*z*	*p*
(intercept)	−0.60	0.61	−0.990	0.322
Group : Child	−2.30	0.56	−4.130	< 0.001 ***
Condition : SDM	1.03	0.63	1.637	0.102
Group : Child × Condition : SDM	0.34	0.43	0.780	0.432

Table 3. Results of the model including Group and Condition and the interaction of Group by Condition as predictor variables. Formula: Target ~ Group * Condition + (1 | Participant) + (1 | Item).

A GLMER model (logit) was fit using maximum-likelihood estimation (Laplace) and included the random effects of Participant (variance = 2.20) and Item (variance = 0.76). This model was based on 1,008 observations from eighty-four participants and twelve items.

Including the interaction did not improve the fit of the model when compared to the previous model with no interaction (AIC = 896.5), and there was no statistical difference between the fit of these two models ($\chi^2 = 0.597$, $p = 0.439$). This further confirms that target responses are best predicted by age status (children vs. adults) and condition (SDM vs. RDM), and that the effect of Condition appears comparable for children and adults.

The effect of age in children's target responses. Our second analysis focused on examining developmental effects within the child participants. For that purpose, we entered children's responses (whether target or not) into a generalized mixed-effects model, using the binomial distribution. As before, this model had Participants and Items as random effects and Condition as a categorical predictor, and Age in months was entered as a continuous predictor. This analysis revealed a highly significant effect of Age, and a highly significant effect of Condition. A subsequent model that included the interaction between the two fixed effects was found to provide a better fit for the data (AIC = 664.1 for the no-interaction model, and AIC = 660.9 for the model with the interaction). This difference was statistically significant ($\chi^2 = 5.226$, $p = 0.022$). As shown in Table 4, there is a highly significant effect of both Age of the children and Condition, and a significant interaction between these factors.

	est.	*SE*	*z*	*p*
(intercept)	−8.57	1.63	−5.27	< 0.001 ***
AgeinMonths	0.09	0.02	3.95	< 0.001 ***
Condition : SDM	−2.34	1.71	−1.36	0.1720
AgeinMonths × Condition : SDM	0.05	0.02	2.29	0.0217 *

Table 4. Results of the model testing the effect of Age as a continuous predictor and Condition as a fixed effect. Formula: Target ~ AgeinMonths * Condition + (1 | Participant) + (1 | Item).

A GLMER model (logit) was fit using maximum-likelihood estimation (Laplace) and included the random effects of Participant (variance = 1.06) and Item (variance = 0.74). This model was based on 852 observations from seventy-one participants and twelve items. The differential effect of age on the two conditions is illustrated in Figure 4. The trendline indicates the line of best fit between age and number of targets.

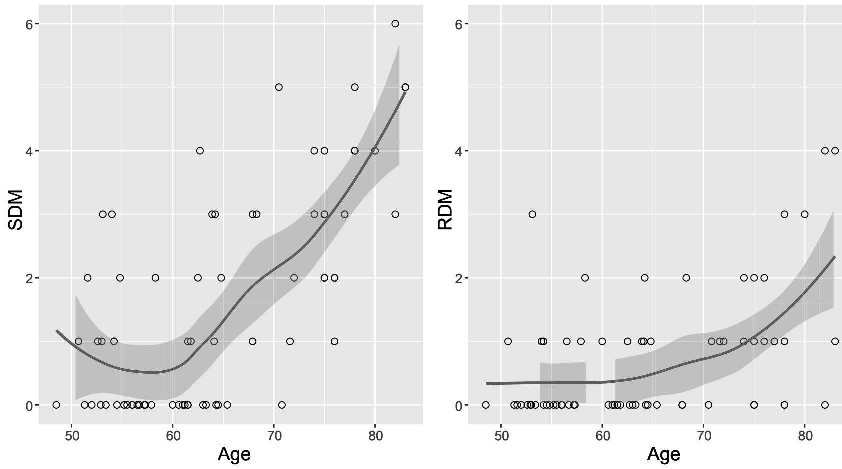


FIGURE 4. Number of target responses produced by individual children for the SDM (left) and RDM (right) conditions, plotted as a function of children's age in months.

The plots in Fig. 4 show the different learning curves of SDM and RDM. For SDM, production shifts around the age of five (sixty months) and rises quickly. For RDM, the shift occurs five months later, and productivity remains low.

Individual analyses of target responses. The last step in the analysis of target responses was to examine the response patterns of individual participants. Participants were classified according to whether they produced at least one target response for each type (RDM, SDM). There were thus potentially four classes of participants: those who produced no targets of either type, those who produced targets for both types, and those who produced targets only in the SDM condition or only in the RDM condition. This classification, based on target performance across the conditions, was cross-tabulated against age groups in Table 5.

