Simplicity and complexity in child language and its explanation
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1. Introduction: the question of complexity in early grammar.

   Is early child language inherently simple, and gradually adds complexity with specific experience? Or do initial grammars carry indications of complex grammar from the outset---not visible from experience, as the classic "Poverty of Stimulus argument" claims? (Chomsky (1965)). Do developmental processes simply refine the full grammar hidden within the initial representations or is there no grammar at the beginning?
   While the last four decades of research have yielded a body of sophisticated observations on child syntax, the most relevant fact is given to us by direct observation: by the middle of the second year of their life, children start joining words together into their first simple sentences, and within a matter of three years, the diversity and creativity of their sentences matches adult complexity. At the core of this discussion on complexity lies the question of the interaction between lexicon and syntax in development. Two contrasting paradigms articulate how these two components interact in development, yielding contrasting views of complexity in early child language. We characterize these below in very general terms:

   Simple syntax. Grammar is learned by general learning mechanisms. Under this view, complexity is an emergent property, a by-product of lexical learning. The initial grammatical production of children is stored, and lacks both abstraction and complexity. These emerge later, as a process of generalization and grammaticalization that takes place once the lexicon achieves sufficient richness.

   Abstract syntax. Even at the earliest stages, there is syntactic complexity. Children's early production may be grammatically conservative, constrained in production and operating with a restricted lexicon, but it still demonstrates abstraction, generative capacity, and principled behavior.

   These approaches can be summarized:

   1. Regularities in grammar are an acquired from experience itself
versus

2. Principles of grammar are innate, pre-existing and require only triggering exposure to constructions.

The latter system is referred to as a Continuity Model because it does not project a role for maturation, although maturation within that model is possible.

How does this connect to General Learning theory? Fodor (1975 and elsewhere) has argued there is no "learning" but rather "warranted fixed belief" where all of learning is highly constrained by a set of possible connections available to the mind. Thus the intereperation of emotion and gesture (like a universal smile) are built in. Even where substantial cultural variation exists---as in the interpretation of intonation---the variation is within a very small domain. Likewise for athletic learning, or for artistic learning, though repeated experience has a role, they are all innately constrained. Thus there is a question about whether General Learning Theory can exist anywhere. Its claim to some legitimacy in language, under the banner of "constructivist" approaches, leads to empirical claims that can be evaluated.

Constructivist approaches predict 1) gradual emergence, 2) an absence of productivity, and 3) item-by-item acquisition. Generative approaches predict children's production to evidence rule-governed behavior, and underlying abstract categories. Nevertheless under both approaches, grammar cannot emerge full-blown at once: lexical items must be acquired, and language-specific syntax as well. Both may require minimal repetition (some frequency) but the latter carries out recognition with respect to a representation and its logic, not frequency. For instance, the fact that a child hears thousands of articles (a,the) but does not initially use them, suggests that the child rejects frequency when it has no interpretation within a representation. The recognition of recursion, which we discuss below, is language specific but succeeds with extremely small amounts of data. These stand as initial challenges to a non-generative account.

Nevertheless, it is not always easy to distinguish between the predictions of constructivist and generativist approaches, when applied to early syntax (Aguado-Orea 2004). At the one-word stage, as Pinker has commented, everyone's theory works. Even at the two-word stage, however, strong biases emerge: while word-order varies dramatically in the child's experience, heavy constraints emerge. Children will say "big truck" or "truck big" and "it big", but they never say *"big it" as Bloom ( ) has shown. Without a sharp representation of sentence-boundaries---in the child's raw experience---such things easily occur, "since your truck is big, it will work" (the kind of sentence returned by Google), and should under a non-linguistic learning theory, appear in child grammar.

The challenge of comparing theories is compounded by the fact they actually pursue different goals: learning approaches are interested in the nature of development, and grammatical approaches are interested in the nature of the representations at different stages.   Without doubt, the actual course of development is affected by myriad real-life influences which a larger theory of human growth needs to acknowledge. Children may learn "watch out!" as a lexical item more easily than "be careful" because the former will be linked to a sharp intonation and visually available danger, though both are short imperatives.

Since our primary goal is not to pit two corners of a field against each other, but to motivate a discussion on children's complexity, we keep the terms Simple syntax and Abstract syntax to describe these alternatives. We acknowledge that, at lower levels of linguistic organization, syntactic and lexicon-only (partly non-linguistic) explanations may compete in determining the acquisition path.   Grammar as an explanation becomes inescapable when considering the more complex cases with interactions between sentence form and discourse.   Any theory of non-grammatical generalization will generate too many false options, utterly unattested, like *big it to succeed in explaining the narrow grammatical representations actually chosen by the child and evident in databases.

What does the innatist view claim?. First, the lexicon and lexical acquisition is crucial to all theories. Lexical learning consists first of isolating words. Children arrive at an inventory of words by segmentation of the phonetic stream, then linking these word-units to specific syntactic environments (i.e., subcategorization). This step already engages a grammatical representation.   Then the child must may semantic inferences to both the lexical items and its "subcategorization", the syntactic frames (particles, objects, complements) it is associated with if it is a verb[1]. The fact that so-called GAP verbs (general, all-purpose verbs like do, get, put, make) are among the first verbs learned show that items are not learned one by one in isolation---they may have no meaning without an object. The expression make toast and make friends require that make itself be abstracted from a single visible action.   If the child depended upon situational consistency, with visual backup, such abstract words would be the last, not the first, learned.

