PP Coordination, Embedding and Feature Sharing: seeking the connections between notation and processing

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ABSTRACT

Abstract: This article presents and discusses two sentence/picture matching experiment in English and in Brazilian Portuguese Prepositional Phrase constructions to try to assess the complexity of the representations in terms of structure, features, and grammatical operations. The results of the experiments in which PP coordination (Direct Unstructured - DU, embedding (Indirect structuring - IS) and Feature-Sharing (Direct structuring - DS) are compared reveal the following hierarchy based on the average response times: DU <IS <DS. An explanation for the hierarchy is explored in which the Feature-sharing construction is discussed in terms of potential connections to Agreement phenomena.

Keywords: *Recursion*; *Prepositional Phrases*; *Sentence/Picture phrase technique*.

RESUMO

Resumo: Este artigo apresenta e discute dois experimentos de correspondência entre frases e figuras em construções com Sintagmas Preposicionais em inglês e em português brasileiro para tentar avaliar a complexidade das representações em termos de estrutura, traços e operações gramaticais. Os resultados dos experimentos em que a coordenação de PPs (Direto Não Estruturado - DU, encaixe (Estrutura Indireta - IS) e compartilhamento de traços (Estruturação Direta - DS) são comparados revelam a seguinte hierarquia com base nos tempos médios de resposta: DU <IS <DS. Uma explicação para a hierarquia é explorada, na qual a construção de compartilhamento de traços é discutida em termos de possíveis conexões com os fenômenos de concordância.

Palavras-chave: *Recursividade*; *Sintagmas Preposicionais*; *Técnica de correspondência frase/figura*.

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Introduction

The modern challenge of Psycholinguistics is in many ways identical to the original challenges of Cognitive Science: What are mental representations and how are they reflected in processing or acquisition? The necessity of mental representations is unavoidable in many spheres from vision to language (although there remain those who are totally procedural reductionists). If there must be a mental representation, now the question arises: how far does a processing system work within exactly the same representation? How far does the complexity of the representation in terms of structure, features, and operations – conceived of outside of time – map perfectly onto a model of how that information is processed through time. In other words, how far can our claims about psychological reality be proven by real time models?

Chomsky has remarked: "every notational choice is a psychological claim" (CHOMSKY, p.c.). If sharp psycholinguistic evidence correlates with the representations that emerge from theoretical work, then they should be considered as vital support for those structures. Without converging evidence, notational variants make it difficult to determine what properties underlie actual mental operations. In a way, one critique of purely intuitionist

approaches to linguistic theory is that they permit too many alternative notations. As Chomsky has remarked in lectures eventually "technical modes of execution should turn into leading ideas". Ideas that can be sustained through different forms of evidence are decisively stronger. Ultimately, if the notation covers both intuition and processing, we may expect that the terminology will reflect both and the leading ideas behind mental representations will be clear.

Much of psycholinguistic experimentation shows that the putative complexity differences in linguistic theory must be psychologically real in a general way. Even though early work such as the Derivational Theory of Complexity (cf. FODOR, BEVER and GARRETT, 1974) has been called into question, its leading idea that sentences with more transformations are indeed harder than those with fewer has been preserved. Broadly speaking, hierarchical structures are more challenging than flatter ones. In this paper, we contrast Coordination structure (conjunction) with two kinds of hierarchical structures: Indirect Recursion and Feature-sharing which differ in how embedded nodes are linked.

(1) a. conjunction: flower on the table and on the book and in the vase
b. indirect recursion: the flower in the vase on the book on the table

(a) produces flat structures *versus* (b) Indirect Recursion, where PP's are recursively inside one another (e.g. flower in the vase on the book on the table) which produces hierarchical recursive structure.

This in turn will be compared to a new construction, discussed in Chomsky (2013) called Feature-sharing (1c) where he notes that one can say both: put the flower in a box on a table or put the flower on the table in a box.

(c) Feature-sharing: (put) the flower on a table on a book in a vase.

This also captures well-known forms of linked PP-phrases, often found in directional PP's:

(2) the ball rolled down the stairs into the gulley down the street

These cannot be captured solely by Indirect Recursion (called "Category Recursion" in GALLEGO and CHOMSKY, 2019). This is, as far as we know, the first effort to obtain psycholinguistic evidence on coordination, indirect recursion and this basic syntactic structure of "stacked" PP's (to use LANGENDOEN's (1989) term). Another typical example is again: John put the jar on the table in a box in a small paper bag where the set of PP's collectively satisfy a single locative argument of put.

