

MILD CONTEXT SENSITIVITY IS NOT ENOUGH

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1. ON THE COMPLEXITY OF NATURAL LANGUAGE

In this squib we step back from any particular theory of language, and focus rather on the shape and complexity of the constructions that manifest themselves. Examining the pattern of copying present in the Yoruba relativized predicate construction, we will conclude that any satisfactory grammar for Yoruba must be capable of copying copies (of copies. . .), and thus also of generating languages like a^{2^n} (the language where each sentence consists of, for some number n , exactly 2^n *as*).

This conclusion is a momentous one, contradicting (if not in letter then in spirit) the widely held hypothesis of the mild context sensitivity of natural language, which we recount in § 2. As a practical consequence, it means that many of our grammatical theories are too weak to describe natural languages, predicting of things that do in fact exist, that they couldn't possibly.¹

These conclusions have been argued for before. Perhaps the best known arguments are Becker et al.'s [1992] based on scrambling in German, and Michaelis and Kracht's [1997] on Suffixaufnahme (case stacking) in Old Georgian. Neither of these arguments have been decisively refuted, although their initial force has been tempered greatly via a reanalysis of the motivating data [Joshi et al., 2000, Bhatt and Joshi, 2004].

There are two major differences between the present argument, and its predecessors. First is the obvious linguistic naturalness of the construction type investigated here, and the plethora of analyses of disparate phenomena that utilize mechanisms designed to capture this very type of construction. Second is the existence of a constrained formalism (minimalist grammars with copy movement) which is able to efficiently

¹We can really only assess this for those theories that have been made explicit. Of these, two of the most widely used, Combinatory Categorical Grammar and Tree Adjoining Grammar in any of its incarnations (except those, such as explored in [Chen-Main, 2006], which add an operation of syntactic copying), are too weak. Head-Driven Phrase Structure Grammar, another popular theory, is untouched by this result, as the formalism makes no non-trivial predictions about natural language [Johnson, 1988].

assign the obvious structures to the constructions in question. Thus, although we will conclude that natural languages require more than mild context sensitivity for their description, we hypothesize that they don't require much more than that.²

2. MILD CONTEXT-SENSITIVITY

The hypothesis of mild context sensitivity, first articulated in [Joshi, 1985], is a claim that all human languages share certain characteristic properties, and that, moreover, these properties are non-accidental from a grammatical perspective. In other words, our theories of language should predict that only languages that are mildly context-sensitive exist. Like claims that natural language is regular or context-free, the claim that natural languages are mildly context-sensitive is stutable independently of any particular grammar formalism, which fact makes its empirical content crystal clear.

Mild context-sensitivity can be given a bipartite characterization, as a list of conditions that a language must meet.³ The first condition is that the language be among those whose strings are recognizable by a deterministic turing machine in polynomial time. This is often called *efficient recognizability*. Although it contains the words 'efficient' and 'recognize', this criterion is emphatically *not* related to ideas about human language processing. We might just as well have characterized this property as definability in first order logic with a least fixed point operator (see e.g. [Immerman, 1995]). The essence of this criterion is to circumscribe a class of patterns of reasonable complexity. It is a non-trivial property. Copying (ww), reversal (ww^r), and exponential (a^{2^n}) patterns are efficiently recognizable, whereas primacy ($\{a^p : p \text{ is prime}\}$) and theorem-hood ($\{a^g : g \text{ is the gödel number of a theorem of FOL}\}$) are not. The second condition is that the language be of *constant growth*.⁴ A language is of constant growth just in case

²This claim is made precise in [Kobele, 2006], where minimalist grammars with copying are introduced, and their formal properties investigated.

³A third condition is often added to this list. This third condition requires that there be a limited number of cross-serial dependencies. This intuition has been notoriously difficult to pin down in a meaningful, grammar independent, way. As it is not clear what it should mean, I will leave it out of my characterization of mild context-sensitivity.

⁴A stronger condition, more in keeping with the intent of the 'constant growth' criterion, is *semilinearity*. Whereas constant growth requires that the lengths of sentences not grow too fast, semilinearity requires this of the numbers of the individual words in a sentence. The language $a^{2^n}b^*$ (the language which has an exponential number of *as* followed by any number of *bs*) is of constant growth, but is not semilinear.

the size of its strings doesn't grow 'too quickly'. Intuitively, the idea is that at each step in the derivation of a sentence, the rules add only a fixed amount of new material. The language a^{2^n} is not of constant growth. Constant growth says nothing about how the words within a sentence are arranged, and is therefore independent of the criterion of efficient recognizability.⁵

3. THE STRUCTURE OF A CHALLENGE

At first blush it seems easy enough to mount a challenge to the MCS hypothesis. We might try and look for a natural language that wasn't recognizable in polynomial time or wasn't of constant growth. However, there is no way to challenge the MCS hypothesis on the basis of a corpus of data. The MCS hypothesis rules out only certain infinite sets of sentences. Corpora are of necessity finite. In order to challenge the MCS hypothesis, we need to first generalize from the observed data to an infinite set of potential data, of which the observed data is but a small sample. Then we can decide whether or not our generalization is compatible with the MCS hypothesis.