The second core claim of the abstract syntax position is that the product of lexical learning, by conceptual necessity, has to interface explicitly with a system capable of formal productivity. The goal is a system capable of semantic compositionality in specific domains, like subject-verb relations. Verb-object relations (make friends) are based on subcategorization which makes them like extended words, open to idioms, while the Subject-Verb relation is uniformly compositional: John sings

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[1] See (syntactic bootstrapping) (Gillete, Gleitman, Gleitman & Lederer , 1999; Gleitman Cassidy, Nappa, Papafragou & Truesswell, 2005)

and <u>Mary sings</u> involves the same relation between <u>John</u> and <u>sings</u> and <u>Mary</u> and <u>sings</u>   This principle of compositionality describes a fundamental property of human language, but it must be aimed and ordered in a specific manner. It is not the same as composing the arrangement of furniture in a living room, which involves notions of spatial composition that are special to vision.   The notion of compositionality is crucial to the understanding of natural language as it allows us to reconcile the infinite and creative nature of syntax with the construction of possible meanings. In other words, an abstract syntax is required to articulate the semantic structure which produces freedom of reference.

     Thus if syntactic productivity and semantic composition are independent, they provide infinite communicative powers. Theories of learning by association have no mechanism to decouple specific experiences from lexical items or whole sentences. Thus <u>roasting chicken, roasting beef</u> and <u>roasting your toes by the fire</u> would not be easily dissociable if the specific visual and mechanical image of <u>roasting beef</u> were immutably associated with the word <u>roast</u>. A productive syntax, linked to semantic composition, allows this freedom of reference to emerge and depart from the overload of specifics that the initial learning environment carries with it.   This may be natural, but it is not automatic and therefore any alternative theory must explain how it happens.

   While grammar is in many respects conservative (Snyder (2007)), we find not only spontaneous new combinations of words ("don't giggle me") but new kinds of syntax---not found in the input---which articulate the range of "possible grammars" available to humans. Departures from the target grammar are never beyond possible grammars, and obvious possibilities on an associative level, like *big it, simply do not occur and cannot be accounted for without assuming principles of grammar a restrictions.

        We will support this perspective 1) first with details from early grammar in Spanish 2) second a discussion of how Merge, which might seem broader than grammar, is subject to narrow linguistic restrictions and is still open to <u>recursion</u>, and 3)   with a discussion of how children's syntax leads to systematic semantic interpretation.

2. Conservativity and creativity: the case of Spanish negation

   Negation has hidden syntactic and semantic complexity. It is a logical operator that can take scope over a whole clause, or simply apply to a constituent within a clause. A sentence string is often many-ways ambiguous as to the scope of the operator, and its interpretation is sensitive to sentential stress.

(1)   María no comió manzanas
        'Maria did not eat apples.'
(2)   a. 'It is not the case that Maria ate apples.' (scope over the whole clause)
        b. 'It was not apples that Maria ate'   (scope over direct object)
        c. 'It was not eating apples that Maria did. (scope over VP)

This variation shows that negative statements cannot be simply mapped onto the worlds as: Negation+Situation. Meaning differences require negation to assign different <u>scopes</u> as the paraphrases reveal above.. In effect, the meaning of a sentence requires us to project <u>two contrasting situations</u>, defined by the scope of the operator. So, (2b) focuses the contrast on the object, matching for instance a situation in which María ate pears.   Nonetheless, as all parents know, despite its abstractness, negation is used early and robustly by young children. Are scope differences present, or do children attach a negation to a sentence and then just guess which meaning might be meant?
     María (López-Ornat, Fernández, Gallo & Mariscal, 1994) reaches what parents call in Spanish *la edad del no*, the 'no' stage, at the age of 1;9. In that file, roughly one in seven words is *no*. However, the negative utterances she produces at that point are primarily of two kinds: holophrastic *no* and final *no*, where a phrase is followed by the sentential negation marker (XP + *no*). Shortly after this initial stage, sentence initial and sentence medial negation become productive, and negative concord appears shortly afterwards. Negation use expands into a variety of complex syntax and uses, beyond rejections into denial, property negation and even counterfactual sentences. By the age of four this child has acquired a full repertoire of negative sentences.

(3)   Earliest negation
        a. No, no .[% throwing herself on the ground]
        b. Pupa no.   'Not a bubu.'
        c. Nene sienta no.   'The child is not sitting.'
        d. Tista [triste] no.   'Not sad'   (María,1;9)

(4)   Additional patterns become robust at 2;1
        a. No la chupan las vacas.
            'It is not being sucked by the cows'
        c. Este no es tuyo, e de mamá solo!
            'This is not yours, it is only Mommy's'   (María, 2;1)

(5)   Negative concord
        a. Nada, caca   'Nothing, poop.'   (María, 2;0)
        b. No sabo nada.   'I don't know anything.'   (María, 2;1)

(6)   Additional complexity: embedded negation, negative tags,
        negation in conditionals and counterfactuals
        a. Teresa no lo estudia porque ella me ha dicho a mi: yo no estudio
        nada de lo que me dice la señorita .
        'Teresa is not studying it because she told me "I am not studying
        anything of what the teacher tells me."   (Maria,
        3;6)
        b. Esto no es plátano, a qué no ?
          'This is not a banana, I bet not.'   (Maria, 3;6)
        c. No, si me quitaran el lápiz no podía escribir.
           'No, if the would take away the pencil I would not be able to
write.'
                                        (María, 3;11)

Relevant to our question is María's seeming lack of productivity at the
initial stage, in terms of syntactic frames associated with *no*. A
quantitative comparison of her utterances with her parents at that stage
shows that her preferred pattern is quite atypical in the adult input: the
final negation pattern is the <u>only</u> productive complex use of *no*, but for her
mother is the <u>least</u> common pattern.