Which aspect of these contrasts plays a key role in mental representation? It could be that the algorithm generates the structure (phrase-structure rule)

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or the consequent hierarchical representation itself or the operations that embed PP's or link features on node labels, which may in turn be forms of agreement. While there are many angles of representation relevant to these variations, our goal is first to see whether we find processing distinctions among them. We can rephrase the question with respect to the new structure of Feature-sharing: will it be processed like conjunction or Indirect recursion, or is it actually processed distinctly from both?

The language processing and acquisition literature seems to suggest that direct unstructured recursion, or coordinate structure, is acquired before the indirect recursion, or self-embedding structure, (TAVAKOLIAN, 1981; LEBEAUX, 2000; SEVCENCO ET AL. 2013; ROEPER, 2011; OSEKI; ROEPER; 2018; and references therein).

MAIA (2016) presented two eye-tracking experiments comparing the processing of coordination and embedding of Prepositional Phrases in Brazilian Portuguese (BP) and of Postpositional Phrases in the Brazilian indigenous language Karajá which were argued to demonstrate that the self-embedding of PPs would be more costly to process than the conjoining of PPs, even though after launching, the subsequent self-embedding of a third PP would be less costly than the previous PP.

2. Sentence Picture-matching experiments with PPs

Our test compares recursive Prepositional Phrases: direct unstructured (DU), indirect structured (IS), and direct structured recursion (DS). In the present experiment, we aimed to ascertain whether the direct structured construction would be computed as a coordinate or a self-embedding structure, initially hypothesizing that the DU condition presented the lowest cost of processing and that the highest cost would be found in the IR condition. In other words, based on previous research, we expected the processing cost of DS (feature sharing) to be located between DU (coordination) and IS (indirect embedding).

We had therefore one single independent variable – Syntactic structure – with three levels, namely, DS, IS and DU, as exemplified below:

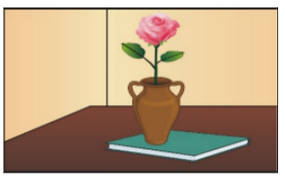
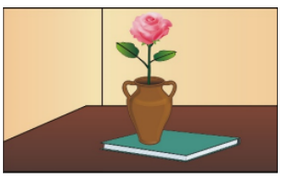
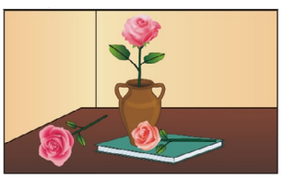
DS	IS	DU
		
A flower on the table on the book in the vase	A flower in the vase on the book on the table	A flower in the vase, on the book and on the table
'Uma flor na mesa no livro no vaso'	'Uma flor no vaso no livro na mesa'	'Uma flor no vaso, no livro e na mesa.'

Figure 1 – Examples of conditions in the Sentence/Picture matching experiment

The dependent variables were the accuracy rates and the average decision times in a Sentence/Picture Matching test. An English version and a Brazilian Portuguese version of the test were prepared and applied to groups of monolingual native speakers of each language. The comparison between these languages had the aim to try to rule out the possibility that any processing differences between the conditions would be specifically related to any one of the languages but could be discussed in terms of Universal Grammar.

Method

Participants

24 individuals were tested in two different groups, namely, one group of Brazilian Portuguese native speakers and a group of English native speakers. Each group had 12 participants, all undergraduate university students between 18 and 24 years old.

Design and Materials

There were 36 items in each experiment. 12 of them were experimental trials distributed in a Latin Square design, interspersed among 24 distracting fillers. Each trial displayed one picture with one sentence as in Figure 1. As indicated above the factor syntactic structuring of the prepositional phrases had three levels: direct unstructured recursion, indirect recursion, and direct structured recursion, creating a 3x1 design with three experimental conditions: DU, IR, and DS, as in the following additional example of the English version:

