AG 13
"[…] von endlichen Mitteln einen unendlichen Gebrauch machen" – Recursion as a Central Issue in Recent Linguistics

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Recursion: Definitions, Promise and Pitfalls

24.02.2010, 14.00–15.00 Uhr, Raum 1.204

There has been great interest and considerable debate recently about the role of sequential versus hierarchical structures, including self-embedded or "recursive" structures, in human language. I argue that several important distinctions concerning recursion have been blurred in recent discussions. I outline three usages of "recursion" that typify different fields (computer science, linguistics, and mathematics), and illustrate why it is important to distinguish these different meanings. Despite a common misconception, the ability to generate hierarchical phrase structure does not, in itself, entail recursion. Furthermore, where a rule system lies in the Chomsky hierarchy (its "weak generative capacity") is independent of its recursive or non-recursive nature. One can generate "flat" finite-state sequences with a recursive algorithm, and one can generate hierarchical structures with non-recursive algorithms. Behavioural tests for recursion should investigate a subject's ability to generalize, over structures that are self-embedded, to new levels of embedding. Such studies require some additional interpretive dimension to exclude alternative non-recursive possibilities. Ultimately, however, determining that a finite system is recursive requires a way to look at the implementing algorithm directly, not just at behavioural experimentation. Important advances in computational neuroscience will be needed before this is possible for actual brains.

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Learning a hierarchical embedded structure with semantics in AGL

24.02.2010, 15.00–15.30 Uhr, Raum 1.204

Center embedded hierarchical structures are a crucial property of natural languages. The learnability of such structures by mere exposure to exemplars is a core debate in theories of natural language acquisition. Recent studies have investigated the learnability of hierarchical self embedded structures in the Artificial Grammar Learning paradigm, with mixed results. Bahlmann & Friederici (2006) report learning. But de Vries et al. (2008) failed to replicate any learning of hierarchical rules in a similar AGL study.

In two AGL experiments, we explore the possibility that learning center embedded structures is facilitated when learners are not only presented examples of the artificial language but also their 'meaning'. In Experiment 1, a set up highly similar to the de Vries et al's study without semantics, no learning was found. When semantic referents (rows of shapes and colors) were added to the learning exemplars, and the test task was to 'parse' new grammatical items by choosing one of two meanings, – rather than to give grammaticality judgments – significant learning was found. We claim that semantics is one of the many cues that help learners to acquire complex structures by learning from exemplars.

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The need for cues in recursive structure learning: An artificial grammar learning experiment

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Hierarchical centre embeddings are theoretically of great interest with respect to potential differences between human language and non-human communicative systems. Hauser et al. (2002) distinguished between the "broad" and "narrow" sense of the language faculty, with "broad" referring to properties of communication that are generic across modalities and shared across species, and the "narrow" sense referring to a language-specific computational system, the core property of which is recursion. The most critical observation, then, is that this property seems to lack any analog in animal communication. Hauser and Fitch (2004) tested whether cotton-top tamarins could learn such structures using an artificial-language learning task. They indeed found that cotton-top tamarins did not distinguish between strings generated from a grammar producing hierarchical centre embeddings, and those generated from a linear grammar (without any embeddings). Human subjects on the same task were sensitive to this distinction. However, Gentner, Fenn, Margoliash, and Nusbaum (2006) trained starlings on a similar hierarchical grammar, and claimed that song birds are able to detect hierarchical centre embeddings, casting doubt on the claim that such structures are unique to humans.

In a related line of investigation, Friederici, Bahlmann, Heim, Schubotz, & Anwander (2006) tested the neural correlates of processing hierarchical centre embeddings in humans, also with an artificial-grammar learning task. They found that the processing of hierarchical centre embeddings specifically activated Broca's area (BA44/45), whereas a linear grammar that generated strings without such embeddings did not result in activation of Broca's area.

Unfortunately, none of these studies conclusively established successful learning of hierarchical centre embeddings in humans or animals, due to the potential application of alternative strategies for task solution (Corballis, 2007a, 2007b; De Vries et al., 2008; Perruchet & Rey, 2005). For instance, in order to recognize a centre-embedded structure $A_3A_2A_1B_1B_2B_3$, one criterion could be that the number of A-elements has to match the number of B-elements, however this fails to observe the important feature of such structures in terms of processing the dependencies between particular A and B elements in the sequence. Alternative strategies such as counting, then, need to be controlled for in the testing sequences, and previous studies had not satisfactorily precluded these alternative processing methods for participants (see de Vries et al., 2008 for a review). So far, only a few studies provided evidence for learning of hierarchical centre embeddings, and only under very specific circumstances, such as prior familiarization of the smaller units (e.g., commencing with learning A_1B_1, Conway, Ellefson, & Christiansen, 2003). Establishing whether hierarchical centre embeddings are learnable at all from artificial languages therefore remains an important issue, both theoretically and methodologically.

