

The Acquisition of Recursion: How Formalism Articulates the Child's Path

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We distinguish three kinds of recursion: direct, indirect, and generalized Transformations. Direct recursion captures the first stage of each recursive structure and delivers a "conjunction" reading. We then provide acquisition evidence from both naturalistic data and experimentation that adjectives, possessives, verbal compounds, and sentence complements all provide evidence for conjunction as the first stage. We then argue that indirect recursion captures the Strong Minimalist Hypothesis which allows periodic Transfer and interpretation. Why is recursion delayed and not immediate? We argue that an interpretation of Generalized Transformations in the spirit of TAG grammar offers a route to explanation. A Labelling algorithm combines with generalized transformations to provide different Labels for recursive structures. Recursion is then achieved by substitution of a recursive node for a simple node. Consequently we can attribute psychological reality to generalized transformations as a reason why recursion requires an extra step for each construction on the acquisition path.

Keywords: recursion; Strong Minimalist Thesis; acquisition; Generalized Transformations; Labelling

1.0. Introduction

Why is language-specific recursion not immediate? Our goal is to articulate the acquisition challenge, review the relevant evidence, and imagine why there is an acquisition path. The evidence leads to a rather tight grammatical edifice which, however, is full of theoretical and empirical weak points that deserve further re-

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search. Why such a strategy? It is really the strategy of linguistic theory in general. Weak points — like question-mark data — can be strengthened by other branches in a logical and empirical, hence persuasive, edifice. If we follow the acquisition path of several kinds of recursion, their faint characteristics can become a strong beam when seen together. Nevertheless each construction deserves much more intensive empirical scrutiny.

In a similar vein, a number of formal alternatives¹ become much sharper when we attach them to empirical phenomena, even if faint. The task at hand, ultimately, is to build an interface between structure and interpretation and then an interface between a theoretical account and the actual time course of acquisition. Yet, like the evolving notation of theoretical linguistics, these are proposals about how to build a notation that responds to both the facts of recursion and the acquisition path, neither of which is fully evident.

1.1. *Language Specific Recursion*

First let us distinguish between the completely universal form of recursion, namely Merge, and language-specific forms. Merge is a binary recursive operation that is invoked as soon as more than two words are combined.² Therefore all languages with 3 word combinations are examples of recursion over two binary acts of Merge. It is possible to imagine a three-term concatenation without a binary substructure, but empirical arguments exist to demonstrate that this is not the case for human language structure-building beyond conjunctive relations, which will form part of our argument.³ This means that all languages must be recursive in a fundamental sense, just as Hauser *et al.* (2002) have claimed, and this constitutes a strong biological claim.

Nevertheless not only the empirical question but the formal question remains alive: recursion may not be captured by a single formalism or be represented as a single object in the brain. In the *Prism of Grammar*, I argued that the principles of grammar are a model for other mental operations. If true, then other analogies should be available as well. Stereoscopy is one concept in science, but it

¹ This is written by someone who is by no means well-trained in mathematical or formal notation. See Tomalin (2007) and Lobina (2010) for formal discussions which articulate some of the distinctions between the formal and the empirical approaches to notation. Nonetheless the argument does build upon, in a broad way, the implicit biolinguistic philosophy that language formalism should be built straight from empirical data — much like the double-helix model in biology — rather than adhering to theorems that logic or mathematics have derived within their own systems. Thus Chomsky (2010) argues, as I understand it, that linguistic formalism should use concepts from set theory without being built from its theorems.

² It is exactly a binary, not a ternary operation, following Chomsky (2010) who argues that theories of sideward movement and Multi-dominance constitute ternary merge, a deviation from this narrower biological claim about how core properties of grammar work.

³ One might, in fact, argue that Direct Recursion and conjunction constitute a non-grammatical interface with Phase-based grammar. This would explain why conjunctions create islands and have links to very challenging forms of Across-the-board movement and gapping. In a sense then, language acquisition begins when children re-analyze conjoined representations. Then conjunction would belong to Primary Linguistic Data representations (Chomsky 1965) whose representational characteristics deviate from what we find in Final Grammars, except in marginal constructions where they reappear.

applies to both eyes and ears, each of which instantly integrates different information sources. Nevertheless their purposes and neurology are quite different, and therefore it is obvious that they must be separately represented in the brain. There is no single stereoscopy center in the brain.

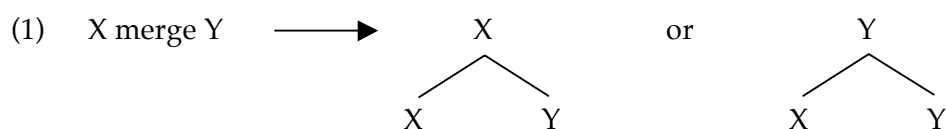
It is possible that we need to look at recursion in the same manner. In other words, our ultimate understanding will involve coordinated representations in both grammatical and biolinguistic terms. Thus current formal proposals should be expected to undergo change as we acquire deeper insights.

We will confine ourselves to three representations: Direct Merge, Indirect Merge, and Generalized Transformations as realized in an adaptation of Tag Grammar. Related forms include iterativity (as in *very, very big*) and Concord (*I don't want any food at any time for any reason*). It is an interesting question — particularly from a biological perspective — whether there are deep connections among all of these constructions, but they lie beyond what we can approach here.