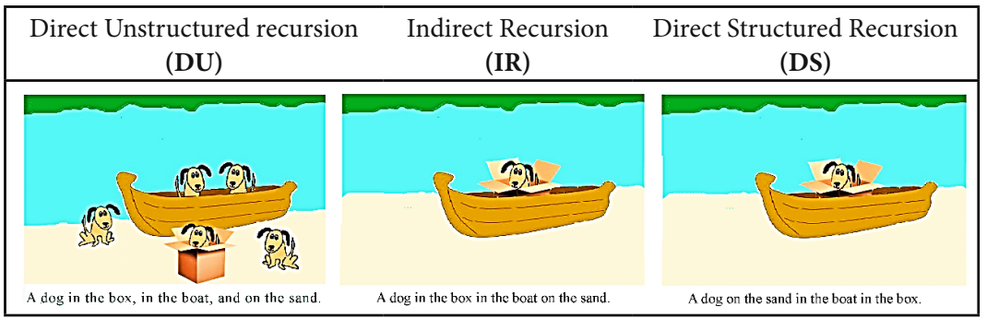


Figure 2 – Trials of experimental conditions in the English version

Procedures

Participants were instructed to press the space bar to call onto the computer screen a picture with a sentence in the bottom part. Their task was to decide as fast as possible whether the sentence and the picture matched, by pressing a green or a red button in the keyboard. The actual experiment was preceded by a training session in which the experimenter would follow the test

in order to make sure that the participant had understood the task correctly. After the training session, the experimenter would leave the room and the participant would be left alone to do the test which would take between 10 to 15 minutes, in average.

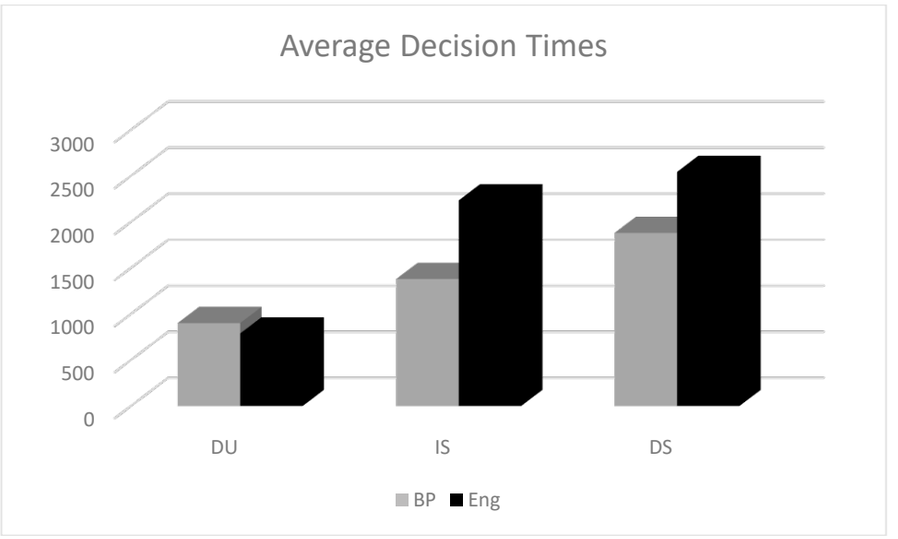
3. Results

BP participants were significantly faster than the English, regarding the matching decisions in the IR and DS conditions. Both groups displayed basically the same decision times in the DU condition. Crucially, the same pattern found in the English experiment was also observed in the PB version, against our initial hypothesis:

DU <IS <DS

Pattern of Decision times in both versions

In both versions, coordination (DU) had faster decision times, followed by self- embedding (IS) and by the Feature-sharing condition (DS). Therefore, the feature-sharing condition (DS) was the hardest to process, as indicated in Graph 1 and Table 1 below:



Graph 1 – Average decision times in the three conditions of the BP and English versions