Despite the difficulties in demonstrating learning hierarchical centre embeddings in artificial languages, there is no doubt that humans *can* process hierarchical centre embeddings in natural language, but substantial additional cues seem to be required to enable their processing. Not only semantics and morphology (e.g., agreement) play a crucial role to correctly link together non-adjacent elements, also available perceptual cues are important. For instance, for hierarchical centre embeddings in natural language, Nespor and Vogel (1986) documented speech pauses and intonation as indices for constituents, and Fisher and Tokura (1996) identified pause length, vowel duration and pitch as phrase boundary cues. It has been found that multiple, converging cues to syntactic structure are useful for processing both natural and artificial languages (Braine, Brody, Brooks, Sudhalter, Ross, & Catalano, 1990; Cutler, 1993; Monaghan, Chater, & Christiansen, 2005; Shi, Werker, & Morgan, 1999). In particular, shared phonological cues are helpful in establishing relationships among constituents, particularly if they are non-adjacent (Newport & Aslin, 2005; Onnis, Monaghan, Richmond, & Chater, 2005). Furthermore, prosodic information may help bootstrap the acquisition of grammar, even in the absence of lexical information, by signalling word order or syntactic phrase boundaries (Chistophe, Nespor, Guasti & Van Ooyen, 2003). Extracting regularities might therefore be particularly sensitive to prosodic information useful in uncovering generalizations in speech (Toro, Nespor, Mehler & Bonatti, 2008). In sum, specific perceptual cues are likely to help the language learner to track particular regularities.

Based on the established value of perceptual cues for learning structural dependencies in grammars, we wanted to test whether such perceptual cues would also be helpful in learning recursive structures in an artificial grammar learning setting. In a previous study (De Vries et al., 2008), we trained participants on hierarchical centre embeddings ($A_3A_2A_1B_1B_2B_3$) and tested for the discrimination between $A_3A_2A_1B_1B_2B_3$, and "scrambled" versions, in which the non-adjacent dependencies were violated, such as $A_3A_2A_1B_1B_3B_2$. Strategies that are not directed at the recursive structure, such as counting, cannot distinguish such testing stimuli. In the study, no perceptual cues to the underlying structure were provided, and there was no evidence of recursive-sequence learning. In the present study, we provided perceptual cues in the form of shared vowels and consonants between constituents, in order to support the recursive structure. We predicted that learning recursive structures, such as hierarchical centre embeddings, should be facilitated when their constituents share perceptual properties. Indeed, the results demonstrate that recursive structures can be learned in artificial language learning settings, and that perhaps previous failures to demonstrate learning were due to the absence of specific cues relevant to language structure. This raises the question of the array of cues necessary in natural languages for learning such complex recursive structures.

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Constraint on recursion and the input: The case of recursive verbal compound nouns

24.02.2010, 16.30–17.00 Uhr, Raum 1.204

The availability of recursive operations varies both across and within languages. Grammar must therefore have a mechanism that prevents recursion in some cases; otherwise, children would overgeneralize the process. Snyder and Roeper (2005) propose that there is a constraint on recursion in natural language. This constraint applies everywhere until children have input that violates it. It is still not known, however, how general or specific the required input must be.

I report the results of two experiments investigating whether the input of recursive nominal (root) compound nouns (NCN) such as *cherry tea pot* can trigger recursion in verbal (synthetic) compound nouns (VCN) such as *tea pourer maker*. Recursive VCNs rarely occur in child-directed speech (0 cases found in the CHILDES database (MacWhinney 2000)), while recursive NCNs occur frequently in child-directed speech (Roeper et al. 2002). The experiments thus tested whether children who do not have input from recursive VCNs but do have input from recursive NCNs can understand recursive VCNs. The study also examined whether the complexity of the VCNs and semantic similarity of embedded and embedding nouns of the VCNs affect children's performance.

In the first experiment, 35 English-speaking children, aged 5 to 9, and 9 English-speaking adults were given a character-selection task. There were 3 cases of recursive NCNs and 5 cases of recursive VCNs. Children were also asked why they chose their answers. While the children chose correct recursive NCNs 100% of the time, they did not perform well on recursive VCNs. The mean number of children's correct responses for recursive VCNs was 1.17 out of 5. Adults' average number of target response for recursive VCNs was 4.4 out of 5. Children's response rates were better in Inst(rument) + Ag(en)t (e.g., *tea pourer(Inst) maker(Agt)*) cases than in Agt + Agt cases (e.g., *picture taker(Agt) liker(Agt)*).