	4-YEAR-OLDS	5-YEAR-OLDS	6-YEAR-OLDS	ALL CHILDREN	ADULTS
None	13	10	0	23	1
Only SDM	5	6	5	16	0
Only RDM	2	2	0	4	0
Both	5	7	16	28	12
N =	*25*	*25*	*21*	*71*	*13*

TABLE 5. Number of participants per group, classified according to conditions for which they were able to produce at least one target response.

Table 5 shows that half of the four- and five-year-old children produced targets in neither condition. This suggests that it is during this period that complex (doubly) modified NPs emerge. All of the six-year-olds produced one target type or the other, and the majority of six-year-olds managed to produce targets in both conditions. All adults except one speaker produced both types of targets. This exceptional individual produced only incomplete and alternative responses. When all of the children are pooled together, the data indicate that the majority of the children were in the 'Neither' or 'Both' class. For the substantial number of children who produced targets in one condition (twenty of seventy-one), the odds of producing an SDM before an RDM (in contrast to the opposite pattern) are 4 : 1.

ANALYSIS OF LINKING STRATEGIES. Our last analysis sought to explore the differences in the response patterns in the two conditions by considering how speakers performed when they did not produce targets. For that purpose, we focused on the referential coding and the various types of linking strategies employed by speakers. Two observations are worth a brief mention.

First, we further examine the asymmetry in the distribution of nonembedded responses noted in the discussion of Table 2. Recall that in the RDM (but not the SDM) condition, six-year-olds produced nonembedded responses as much as two to four times the rates of other groups. These responses resulted from the use of either a nonembedding linking strategy, such as apposition, or some other clausal relation. Additionally, for the recursive structures, responses are considered nonembedded if the two modifiers are reordered, as in 30, or coordinated, as in 31 (cf. 1 and 2).

(30) the one on the orange shelf in the bowl (C316, 6;05)
Target: the one in the cup on the shelf (in contrast to other cups not on the shelf)

(31) the one on the crocodile on the head and in the water (C301, 6;00)

About four fifths of the nonembedded responses were instances of 2 level 1 structures such as in 30 and 31, where the speaker used embedding linking strategies (RC or PP) but failed to structure these into a recursive configuration. This allows us to precisely identify the recursive embedding step as the locus of the six-year-olds' delay with RDMs.

The second observation concerns the unexpected use of RC responses. These were frequent for all groups, making up almost one quarter of the first links in the RDM responses, and about one seventh of all the first linking strategies in the SDM responses, for both children and adult controls. These responses were particularly surprising in the case of the children because both length and structural complexity of the response NPs are increased without further informational gain.

To explore the use of RCs in doubly modified NPs, we extracted and classified responses according to whether they were linked by PPs alone (32a), by RCs (32b), or by a combination of both (32c).

(32) a. PP: the one on the plate with the apple [= in the apple on the plate] (LAR, 5;10)
b. RC: the bird [Which one?] The bird that's on the crocodile that's in the water. (IR, 5;08)
c. MIX: The one on the one on the crocodile's eyes that was in the water (AG, 5;03)

Comparing the distribution of these responses across conditions yields an interesting observation: while mixed and RC responses were common in the SDM condition (33% and 30% of all target responses for children and adults, respectively), these rates are higher for the recursive condition in both groups (42% and 45%, respectively).

5. SUMMARY AND DISCUSSION. During the period under study we were able to document children's acquisition of double modification. Our data show that these structures are rarely produced initially, and only by a few children, and that children's abilities rapidly grow to approximate adult patterns. Our results also show continuity in many aspects of the production of complex NPs. The data of both children and adults reveal a clear contrast between our two conditions, with higher numbers of target responses in the sequential condition than in the recursive one. Our results place the emergence of recursive ability in the late preschool years, and confirm the observation in Pérez-Leroux, Castilla-Earls, Béjar, & Massam 2012 that over a third of children aged four and five can produce recursive NPs.

Our results can be summarized as follows:

- All groups produce significantly more target responses in the SDM than in the RDM condition, but children produce them much less frequently than adults.
- The ability to produce complex NPs undergoes significant growth in the period between the ages of four and six, with six-year-olds approaching adult performance.
- Children initially respond by producing simpler descriptions; adults do so also but only occasionally.
- Both children and adults frequently rely on a structurally elaborate RC strategy to express the modification relation. Surprisingly, both groups produce more of these responses in the recursive condition.