Table 1. Frequency of basic sentence patterns with negation.

	Holophrastic no	Initial no	Medial no	XP +no
Maria at age 1;09	44% (28/63)	5% (3/63)	2% (1/63)	49% (31/63)
Mother at file 109	20% (21/105)	34% (36/105)	35% (37/105)	10% (11/105)

Three observations are relevant, which indicate that the child shows both
simplicity and productivity in her early negation. First, María's use of the
lexical entry *no* follows the least frequent surface pattern in the maternal
input. Second, While María links negation to a single distributional frame
(the negation-final fragment), the negative word itself does not exhibit
narrow distribution, neither lexically nor syntactically. It clearly combines
with many different words, and a range of phrases including nominal,
adjectival, verbal phrases, as well as small clauses appear fronted to the
negation in (3). Third, the patterns attested are <u>internally consistent</u> but not
<u>target-compliant</u>: (3c) is deviant for an adult speaker, for whom only one
element could be fronted. This type of derivation (raising and deleting
larger constituents) appears several times in María's early files, as shown
in (7). This suggests fronting larger negative fragment reflects the internal
grammar and not a speech error.

(7)   *MAD: De pie.
                 on foot   'Get up.'
        *CHI: Nene sito [= sentar/sienta] no, e sienta [= se? sienta]
no.
                 baby sit-1sg   no   SE-ref sit-3Sg no
   'The baby does not sit.' (María 1;10)

While the surface form of María's negative utterance defies the input
(qualitatively and quantitatively), we will show that it fits perfectly the
abstract representation of the target grammar of Spanish, which allows
sentence fragments that are negation final. Sentence fragments are the
result of raising relevant constituents to the left periphery, and deleting the
remnant phrase (Merchant 2004; Vicente, 2006).
    Why should Maria adopt the least frequent option in the repertoire in
the input? This indicates a sophisticated understanding of information
structure in the target grammar. According to Vicente (2006) the two types
of negative fragments in Spanish, negation initial and negation final, are
not semantically equivalent. While both the cases in (8) presuppose the
possibility of going to the movies, the neutral derivation is the one in (8b).

(8)   a. ¿A dónde quieres ir?   'Where   do   you
want to go?'
        b. Al cine no ~~quiero ir~~   'Not   to   the
        movies.'
        c. No al cine ~~quiero ir~~ (sino al juego de fútbol)
        'Not TO THE MOVIES (but to the football game).'

In Spanish and related languages, presupposed information often moves
leftward, raising above the scope of the sentence polarity node
(represented by Σ, after Laka 1990). Focalized or new information remains
lower, to the right of the clause.

(7) Information and negation

            TopP   presupposed information

        XP   ΣP

        Σ   TP
        no   remnant: remains under the scope of negation
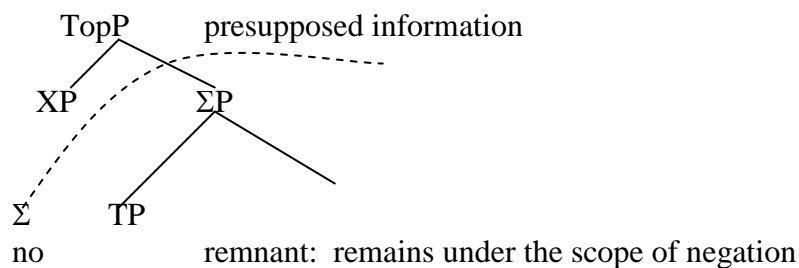
This derivation removes the topicalized constituent (the movie, in 8b
above) from the set of the places under consideration as a possible
response to the interrogative. In (8c) the presupposition that she wants to
go to the movies is directly denied, and a contrast with some other option
is implicitly introduced. This more marked option is used, say, when the

speaker is rejecting a proposal to go to the movies, and has something else, like the soccer game, in mind. It is easy to verify that the fronted constituents in María's negation are elements in the presupposition. There is previous mention by the mother, in (9), and no constrastive element to pit it against.

(9)   *MAD: Te hacen pupa las botas?   'Are the boots giving you a bubu.'
        *CHI: No, pupa no.   'No, bubu no.'
        *CHI: Pupa bota no.   'Bubu boot no.'

(10)   a. pupa no ~~me hacen~~   'bubu not me-DAT make'
        b. pupa botas no ~~me hacen~~   'bubu boots not me-DAT make'

The child has evidently mastered the fundamental patterns of information structure in the Spanish clause, and employs the most unmarked negative fragment possible.

Is this an isolated case? S. Lima has looked for the same acquisition pattern in Brazilian Portuguese and found precisely the presence of post-sentential negation as we have seen above:

*MOT: agora da o pé pra mamãe lavar (.) dá . •
52 *CHI: u@fp lavá pé não .
83 *INV: <viu (.) eu quero ver> [<] se ele faz <uma coisa que eles fazem>

We must also ask: How did Information Structure get established? Some languages overtly mark the Topic—"what is this all about"---as the first information needed for communication.   In effect, what becomes the Common Ground. is accomplished by fronting of material and strong intonation.   It seems like a natural first move for an acquisition device. However, to capture this continuity between this specific syntactic pattern, the input, and Information Structure, one needs abstract grammatical representations.

Now one might ask: Why does this not occur in English? In fact it does, but it must wait for syntax. Thus presupposed information is found in the contrast between:
    can you play baseball
    you can play baseball, can't you
In other languages one might have,
    you can play baseball, no?
but English has a syntactically complex form, so the input does not submit to an early analysis. In addition, Spanish and other languages involving Topicalization and Clefting, have more operations that put the presupposed information first.   Thus it is plausible that a very young child could pick out this property before the age of two.