In the second experiment, test items had a simpler form, *V-er+V-er* (e.g. *cleaner opener*), than items in the first experiment. The test items were divided into four types: Agt+Agt, Agt+Inst, Inst+Inst, Inst+Agt. Thirty-three English speaking children between 6 and 10 years old and 21 English speaking adults participated in the experiment. Children performed better in the second experiment than in the first experiment. Moreover, while 21% of the children younger than 9 years old chose the target answers more than 50% of the time, 60% of the children older than 9 chose the target answers more than 50% of the time. This shows that there is a developmental stage for acquisition of recursive VCNs, and that children around the age of 9 start to acquire the recursive VCNs. The results showed that the semantic roles do not affect children's performance.

This study shows that the input of recursive NCNs does not trigger recursion in VCNs, and thus suggests specific input is necessary for acquisition of recursive structures.

Roeper, T. and Snyder, W. (2005) “Language learnability and the forms of recursion." In A.M. Di Sciullo and R. Delmonte (eds.) UG and External Systems: Language, Brain and Computation, 155-169. Amsterdam: John Benjamins.

Roeper, T., Snyder, W., and Hiramatsu, K. (2002) “Learnability in a Minimalist framework: Root compounds, merger, and the syntax-morphology interface." In I. Lasser (ed.) The Process of Language Acquisition. Frankfurt: Peter Lang Verlag.

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Indirect recursion and the importance of second order embedding

24.02.2010, 17.00–17.30 Uhr, Raum 1.204

Language provides us with an unlimited freedom of creative reference. And at the same time language has ways to restrict the range of possible meanings. Constrained recursion allows focusing on one single logical sequence. This constrained form of recursion belongs to the core of grammars for natural languages.

In its unconstrained form recursion, being a function that calls itself, raises a problem. It results in an abundance of information. The effect of such a function is that it adds more and more information. This would be highly inefficient and would make recursion not very suitable for natural language. Recursion achieves efficient communication if the set of possible interpretations is highly constrained. Therefore recursion should be part of the biolinguistic program.

For example what Mary likes in (269) can be variety of propositions: John arriving early; he buying a lovely cake, etc. However what Mary likes in (2) is the single proposition: John arrived early and brought a lovely cake for Christmas.

(1) John arrived early, and he brought a lovely cake for Christmas. Mary likes that.

(2) Mary likes that John arrived early and brought a lovely cake for Christmas.

Constrained recursion is exclusively visible at the second order level. A single embedding can be represented in syntax and in discourse ((3) <=> (4)), but a multiple embedding cannot ((5) <=/=> (6)).

(3) The bridge is broken. John knows that.

<=>

(4) John knows that the bridge is broken.

(5) The bridge is broken. John knows that. His sister doesn’t think that.

<=/=>

(6) His sister doesn’t think that John knows the bridge is broken.

We have tested this with over 40 adults in English and Dutch and 18 6 year-old children. None of the populations allows a recursive system in discourse, showing that the syntax-semantics interface plays an essential role in constrained recursion (at least for Germanic languages). The visibility of true recursion can also be seen in (7) and (8), which are equivalent. However, (9) is not equivalent to (10).

(7) According to John, the earth is flat.

(8) John thinks the earth is flat.

(9) #According to John, according to Mary the earth is flat.

(10) John thinks that Mary thinks the earth is flat.

This shows that multiple embedding not necessarily equals multiplying single embeddings. Knowledge of recursion plays a crucial in the step from first to second order.

We propose that indirect recursion creates a phase edge boundary. At the syntax-semantics interface the *Exclusivity Constraint* is effective. What is embedded in both is not only a single proposition, but also an evaluation by the main clause subject and that is why multiple embedding (10) is excluded. It captures the distinction between (9) and (10).

In this talk we will make two important claims: 1. indirect recursion is a restriction on meaning made at the syntax-semantics interface and 2. multiple embedding is the product of indirect recursion.

Additionally we will show that children acquire second order (=multiple) embedding and second order Theory of Mind at a later stage. So for the child knowing a single embedding does not automatically leads to recursive multiple embedding. This also indicates that the phenomenon of recursion in language might be very similar to the one in Reasoning.

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Recursion interfaces

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Our goal is to sketch computational proposals for interface interpretations that will explain the diverse acquisition path for recursion. The empirical data needs substantial further research and the architecture of interface computations remains largely unarticulated.