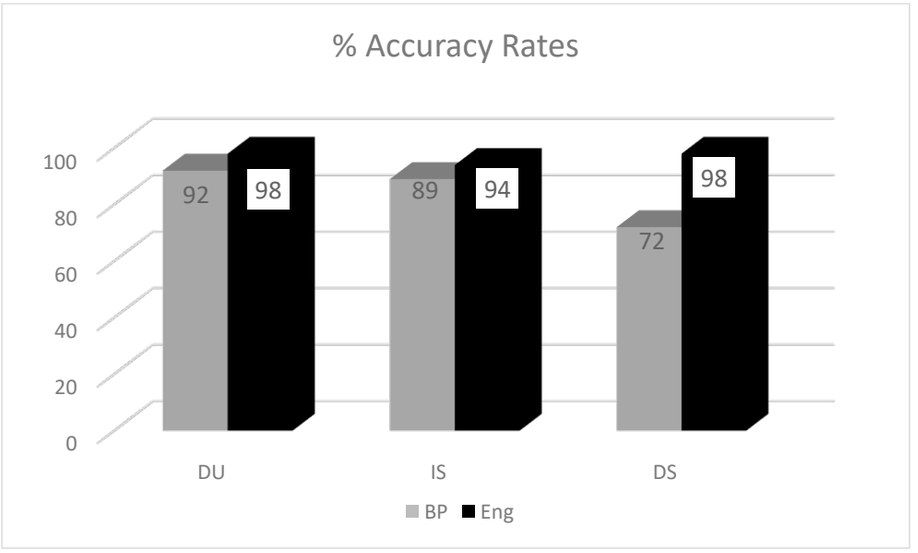
Lang/Cond	DU	IS	DS
BP	901	1380	1881
Eng	789	2235	2544

Table 1 – Average decision times in the three conditions of the BP and English versions

In the English version, a one-way ANOVA by subjects indicated a highly significant main effect of structure ($F(2,94) = 61.7$ $p<0.000001^{***}$) and pairwise comparisons showed that DU average decision times were significantly lower than DS ([DU]vs[DS] $t(47)=10.44, p< 0.0001^{*}$) and than IS ([DU]vs[IS] $t(47)=8.07$, $p< 0.0001^{*}$). Average decision times for DS were higher than for IS, in English ([DS]vs[IS] $t(47)=1.94$ $p< 0.05$).

In the Brazilian Portuguese version, a one-way ANOVA by subjects also indicated a highly significant main effect of structure ($F(2,94) = 9.83$ $p<0.0001^{**}$) and pairwise comparisons showed that DU average decision times were significantly lower than DS ([DU]vs[DS] $t(47)=3.97$ $p< 0.0002$) and than IS ([DU]vs[IS] $t(47)=2.73$ $p< 0.008$). Average decision times for DS were also significantly higher than for IS, in BP ([IS]vs[DS] $t(47)=2.14$ $p< 0.03$).

Accuracy rates in both experiments are displayed in Graph 2:



Graph 2 – Accuracy rates in the three conditions of the BP and English versions

In the English version, there are no differences in the percentage of correct answers which were equally high across the three conditions ([DU/DS x IS] $X2= 0.16$, $p = 0.78$). In the BP version, on the other hand, even though there was no significant difference in the correct answer rates for the DU and IS condition ($X^2= 0.09$, $p = 0.75$), the DS condition received significantly lower correct answers than both the DU ($X^2= 4.8$, $p=0.03$) and the IS condition ($X^2=4$, $p= 0.04$)

3. Discussion

Overall, Brazilians were faster than the Americans in IS and DS matching decisions and American subjects were faster in the DU decisions, but **the same pattern** found for English is also found in PB: DU <IS <DS, that

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is, coordination obtains decision times faster, embedding is in the middle, and feature sharing (DS) is more costly to evaluate in both languages. The accuracy rates are similar in both tests.

In general Brazilian and American subjects get the matchings significantly right in all three conditions. However, RTs definitely show that Feature-sharing does NOT pattern with Coordination in both languages. And, while DS is closer to IS, it appears to make distinct processing demands as it is also shown by the significant difference in the correctness rates in the BP version in which the DS condition receives the smallest percentage of correct answers.

5. Recursion in Representation

Recursion has been a central concept in linguistics from the outset. The basic operation of **Merge** is recursive and in that sense every sentence is composed of multiple instances of recursion. Other forms of recursion are of particular interest because, as we have shown here, they are clearly differentiated in experimental tests, allowing us to begin asking exactly which forms of linguistic notation reflect psychological operations. The classic form of recursion has been represented in phrase-structure rules that allow an element to be repeated within the same category. This in turn has two forms: Direct and Indirect recursion where Direct recursion allows a category to generate itself as an immediate rewrite option.

(3) (3) XP => XP XP+

Indirect recursion arises when a different category intervenes. This can be abstractly represented with the X-bar notation:

(4) (4) XP => X YP, YP => Y XP

As it is well known, this creates an infinite loop. DiSciullo (2015, 2017) argues that all recursion involves a specific recursive node, even when it is not marked by visible morphology. Prosody and self-embedding of identical meanings suggest that the recursive nodes are psychologically linked by a recursive Operator.