A critical ingredient in our account is the interface with interpretation which, we argue, is linked to indirect Merge in an important, putatively innate, way. We approach the question through Phase theory and the Strong Minimalist Thesis. Ultimately the ideal notation for an interface should be transparent in both directions. The critical biological claim is that there is a strict interface between points of recursion and points of interpretation. One could imagine that an organism could have both capacities, but lack the interface.⁴

2.0. Merge and Labelling Algorithms

Merge is the putative universal form of an operation that underlies any form of syntactic hierarchical structure.⁵



⁴ Roeper (1978) argued that both hierarchy and node labels could have other origins but the innate property of language is to link them in a fixed way. Hauser (2009) argued that animals might have all abilities, but lack only the interfaces. Jackendoff (in prep.) argues that it is the connection to **words** that is unique to grammar. This view will reduce to the categorical feature that words carry and thus be a similar claim. However, left unarticulated is how to interpret his idea that “recursion is a general cognitive capacity”. The term *general* is where we must be careful. We might say that “motion” is a general capacity of all muscular organisms, but the claim would have little biological force since it is obvious that the mechanisms for motion are so differently represented in different organisms, or different parts of one organism. This is analogous to our argument that there is no Stereoscopy Center in the brain, but rather the principle is independently represented in eyes and ears. See Roeper (2009) discussion of the distinction between an **interaction** and an **interface**.

⁵ See Roeper (2003) for discussion of the interaction between successive forms of Merge and compositionality for DP.

Although a set may be defined without a label or ordering, a signal feature of Merge lies in the fact that human languages always assign a Label to every Merge.⁶

A label must be chosen reflecting the **dominance** of either the right or the left branch (or possibly a more complex choice—see Chomsky’s (1995, 2008) discussion of labeling algorithms⁷. Hornstein (2009) has suggested that it is the **combination** of Merge and Labeling which may define human grammar as distinct from animal constructs. We take the argument one step further in arguing that the connection between recursion and the Strong Minimalist Thesis (SMT see below) is where the particularity of innateness lies. We have made a similar argument for the role of the SMT in the acquisition of long-distance movement and the presence of partial movement in child grammars (Roeper 2009, de Villiers *et al.* in press).

2.1. *Direct and Indirect Recursion*

An initial distinction between Direct and Indirect recursion can be made in terms of Phrase-structure rules (Snyder & Roeper 2004). Direct recursion is where a category reproduces itself and characteristically produces a **conjunctive** reading:

- (2) Direct Recursion: $X \rightarrow Y(X)$
 $NP \rightarrow NP ((\text{and}) NP)$

This will produce potentially infinite sentences like:

- (3) John, Bill, Fred, and Susan arrived.

It has a critical feature: there is no significant semantic ordering among the elements. They are parallel and interchangeable:

- (4) Bill, Susan, John and Fred arrived.

It is applicable to any category, even below the lexical level:

- (5) a. in and around and over an under the structure
 b. pre- and post- operative care

but does not participate in other aspects of grammar, for instance, there are no movement rules that allow extraction from conjunction (Ross 1967):

- (6) * how did he go in and __ the structure \rightarrow “how= around”

⁶ A question, of course, arises about how linearization occurs and whether it belongs to a process of Externalization as Chomsky (2010) has suggested. Even if such a reframing were to occur, the role of order and labeling in the definition of the externalization interface would leave these claims unchanged I believe.

⁷ See Perez and Roeper (2010) for discussion.

It is, in a sense, at the margins of grammar, but it is also a mental ability which characterizes the first stage — and the default grammar — of children with respect to every category in the grammar, as we shall illustrate.

By contrast, Indirect recursion may (or may not) involve an interpretive step which changes meaning, as in the way that possessives are stacked:

(7) John's friend's father's student's essay

is quite different from:

(8) John's student's father's friend's essay

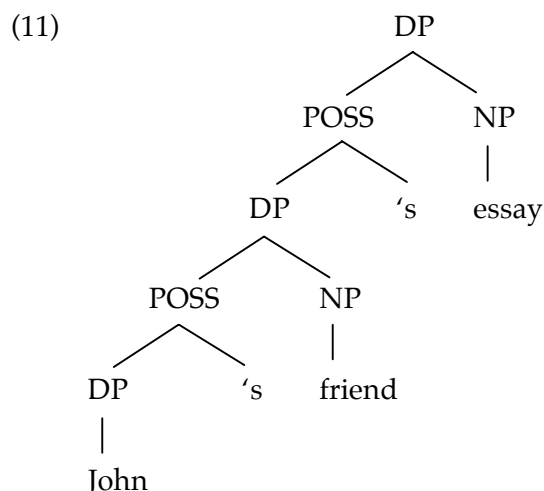
We can capture the difference by introducing the Strong Minimalist Constraint (SMT) (see Chomsky 2005, 2010):

(9) Phase by Phase interpretation

Although it remains an open question just where Phases occur, good arguments for CP, vP, PP and DP have been made (see Kamiya *et al.* in press). The recursion is **indirect** because another category is present:

(10) Indirect Recursion: DP → (Determiner) NP
 Determiner → {ARTicle POSSessive}
 POSS → DP 's

The Determiner Phrase (DP) is repeated inside the Possessive phrase, and therefore can generate another 's for John's friend's essay:



If interpretation occurs at each Phase, the Phase-assumption is critical:

(12) A DeterminerPhrase is a Phase

which is a designated interpretive Phase, as are clauses (CP), verbphrases, and PP's.⁸ Here is Chomsky's statement of the Strong Minimalist Thesis:

there are Transfer [...] hands Syntactic Object to the semantic component, which maps it to the Conceptual-Intentional interface. Call these SOs *phases*. Thus the Strong Minimalist Thesis entails that computation of expressions must be restricted to a single cyclic/compositional process with phases. Chomsky (2005)

As a strong constraint, it should guide acquisition as well.

2.2. *Alternating Phase Constraint*

Boeckx (2008) argues for what we can call the Phase Alternation Constraint:

- (13) Interpretation must occur in alternating sequence:
 Transfer takes place every other time Merge applies yields the following pattern: Phase—Non-phase—Phase—Non-Phase

In each of the constructions above we find that this sequence is followed: every other time Merge applies yields the following pattern:

- (14) a. {Head Transfer1 , {Head2, {HeadTransfer3 , {Head4}}}}
 b. = [C Phase [T [Phase [V]]]]"

This leads to the following kinds of familiar alternations:

- (15) Sentence: John thinks that Bill thinks that Fred...
 V CP V CP...
 PP: John's knowledge of Bill's knowledge of
 DP PP DP PP
- (16) Possessive: John 's friend 's father 's car
 NP Poss NP Poss NP Poss NP

In sum, it is indirect recursion linked to the interpretive requirement (SMT) on Phases, that carries the weight of recursion as a pivotal grammatical device. We will now show how languages differ in where they allow indirect recursion, and

⁸ If indirect recursion occurs through an intermediate Phase of a very different type, like a PP, it does not impose the interpretive demand we can feel when one DP is directly inside another, as in (i) where a PP intervenes between two DP's:

(i) [_{DP} the box [_{PP} in [_{DP} the corner

Here we are basically unaware that one Determiner (*the*) is inside another. Thus the pattern of alternating Phases deserves study on its own.

then reveal a two-step acquisition path for each form of language-specific recursion.

2.3. *Grammar Variation*

Now let us provide an overview of how grammars may vary in recursion. German (and most Germanic languages) allows a single pronominal genitive, limited to proper nouns:

- (17) a. Maria's Haus [Maria's house]
 b. *Maria's Nachbar's Haus (Maria's neighbor's house)

Therefore the child needs to identify where in his language recursion occurs. Here we argue that the POSS directly dominates the lexical item's and therefore does not dominate DP producing recursion. This is the child's first assumption.

Here is a summary of major known recursion contrasts:

- (18) a. Compounds: Germanic languages → recursion
 Romance languages → no (recursive)
- b. Possessives: English → recursive possessives (Saxon Genitive)
 German → no recursive possessives
- c. Adjectives: English → recursive pronominal adjectives and
 no recursive post-nominal adjectives
 French → no recursive pronominal adjectives
 recursive post-nominal adjectives
- d. Serial verbs: Bantu → recursion
 English → no recursion
- e. PP recursion: English → recursion
- f. Clausal recursion: Germanic, Romance → recursion
 Sign Language, Pirahã → (disputed)
 Walbiri, Tiwa → no recursion

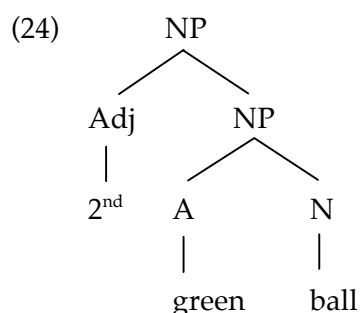
One important challenge is to uncover exactly where recursion occurs in less studied languages around the world. Each will provide an acquisition challenge.

3.0. *Data for Direct Recursion: The Appearance of and*

One major hypothesis in this essay is this:

- (19) Direct Recursion is the Acquisition Default:
 A child first analyzes adjacent identical structures as Direct Recursion with a Conjunctive reading.

The structure they needed was essentially indirect where an adjective modifies an NP, second [_{NP} green ball], not directly modifying another adjective as in (*crystal-clear water*, where *crystal* modifies *clear*) but going through another NP, thus becoming indirect:



Thus the default form appears to be **conjunctive**. Bryant (2006) had a similar result in German showing that children interpret the big black balls as the big balls and the black balls.

3.2. Prepositional Phrases

Naturalistic evidence from CHILDES analyzed by Chloe Gu shows that children will treat PP's conjunctively and resist recursion (Gu 2008).