Recursion must have particular triggers because it is not the same in all languages (Snyder and Roeper (2003)). Compounds, adjectives, possessives exhibit left-branching recursive structures in Germanic, but not Romance (see Hollebrandse and Roeper (2008) Roeper (2009)). Sentential complements may or may not be universally recursive (see Sauerland (2009) demonstration for Teiwa and Piraha). It follows therefore that language particular statements are relevant and what guides a child down the acquisition path for each must be articulated. Snyder and Roeper (2003) advanced the first order hypothesis that children must be exposed to recursion and therefore must be sensitive to it. Are there generalizations across recursion types for the acquisition path?

Hollebrandse and Roeper (2009) argue that there is both Direct recursion, which gives conjoined readings, and Indirect recursion, which requires (under Chomsky's Strong Minimalist Thesis) Phase-based interpretation, which produces embedded readings and the basic challenge. We find evidence for conjoined adjectives (Gu) (Hubert), relative clauses, possessives, and compounds (Hiraga (2009)) as the first analysis that children give.

Most of these structures are demonstrably rare, such as double possessives, others quite common (compound nouns in German, pronominal adjectives in English). Therefore it is possible that the order of acquisition is influenced by input frequency (Yang 2002, 2009)). Input frequency is obscured by the fact that children prefer Direct recursion, delivering a conjoined reading. Often input data can be analyzed as conjoined, not embedded, and therefore the input data may not indicate that a form of indirect recursion with embedding is called for. However we argue, from a still shaky empirical foundation, that interface factors are very relevant.

Where does the child begin? Current evidence of when children master these constructions – far from complete – suggests nonetheless an interesting division: adjectives (gu) 3-4 yrs ("a big little truck"), simple compounds (3 yrs) ("baby doll napkin"), PP's ("in the corner in the kitchen"), and recursive infinitives seem to be arriving productively between 2.5 and 4.0. Here are examples of early recursive infinitives which have not been reported before (with go, try, get) from Childes:

1) *Naomi 2.4yrs: to go to sleep xxx

adam30.cha:*CHI: Paul want to go to sleep and stand up

castp2.cha:*CHI: where am I going to get to put the chimney

boys44.cha:*CHI: yeah # when I got bigger then I'm going to get to go

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

tre21.cha:*CHI: now I'm going to try to touch your knee

On the other hand, double possessives (John's father's car), tensed sentential complements (Adam 5trs "I thought you said the animals gonna be warm"), and verbal compounds (tea-pourer-maker) arrive between 4-6yrs (or later). Is an identifiable form of complexity causing delay?

Both the complex verbal compounds: tea-pourer-maker (Hiraga 2009) and the complex possessives (Limbach (2009)) can be analyzed in terms of Relativized Minimality (Rizzi (1990)), Friedmann et al (2009), where an -er is incorporated and crosses over another -er (Hiraga (2009)), and a possessive crosses over another possessive:

2) the hat of the father's of a friend's => friend's father's hat

following Johnson (2003)). The combination of a Phase-based interpretation and movement must be represented at the interface.

The third form of delayed recursion lies in Tensed complements. Hobbs et al (2008) shows that 6yr olds have difficulty with "Jane told Mom that Billy said sisters are stupid". No movement is involved here, but a delay in assignment of Propositional Force to the Final Phase, unlike non-propositional infinitives. Hinzen (2006) observes that every sentence has a single truth value. Therefore the potential propositional force (truth-value) associated with each clause must be blocked. The proposition "sisters are stupid" must not be truth-functionally evaluated in its Phase. Therefore we suggest, informally, that in analogy to Trace-conversion (Fox (1999), Sauerland 2004), a mechanism must exist to drop assertive force at the point when a higher Phase is entered. This suggests that it is not the cross-over property of RM which is crucial but putting a kind of interpretation inside an identical kind of interpretation which is crucial to the interface computation. This approach can be extended to explain the fact that False Belief tests are more easily successful with infinitives.

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Against direct recursion in syntax

25.02.2010, 9.00–10.00 Uhr, Raum 1.204

Recursion is a prominent property of the syntax of human language (for instance Chomsky 1963, 326-327) and arguably the main source of its generative capacity. However, its availability enlarges the space of possible grammars to be considered by the learner and therefore aggravates the problem of language acquisition. Explanatory adequacy suggests to look for restrictions on recursion. To this end, I suggest that syntax lacks (a particular kind of) *direct* recursion, due to the constraint in (1).