A good challenge will have the following two attributes. First, the generalization argued for is a reasonable one, in the sense that it is an instance of an already established type. That is, for the proposal to be empirically secure, we expect it to be parsimonious, compatible with and even supported by other independently motivated assumptions about language mechanisms. Second, there aren't alternative reasonable generalizations compatible with the data that are compatible with the MCS hypothesis. Accordingly, a response to a good challenge takes the form of coming up with a novel reasonable generalization compatible with both the data and the MCS hypothesis.

4. YORUBA

Here I will present a challenge to the MCS hypothesis, based on the relativized predicate construction in Yoruba. I will argue that Yoruba relativized predicates can themselves contain relativized predicates (which may in turn contain relativized predicates etc.). This

⁵Although the language of primes, a^p is not efficiently recognizable, and thus neither is the language $a^p b^*$ (the language with a prime number of a s followed by any number of b s), this latter *is* of constant growth. In other words, we can 'pad out' a set of strings of non-constant growth with dummy symbols to satisfy the constant growth property. The stronger property, semilinearity, is also independent of efficient recognizability, with $a^p b^* + b^* a^*$ (the language in which a s precede b s if there are a prime number of them, and follow the b s otherwise) being semilinear, but not efficiently recognizable.

means that copies can be of copies. In other words, copying operations can apply iteratively. Although the set of sentences of Yoruba does not in itself cause trouble for the MCS hypothesis, the mechanisms that we require to describe these sentences elegantly do. The claim is, then, that as soon as we are able to give a natural account of languages like Yoruba, we are also able to describe non-MCS languages using the *very same* mechanisms in the *very same* way. Therefore, while it may be true that all attested languages are in fact semilinear, this fact, like the fact that ww^r (the language of palindromes) is not an attested language, cannot receive a syntactic explanation.

My argument is simple and can be summarized as follows. I begin by arguing that the relativized predicate construction in Yoruba involves copying (4.1). Next I will argue that relative clauses can be copied in the relativized predicate construction (4.2). As relative clauses are themselves clauses, and can contain arguments beyond the one abstracted over, we must countenance one of these arguments being itself a relativized predicate, and thus that relativized predicates may be copied in the relativized predicate construction, from which the broader conclusion follows.

4.1. Relativized predicates. Verb phrases may appear in constructions which look very much like relative clauses. When they do, the resulting phrase has the distribution of a(n abstract) noun. Of particular interest to us is the relation between the verb (phrase) which acts as head of the relative clause, and the verb (phrase) that is inside the relative clause. Consider the following examples. 1 is a simple transitive sentence. In 2, a (nominalized) copy of the verb heads the relativized predicate. We see that it must be a copy of the verb, as evidenced by the ungrammaticality of 3.⁶

- (1) *Jimọ ra adie*
 Jimọ buy chicken
 “Jimọ bought a chicken.”
- (2) *Rira ti Jimọ ra adie*
 buying TI Jimọ buy chicken
 “The fact/way Jimọ bought a chicken”
- (3) **Jije ti Jimọ ra adie*
 eating TI Jimọ buy chicken

⁶Yoruba orthography uses the letters ọ and ẹ to represent the same sounds as IPA ɔ and ɛ respectively. Yoruba also has three level tones, which I do not represent here.

In example 4, a (nominalized) copy of the verb phrase *ra adie* acts as the head of the relativized predicate. Again, we see that it must be a copy of the verb phrase, as changing the verb (as in 5) or the object (as in 6) lead to ungrammaticality.

- (4) *Rira adie ti Jimo ra adie*
 buying chicken TI Jimo buy chicken
 “The fact/way Jimo bought a chicken”
- (5) **Jije adie ti Jimo ra adie*
 eating chicken TI Jimo buy chicken
- (6) **Rira nkan ti Jimo ra adie*
 buying something TI Jimo buy chicken

The obvious generalization is that in a verbal relative clause the element to the left of *ti* is a copy of the (main) predicate to the right of the *ti*.⁷ Somewhat schematically, we might represent the possible relativized predicates given a sentence of type S V O in the following terms.

V (O) *ti* S V O

4.2. On the size of the copied object. Having established that the relativized predicate construction does indeed involve copying, we turn now to the question of how much material can be copied. We will conclude that whatever mechanism we decide to use to account for the Yoruba data, it must be able to copy *unboundedly much* material. We base this on the fact (to be shown) that the copied object is in fact a DP, as evidenced by the fact that it may head a relative clause. As DPs are unbounded in size (as one may always add yet another relative clauses), the conclusion follows.