Another point where syntax plays a critical role is via constraints which predict the absence of otherwise possible errors. Spanish is characterized by negative concord that is sensitive to word order. Negative phrases (*nadie* 'nobody/anybody'; *nunca* 'never', *nada* 'nothing/anything', appear alone when to the left of the verb (V), but appear doubled by the negative word if in a postverbal position, as shown in (10). Most analyses assume that when the indefinite negative phrase raises above the polarity head, it checks its features by movement. If unchecked, the features are spelled in situ as no (Zagona, 2002).

(11)   a. Nadie vino
            nobody came-3Sg   'Nobody came.'
        b. Nunca vino.
            Never came-3Sg   '(She) never came.'
        c. No viene nadie
            no come-3Sg nobody   'Nobody came.'
        d. No vino nunca.
            no come-3Sg never   '(She) never came.'

Children are exposed to the patterns represented in (12):

(12)   <u>Negative sentences</u>   <u>Corresponding affirmatives</u>
        No + V +NegP   Subj + V+ XP/AdvP
        No + V+ NegP   V + XP/AdvP
        NegP + V   AdvP V or   Subj V

                                     Also: V AdvP or V Subj or VXP

The question, from the perspective of the logical problem, is, could children generalize from the positive case (from adverb distribution to negative adverb distribution) to an ungrammatical sequence, where the negative phrase is not preceded by negation? If such generalizations are viable, the children will simply match the distribution of Neg P to that of corresponding object/subject or adverbial phrases, generalizing to the incorrect order in (13).

(13)   *Vinieron nadie.   'Nobody came.'
         V NegP   → unattested.

If the child understands negative phrases are discontinuous constituents, and their syntax must be sensitive to negation markers, such errors should not occur. María did not produce such cases that could have easily happened if negation and deletion were unconstrained processes in her grammar. Logical arguments are traditional in the generative approach,

but not considered valid within the learning theorist camp (Grinstead, 2000; Gathercole, Sebastian & Soto, 2002). The point is not whether a particular logical argument succeeds), but whether a system that predicts rigid, lexical associations between form and interpretation can describe overall children's language. Parametric approaches assume the learning space is constrained, but also assume that children should not fluctuate wildly within it. For arguments for conservative learning within parametric approaches, see discussion in Snyder (2007), and on learnability grounds in Fodor (1998).

2. The building blocks of syntactic creativity: Recursion and Merge

How does generative grammar view the act of "combining" or "association"? It is far from random and needs to be formally articulated to grasp the stages of acquisition. Combining three words already involves a recursive act: combine once, then combine that combination with a new element. This second act already raises significant representational choices, and only certain kinds of recursion are found in language.[2] It is not simply a general cognitive ability. Recursion in vision will be different. While recursion has an extensive history in computer science and mathematics, our goal is to see exactly how to make it fit grammar and acquisition. We must break it down into its logical pieces.

Hornstein (2009) shows that a general notion of concatenation is not sufficient to describe natural language because it delivers non-hierarchically ordered (flat) objects. Another general cognitive notion, set formation, delivers hierarchical structure, but it does not does not entail linearizations. It is the ability to form categories and establish conceptual taxonomies, which relies on the notion of categorial membership *is-an X*. The relation between a super-ordinate category and its hyponym is itself recursive: poodles, terriers and labradors are dogs, and dogs, cats and cows are mammals, which in turn are animals, etc.

 (14)   a. Concatenate: A, B$\rightarrow$ A^B   concatenate C$\rightarrow$ A^B^C
         b. Set formation: X={A, B, C} but also {B,C,A}, {C, B, A}, etc.

Syntax, crucially, involves representations with both types of properties. Hornstein (2009) proposes that concatenation is the primitive operation out of which linguistic merge may have evolved. Concatenation is pervasive through the human language faculty: syllables contain

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[2] see Hauser, Chomsky and Fitch (2002), and for acquisition, see Snyder and Roeper (2003), Roeper (2009), and for a more intuitive e discussion see Roeper (2007). See van der Hulst (2009), and the papers from the NSF conference on recursion Roeper and Speas (to appear).

concatenated segments, and concatenated syllables result in words. [3] But phonology does not represent syllables within syllables. How to arrive at syntactic systems from concatenation? Horstein (2009) proposes that endocentric <u>labeling</u> with concatenation suffices to yield a generative system with the relevant properties. This means that when two elements merge, a node label must be projected, corresponding to one of the elements, the head. Endocentric labeling turns concatenated atoms into complex atoms and hence liable to further concatenation.

(15) Merge and Label

   a.   ?   b.   A

        / \   / \

     A   B   A   B

Hornstein suggests that the evolutionary step of labeling concatenated elements was the crucial step in the evolution of the system underlying human languages. He makes a further evolutionary claim about <u>interfaces</u>: the grammatical notions such as subject and predicate is not part of the phrase structure system but emerges as a need to create a structure capable of fitting the interface between syntax and the conceptual-intensional system that represents events, intentional actions and information structure.

     How should we approach acquisition from such a minimal system? One consequence is that initial limits on recursion are related to the development of labels. Roeper (2003) suggests that a child's initial combination is unlabeled, as in (15a) but that the recursive operation is impossible without a label, as shown in (16a) because the identity of the element that combines with C is not definable. Only a labeled case such as (15b) can become part of the more complex structures, as shown in (16b):

(16)   a   C   b.   C

               \   / \

       ?   C   A   C

    / \   / \

   A   B   A   B
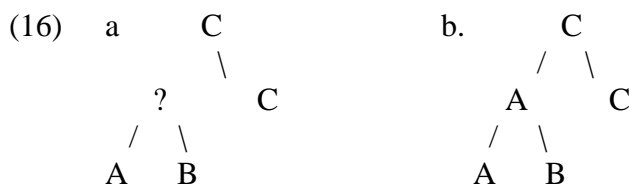
This proposal has consequences about how the capacity for recursion will be expressed in children.