- (25) Father: Up in the shelf in the closet
 Child: yeah
 Father: can you say that
 Child: up in the shelf in the closet
 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
 Father: up in the shelf in the closet in the kitchen
 Child: up in the shelf in the # what
 Father: closet
 Child: in the closet in the kitchen
 Father: in the jar up in the shelf? can you say that?
 Child: I can't
 Father: you can
 Child: in the jar # say in the jar
 Child: up in the shelf in the jar in the closet in the kitchen

Note that the PP's must be seen as conjoined (in the shelf and in the jar), rather than recursively embedded (the shelf is not in the jar). It would be good to gather experimental evidence on this point. The experiment is easy to see: put a box on a shelf and one on the floor and a book in each. Then ask: show me the book in the box on the shelf. If the child treats the question as conjoined, they will point to both the book in the NP in the box on the shelf and the one on the floor. As we will see, this response is found with possessives.

3.2.1. Recursive Possessives

Naturalistic data on recursive possessives indicates that they are difficult (see Roeper 2007 for more examples):

- (26) 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?
- MOTHER: What's Pebbles-' momma's name?
 SARAH: Wilma.
 MOTHER: Wilma... yeah.
 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.
 SARAH: Barney.
 MOTHER: What's his mumma's name?
 SARAH: She's right here.

Sarah is resisting a recursive understanding although all the pragmatic support and world-knowledge she needs is close at hand. A 6yr old, though, finally produces one:

- (27) where's Toto's girl's

The child initially finds any way possible to resist the interpretation that recursion demands, but the favored move is to convert the sentence into conjunction as data below indicate.

3.2. Possessives Explored

In a series of explorations by various students and colleagues we began to pursue

the question experimentally. The first step is to invent a context where several options are available and equally plausible. The first was invented by Sarah Gentile (2003) who gave a child three pictures based on familiar Sesame St characters, but no story was presented.

- (28) A. Picture of Cookie Monster
 - B. Picture of Cookie Monster and his sister
 - C. Picture of his sister
- Can you show me Cookie Monster’s sister’s picture?

The results showed that about 1/3 of the 3-4 yr olds took the conjunctive reading (Cookie Monster’s and sister’s picture) and chose Picture B.

In the next experiment by Maxi Limbach (2010) children and L2 German speakers whose L1 has possessives, but no recursion, were given a series of stories, like this one, where both options are equally attractive:

- (29) Context story example for screen setting:

Jane has a nice blue bike and Jane's father Gordon has a racing bike. When they do a tour together they have another bike which they both can ride together. Sam has a red bike and his father Paul has a silver bike.

father’s both Jane’s
 | | |



Figure 1

The bikes were then shown in separate pictures and people chose which fit “Jane’s father’s bike”.

Subjects (25 American/ 23 German university L2 students) who were either native (NS) or non-native were involved. Non-native (NNS) gave a conjoined reading or dropped one of the possessives (38% adults/ 37% 5yr olds). It is noteworthy that the 5yr olds gave 22% conjoined readings, while Non-natives gave only 8%, and 30% avoid recursion by dropping the first or second possessive:

Age	All	Correct	Middle	First	Random	Conjunctive	Other
Age	All	Correct	Middle drop	First drop	Random	Conjunctive	Other

5	32	19 (59%)	3 (9%)	2 (6%)	0	7 (22%)	1 (3%)
4	23	16 (70%)	1 (4%)	1 (4%)	0	4 (17%)	1 (4%)
3	32	18 (56%)	6 (19%)	2 (6%)	0	3 (9%)	3 (9%)
Adult NS	10 9	90 (83%)	2 (2%)	11 (10%)	1 (1%)	5 (4%)	41 missing
Adult NNS	10 2	63 (62%)	10 (10%)	12 (12%)	9 (8%)	8 (8%)	36 missing

Table 1: Results

Moreover, L2 speakers of English persistently claim that recursive possessives are difficult, and triple recursion virtually impossible. The mere fact that we explain it to someone, for instance professional linguists, does not enable them to process recursion easily.

3.3. Japanese

Now we look at a pilot experiment on recursive possessives in Japanese where, for the first time, four level recursion has been explored by C. Fujimora (2010). In Japanese we have a structure similar to English but marked by *no*:

- (30) a. John's brother's car. *English*
 b. John no otouto no kuruma. *Japanese*
 John 's brother 's car.

A simple set-up was matched by a picture sequence that allowed the relations to be easily kept in mind.

- (31) The story (told in Japanese): This girl is Mika and this is her dog. This boy is Mika's friend and his name is Kenta. This is Kenta's dog. This is Mika's brother and his name is Sho. And this is his dog. This is Sho's friend, Yuki and this is her dog. And look, everyone is holding a ball.



Sho Yuki

Figure 2

- (32) These are single possessive questions.
1. What color is Mika's ball?—Orange
 2. What color is Kenta's flower?—Yellow
 3. What color is Sho's shirt?—Red
- These are double possessive questions.
4. What color is Mika's dog's ball?—Black
 5. What color are Mika's brother's shoes?—Yellow
 6. What color is Sho's friend's ball?—White
- These are triple possessive questions.
7. What color is Mika's friend's dog's ball?—Purple
 8. What color is Mika's brother's friend's flower?—Red
 9. What color is Sho's friend's dog's tail?—Black
- This is a four time possessive question.
10. What color is Mika's brother's friend's dog's ball?—Yellow