Children and adults differ in how often they produce incomplete responses. We gave anecdotal evidence (in §4.2) that adult incomplete responses can result from the challenge of attending to multiple referential contrasts simultaneously; it is reasonable to consider this a possibility for children as well. As the adult we quoted earlier suggested to us, it is easy to forget the other plate. The point is that we cannot properly tell when a child's incomplete description results from a grammatical limitation or from a failure to attend to all of the relevant elements in the referential context. However, we must consider that for the younger children, the primary response is to produce simpler NPs, in the form of either incomplete or sequential responses. Close to half of the four- and five-year-olds failed to produce any instances of NP embedding. For those children, it is reasonable to infer that they have not acquired this grammatical operation.

Our results also point to significant changes around the age of six. Six-year-olds' data show a reduction in the structurally simpler responses and an increase in the production of targets. One pattern specific to this age group is the higher proportion of alternative responses in the recursive condition. It is not possible to determine from the current data whether this difference lies in item-level properties, or whether it represents another structurally simpler avoidance strategy. Most importantly, six-year-old children were also different from other groups in producing many more complete but nonembedded responses, and producing them more frequently as responses to the recursive condition. Further analysis revealed that most of these nontarget responses were, in fact, equivalent to sequential double modification, where two different modifiers restricted the head noun of the complex NP. Such responses in the recursive condition were sufficient to account for the contrast in targets between the two conditions for this group of children. This clearly endorses the intuition that recursive embedding is a distinct step in acquisition, while at the same time supporting the possibility that this is not because of the syntactic structures or the semantic derivations, but because children are unable to deploy their knowledge of the syntax and semantics of complex NPs in real time. If, as suggested by McDaniel and colleagues (2010), the sentence-planning capacities of children are limited, and if RDMs require more planning resources than SDMs, this is precisely the picture we expect to see.

Our data suggest that producing complex NPs is challenging for all speakers. Notably, children and adults appear sensitive to the same types of structural conditions: the structures that are harder to produce for adults are harder to produce for children, and as a consequence emerge later. By comparing two types of complex NPs—recursive locative modifiers, and doubly modified NPs with either two locatives or a locative and a modifier combined—we sought to find out whether depth of embedding introduced an additional challenge for children. To the extent that the present findings generalize beyond our materials, we conclude that it does. This leads us to reject the null hypothesis and conclude that RDMs and SDMs are not comparable, acquisitionally speaking.

We therefore need to determine the nature of the challenge posed by RDM structures. What is clear is that degree of embedding, and not just quantity of embedded structures, is a distinct developmental feature. However, the source of the differential patterns observed in our results remains unclear. Given the syntactic and semantic analyses provided in §2, articulating the locus of the difference between RDM and SDM is far from straightforward. Both types of doubly modified DPs are built from the same number/kind of syntactic atoms and structure-building steps (iterations of Merge). There is no a priori reason to think that more deeply embedded instances of Merge are more complicated to apply than less embedded ones. Semantically, both types of complex DPs are derived by iterations of predicate modification; they are identical with respect to the individual steps or semantic operations involved in composing the semantic structure. Utterance length of the RDM cannot be the issue, given previous work by Pérez-Leroux, Castilla-Earls, and Brunner (2012), which showed that while children avoid embedded NPs, they produce coordinated NPs of comparable length without difficulty.

From an input perspective, it could be that multiple modification is rare overall (either type), but Perfors and colleagues (2010) show that a Bayesian learning system can establish recursive rules on the basis of minimal input. From our perspective, the acquisition of recursive modification in children should not be exclusively dependent on the input frequency of level 2 embedding, but could crucially involve some learning step generalizing from level 1 to level 2. To argue otherwise would make the emergence of recursive modification in language a complete mystery to begin with.

This reasoning, along with the evidence presented in this article, leaves us with two logical possibilities for interpreting the difficulty arising from recursive modification. One possibility is that the difficulty of recursive embedding represents a measure of the challenge of integrating complex structures (beyond narrow syntax). Children's (incomplete) extralinguistic capacity to coordinate complex sources of information may be just enough to allow them to produce the doubly modified structures but not to embed them recursively. Under this view, changes in general capacities give rise to the ability to produce recursive configuration. While this is a reasonable interpretation, it is not the only one available. The contrast, suggested in Yang 2016, between learning a rule and learning that a rule is productive leads to an alternative view, namely, that the shift observed by the age of six reflects an actual change in grammatical competence resulting in the learning of the recursive step. This does not actually imply learning a new syntactic operation, but simply realizing that the embedding rule is unrestricted or productive (see also Roeper & Pérez-Leroux 2011).

Interestingly, whatever the challenge involved in the production of RDM DPs, when children actually manage to articulate them, they frequently end up producing more structure rather than less. Instead of the simpler stacked NP/PP sequences, English-speaking children favor the production of forms that introduce additional structural material. Consider again that children preferred to produce RCs over the superficially 'simpler' double PP target structures in both conditions, and even adults produced more mixed PP/RC structures than double PP structures in the recursive condition. RC alternatives are systematically longer than their PP counterparts and yet preferred. Importantly, the availability of modification by RC demonstrates that modification per se is not the source of difficulty.