One might predict that a recursive Operator that links these nodes is more difficult to acquire, which is what current evidence suggests (see AMARAL et al, 2018) but also that it is either more difficult or easier to process (MAIA, 2016). If this connection is "psychologically real" then it involves a discontinuous connection between one XP and the next identical XP. It may show other locality constraints and we therefore expect it to arise in tests of

psychological reality through processing. There are many possible ways that notation can be reflected in processing and one goal of psycholinguistics is to establish tight contrasts that begin to tell us which notational properties reflect cognitive organization.

5.1 Direct Structured Recursion (Feature-sharing)

Chomsky's (2013) Feature-sharing concept (which we call Direct Structured Recursion (DSR), following Roeper and Oseki (2018), introduces another variety that has long been known but fairly neglected in consideration of its formal properties, as we mentioned above". Chomsky (2013) points out that one can use either of these forms:

(5) a. John put a jar in a bag in a box on the table.
b. John put a jar on the table in a box in a bag.

The latter case cannot be a form of PP-DP-PP indirect recursion because it would imply that the "table is inside the box". Instead the second PP is a further extension of the initial PP and all three together, once again, collectively satisfy the LOCATIVE argument of the verb (which supports the idea that they should be representationally linked). Moreover, we find these complex locatives in many environments:

(6) the ball rolled down the stairs into the street into the gutter
(7) put the lamp over there on the rug in the corner on top of the table.
(8) see the lamp over there in the corner next to couch near the socket.

These can be captured with the Kleene Star notation that indicates possible repetition of the category:

(9) put [PP]* => PP*-PP*-PP*-PP*

The Feature-sharing concept in effect allows indefinite copying of a Feature [+LOC] on these identical nodes, which then manifest Agreement as the output. The psychological status of this form has never been squarely addressed and it look like a substantial addition to UG capacities as it stands. It is certainly not widely used in linguistic structural analysis.

The phrase structure responsible for DSR can be formulated as in (10). The feature of [+LOC] is required by the verb put and it is collectively satisfied by the linked PP's

(10) Direct Structured Recursion:

XP[+F] → XP[+F] XP[+F]...

a. Put an apple [[[PP in the house] [PP in the kitchen]] [PP in the cabinet]].
b. Bill saw Mary [[[PP on Saturday] [PP in the morning]] [PP at nine]].

Unlike DUR, the phrase structure rule is binary and crucially generates hierarchical structure; namely, more than two branches are impossible because there is a sequential composition of meaning in (10 a,b). This is achieved by the shared feature [+F] between XPs (CHOMSKY, 2013). Typical examples of DSR are what Langendoen et al. (1989) call "stuffing", where XP = PP.

It is worthy to note that children's early expressions at 2yrs appear to follow this path:

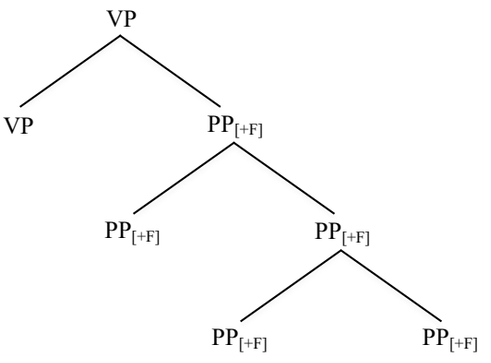
(11) Naturalist data from CHILDES
a. I will go right on the street in a car. [2;3.0]
b. He left his bear alone in the park on the seat. [3;6.9]
c. Put it under the other puppet in there on your hand. [3;2.4]

Therefore, it is not simply a rare and remote structure. Subject-verb agreement has shown great variation in the acquisition, L2 (see GARSHOL, 2019) and disorders realm while Agreement inside NP's shows virtually no errors (no child says: *"this hats"). A full typology of Agreement is not yet established. An important fact about FS-recursion is that it permits wh-extraction (12b) where Direct Recursion does not (12a):

(12) a. *what did you buy milk, sugar and __
b. Where did you put the jar on the table in the large box t => "next to the can of tuna in the corner of the box"

These facts indicate that the FS recursion must involve a hierarchical structure that satisfies the c-command constraints for wh-extraction (see tree below (12c)).

12) c.