	child 1	child 2	child 3	child 4	child 5	child 6	child 7
age	2;5.26	3;2.1	4;3.18	4;4.8	5;2.13	5;7.18	6;0.13
1	○	○	○	○	○	○	○
2	○	×	×	○	○	○	○
3	○	○	○	○	○	○	○
4	×	×	○	○	○	○	○
5	×	×	×	×	○	×	○
6	×	×	×	○	×	○	○
7	×	×	×	○	×	○	○
8	×	×	×	○	×	○	○
9	×	×	×	×	×	○	○
10	×	×	×	○	×	○	○

red = success, green = failure

Table 2

Again the youngest children correctly get a single possessive, but then fail. With the exception of example 5 (about shoes, not balls) and child 5, who manages double, but not triple recursive constructions, what stands out in this chart is that those children who master 3 part possessives (7,8,9) have no difficulty with 4 part possessives (10). The 2 part possessives (4,5,6) are likewise grasped almost at

the same time as 3 and 4 part possessives by children, all below 7yrs, clearly much younger than the L2 college students.

What role do the pictures play? One might observe that they give us a visual hook with which to keep track of all the relations. They are an additional cognitive guide to the meaning. While this is correct, it is not a substitute for grammar. If we had the conjoined version:

(33) show me Mika's and brother's and friend's and dog's ball

it would call for us to point to all of their balls and not just the final one, just as our first example elicited a reference to Cookie Monster's and sister's pictures.

This is precisely what transpired with the younger children who failed to grasp the recursive sentences. When there were more than one possessive, child 2's answers were more than one. For example, for the question, "What color is Sho's friend's dog's ball?" his answer was "this and this and this" and pointed to Sho's ball, Sho's dog's ball, and his friend, Yuki's ball. Other answers among the younger children involved deleting one or more possessive.

In sum, we have pointed evidence that the acquisition of recursion is not immediate, but that once recursion is acquired, there is not a significant processing demand producing a difference between 3 and 4 level possessives.¹⁰

3.4. Verbal Compounds

Snyder (1995) showed that 3-4 year olds produce novel two-word compounds and Hiramatsu *et al.* (2002) showed that the ability was productive. For verbal compounds Hiraga (2010) found that children at the age of 4-5 were easily able to understand and produce a single verbal compound: when asked "what is someone who pulls a wagon?" with the answer "wagon-puller", corroborating claims in Clark (). Novel compounds like "I'll be the lunch-bringer" occur as well at 4 years. When Hiraga sought to see if recursive compounds were possible, much greater difficulty was encountered. Only by the 6-7yr old range did children show clear knowledge. Here is one of the stories and the picture that accompanied it:

(34) Kitty makes a great machine. The machine pours tea into many cups at once. Bunny bought the machine from Kitty, so Bunny only makes tea and doesn't have to pour it. The machine pours tea into five cups at once, so Bunny's sisters and brothers can drink it. Doggy doesn't have the machine, so he makes and pours tea himself. One of them said "I am a tea pourer maker."

¹⁰ We need a method to explain why, once an operation occurs, it is so easy to reproduce. The term "priming" is used in psychology, but it is not exactly clear what the notion entails in representational terms. If I lift 50 pounds, then add an identical 50 pounds, it is not equally easy to lift 100 pounds. If priming were all that one needed, then center-embedded recursion should be easy too.

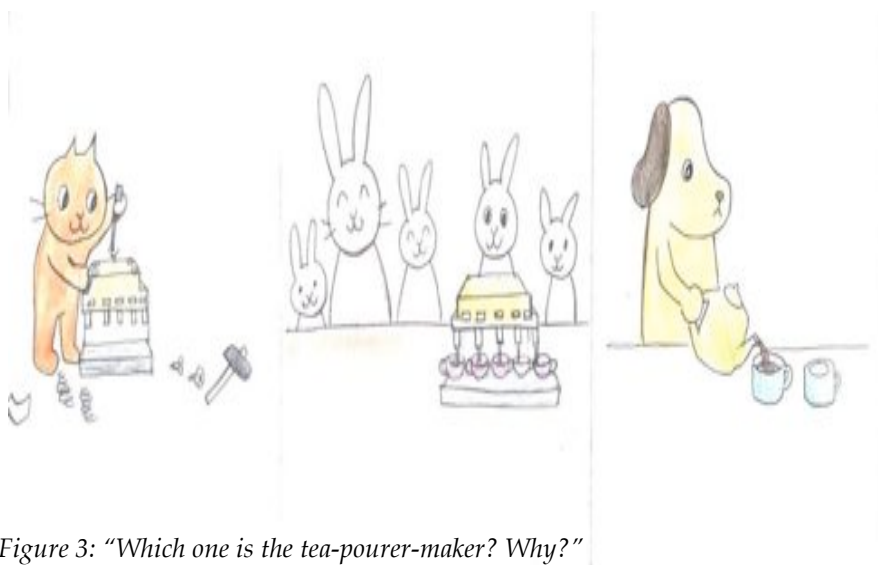


Figure 3: "Which one is the tea-pourer-maker? Why?"

Conjunctive:

6yrs: "because he makes and pours tea"

Recursive:

(35) N.I (6;11.2):

- a. tea pour maker: because she pours, actually, she made the machine that pours tea
- b. tea pourer maker: because he makes the machine that pours tea

(36) I.R (6;5.4):

tea pourer maker: because she made the machine that can pour tea

(37) P.H (5;11.20):

tea pourer maker: because he made the machine that could pour it for you.