The favoring of RC structures over double PP structures belies attempts to account for production difficulties within the confines of narrow syntax. Indeed, the propensity for RCs in the experimental results for the children can be seen as a curious result when considering their syntactic and semantic complexity compared to the recursive PP targets. On the syntactic side, it is standardly assumed that relativization involves the displacement of an NP (or alternatively an operator) to a position higher in the clause, thus creating a dependency in the syntax along with the insertion of a relative pronoun such as *that*.

(33) The bird$_i$ [$_{CP}$ that t_i is on the alligator$_j$ [$_{CP}$ that t_j is in the water]] …

On the semantic side there is also added complexity: a number of extra semantic rules are needed not only to account for the displaced structure, but also to calculate the semantic values of the trace left behind by the movement and the insertion of the relative pronoun. This is typically achieved through the application of three additional rules, none of which are needed in the recursive PP structures.[13] We reiterate that these rules are in addition to the semantic and syntactic rules given in §2.1 (for example, predicate modification and the derivations in n. 13) that derive the PP recursive structures: they do not replace them. Even a cursory assessment of the semantic and syntactic ingredients involved in RCs reveals that they are overall more elaborate than the recursive PP structures, in the sense that additional steps and operations are needed to derive the meaning and structure.[14] This brings us to a speculation about recursion. The parataxis and RC effects observed in our results suggest that the faculty of language (as revealed through the process of acquisition) may aim to maximize the structural distance existing between a higher referential expression and lower expressions embedded under its domain. Hinzen and Sheehan (2013) use a 'phasal template' comprising a lexical concept and an edge containing the functional elements that allow the concept to be used referentially. In cases of embedding, there is only one referent established at the edge. Accordingly, a DP embedded in a higher DP must act as a descriptor predicate related to the higher DP via the expression of a relation (e.g. location). It is possible that the extra structure in a complex NP with RC modifier may supply a more robust buffer for reference tracking and is therefore favored over the RDM structure.

In closing, let us take another look at phase theory and consider its potential to illuminate our results. Arsenijević and Hinzen (2012) propose that the forms of recursion arise from the way that narrow syntax and interpretation interlock in phase theory, rather than from narrow syntax itself. As discussed in §2.2, they differentiate embedding and embedded nominal categories on the basis of the two potential denotations of a DP (referential and predicative). The cases examined here fall into a lacuna in the existing discussion on the syntax/semantics of embedding and of recursion. This two-way split does not clarify the contrast between recursive and nonrecursive modification. In either type, at the highest point of the derivation, all PP modifiers have become part of predicative content. While all of the descriptive content in lower phases remains relevant at the interface, the scopal possibilities (particularly that of the intermediate iota operator) are fixed by the derivational history. Thus, each step in embedding introduces

[13] To sketch this out: first, a standard analysis of relative pronouns (e.g. Heim & Kratzer 1998) treats them as an IDENTITY FUNCTION of the semantic type ($\langle e, t\rangle$). This function simply ensures that the semantic type of the complement the relative pronoun takes is 'transferred up' to the next dominating node: $[\![\text{that}]\!] = [\lambda f : f \in D_{\langle e,t\rangle}. f\,]$. Second, PREDICATE ABSTRACTION is the semantic rule responsible for the actual relativization: if we reconstruct *bird* to its base-generated position, we have the sentence *the bird is on the alligator*. The relativization of *bird* leaves a trace; this is still a sentence, however: t_i *is on the alligator*, the semantic value of which is a truth value. In order for a semantic derivation to proceed after relativization, the rule of predicate abstraction 're-predicates' the sentence relative to a VARIABLE ASSIGNMENT. Third, the application of the TRACES AND PRONOUNS RULE ensures that the trace in the RC shares a referent with a main clause element, one on which the subordinate clause is grammatically dependent.

[14] The possibility that the relevant PP structures might in fact be reduced RCs cannot be discounted. This would add yet another dimension to the challenge of assessing the relative complexity of PP and RC structures, perhaps turning the tables yet again.

a new layer of descriptive complexity. The reasons why are not evident within a framework in which earlier phases are rendered fully inert. It therefore becomes apparent that the inertness of the content of a phase refers exclusively to the syntactic computation and does not refer to the interfaces.

In sum, elaborated structures such as the ones examined in this study point to the limitations of syntax-only or semantics-only approaches to complexity. Structurally, these NPs 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) stepwise do not help us articulate why there should be a difference in level of difficulty. A difference does exist, however, 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 system, 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 difficult. The referent identified by nonrecursive 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 set intersection. Instead, in the task of contrastively describing the referent of a recursive description, speakers must represent an intermediate domain of reference 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 (e.g. the lowest preposition). Applying these operations recursively/cyclically isolates independent scopal domains. The application of ordered operations (modification, in semantic terms, or embedding, in syntactic terms) yields increasingly elaborate and descriptively rich expressions.