In the example above, PPs collectively saturate the obligatory locative argument of "put" (12b) and can be interpreted in a single event and three PPs together express one specific time (i.e., Saturday is not in the morning). Therefore, in contrast with DUR, permutation of recursive XPs does affect semantic interpretations, making the example ungrammatical or at least infelicitous, as shown in (13).

(13) #Put an apple [[[PP in the cabinet] [PP in the house]] [PP in the kitchen]].

Importantly, extraction out of DSR is possible, indicating that PPs here must be hierarchically organized, subject to c-command, and not coordinated in a linear manner as in (12b) or (14).

(14) What did John put an apple in the house in the kitchen in <what>?

How should such a Feature-sharing connection be expressed? We turn to a more careful discussion of the technical issues of Agreement and thematic roles below. A first observation: it may entail some form of Operator of the kind that link elements in Negative Polarity items, but we will develop a simple Probe-Goal representation at this point.

(15) John didn't buy <u>anything</u> from <u>anyone</u> for <u>any</u> reason.

NEG-OP	NPI	NPI	NPI
	+neg	+neg	+neg

Where the initial Negation causes NPI (negative polarity items) elements to mark every quantifier that follows in the c-command domain as sharing a single negative feature.[1]

The fact that DSR involves linked phrases has led Everett (2005) to suggest that it is a form of Parataxis and therefore should pattern with Direct Unstructured Recursion. However, the identity of PP's resembles the Indirect Recursion where NP has a PP that has another NP inside (reflected in the output structure of the Phrase-structure rule). Therefore, DSR might pattern with Indirect Recursion. Alternatively, the <u>Feature-sharing</u> could be a unique operation within the class of Agreement phenomena where a great deal of evidence (Agreement illusions) indicate that Agreement markers make operational demands. Our evidence suggests clearly that DSR does not belong with DUR or conjunction. It is closer to IR which suggests that it shares its hierarchical structure. Nevertheless, it is consistently more time-consuming in both BP and English.

1 See Homer (forthcoming) for discussion of further semantic effects, such as ***<u>exhaustivity</u>*** which this representation does not capture, and for an approach that does not use Operators to capture NPI.

We can now review the question: Does DSR-feature-sharing pattern with Direct recursion or Indirect recursion?

(i) Since DSR - FS involves no intermediary nodes, it might be a form of Direct recursion therefore pattern with simple co-ordination.
(ii) If it is hierarchical recursive character is critical, then we expect it to pattern with IR.
(iii) It might also fall between them as more complex than DR and less complex than IR.

However, our results show that it is more difficult than IR. This indicates that the impact of FS contains a time-demanding processing component. That is FS is not a purely representational option but a psychological operation that demands computational time. We conclude therefore that the potential to infinitely add new PP nodes that share a LOC feature is a mental computation.

6. Experimental Conclusions

In sum, our experiments showed that both in English and in Brazilian Portuguese the distinction between Direct and Indirect recursion is surprisingly robust. We also showed that the Feature-sharing (DSR) sentences took significantly longer to process in the sentence picture matching task than the conjunctive DUR and slightly longer than the IR sentences. In the BP test, difference also showed in the correctness rates in addition to the decision times.

We do not know whether the difference is due to the hierarchical depth of the tree or to existence of identical recursive nodes or to the fact that the relation is discontinuous over another kind of node (PP-DP-PP). And, it may be that the psychological representations involve an interesting combination of them. It appears then that the link between PP* and PP* is real and the cause of time-consuming computation.[2]

At this point our results show that the FS forms are clearly distinct from Direct Recursion and pattern closer to IR, suggesting that the PP* Kleene notation makes demands just like IR in fixing an Operator Chain across PP's. The DSR are slower than IR. The DUR (conjoined forms) are much faster than the recursive ones which is strong evidence in behalf of the view that flatter structure is easier.

2 There remains another question to isolate the effect of recursion: is it distinct from non-recursive embedding? In another acquisition work (cf. PEREZ et al, 2012), it has become very clear that children often Avoid recursion by maintaining embedding with a different structure. That is, a sentence like:

i. the woman with a child with flowers (child has flowers) will be repeated as:
ii. "Show me the woman with a child that has flowers" (see Perez et al., 2012)

This recursion-avoidance also entails that recursion must be psychologically real.

Mental Models

How do we interpret these results in a larger mental model? The modern challenge is not to find global correspondence between the results of intuitionist linguistic theory and experimental results, but to meet a deeper challenge: do the details of representational information in terms of structures and operations match the subtler details of experimental results?