Other examples with stories:

(38) Other examples:

- "pencil sharpener spiller"
- "picture taker liker"
- "bottle opener breaker"
- "tea lover taker"

These examples feel intuitively more difficult for adults as well, but 9/10 adults gave correct answers: 89% and only 2/45 gave a conjunctive reading.

A question arises: Why should this form of recursion be so much later than adjectives? Why does it feel more difficult to adults? Noun compounds [school lunch box] are much more frequent than recursive verbal compounds [bread-baker watching]. This means that, although just a few can trigger the process, their rarity could affect when they appear. This does not offer a full explanation

of delay however.

We argue elsewhere that the **derivational path** is relevant: it is a reflection of leftward movement operations and Relativized Minimality (see Friedmann *et al.* 2009). In effect, in *tea-pourer-maker* one compound with –er must “cross-over” another –er [maker of tea-pourer → tea-pourer-maker]. Nevertheless this approach does not explain why there is a delay with rightward forms of recursion, as in adjectives and PP’s and, as we now discuss, complements. Recursion itself seems to be a challenge.

3.5. Sentence Complements

Finally we add sentence complements to our overview, although they engage many more aspects of grammar than simply recursion. The first observation to make is that children appear to acquire infinitives very quickly in a recursive form, although they are arguably not Phases, and certainly do not contain propositional content. A cursory search (get,go,try) reveals recursive infinitives as early as 2.4 years, but a careful study of their emergence would be very useful.

(39) Naomi 2.4yrs: to go to sleep

From Adam:

Adam 27*CHI: what you use to carve [?] it to do what?

Adam30.cha: aul want to go to sleep and stand up

Adam 54*CHI: here (.) we going to have to build one with another string on it.

Anne 34b*CHI: you have to get this one to go as_well.

stp2.cha: here am I going to get to put the chimney

boys44.cha: when I got bigger then I'm going to get to go

cha:*CHI: dad you're suppose to try to get it on me

e21.cha:*CHI: Now I'm going to try to touch your knee

aran 29*CHI: I went to climb the house to see them.

*CHI: I want to get to see.

nic34b.cha*CHI: you have to go to sleep now.

liz22b*CHI: this one [* 0is] going to go down to drink

How come these forms emerge at such an early point? Do they really represent a series of Phases? Evidence of this kind may fit the notion that infinitives are not Phases, but much more argument is needed.

Nonetheless when we turn to tensed complements, we both find some at the 4-5 year range (from Adam) just a few earlier, though a more thorough search would be useful:

(40) Danilo 3.2 I think Daddy says he wears underpants

adam45.cha:*CHI: he thought those guns were coming from outside him
adam45.cha:*CHI: he thought I said something (a)bout... window
adam52.cha:*CHI: he thought # bad people would get him
I thought you said they gonna be warm

These forms might, however, be represented by a recursive adjunct that is not really sentential, much like:

(41) to me and for you they gonna be warm

Diessel (2005) argues that the early forms of *I think* simply mean *maybe*.

When we look at real comprehension, we find that children, anti-pragmatically, resist complementation. Experimentally Hollebrandse *et al.* (2008) with 18 children (6;3 – 6;11, avg: 6;9) have shown that they have no difficulty giving single complement answers for situations with sentences like: “Dad is talking to Billy about moving his tools. Dad tells Billy that Jane said that hammers are too heavy. What did Jane say?” Children easily respond “hammers are too heavy”.

However when the higher verb is needed to make sense of the question, implying recursive subordination, correct answers fall off sharply. Thus among children as old as 6yrs, only 1/3 provide the recursive answer although the meaning is very misleading if you do not. Often conjunction can deliver the same inference. Therefore experimentally we sought each time to determine that only comprehension reveals the recursive structure.

(42) Jane talks to mom. She is having a fight with Billy on the phone. Jane tells mom that Billy said that all sisters are stupid. What did Jane tell mom?



Figure 4

(43) Single complement: [said] “that all sisters are stupid”
Recursive complement: [tell Mom] “that Billy said that all sisters are stupid.”

The experiment is constructed anti-pragmatically because if she gives a single complement answer “all sisters are stupid,” then she condemns herself. Here are the results (44):

(44) 23% irrelevant 34% single, 33% recursive

Thus 2/3 of these children, until the age of 6yrs, despite being invited by the momentum of the story to oppose the boy by mentioning that he is the speaker, offer a single clause or an irrelevant answer in 2/3 of the answers. This leads to the clear conclusion that a single complement answer is not represented in the same manner as a recursive complement.

In sum, the children allow a single possessive, single adjective, single complement preferentially as the first step. The second step involves a direct-recursion conjoined response. Finally we obtain an indirect recursive response.

4.0. Generalized Transformations and Tag Grammar

Now we need to address the question squarely of what change could occur to shift from a conjunctive representation to a recursive one. In principle, recursion is an automatic consequence in a PSR system. If a category contains another, then what would block the generation of recursive forms? Thus if I have:

(45) *John said S2* and I realize *S2* as NP VP and choose *Bill said* for VP, then I automatically introduce another VP and *it is raining* is possible, giving:

(46) John said Bill said it is raining.