Some evidence for (1) comes from the distribution of clauses. **(A)** If subject sentences in English are merged in SpecC with an empty correlate e in subject position (Koster 1978), then (2-a) is excluded by (1): [$_C$ *that*] must bear [*u*C] for CP_2 to be merged in SpecC, thus violating (1). (2-b) suggests a difference in the featural make-up between [$_C$ *that*] and [$_C$ –], avoiding a violation of (1). This is supported by the fact that if two [$_C$ –]s co-occur, as in (2-c), then the effects of (1) return with full force. **(B)** Verb-final complement clauses in object position are marginal in German (3-c). But if the complement is a V/2-clause, then the lack of extraposition results in radical ungrammaticality, (3-a), (3-b). The additional degradation is accounted for by (1), if the C-position of a V/2-clause bears [V] (Webelhuth 1992, 90; von Stechow & Sternefeld 1988, 388-402): In order to merge with a V/2-CP, matrix V must bear [*u*V] which violates (1). To avoid this, V/2-clauses are merged to the right, outside VP (Reis 1997). This also explains why clausal complements in SVO languages are uniformly post-verbal, while in SOV languages they sometimes appear pre- and sometimes post-verbally (Bayer 2007): “Extraposition” applies string vacuously in SVO languages, if it applies at all. **(C)** If Relative clauses (RCs) are merged in a pre-nominal position (Cinque 2009), then the question arises why they appear post-nominally in German, (4-a), (4-b). Suppose the C-head of a RC is nominal (bears [N]), see Sternefeld (2006, 368-369). Then (1) bars direct Merge of the RC-CP with the head noun (which would have to bear [*u*N]). If the head noun is merged with an empty D-correlate instead, then it bears [*u*D] and (1) is respected. This still leaves the question where the RC is merged. It may be rightadjoined to the matrix DP, stipulating that the correlate must be cataphoric (4-c). Or it may be merged as complement of the D-correlate. Then there must be some independent requirement that forces the RC to move. Extraposition is then preferred over leftward movement if the correlate DP is an island for the latter but not for the former (Müller 1996), (5-a), (5-b). **(D)** Pre-nominal RCs typically do not exhibit initial C-elements (Downing 1978, 391-393). Instead, the verb of the RC is marked with a particular affix (see (6) for Navajo). The affix may be interpreted as a C-head in final position that is the target of V-movement. As a result, the RC C-head acquires [V] and the RC can be merged in pre-nominal position (the head noun bears [*u*V]). There is no correlate and no extraposition.

(1) Category α (bearing [*u*F]) cannot merge with category β (bearing [F]) if α also bears [F].

(2) a. *[$_{CP1}$ [$_{CP2}$ That the world is round] [$_{C}$ that] e is obvious] upset John.
b. [$_{CP1}$ [$_{CP2}$ That the world is round] [$_{C}$ –] e is obvious].
c. *[$_{CP1}$ [$_{CP2}$ That the world is round] [$_{C}$ –] e is obvious] [$_{C}$ –] e upset John.

(3) a. weil ich [$_{VP}$ glaube] [$_{CP}$ sie schläft]
b. *weil ich [$_{VP}$ [$_{CP}$ sie schläft] glaube]
c. ??weil ich [$_{VP}$ [$_{CP}$ dass sie schläft] glaube]

(4) a. *[$_{DP}$ eine [$_{NP}$ [$_{CP}$ die ihr gefällt] Geschichte]]
b. [$_{DP}$ eine [$_{NP}$ Geschichte [$_{CP}$ die ihr gefällt]]]
c. [$_{DP}$ [$_{DP}$ eine [$_{NP}$ [$_{DP}$ [$_{D}$ e_2 (t_2)] Geschichte]] [$_{CP2}$ die ihr gefällt]]

(5) a. Ich konnte [$_{DP}$ es t_2] nicht glauben [$_{CP2}$ dass sie schläft].
b. *[$_{CP2}$ Dass sie schläft] konnte ich [$_{DP}$ es t_2] nicht glauben.

(6) [$_{CP}$ Ałhosh-ígíí] ashkii ałhą́ą́ʼ
IMPERF.3.sleep-C.REL boy IMPERF.3.snore
"The boy who is sleeping is snoring."

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Phasal recursion of FocP: Evidence from Malayalam

25.02.2010, 10.00–10.30 Uhr, Raum 1.204

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1. Introduction Malayalam is a SOV Nom-Acc Dravidian language spoken in South India. The language does not exhibit any subject-verb agreement and is conventionally described as a Wh in situ language. However, certain peculiarities in Malayalam with respect to the interrogative constructions along with other factors led Jayaseelan (2001) to propose a Focus Phrase immediately above vP in the language. He cited the mandatory movement of question words to an immediately preverbal position in interrogative constructions in an otherwise SOV language:

1. ninne a:ru adiccu? 2. *a:ru ninne adiccu?
you-ACC who beat-PST Who beat you?
(Note that contrary to expectations, the canonical SOV order is ungrammatical)

However, a closer examination of Malayalam shows that the nature of Focus in the preverbal focus constructions differ markedly from that of Clefts.