Recall Chomsky's (1969) remark that "every notational choice is a psychological claim". It is not easy to link subtle seemingly microscopic notational choices to measurable processing behavior. We have a 3-way contrast: Direct recursion (conjunction), Indirect recursion (self-embedding) and what we call Feature-sharing. The first contrast is a familiar one and can be seen as a contrast between a flat structure with conjoined elements and a hierarchical structure. The fact that the FS structures are more difficult than IR provides immediate evidence that FS is a computationally real notational decision.

Feature-Sharing Technology

What exactly contributes to that difficulty? We begin to examine that question by varying the hierarchical structure. One mode lies in the introduction of Indirect Recursion where a rule embeds a structure inside itself producing an output that has hierarchy with identical nodes. The output and the algorithm that produces it are not identical concepts (cf. LOBINA, 2014) and either could be a source of difficulty. We can examine the output structures more readily:

S => [s. NP. VP [s NP. VP [s

If the parser recognizes each identical form as identical, then it could either complicate or facilitate further production in principle. Why would it make it easier? Theories of expectation with even rarer structures show that if a rare form is repeated, it is easily recognized:

(16) what can you carry__ without dropping__ and take__ without losing__

Here the initial what is fed into four positions, but still the second instance of a parasitic gap is recognizably easier after the first has been processed (see Frazier et al, 1989). Identical words and morphemes also appear to mark indirect recursion and lead to a particular prosody.

(17) this is the cat that chased the rat that ate the cheese that Mom bought.

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It is clear that the simple notion that additional dimensions should create additional difficulty is false. How could additional information make something easier? Our 3-way contrast between flat, hierarchical, and feature-sharing structure invites us to make a stronger claim about what Feature-Sharing is. As with all evolving notation, we make a choice for the sake of concreteness, but it is again a real psychological hypothesis. We claim that it belongs in the domain of Agreement phenomena (about which there is much debate in terms of upward, downward, probe-goal, etc.). Our evidence will serve only the first small step of showing that DS-FS does not assimilate to either co-ordination or to hierarchy. We were quite open to the possibility that we would find that result or that it would be between co-ordination and hierarchy. But it turns out to be more difficult than either other form. One can always advance ideas about context, task difficulty, or frequency of the construction. We believe that FS is a form of Agreement at the Node Level, where for instance, a locative feature is shared.

Therefore, one might ask if it correlates psycholinguistically with other agreement phenomena. One question to ask is in terms of locality. Agreement within an NP for instance is known to be easy for children. They never say *"this hats. By contrast, local Subject-verb agreements (John sings) is often problematic in disorders and L2 acquisition.

Where do Operator constructions fit in? If Negation is linked to NPI (Negation Polarity Items) by a form of Probe-Goal relation, what is the psycholinguistic reflection? The notion of Feature-sharing essentially says that there is Agreement: The concept of Feature-sharing has in its name the reference to a mental operation that we should characterize and, ultimately, do so in a way that makes predictions. It appears to be Agreement between Features at a Node level, which may be part of a Probe-Goal satisfaction of argument structure:

(18) PUT PP PP
[+LOC] [LOC] [LOC]

It can apply to our constructions if there is an optional LOC feature associated with be

(19) [it **is**] **in** the kitchen **in** a box **under** a napkin
[be] | | |
|
LOC LOC LOC LOC

(20) [rolll [PP down [PP in PP into
| | | |
LOC PP LOC PP LOC PP LOC
FS-LOC FS-LOC

The feature is carried by the abstract PP not by the lexical item (20), as illustrated in (12c) Therefore, the critical operation is discontinuous but different from the discontinuity produced by IR.[3]

To capture the phenomenon with more precision, note that it applies to Arguments and not Adjuncts. In general an Argument is located on a verb and becomes a Probe which is satisfied, or saturated, by finding the same set of features in a lower c-command domain, as we find with transitive verbs that demand an object like push [THEME] which demands an object to satisfy the THEME-PROBE: push wagon and once satisfied cannot be again: *push wagon car is impossible (unless a conjunction is introduced that allows the higher node to be the satisfied: push [wagon and car]NP. In our scenario, this constraint must be lifted or the new mechanism of FS is needed, because we allow further LOCs:

(21) put the jar in the cupboard [in the kitchen] [in the house]...
LOC [+LOC] [+:LOC]

In effect the PROBE is still alive, and notably the collection of LOCS *collectively and simultaneously* satisfy the Argument PROBE. Preminger (2017) summarizes the conception of FS in the Agreement literature;

"The central idea of feature-sharing (Frampton & Gutmann 2000, 2006, Pesetsky & Torrego 2007, i.a.). is that when two constituents enter into an agreement relation, the result is one single feature bundle, that is subsequently shared by both constituents:" [cf. Frampton & Gutmann 2006:128].