6. CONCLUSION. What have we learned about the difficulty embedding presents to children? The results of our study support previous claims that what is difficult for adults is also difficult for children, just more so. Enough, we would argue, to account for the general modification gap found in production studies and in spontaneous speech studies. The present study shows that recursive embedding introduces a level of difficulty that goes beyond the elements and operations used during the semantic composition of the structure, or the cyclic syntax that generates it. The exact nature of the particular complexity that emerges from recursive doubly modified structures remains a mystery to be explored in future research, but it is very tempting at this early stage to see a parallel between what we observe here and Chomsky and Miller's (1963) conclusions with respect to the complexity of recursive self-embedding, which, they argue, stems from performance processes, not formal grammar. In other words, as stated by Trotzke and Zwart (2014:131–32), 'the performance limitations on recursive self-embedding are captured by factors extrinsic to the competence grammar', but crucially 'the generative approach postulates a competence grammar allowing unbounded recursion'. This is clearly the case here as our results reveal the difficulty associated with RDM, not their impossibility. As pointed out by a referee, our results also lead to the overall conclusion that recursive embedding is hard for humans to perform, in spite of the fact that it appears to be a central characteristic of human language.

REFERENCES

Arsenijević, Boban, and Wolfram Hinzen. 2012. On the absence of X-within-X recursion in human grammar. *Linguistic Inquiry* 43(3).423–40. DOI: 10.1162/LING_a_00095.

Béjar, Susana; Diane Massam; Ana Teresa Pérez-Leroux; and Yves Roberge. 2017. Rethinking complexity. Toronto: University of Toronto, ms.

Bloom, Lois. 1973. *One word at a time: The use of single-word utterances before syntax*. The Hague: Mouton.

Bloom, Lois; Patsy Lightbown; and Lois Hood. 1975. Structure and variation in child language. *Monographs of the Society for Research in Child Development* 40.1–97. DOI: 10.2307/1165986.

Bošković, Željko. 2014. Now I'm a phase, now I'm not a phase: On the variability of phases with extraction and ellipsis. *Linguistic Inquiry* 45(1).27–89. DOI: 10.1162/LING_a_00148.

Brown, Roger. 1973. *A first language*. Cambridge, MA: Harvard University Press.

Caponigro, Ivano; Lisa Pearl; Neon Brooks; and David Barner. 2012. Acquiring the meaning of free relative clauses and plural definite descriptions. *Journal of Semantics* 29.262–93. DOI: 10.1093/jos/ffr014.

Chien, Yu-Chin, and Kenneth Wexler. 1990. Children's knowledge of locality conditions in binding as evidence for the modularity of syntax and pragmatics. *Language Acquisition* 3.225–95. DOI: 10.1207/s15327817la0103_2.

Chierchia, Gennaro. 1998. Reference to kinds across languages. *Natural Language Semantics* 6.339–405. DOI: 10.1023/A:1008324218506.

Chomsky, Noam. 2001. Derivation by phase. *Ken Hale: A life in language*, ed. by Michael Kenstowicz, 1–52. Cambridge, MA: MIT Press.

Chomsky, Noam. 2007. Approaching UG from below. In Sauerland & Gärtner, 1–29.

Chomsky, Noam, and George A. Miller. 1963. Introduction to the formal analysis of natural languages. *Handbook of mathematical psychology*, vol. 2, ed. by R. Duncan Luce, Robert R. Bush, and Eugene Galanter, 269–321. New York: Wiley.

Cowart, Wayne, and Dana McDaniel. 2012. What kind of a thing is a coordinate? *In search of grammar: Experimental and corpus-based studies* (Language and linguistics monograph series 48), ed. by James Myers, 175–214. Taipei: Academia Sinica.

Culicover, Peter W. 2013. *Grammar and complexity: Language at the intersection of competence and performance*. Oxford: Oxford University Press.

Culicover, Peter W., and Ray Jackendoff. 2006. The simpler syntax hypothesis. *Trends in Cognitive Sciences* 10.413–18. DOI: 10.1016/j.tics.2006.07.007.

Davies, Catherine, and Napoleon Katsos. 2010. Over-informative children: Production/comprehension asymmetry or tolerance to pragmatic violations? *Lingua* (Special issue on asymmetries in child language) 120.1956–72. DOI: 10.1016/j.lingua.2010.02.005.