2. Problematisation A cleft in Malayalam is given in (3)

3. Mary-e a:nu John kand-a-Du
Mary-ACC FM John saw-*a*-SG.NEUT It is Mary that John saw (FM: Focus Marker)

It is shown in the paper, drawing on the results of tests pertaining to exhaustivity (e.g 4,5) and distributional restrictions (6,7) (cf. Szabolci 1981) that cleft constructions in Malayalam encode Exhaustive Identification. Exhaustivity: 5 is not a logical consequence of 4.

4. john-um Bill-um a:nu Mary-e kand-*a*Du
john-conj bill-conj FM mary-ACC saw-a-SG.NEUT It is John and Bill who saw Mary
5. john a:nu Mary-e kand-*a*-Du
john FM mary-ACC saw-*a*-SG.NEUT It is John who saw Mary
6. *patti-yum a:nu pu:cca-ye pidicc-*a*-Du
dog-conj FM cat-ACC caught-*a*-SG.NEUT It is the dog also who caught the cat.

7. *patti po:lum a:nu pu:cca-ye pidicc-*a*-Du
   dog even FM cat-ACC caught-*a*-SG.NEUT
   It is even the dog that caught (a) cat.

It can be seen straightforwardly that these results are in accordance with E. Kiss (1998). She explains that while Information focus conveys non-presupposed information, Identificational Focus expresses exhaustive identification and syntactically acts as an operator, moving into a scope position and binding a variable. This distinction is evident in Malayalam in constructions that involve the cleft focus marker *a:nu* versus constructions that involves preverbal Focus position in that we get none of the exhaustivity related results in the non cleft sentences that use the preverbal Focus position. The movement of an element to a scopal position thereby creating an operator-variable pair in cleft sentences is evidenced by the retention of case-morphology (e.g. 3) as well as restrictions on what can be moved to the cleft focus (e.g. 6,7). More over, all these tests fail to produce positive results in the preverbal focus position:

8. Mary-ye JOHN-UM BILL-UM kandu
   Mary-ACC John-conj Bill-conj saw JOHN AND BILL saw Mary
9. Mary-ye John kandu [9. follows logically from 8.]
   Mary-ACC John saw John saw Mary
10. Mary-e JOHN PO:LUM kandu
   Mary-ACC John even saw Even John saw Mary; no distributional restrictions.

That is, the preverbal focus position cannot be invoked for clefts if we are to account for the facts related to clefts.

3. Analysis The paper argues that the lower preverbal Focus position that Jayaseelan (2001) proposes is an instantiation of Information Focus as can be seen from answering strategies. It is proposed that the cleft construction do not involve the preverbal focus position as Jayaseelan argues, but rather involves a higher scope position in the C-level that is crucial in creating an operator-variable pair produced by movement of the clefted element as would be expected in Identificational Focus constructions. This is evidenced by the scope relations obtained in cleft constructions (e.g. 11-12).

11. ella: channel-um Obama-ye a:nu ka:nicc-a-Du
   all channel-conj Obama-ACC FM show-PST-A-SG.NEUT
   It is Obama whom all the channels showed. (There were others like Palin and McCain present; but only Obama was shown by the channels.)

12. Obama-ye a:nu ella: channel-um ka:nicc-a-Du
   Obama-ACC FM all channel-conj show-PST-A-SG.NEUT.
   It is Obama whom all the channels showed. (Palin and McCain were shown by some channels; but Obama was shown by ALL channels.)

Thus, the element at the cleft focus interacts with quantifiers. This does not happen with the elements in the preverbal focus position as would be expected if it is not a C-level scope position.

It is shown that the preverbal lower Focus position encodes Information Focus as argued by Belletti (2004) while Identificational Focus mandatorily requires a higher C-level position provided by clefts in the language. Thus different types of Focus manifest in different phases, namely, *v*P and CP. It thus proves to be not just a mere phasal recursion of the same FocP.

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On the proper role of recursion in linguistic studies

25.02.2010, 10.30–11.00 Uhr, Raum 1.204

Recursion as 'definition by induction' is used to formalise an algorithm, and recursive functions consist of a pair of equations. Turing defined a computable function if computable by a Turing Machine, an “iterator” lacking recursion. Church proposed the general recursive functions while Post suggested production systems. The last two are “recursors”: mappings that involve a recursive step. Recursion is sometimes taken to be synonymous with computation, and it is thus we must understand Chomsky’s introduction of recursive devices to explain discrete infinity (cf.‘there is a technical definition of “recursion” in terms of Church’s thesis...a formalization of the notion algorithm/mechanical procedure’(p.c. May 2009)).