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[3] Metathesis, alteration of syllable order in speech production, is a performance phenomena and should not be taken as insensitivity to linear order. Paul, a boy age 3, consistently pronounced the word "pizza" as [sapi], but he would become upset if adults imitated his pronunciation.

So we have three possible formal systems.

Concatenation: One, based on concatenation alone, is equivalent to a purely lexical approach to children's phrases that gives us no hierarchy but is sensitive to word order. This word order is not itself structured, just based on transitional probabilities much in the way our knowledge of parts of a word is ordered. This system, being linear, does not provide for hierarchical structure.

Set Formation: A second system is based on set formation, which allows us to nest elements in sets, and build up a hierarchical structure, but is insensitive to order. Important components of conceptual structure, taxonomies, are structured in this fashion.

Merge: Finally, there is the third system provided by merge, which gives us both hierarchical structure and word order.

The simplest form of recursion appears when objects of the same type merge to form larger structures. We call this direct recursion, which receives a conjunction (and) relation. Note that it appears very early in child grammar:

(17)   *MOT: quién se sienta?   'Who is sitting?'
        *CHI: éste [=! señalando] # éste y éste. 'This one [child points] # this one and this one.'   Jaanov97.cha   3;6.23
        (Fernandez & Aguado)

Every form of recursion (adjective, possessive, complement, PP see Roeper (2009)) appears with direct, hence conjunctive recursion. Adults are familiar with children's overuse of "and" as in these random cases from Childes:[4]

(18)   15a.cha:*CHI: and I show them to you .
        15a.cha:*CHI: and I put them inside .
        15a.cha:*CHI: and I would pet the sheep like this .
        05a.cha:*CHI: and I want him back .
        08b.cha:*CHI: and I gonna drive it .
        08b.cha:*CHI: and I won't &p, I won't pick, pick at it .

Children seem to first employ *que* to coordinate events in narrative, as in (19). Later they start to use it to link two sentences, but producing sentences where the subject of the second clause was the same as the

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[4] Similarly, Ferreiro, Othenin-Girard, Chipman and Sinclair (1976) note an initial coordinating use of the subordinating conjunction *que* and Tavakolian (1978) provided further experimental evidence along these lines.

object of the first clause, as in (20), rather than a relative clause as it would be used in an adult grammar, therefore receiving an "and" reading:

(19)   que el conejo se siente acá; que el elefante traiga la taza
        'that the rabbit sit here; that the elephant bring the cup'
(20)   el gato empuja al perro que el conejo lava al perro
        the cat pushes to-the dog that the rabbit washes the dog

The direct recursive structures are treated symmetrically, in parallel. For interpretive or formal purposes, there is no difference between A^B or B^A if the category projected is of the same type, be it noun phrases, as in (17) or clauses as in (18) and (19).

A second type of recursion is pervasive and uniquely linguistic; a category recurs indirectly inside another category.

(21)

NP

The man   PP

near   NP

the corner   PP

with   NP

the newsstand …
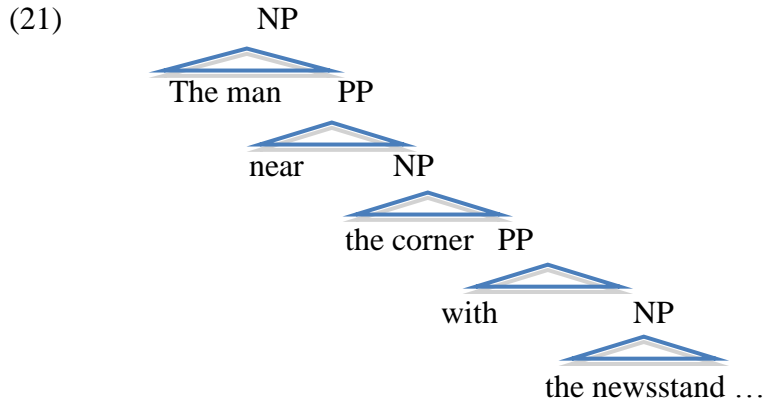
Here we have three noun phrases (NPs) nested inside the other, by virtue of the PP complements of the higher two. In this kind of indirect recursion, speakers are virtually unaware that identical categories are nested inside of each other. The examples below illustrate constituents within NPs.

(22)   *MAD: Se inventa palabras.   'She makes up words.'
        *CHI: Sí, pero te estoy vacilando poque poque poque, una paloma # una
        paloma ve(r)de paque haga caca.
        'Yes, I am teasing you because, because a pigeon # a green pigeon to make caca,'

                                                                        (Maria 2;5)

(23)   *MAD: Que les expliques a tus hijos lo que van a hacer esta tarde.
        'That you explain to your children what they will do this afternoon.'
        *CHI: No me se ninguna historia mamá.
          'I don't know any story, Mom.'
        *CHI: No se ninguna historia de mis hijos
        'I don't know any story about my children.' (Maria 3;1)

(24)   *PAD: Ponte donde estabas y vas a seguir contando cosas, no?
        'Place yourself where you were, and you'll keep telling things, won't you?'
        *CHI: Pimero, la película de ET.Maria, 2;09
        'First, the film about ET.'