The examples below show that relative clauses can be copied in the relativized predicate construction. Sentence 7 shows our simple SVO sentence 1 with the addition of a relative clause modifying the object *adie*.

- (7) *Jimo ra [adie ti o go]*
 Jimo buy chicken TI 3S dumb
 “Jimo bought the stupid chicken.”

The remaining examples show that although a relative clause can appear either just in the lower copy (8), just in the higher copy (9), or in

⁷It is perhaps interesting to note that, when a verb appears in a suppletive form (such as *bo* the suppletive progressive form of the verb *wa*, come), it is the suppletive form that surfaces in the copy, never the ‘standard’ one. Nonetheless, it is extremely unlikely that this can be assimilated to typical cases of phonological reduplication (perhaps over intonational phrase boundaries, as has been proposed for Bengali in [Fitzpatrick-Cole, 1996]), for reasons discussed in [Kobele, 2006].

both (10), if there are relative clauses in both higher and lower VPs, they must be identical (11). In other words, although relative clauses are not *required* to be copied, the grammar of Yoruba *allows* them to be.

- (8) *Rira adie ti Jimo ra [adie ti o go]*
 buying chicken TI Jimo buy chicken TI 3S dumb
- (9) *Rira [adie ti o go] ti Jimo ra adie*
 buying chicken TI 3S dumb TI Jimo buy chicken
- (10) *Rira [adie ti o go] ti Jimo ra [adie ti o go]*
 buying chicken TI 3S dumb TI Jimo buy chicken TI
 3S dumb
- (11) **Rira [adie ti o go] ti Jimo ra [adie ti o kere]*
 buying chicken TI 3S dumb TI Jimo buy chicken TI
 3S small

5. EVALUATING THE CHALLENGE

The challenge to the MCS hypothesis is that given that Yoruba has constructions which involve copying of arbitrarily large structures which may themselves contain copied structures, we need to have on hand a mechanism that is able to copy copies.⁸ Once we have such a mechanism in our grammar, we are able to generate languages that are not of constant growth.

Our challenge is a strong one. Not only is the generalization we have argued for the obvious one, it is robustly attested in numerous West African (influenced) languages. Bùlì (Gur) [Hiraiwa, 2005], Krio (Creole) [Nylander, 1985], Twi (Kwa), Vata (Kru) [Koopman, 1983], Wolof (Atlantic) and many others have relativized predicate constructions, in which a copy of a verbal constituent appears both as the

⁸Even in English, we find data which argues for a similar conclusion. Consider the X-or-no-X construction, exemplified in 1 below. If we imagine that 1 were reported to have been said by an impetuous youth to said youth's father, we might consider an utterance of 2 to be appropriate, if somewhat involved.

- (1) War in Iraq or no war in Iraq, I'm joining the army.
- (2) (Statement to the effect that) war in Iraq or no war in Iraq, he's joining the army or no (statement to the effect that) war in Iraq or no war in Iraq, he's joining the army, he's *not* joining the army.

The important fact of note is that, whatever identity condition obtains between the two 'copies' in the X-or-no-X construction, *the very same* condition continues to hold, *even when embedded* in another X-or-no-X construction.

head of the relative clause, and internally to the clause. These languages differ with respect to the size of the copied constituent, with Twi on one end of the spectrum allowing only a single verb root to be copied, Wolof somewhere in the middle permitting verbal complexes to be copied, and Yoruba on the other end allowing full VPs to be copied. Moreover, analyses appealing to mechanisms like ours abound in the literature. Copying of some sort has been assumed to underlie ellipsis [Sag, 1976, Chung et al., 1995, Murguía, 2004], A-not-A questions in Mandarin Chinese [Radzinski, 1990, Huang, 1991], predicate clefts in languages as diverse as Hebrew [Landau, 2006] and Korean [Cho and Nishiyama, 2000], and free relatives in languages as diverse as Bambara [Culy, 1985] and Italian [Gulli, 2003], not to mention the plethora of analyses of non-surface-copying phenomena using the copy theory of movement in the minimalist program.

6. CONCLUSIONS

Copying is big trouble for current MCS formalisms—they can do it to a limited extent, but only by encoding the string component of a lexical item in its category. This makes the structures assigned to copies very unnatural, and therefore the *same* syntactic generalization needs to be stated twice: once over non-copies, and then once over copies, making the resulting grammars unnecessarily complex (a point made nicely by Pullum [2006]). The natural and obvious generalizations I have drawn about Yoruba, where there exist copies with copies (of copies. . .) contained in them, is impossible to be stated in these formalisms.

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