Our aims are twofold: a) to clarify its role regarding core properties of language; and b) to describe the distinction between recursors and iterators in some detail, with repercussions for competence and performance. CHL was characterised as rewrite rules in the 50s, and its recursive component generated self-embedding (an X within an X, where X is a category type). Much work attempts to show that self-embedding is not present in all languages, but this has little to do with recursion. The onus is on demonstrating that a given language is finite, allowing for storage and making a computational system redundant.

The computable functions identify objects, but the implementations may either be recursive or iterative. Recursors involve reflexive calls and subroutines, while iterators repeat one single operation. All recursive relations can be reduced to iterative ones, but there’s a fit between recursive structures and the recursive mechanisms operating over there. This can be applied in studies of competence and performance: a) competence: all phrases respect the same geometry: [Specifier [Head - Complement]]. Thus, a CP is a SHC composed of further SHCs. At this level, an X within an X refers to geometry and not to the category type of the H. Such structures are present in languages that appear to lack category type self-embedding. Cross-linguistically, differences appear in the linear ordering of this scheme, but not in its hierarchical structure: S is more prominent than [H-C], and H more so than C. The scheme is universal, and provides the child with a head start: a SHC geometry is expected. Regarding derivational accounts, we know two things: the structural organisation of the resulting expression, and the atomic elements that compose it. Current theory postulates that the intrinsic features of the atoms plus external conditions drive a derivation. The challenge is to work out if there are computational principles that operate over these. We define Merge as a recursor, subdivided into External (EM) and Internal (IM) applications of the same merging operation. It will be shown that as EM (an iterator) introduces an element that will be moved later by IM, a chain containing a deferred operation is introduced, indicating a recursive subroutine; and b) performance: this work pertains to implementations in real time, not the abstract computations we have treated. The parser carries out a number of operations, such as segmenting the string into units, assigning syntactic roles et alia, but a suboperation is to recover the matrix SHC and the internal phrases. These may only appear in either S or C, the loci of possible deferred operations. Such recovery could be recursive or iterative; it will be a matter of memory load plus flattening operations that will determine which one the parser employs –an empirical matter. We will provide preliminary details of experimental work which ought to result in the elucidation of the nature of the structure-building mechanisms.

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Resumption and concealed relatives

25.02.2010, 11.30–12.00 Uhr, Raum 1.204

Starting from a well-known observation, namely that in a language like Hebrew there is no free alternation between traces and (overt) resumptive pronouns, the goal of this paper is to show that even in languages with seemingly little or no resumption such as English, the distinction between a putatively null resumptive pronoun (*pro*) and trace is equally material. I contend that positing a resumptive (i.e. bound variable) *pro* also in English (and other Germanic languages) is not only theoretically appealing for various, independent reasons (a.o. ideas in Hornstein 1999, 2001, Boeckx & Hornstein 2003, 2004, Kratzer 2009), but also empirically adequate (beyond the arguments in Cinque 1990). The central claim that I put forward is that resumption, including resumption via *pro*, is restricted to (sometimes concealed) relative clauses – hence, (resumption in concealed) relatives as a case of recursion. Applying this proposal to English-like languages, I show that the distinction drawn between (resumptive) *pro* and trace accounts for a variety of mysteries, such as lack of weak crossover in appositives (Safir 1986), lack of Principle C effects in several construction types (notably restrictive relative clauses and emphatic contexts; Munn 1994), sluicing, ATB movement phenomena, and case (mis-)matching patterns in comparatives.

Specifically, I propose that a sentence like (1b), which unlike (1a) contains an appositive relative clause and exhibits an alleged weak crossover effect, has the structure in (2), the highlighted part of which is a null couplar construction containing a hidden relative and a bound variable (i.e. resumptive) *pro*.

(1) a. ?*A man_i who_i his_i wife loves t_i arrived early.
b. Ben_i, who_i his_i wife loves t_i arrived early.

(2) Ben_i, who_i is [$_{DP}$ the one (person)]$_i$ that his_i wife loves *pro*$_i$, arrived early.

Likewise, I contend that a sentence such as the one in (3), which under the raising analysis of relative clauses should give rise to a Principle C effect, has the structure in (4), the highlighted part of which is again the null couplar construction containing a concealed relative and a resumptive *pro*.

(3) The picture of $John_i$ which he_i saw in the paper is very flattering.