A different kind of indirect recursion occurs when items of the same kind are nested inside one inside the other. In this homologous indirect recursion an operation takes its own output as input. Consider these forms:

(25)   John's friend's father's car

Windshield-wiper-cleaner
A big little truck
The rat that the cat that my mother bought died

Here we see three factors to bear in mind:

a) many of these multiply-recursive forms are quite rare proportionally in the input,

b) they show variation across languages. For instance, German possesses a genitive structure comparable to Xa, but his is possible once but not recursively; similarly, noun-noun compounds are productive and recursive in English but not in Spanish, as will be discussed below.

c) they involve asymmetric interpretations. We can see this in the contrast with direct recursion: John, Bill, and Fred came is identical to Bill, Fred, and John came in terms of truth conditions. This is because conjoined structures all relate to the predicate at once in an unordered manner. However, the interpretation of nested possessives require sensitivity to order (e.g., Roeper, 2007; 2009).

(26)   John's father's friend's car =/= John friend's father's car

How can we account for periodic interpretation?

Chomsky (2008) has proposed that one interface between grammar and interpretation is captured through the Strong Minimalist Thesis, which holds that each phase in a derivation is subject to immediate interpretation. That is, while syntax recursively build increasingly complex objects, certain categories such as determiner phrases (DPs) and clauses, are interpreted at the two interface components, the logical-semantic interface, and the phonetic interface. According to Boeckx (2008), the periodic interpretation results from systematic indirect recursion: Phase/non-Phase/Phase/non-phase, which consists of sequences of verb phrases (VPs, non-phase) dominated by clausal nodes (CPs, phases) in the domain of clauses, or NPs (non-phases) dominated by DPs (phases), in the nominal domain. It appears that this form of indirect recursion presents a specific challenge for a child.

There is immediate naturalistic evidence, available from CHILDES, of children's difficulty:

(27)   MOTHER: What's Daddy's Daddy's name?
        SARAH: uh.
        MOTHER: What's Daddy's Daddy's name?
        SARAH:uh.
        MOTHER: What is it? What'd I tell you?   Arthur!
        SARAH:Arthur! Dat my cousin.
        MOTHER:Oh no, not your cousin Arthur.   Grampy's name is
        Arthur.
      Daddy's Daddy's name is Arthur.

SARAH:(very deliberately) No, dat my cousin.
MOTHER:oh.   What's your cousin's Mumma's name?
What's Arthur's Mumma's name?
 And what's Bam+Bam's daddy's name?
SARAH: Uh, Bam+Bam!
MOTHER: No, what's Bam+Bam's daddy's name?
SARAH: Fred!
MOTHER: No, Barney.   (from Roeper (2007))

We propose that the problem lies in the requirement of periodic interpretation. The child must not simply grasp the fact that a category is embedded inside an identical category, but also generate an interpretation at each Phase Edge. Thus the child interprets a possessive as possessive and the next point of interpretation calls for embedding that possessive meaning inside another. As in the conjoined clauses above, children revert to direct recursion, and project conjoined readings.
In production, there is evidence that at least by four, children are able to produce adjective sequences that entail recursive, asymmetric interpretations. In (28), the child referred to the big truck among little trucks, rather than a contradictory, conjoined reading.
(28)   The big little truck (Gu 2008)

Some comprehension data by Gentile (2000) supports this observation. Children aged 3 and 4 years were asked to "point to Cookie Monster's sister's picture". The children were provided with a picture of cookie monster, another of his sister and another of both. None of the children choose the picture of Cookie Monster alone, showing that they were not simply deleting parts of a complex phrase. Most of them interpreted correctly, but a third of the responses consisted of choosing the picture of both, which entails a conjoined reading: the picture of Cookie Monster, and his sister. For a similar, 'flat' interpretation, see Matthei (1981) on the interpretation of adjectives sequences such as in *the second green ball.* Further evidence originates from a study on recursive compounding (Hiraga (2009)). Children were presented with novel compounds such as *tea pourer maker*, in contexts where they could choose between a character that made tea-pouring machines, and another that made tea and poured it himself into cups because he lacked such machine. Another scenario targeted a referent for *pencil-sharpener spiller*, where children had the choice of choosing someone who sharpened the pencils, and then dropped them, from a person who knocked and broke the pencil sharpeners. While adults choose the correct response 9/10 times, school-aged children overwhelmingly preferred the conjunctive reading, but gave some evidence of possessing the recursive reading.

(29)   a. tea pourer maker: "because he made the machine that could pour it for you" P.H (5;11.20)

b. pencil sharpener spiller : "because he spills pencil sharpeners" T.H(6;7.)

Children preferred the conjoined reading to the recursive interpretation. This is not surprising, given the facts noted above, namely, the scarcity of these structures in the input, and the fact that they should be triggered for each construction, since homologous indirect merge (where merged phrases are of the same kind) shows variation across languages of the world. Spanish and English both have nominal compounds, where two nouns can be compounded to produce a new one. But only in English is such compounding fully productive and recursive, as shown in (30) To express the second level of embedding, Spanish must resort to the prepositional phrase system as in (31), which is fully recursive, as shown in (32) (Liceras, Díaz and Salooma-Robertson, 2002)

(30)   Dog>Police dog> police dog trainer
        Perro> perro policía > *entrenador perro policia

(31)   Entrenador de perros policía
        'Trainer of police dogs.'
(32)   El entrenador del perro de la vecina de Luisa…
        'Luisa's neighbor's dog's trainer…'