Davies, Catherine, and Napoleon Katsos. 2013. Are speakers and listeners 'only moderately Gricean'? An empirical reply to Engelhardt et al. (2006). *Journal of Pragmatics* 49.78–106. DOI: 10.1016/j.pragma.2013.01.004.

Dethorne, Laura S.; Bonnie W. Johnson; and Jane W. Loeb. 2005. A closer look at MLU: What does it really measure? *Clinical Linguistics & Phonetics* 19.635–48. DOI: 10.1080/02699200410001716165.

Diessel, Holger, and Michael Tomasello. 2001. The acquisition of finite complement clauses in English: A corpus-based analysis. *Cognitive Linguistics* 12.1–45. DOI: 10.1515/cogl.12.2.97.

Diessel, Holger, and Michael Tomasello. 2005. A new look at the acquisition of relative clauses. *Language* 81.882–906. Online: http://www.jstor.org/stable/4490021.

Dixon, James A., and Virginia A. Marchman. 2007. Grammar and the lexicon: Developmental ordering in language acquisition. *Child Development* 78.190–212. DOI: 10.1111/j.1467-8624.2007.00992.x.

Dollaghan, Chris, and Thomas F. Campbell. 1998. Nonword repetition and child language impairment. *Journal of Speech, Language, and Hearing Research* 41.1136–46. DOI: 10.1044/jslhr.4105.1136.

DUNN, LLOYD M., and DOUGLAS M. DUNN. 2007. *Peabody picture vocabulary test (PPVT™-4) manual*. 4th edn. Bloomington, MN: NCS Pearson.

EISENBERG, SARITA L.; TERESA A. UKRAINETZ; JENNIFER R. HSU; JOAN N. KADERAVEK; LAURA M. JUSTICE; and RONALD B. GILLAM. 2008. Noun phrase elaboration in children's spoken stories. *Language, Speech, and Hearing Services in Schools* 39.145–57. DOI: 10.1044/0161-1461(2008/014).

EVANS, NICHOLAS, and STEPHEN C. LEVINSON. 2009. The myth of language universals: Language diversity and its importance for cognitive science. *Behavioral and Brain Sciences* 32.429–92. DOI: 10.1017/S0140525X0999094X.

FRIEDMANN, NAAMA; ADRIANA BELLETTI; and LUIGI RIZZI. 2009. Relativized relatives: Types of intervention in the acquisition of A-bar dependencies. *Lingua* 119.67–88. DOI: 10.1016/j.lingua.2008.09.002.

FRIEDMANN, NAAMA, and JOÃO COSTA. 2010. The child heard a coordinated sentence and wondered: On children's difficulty in understanding coordination and relative clauses with crossing dependencies. *Lingua* 120.1502–15. DOI: 10.1016/j.lingua.2009.10.006.

GIVÓN, THOMAS. 2009. *The genesis of syntactic complexity*. Amsterdam: John Benjamins.

GU, CHENJIE. 2008. Structural ambiguity and AP/PP recursion in language acquisition. Amherst: University of Massachusetts, MS.

GUASTI, MARIA TERESA; CHIARA BRANCHINI; and FABRIZIO AROSIO. 2012. Interference in the production of Italian subject and object *wh*-questions. *Applied Psycholinguistics* 30.185–223. DOI: 10.1017/S0142716411000324.

HAUSER, MARC D.; NOAM CHOMSKY; and W. TECUMSEH FITCH. 2002. The faculty of language: What is it, who has it, and how did it evolve? *Science* 298.1569–79. DOI: 10.1126/science.298.5598.1569.

HEIM, IRENE, and ANGELIKA KRATZER. 1998. *Semantics in generative grammar*. Oxford: Blackwell.

HELLER, DAPHNA, and CRAIG G. CHAMBERS. 2014. Would a *blue kite* by any other name be just as blue? Effects of descriptive choices in subsequent referential behavior. *Journal of Memory and Language* 70.53–67. DOI: 10.1016/j.jml.2013.09.008.

HINZEN, WOLFRAM, and MICHELLE SHEEHAN. 2013. *The philosophy of universal grammar*. Oxford: Oxford University Press.

HUNSICKER, DEA, and SUSAN GOLDIN-MEADOW. 2012. Hierarchical structure in a self-created communication system: Building nominal constituents in homesign. *Language* 88.732–63. DOI: 10.1353/lan.2012.0092.

JAKUBOWICZ, CELIA, and LÉA NASH. 2002. Why accusative clitics are avoided in normal and impaired language development. Paris: Université Paris 8, MS.

JAKUBOWICZ, CELIA, and NELLEKE STRIK. 2008. Scope-marking strategies in the acquisition of long distance wh-questions in French and Dutch. *Language and Speech* 51.101–32. DOI: 10.1177/00238309080510010701.