In effect we must **stop** this core process from occurring to explain the delay.

How should we, exactly, account for the extra difficulty that recursion causes and is it all of the same stripe? A frequent suggestion in all such contexts is that parsing or processing challenges are created.¹¹ However it is not obvious that, at least to the adult, recursion causes significant processing difficulty. Direct recursion, for instance, is very easy for children of 3yrs with relative clauses:

(47) this is the one that you gave me, that I really like, that I am taking to school with me.

And adjectives and PP's in indirect recursion do not feel difficult for adults. Given differences among structures, a common explanation needs to refer to properties of those structures.

In order to acquire a unified explanation we should ask if there is a formal option that could capture such a stage in acquisition. In fact Robert Frank (1998) has proposed that TAG grammar captures a difference which matches results in

¹¹ See Joshi (in draft) for an argument that recursion stops after two or three and this should be accounted for formally.

acquisition for several of these structures, advocating as well that conjunction is a default form which leads to a conjoined reading. This follows as well from Lebeaux's (2000) approach to Adjuncts and his proposal that children begin with Adjoin Alpha.

In principle, the argument is a form of Generalized Transformation which was part of Syntactic Structures and advocated in Minimalism as well by Chomsky (1995). It becomes a more powerful claim under the SMT where it is argued that not only syntax but semantics is entailed in each Phase. It leads to this strong view: Every phase that can be separately interpreted is separately generated. After independent generalization, two structures are then combined.

The pivotal technical proposal in the TAG approach is that one can either a) insert a new node or b) **substitute** a new node for an old one. We will adapt only the latter concept. Thus to examine Frank's account of relative clause attachment we have:

- (48) $S \rightarrow DP_1 VP \rightarrow \text{John like}$
 $VP \rightarrow V DP_2 \rightarrow \text{John liked the cat}$

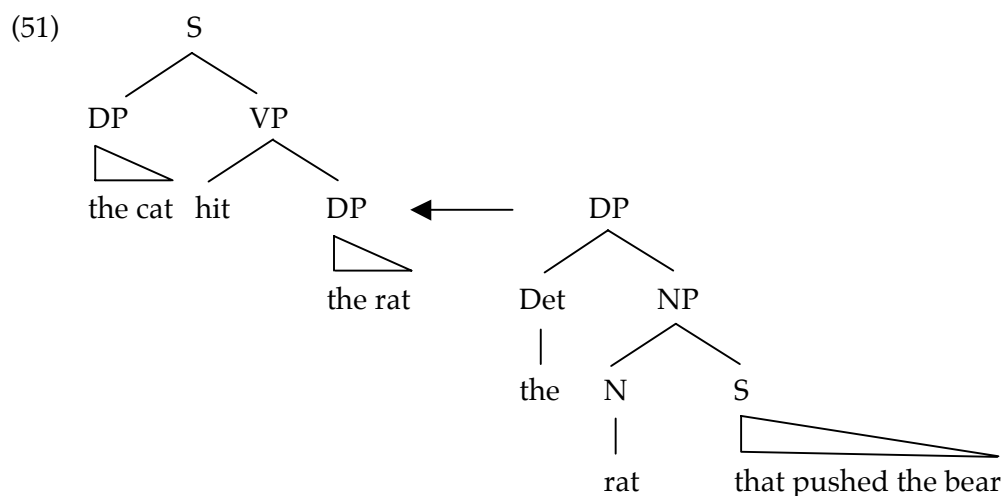
However, independent of this form we have a second rule:

- (49) $DP_3 \rightarrow NP S$

which carries a branching node and a meaning that allows the relative clause to restrict the range of reference, therefore to participate in the interpretation of the DP. Thus the TAG grammar allows the generation of two forms:

- (50) Sentence: DP [the rat] VP [hit] DP [the cat]
 DP [the cat] Sentence [that I like]

and the second tree is inserted by substitution of DP3 for DP2 into the first:



and possibly PP's as well. And the question becomes — if the top node of each Phase is interpreted — whether the information on the node plays a critical role in interpretation, which has been argued by Morzycki (2010 and earlier work).¹²

If this proposal is carried forth, it will require that the Labelling Algorithm be one that fits this move (Chomsky 2005). This might in fact be an important criterion to evaluate the formulation of a labeling algorithm. In effect it would be a method whereby recursive nodes could look different from non-recursive ones which in turn would fit the claim we make that the acquisition path for recursion involves a critical step beyond recognition of the basic syntactic category.

If our reasoning can be sustained, then the acquisition path provides unique arguments for aspects of linguistic theory that reach deep into the notational choices that are made.

5.0. *The Experience of Recursion*

We are now in a position to answer the question raised by William Snyder and Roeper in a series of papers examining the appearance in naturalistic data of recursive compounds, possessives, adjectives, and serial verbs. We (Roeper & Snyder 2004, 2005) advanced the hypothesis that children must “experience” recursion in order to allow it in their language. We had no statement about what impact the experience of recursion would cause.