In sum, this powerful mechanism is located in specific places, and needs a dedicated explanation. Recursively interpreted structures resulting from same-type indirect recursion are not found in every language. Therefore they have to be specifically triggered and learned in each language. Triggered information is rare: the learning organism must have the capacity, rather than build, recursion itself. These structures also present specific processing challenges per se, which can only be described in computational terms such as above, and not in terms of linear notions such as length of utterance. We have framed this discussion in terms of current minimalist assumptions, which takes us away from a blueprint model of the biological basis for language, into a model where learning is seeing as the interaction of simple, fundamental capacities, and the environment (Lorenzo & Longa, 2009).
        We have also argued that the basic, asymmetric system of merge is fundamental to be able to describe how the syntactic system can interface with the conceptual-intensional system, producing the right type of objects that can be compositionally interpreted.
        Words on their own have reference, but words in a phrase are not a simple function from the references of words. The order of how the phrases are composed determines reference, so that *John's father's friend's car* does not refer to the same object as in *John's friend's father's car*. Crucially, it is not the linear order differences that is at issue, but the

underlying hierarchical structure, as can be demonstrated with textbook cases of syntactic ambiguity.

(33)   Traje a mi amigo de Santiago.
         'I brought my friend from Santiago.'

(34) is ambiguous between attaching the PP *de Santiago* to either the NP *mi amigo*, resulting in the interpretation that my friends is from Santiago, or to the VP, where it is interpreted as I am giving him a ride from the city, but it does not matter where he is from. The bracketed structures in (35) represent these interpretations, respectively.

(35)   a. [VP traje [NP a mi amigo [PP de Santiago]]]
         b. [VP traje [NP a mi amigo] [PP de Santiago]]

The core message is that at the point of which meanings are composed, we need the notion of phases that feed into periodic interpretation, although many open questions remain about how to implement the formal system behind this. A simple linear concatenative system is not capable to explain human languages, so it is difficult to accept that it can explain children's capacity to learn language. However, not all the form of recursions are equally accessible to children, who initially seem to have easy access to direct recursion (the kind resulting in conjoined, flat structures), and to indirect (asymmetrical) recursion over heterogeneous constituents, but exhibit difficulty with the demands of indirect recursion over constituents of the same kind.

3. Linking structure to interpretation
All of the proposals and arguments so far pertain to the formal properties of language and whether children's language possesses them. But the problem of how children link structure to interpretation is far more interesting, and considerably more challenging. In the previous section we have argued that periodic interpretation is an intrinsic part of how the human mind structure meanings through language, as it determines the mode of composition between the meaning of the parts. We follow the classical approach where syntax is capable of generating more structures than are useful.

These abstract structures must be translated into two adjacent systems: one is perceptual, and the other is conceptual. Whatever object the grammar generates must meet the demands of these peripheral systems. Semantics then selects some of the potential outputs of syntax: only those that are meaningful are produced. Another way of expressing this is to say that the interfaces reduce the degrees of freedom available to the recursive system.

Nevertheless the acquisition challenge comes from a different angle: for the child, experience (input) does not go from structure to context, but

in the opposite direction. The child hears an utterance in context, and she must use context to infer what the parts are and how they are composed together. Context can be less than informative; or receive many potential descriptions.   Sometimes Context can teach the right associations between theta roles and positions in a simple way.

(36)   Cat bites dog   PICTURE
        Dog bites cat

However, other relations are harder to capture. Consider the association between classes of verb, according to the lexical aspect or aktionsart, and the different elements that enter into aspectual composition.

(37)   a. I was drinking milk/the milk (event is undelimited)
        b. Drink the milk up! (particle contributed telicity)
        c. I was drinking the milk up (telicity cancelled by gerund)

How does one arrive at the right inference about how aktionsart and grammatical aspect interact? Does the child perceive a contradiction: -ing says it is not done, and up says it is done. Which is right? Context alone gives the wrong answer: up is present, but the activity is ongoing, and –ing is present too. Context will provide no ordering.   The child must learn to interpret such sentenes in terms of the hierarchy of the sentence. Since up is lower in the tree, inside the VP, its interpretation will be subordinated to the –ing which is higher in the tree, even though, in the surface order and in the phonology the –ing seems to be closer to the verb and ought to be lower. Thus there is a mismatch between the linear sequence and the syntactic tree, and the context would only seem to be confusing, offering no help. The answer then, is that the child must already know how to compose the sentence in the proper sequence. Universal Grammar disentangles the sequence by simply dictating that the aspectual marker –ing must be higher and therefore syntactically and semantically dominate up which is ultimateluy---though discontinuously—part of the verb. Puzzles like this defy simple surface sequence based learning as far as we can see.
    Evidence from (Wagner, 2001,Valian, 2006, van Hout ( ) and many others) indicate that children do not simple fix upon the time interpretation of Tense markers, but seek aspectual interpretations first. Children thus learn early the meaning of –ing.

3.1 Ellipsis and Reconstruction
    There is a more profound challenge than disentangling the countert-intuitive sequence of grammatical morphemes. Children must also interpret silent structures—the many times where unarticulated meaning is the primary meaning.   Ellipsis is pervasive in discourse, but it is seldom recognized in acquisition work. This aspect of the connection between

structure and interpretation provides an excellent view of how interfaces work. In a conversation, almost every sentence borrows syntax from the previous discourse. Consider this example of mother-child interaction from Roeper (2009):

(38)   Success: (39) Failure:
        Child : I drink it all up .   Mother: you want
    milk or juice?
        Child: give me some more. A lot.   Child: Milk…juice?
        Mother : I don't see any more.   Mother: you can have
    one or the
        CHI: yes you do.   other but not both…
        Mother: mmhm.   Child: huh?