A. Traditional probe goal = movement version
[...]probe [...]goal
=⇒
B. probe goal = feature-sharing
put PP-on
\ / \
probe..goal goal...
| / / ...../
PP-LOC" [4]

This operation allows the parser to incorporate new material and collapse identical features on a node into a single set. We return now to the parsing challenge. The sequence of PP's is still open to both Adjunct and Argument interpretation, hence ambiguous. If the next PP is attached high

3 The idea that an Argument feature might be satisfied in a complex way that refers to multiple positions resembles the fact that successive cyclicwh- movement complicates a movement account of Probe-Goal satisfaction. In addition Multi-dominance theories might allow other technical conceptions which may or may not fit the psycholinguistic evidence.
4 While FS (Preminger (2017)) works naturally for Argument-satisfaction, it may be less ideal for other sorts of agreement that Preminger discusses.

to the VP above V, it modifies the whole Event and not the verb alone. If construed as lower then it can be a DP-PP. For instance, if one says:

(22) he put the jar in the cupboard in the house near the river....in the afternoon

Then near the river is a DP-PP modifying the house not the action, and in the afternoon modifies not the house nor the LOC argument of put, but the whole Event (VP). So the parser faces some complicated choices. The choices are starkly evident in a well-known paper about Garden Paths from Trueswell (1999) where children were given the sentence:

(23) Put the frog on the napkin in the box. (Ambiguous)

which can be analyzed as an adjunct PP on the NP with a meaning like a relative clause:

(24) Put the frog that's on the napkin in the box. (Unambiguous)

5 year old children put the frog on the napkin for (23) – satisfying the LOC argument – and then in the box, satisfying it again. This essentially fits the FS analysis. If we invoke a further principle of Minimal Attachment, which states that new material should extend whatever node has been introduced, then it should be the preferred analysis, which fits the child behavior in this experiment and our earlier examples. That is if an Argument needs satisfaction, then that is the child's first choice and it invites the FS operation that includes further PPs.

Let us now look at the adult steps more closely. The first Parse under FS delivers:

(25) V- PP+loc = put the frog on the napkin = satisfy LOC ⇒ move frog to napkin

before the adult settles on this analysis, in the box arrives, which forces a reanalysis for adults (not children) supported by context. The napkin is not in the box, so the adult must generate another analysis: The first PP can be not the LOC-goal, but simply the THEME [NP the frog [PP on the napkin]] so that only the next PP satisfies the LOC argument [put in the box]. The upshot is that the grammar has to adjudicate between an FS analysis for a complex LOC-argument, and a complex Theme argument [frog on a napkin], and in principle an Event-LOC, each with different attachment sites:

(26)
```
VP
|    \
V     PP [Event :LOC]
|     |  \
V    NP   PP [put-LOC] frog gets put on napkin
|     /     \
put   N     PP [NP-LOC] frog is on napkin
|
frog
```

Our evidence above suggests that the FS option is the most computationally demanding where several sets of LOC features are treated as one feature satisfying Argument structure. Thus the evidence suggests that the process which collapses them into one is a real psychological process not simply a representational choice.[5]

Further steps would be to project more refined experiments to seek how much FS resembles other forms of long-distance Agreement.

7. Conclusion

We have compared Feature-sharing PP's to Coordination and Category Recursion in the context of established psycholinguistic reaction time techniques and found that it was significantly different from both. Psycholinguistic work now supports the claim that the independent concept of Feature-sharing is psychologically real. We have further explored the Feature-sharing idea as a formal representation and discussed potential connections to Agreement phenomena. Exactly how it relates to other forms of Agreement both formally and psychologically is an important next step.

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5 We note that there are many more refined issues about Feature-valuation that Preminger (2017) discusses which we do not explore. Thus in the larger Agreement typology FS is a special case that will call for more careful analysis in what one hopes are converging linguistic and psycholinguistic terms.

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