This hypothesis followed from the observations above, that single instances of possessives, adjectives, and compounds in a language did not guarantee recursion.¹³ If we now argue that recursive nodes are discernibly different from non-recursive nodes, then the argument that experience is necessary is clearly justified. A consequence, of course, is that such triggers are rare and hence we can predict that they may arise late or in a non-uniform fashion among children. The number of times one hears *coffee-maker* in comparison to *coffee-maker-maker* is obviously small.

5.1. *Recursion as a defining Property*

Is language specific recursion a marginal phenomenon—as much of the public controversy would suggest (Everett (to appear))? Or is recursion the fundamental pivot, the axis which forces productivity and allows an efficient flow of thoughts into language?

¹² The question of how much information percolates to the node level is relevant to exactly how various kinds of adjectives can be modified, why for instance, one cannot say **very gigantic* as Morzycki (2010) asks. One can formulate this question in semantic terms, but one can formulate it syntactically by observing that *very* must not only modify a DegreePhrase, but that extreme adjectives cannot participate in *very*-modification. If the syntactic system had only DegP as the node to which *very* applies, then it would not make this distinction. We take this to be parallel to the question of whether a restrictive relative clause is relevant to the node projected by DP. We will not delve further into this question beyond observing that we take the acquisition facts here to be relevant.

¹³ The idea originated with the observation about productivity from Nida () that only those grammars with recursive compounds had productive compounds.

It is not simply an abstract question. A close look supports the latter view. Recursive operations operate upon hierarchical structures. Those labeled hierarchical structure represents a range of abstractions that allow some productivity. Identifying a node with an NP allows any NP to occupy that node. However subcategorization, which applies to verbs, but also other lexical items, allows the hierarchy to be overruled by lexically specific information. Thus the verb *crane* allows only *necks* as an object; one cannot **crane your elbow*. Recursion, once recognized by the child, never allows this constraint: it operates only on grammatical categories. A single complement may be an idiom: *John knows what's what*. It is not possible for *know* to project such an idiom into a recursive domain, that is, over another clause: **John knows Bill thought what is what*.

The recognition of recursion is an automatic liberation from searching for idiomatic subcategorizations. And it relegates exceptional constructions to secondary grammars. Under the Multiple Grammar approach (see Roeper 1999), a signal feature of the presence of a subgrammar is the absence of recursion. An example is V2 in English, which applies to quotations ["nothing" said Bill] and stylistic inversion [in the room ran John] but notably neither allows recursion [*"nothing" said Bill" said John]. There is no evidence that children ever overgeneralize recursion where it does not belong.¹⁴

This bifurcation between recursive and non-recursive rules gives the child a means to assemble his core grammar and exclude marginal exceptions. Before specific nodes, entailing recursion are recognized, it is commonly suggested (Roeper 1992, Tomasello 2006) that there is a great deal of lexical specificity that blocks or limits easy overgeneralizations. Thus the child may first represent possessives in both English and German with a constraint on human or animate possession. Independently assembling examples from Galasso (2003), of early possessives, here is what I found:

- (55) Me: I want me bottle. Where me Q-car? That me car. Have me show.
Me turn. Me cat. Me pen. (2;6-2;8)
You: No you train. It's you pen. It's you kite. It you house? (3;2)
Him: I want to go in him house. Him bike is broken. It's him house.
Lexical:
Mine: Mine banana. Mine bottle. Mine car. Mine apple. Mine pasta (2;4)
My: My car. (3x at 2;4) My pasta. I want my key. It is my t.v.

- (56) Single Poss:
[whose hat is that] "Mrs. Wood's" (2.7)

Jensen and Thornton (2007)

They are all human possessors, no cases like *the car's tire* and, of course, none are recursive. Therefore at Stage 1, the English and German child may have the same grammar. When the child re-analyzes the possessive to allow recursion, as we saw above, then the grammars diverge. Thus we suggest that it is exactly recur-

¹⁴ A possible minor exception is the "as... as" construction discussed in *The Prism of Grammar* (Roeper 2007) which one child extended to "as...as...as."

sion which the child uses to define the difference between English and German.

5.2. Conclusion

Our focus has been various language-particular forms of recursion. We have seen a variety of evidence of a default conjunctive interpretation that can be captured by Direct Recursion: the included possessives, PP's, adjectives, and complements.

We claimed that the real challenge lay in a combination of Indirect Recursion and the Strong Minimalist Thesis. Finally we sought to explain why recursion is not immediate via the proposal that Generalized Transformations cause the definition of recursive nodes to be distinct from non-recursive ones such that an operation of Substitution is necessary, as proposed in TAG grammar.

Implicit in the study are several broader claims:

- 1) if variation exists, an acquisition challenge and path must exist,
- 2) the grammar, not just processing, must be engaged in formally specific ways to capture this acquisition path which, moreover, provide insights into the formalisms themselves.
- 3) the time-course of each form of recursion may be a function of how much exposure is involved, the nature of the derivation, the intersection with morphology, and other factors.
- 4) the representation of recursion critically involves an interface with interpretation — via Phases and the SMT — which we take to be an innate interface.
- 5) our mode of argumentation, given the obscurity of the process and the evidence, is to include small amounts of suggestive evidence if they point in the same direction and contribute to a deeper generalization, or acquisition hypothesis, which invites a more thorough program of research.

In sum, we argue that the child seeks recursion as the core of productivity.

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