JOHNSTON, JUDITH. 1985. Cognitive prerequisites: The evidence from children learning English. *The crosslinguistic study of language acquisition*, ed. by Dan I. Slobin, 961–1004. Hillsdale, NJ: Lawrence Erlbaum.

KAUFMAN, ALAN S., and NADEEN L. KAUFMAN. 2004. *Kaufman assessment battery for children*. 2nd edn. San Antonio, TX: Pearson.

KIDD, EVAN; ANDREW J. STEWART; and LUDOVICA SERRATRICE. 2011. Children do not overcome lexical biases where adults do: The role of the referential scene in garden-path recovery. *Journal of Child Language* 38.222–34. DOI: 10.1017/S0305000909990316.

LEBEAUX, DAVID. 2000. *Language acquisition and the form of the grammar*. Amsterdam: John Benjamins.

LIMBACH, MAXI, and DANI ADONE. 2010. Language acquisition of recursive possessives in English. *Proceedings of the Boston University Conference on Language Development (BUCLD)* 34.281–90.

MACWHINNEY, BRIAN. 2000. *The CHILDES project: Tools for analyzing talk*. Mahwah, NJ: Lawrence Erlbaum.

MAIA, MARCUS; ANIELA FRANÇA; ALINE GESUALDI; ALERIA LAGE; and CRISTIANE OLIVEIRA. 2013. The processing of PP embedding and coordination in Karaja and in Portuguese. Paper presented at Recursion in Brazilian Languages & Beyond 2013, August 5–16, UFRJ, Rio de Janeiro.

Matthews, Danielle; Elena Lieven; and Michael Tomasello. 2007. How toddlers and preschoolers learn to uniquely identify referents for others: A training study. *Child Development* 76.1744–59. DOI: 10.1111/j.1467-8624.2007.01098.x.

McDaniel, Dana, and Cecile McKee. 2004. Multiple influences on children's language performance. *Journal of Child Language* 31.489–92. DOI: 10.1017/S0305000904006130.

McDaniel, Dana; Cecile McKee; and Merrill F. Garrett. 2010. Children's sentence planning: Syntactic correlates of fluency variations. *Journal of Child Language* 37.59–94. DOI: 10.1017/S0305000909009507.

McWhorter, John H. 2011. *Linguistic simplicity and complexity: Why do languages undress?* Berlin: De Gruyter Mouton.

Morisseau, Tiffany; Catherine Davies; and Danielle Matthews. 2013. How do 3- and 5-year-olds respond to under- and over-informative utterances? *Journal of Pragmatics* 59(Part A).26–39. DOI: 10.1016/j.pragma.2013.03.007.

Moro, Andrea. 2011. A closer look at the turtle's eyes. *Proceedings of the National Academy of Sciences of the United States of America* 108.2177–78. DOI: 10.1073/pnas.101 9723108.

Moscati, Vincenzo, and Luigi Rizzi. 2014. Agreement configurations in language development: A movement-based complexity metric. *Lingua* 140.67–82. DOI: 10.1016/j .lingua.2013.12.004.

Munn, Alan. 1993. *Topics in the syntax and semantics of coordinate structures*. College Park: University of Maryland dissertation.

Munn, Alan; Karen Miller; and Cristina Schmitt. 2006. Maximality and plurality in children's interpretation of definites. *Proceedings of the Boston University Conference on Language Development (BUCLD)* 30.377–87.

Nadig, Aparna S., and Julie C. Sedivy. 2002. Evidence of perspective-taking constraints in children's on-line reference resolution. *Psychological Science* 13.329–36. DOI: 10 .1111/j.0956-7976.2002.00460.x.

Nevins, Andrew; David Pesetsky; and Cilene Rodrigues. 2009. Pirahã exceptionality: A reassessment. *Language* 85.355–404. DOI: 10.1353/lan.0.0107.

Newmeyer, Frederick J., and Laurel B. Preston. 2014. *Measuring grammatical complexity*. Oxford: Oxford University Press.

Pallier, Christophe; Anne-Dominique Devauchelle; and Stanislas Dehaene. 2011. Cortical representation of the constituent structure of sentences. *Proceedings of the National Academy of Sciences of the United States of America* 108.2522–27. DOI: 10.1073 /pnas.1018711108.

Partee, Barbara H. 2002. Noun phrase interpretation and type-shifting principles. *Formal semantics: The essential readings*, ed. by Paul Portner and Barbara H. Partee, 357–81. Oxford: Blackwell. DOI: 10.1002/9780470758335.ch15.

Pérez-Leroux, Ana Teresa. 1998. The acquisition of mood selection in Spanish relative clauses. *Journal of Child Language* 25.585–604.