As is often the case the topic of the dialogue in (38) is not mentioned, but other forms of ellipsis are also present. The child says "yes you do" meaning "yes you do SEE SOME MORE" where the verb phrase is presumed, as well as the element internal to the ellipsis *any*, but negation *don't* is lifted. In (39) the complex deletions behind "one or the other but not both" are too much for the child to unravel. Although some form of ellipsis or at least semantic continuity is present from the earliest answers to a question with the word "no!", children do not begin with correct ellipsis all the time. Jensen and Thornton (2007) show that the full capacity to perform ellipsis in sentence fragments develops, and younger children fail at times to use the minimal structure that would serve the purpose of the interaction:

(40)   Mother: Who did you feed?
        Nina: Feed the llama (T3, 1;11)
(41)   Mother: What is the little girl holding?
        Nina: Holding a flower (T3, 1;11)

Two possible interpretations can be given to this fact. One is that children do not understand the discourse conditions on ellipsis, and are unable to link utterances to preceding discourse. The other is that they do, but they are proceeding carefully as they learn the syntactic conditions on ellipsis, or two. The large body of evidence on children's sensitivity to discourse conditions in terms of argument realization weights against the first option.The crosslinguistic data shows that when dropping arguments children pay exquisite attention to a range of pragmatic factors, including gesture, context and discourse, whether the language or now licenses the null arguments, Allen 2000, Serratrice 2005, Serratrice et al 2004, Guerriero et al 2006. Serratrice et al's (2004), for instance, finds that Italian and English children omit subjects and objects exclusively in contexts where the object itself does not add new information, or, in their terms, when the object associates with 'uninformative features'. It is difficult to associate this body evidence with a proposal that what children don't understand about ellipsis is how to link to previous discourse. Rather than suggesting children have deficit in computing the interaction with other, the most logical option seems to posit continuity in both the pragmatic and the formal abilities of the child. Both strong abilities are

needed to face the challenge of putting together the fine-grained system which underlies our ability to communicate.

This leads us to a strong, but natural hypothesis, which has not been formulated in the acquisition literature before:

(42) Maximize reconstruction of syntactic and semantic materials in dialogue.

Because (42) is not always obeyed the opposite assumption has been made in most theoretical work, that links in conversation are largely inferential rather than structural. For instance, this dialogue is completely acceptable:

(43)   --Are you going to school?
         --I'm sick.

However, we may consider it not quite correct. Usually we borrow grammar from preceding discourse and say "no, because I 'm sick" which is still a reconstruction:

(44)   [=no ~~I am not going to school~~ because I am sick]

Reconstruction errors are involved with disordered children who produce answers like (45), where "with a broom" is demanded of adults (==see Seymour and Roeper (==1991)).

(46)   --How did she sweep the room?"
         --Broom.
Looked at carefully, almost every sentence in a dialogue borrows from the previous one The same kind of ellipsis is called for within sentence-grammar in the larger domain of comparatives and other connected cases. Here is a not quite right sentence from a 3yr old:

  (47)   He got a toy like I do.

where the "like I do" reconstructs "I do got a toy", an unlikely adult sentence. Nonetheless, these forms obey what we can call the interface ellipsis constraint, which constraint captures both VP ellipsis (don't push) and nominal ellipsis (I want some).

(48)   Interface Ellipsis Constraint: Contextual Ellipsis applies to
         constituents under direct syntactic dominance (VP, DP).

Cross-linguistically there are radical differences in where ellipsis can occur, so

a child has much to learn. In languages like Spanish, German and Dutch nouns can be dropped in context but in English pronominalization is needed rather than do ellipsis:

(49)   Una___ azul pequeña
         a small, blue one.

Children seem to know that the agreement system between adjectives and nouns in Spanish, Dutch and German allows greater ellipsis. Work by Snyder and colleagues (2001) examined the acquisition of the noun drop construction with relation to the acquisition of nominal agreement. Most often, the two properties were acquired in synchrony, but not always. The child Koki, for instance, shows mastery of agreement at 2;02. For a period of four months he uses several sequences of determiner, noun and adjective, but no instances of noun drop, which abruptly becomes productive at 2; 06.

The evidence above suggests that very young children do not automatically go for the smallest possible structure, even if it is justified by the input. In both this case and in the fragment answers examined by Jensen and Thornton, young children proceed carefully reconstructing more of the previous syntax than needed, until all the relevant pieces of grammar have entered.

In sum our effort to impose rigor on the analyses of the acquisition process has led us to proposals that engage discourse and pragmatics as precise dimensions of the acquisition challenge. They might engage common sense as well. It is clear that children structure discourse in grammatical terms and that they seek to "make sense" of conversations and use the implications of our statements to refine their grammars.

4. Conclusion

Simple syntax is not satisfying, either on conceptual or empirical grounds. It fails to capture systematic deviations from parental input, and leaves little room to develop theories and analyses of how language form and language meanings can be compositionally linked. In this paper we have concentrated on the hierarchical structure of language, and the challenges it presents for children. We suggested that proposals that give the children possession only of linear representations that have rigid, lexical links to interpretation cannot describe children's behavior. Instead we see creative capacities carefully bound to linguistic experience and ongoing discourse and context. We have also theorized that given that all human languages have hierarchical, asymmetrical concatenated structures, it is more sensible to posit continuous access to this ability by children, since to date no theories have been articulated as to how such properties might emerge from experience. We have also argued that the full complexity of this human ability progresses from the most simple (to directly conjoin elements of the same type, and to nest constituents of different type each inside the other), to the most computationally demanding ability (to nest elements of the same type in iteration). Through this development, all

evidence points to the view that children are constrained by configurationality and compositionality. For children, as for less studied languages, the evidence may not be immediately obvious and must be carefully considered (Pesetsky, 2009).

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