Pérez-Leroux, Ana Teresa; Anny P. Castilla-Earls; Susana Béjar; and Diane Massam. 2012. Elmo's sister's ball: The problem of acquiring nominal recursion. *Language Acquisition* 19.301–11. DOI: 10.1080/10489223.2012.685019.

Pérez-Leroux, Ana Teresa; Anny P. Castilla-Earls; and Jerry Brunner. 2012. General and specific effects of lexicon in grammar: Determiner and object pronoun omissions in child Spanish. *Journal of Speech, Language, and Hearing Research* 55.313–27. DOI: 10.1044/1092-4388(2011/10-0004).

Perfors, Amy; Joshua B. Tenenbaum; Edward Gibson; and Terry Regier. 2010. How recursive is language? A Bayesian exploration. *Recursion and human language*, ed. by Harry van der Hulst, 159–75. Berlin: De Gruyter Mouton.

Progovac, Ljiljana. 1998. Structure for coordination: Part 1. *Glot International* 3.3–9.

Roeper, Thomas. 2011. The acquisition of recursion: How formalism articulates the child's path. *Biolinguistics* 5.57–86. Online: http://www.biolinguistics.eu/index.php /biolinguistics/article/view/178/215.

Roeper, Thomas, and Ana Teresa Pérez-Leroux. 2011. Simplicity and complexity in child language and its explanation. *Infancia y Aprendizaje* 34(3).363–80. DOI: 10.1174 /021037011797238612.

Roeper, Thomas, and William Snyder. 2005. Language learnability and the forms of recursion. *UG and external systems: Language, brain and computation*, ed. by Anna Maria Di Sciullo, 133–66. Amsterdam: John Benjamins.

Roeper, Thomas, and Margaret Speas (eds.) 2014. *Recursion: Complexity in cognition*. Dordrecht: Springer.
Ross, John Robert. 1967. *Constraints on variables in syntax*. Cambridge, MA: MIT dissertation.
Russell, Bertrand. 1905. On denoting. *Mind* 14.479–93. Online: http://www.jstor.org/stable/2248381.
Sauerland, Uli, and Hans-Martin Gärtner. 2007. *Interfaces + recursion = language? Chomsky's minimalism and the view from syntax-semantics*. Berlin: Mouton de Gruyter.
Sedivy, Julie C. 2003. Pragmatic versus form-based accounts of referential contrast: Evidence for effects of informativity expectations. *Journal of Psycholinguistic Research* 32.3–23. DOI: 10.1023/A:1021928914454.
Strawson, P. F. 1950. On referring. *Mind* 59.320–44. Online: http://www.jstor.org/stable/2251176.
Syrett, Kristen; Christopher Kennedy; and Jeffrey Lidz. 2010. Meaning and context in children's understanding of gradable adjectives. *Journal of Semantics* 27.1–35. DOI: 10.1093/jos/ffp011.
Takahashi, Eri. 2009. *Beyond statistical learning in the acquisition of phrase structure*. College Park: University of Maryland dissertation.
Tanenhaus, Michael K.; Michael J. Spivey-Knowlton; Kathleen M. Eberhard; and Julie C. Sedivy. 1995. Integration of visual and linguistic information in spoken language comprehension. *Science* 268.1632–34. DOI: 10.1126/science.7777863.
Trotzke, Andreas, and Josef Bayer. 2015. *Syntactic complexity across interfaces*. Berlin: De Gruyter Mouton.
Trotzke, Andreas, and Jan-Wouter Zwart. 2014. The complexity of narrow syntax: Minimalism, representational economy, and simplest Merge. *Measuring grammatical complexity*, ed. by Frederick J. Newmeyer and Laurel B. Preston, 128–47. Oxford: Oxford University Press.
Wiig, Elizabeth H.; Wayne A. Secord; and Eleanor Semel. 2004. *Clinical evaluation of language fundamentals 2*. San Antonio, TX: Pearson.
Yang, Charles. 2004. Universal grammar, statistics or both? *Trends in Cognitive Sciences* 8.451–56. DOI: 10.1016/j.tics.2004.08.006.
Yang, Charles. 2016. *The price of linguistic productivity: How children learn to break the rules of language*. Cambridge, MA: MIT Press.

[at.perez.leroux@utoronto.ca] (Pérez-Leroux)
[trg.peterson@gmail.com] (Peterson)
[annycastilla@uh.edu] (Castilla-Earls)
[sbejar@chass.utoronto.ca] (Béjar)
[diane.massam@utoronto.ca] (Massam)
[yves.roberge@utoronto.ca] (Roberge)

[Received 16 October 2014;
revision invited 24 June 2015;
revision received 16 January 2017;
accepted with revisions 4 May 2017;
revision received 7 July 2017;
accepted 25 July 2017]