(4) [$_{CP}$ [$_{DP}$ The $picture_k$ of $John_i$ [$_{CP}$ which is [$_{DP}$ the one ($picture_k$)]$_j$ [$_{CP}$ that he_i saw *pro*$_j$ in the paper]]] is very flattering]

Following ideas in van Craenenbroeck (2009), I suggest that sluicing as well sometimes involves a concealed *such that* relative. For instance, it is well-known that an interrogative cleft cannot be combined with a modifier such as *for example*, since the former requires an exhaustive list as answer whereas the latter explicitly indicates that the answer to the question need not be exhaustive. Contrary to the expectations of the cleft-analysis of sluicing however, such modification is fine in sluicing, (5). These facts present an argument against a derivation-from-cleft account of sluicing à la Merchant (2001). A (hidden) *such that* relative account as the source of sluicing does not face this problem however; see (6).

(5) A: You should talk to somebody in the legal department for help with that.
B: a. Who, for example?
b. *Who is it, for example?

(6) Who, for example, is such (a person) that I could talk to in the legal department?

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Gesture and structural complexity: Recursion in co-speech gestures

26.02.2010, 11.30–12.00 Uhr, Raum 1.204

Some linguists claim that recursion is a fundamental characteristic of human language. They argue that recursion is shared neither by animals, nor by cognitive capacities other than the language faculty (Hauser, Chomsky and Fitch 2002). In contrast to this view, Everett (2005) claims that the Amazonian Pirahã lacks evidence of recursion in its syntax. Other researchers consider recursion as the defining feature not only of human language but of human cognition in general (Corballis 2007).

New data are one possibility to break vicious circles of theoretical argumentation. In my paper, I will present empirical examples from route descriptions in German that give evidence of recursion in co-speech gestures. When people are engaged in a conversation, they communicate not only with speech but also with gesture. In gesture studies, speech and gesture are considered “as manifestations of the same process of utterance” (Kendon 1980: 208). Moreover, they can be used as a “second channel of observation onto the speaker’s mental representation during speech” (McNeill 1986:108).

The fundamental questions of my paper are: Is it possible to analyse co-speech gestures independently of speech in terms of constituency? Do gestural constituent structures display recursion? And what would be the implications of gestural recursion for language theory? Gesture scholars have so far neglected the syntactic dimension of analysis, and linguists have largely considered gesture as “non-verbal”, excluding it from their subject (Fricke in press).

One major problem is this: What is recursion? The concept of recursion entered linguistics from mathematics and computer science. But, as Lobina and García-Albea (2009) pointed out, the adaptation of this notion in linguistics and cognitive sciences is not very clear. But if recursion – in the context of linguistics – applies to “a constituent that contains a constituent of the same kind” in vocal language (Pinker and Jackendoff 2005: 203) as well as to the possibility of producing an infinite number of expressions with finite means, then some gestural structures can be called recursive, e.g. gesture units (GU) in German.

Corballis, M. (2007). The uniqueness of human recursive thinking. *American Scientist*, 95, 240–248.
Everett, D. (2005). Cultural Constraints on Grammar and Cognition in Pirahã: Another Look at the Design Features of Human Language. *Current Anthropology* 76 (4): 621–646.
Fricke, Ellen (in press). Grammatik multimodal: Wie Wörter und Gesten zusammenwirken. Berlin, New York: de Gruyter.
Hauser, M. D., N. Chomsky, W. T. Fitch (2002). The Faculty of Language: What Is It, Who Has It, and How Did It Evolve? *Science* 298: 1569–1579.
Kendon, A. (1980). Gesticulation and Speech: Two Aspects of the Process of Utterance. In: Key, Mary R. (ed.), *The Relationship of Verbal and Nonverbal Communication*. Den Haag, Paris, New York: Mouton, 207–227.
Kendon, A. (2004). *Gesture: Visible Action as Utterance*. Cambridge: Cambridge University Press.
Lobina, D. J. and J. E. García-Albea (2009). Recursion and Cognitive Science: Data Structures and Mechanisms. To appear in the proceedings of CogSci 09.
McNeill, D. (1986). Iconic Gestures of Children and Adults. *Semiotica* 62, 107–128.
McNeill, D. (2005): *Gesture and Thought*. Chicago: Chicago University Press.
Pinker, S. and Jackendoff, R. (2005). The faculty of language: What's special about it? *Cognition*, 95 (2): 201–236.

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What artificial grammar learning reveals about the neurobiology of syntax

26.02.2010, 12.00–12.30 Uhr, Raum 1.204

In this study we examined the neurobiological correlates of syntax, the processing of structured sequences, by comparing FMRI results on artificial and natural language syntax. We employed a simple right-linear unification grammar and examined it in an implicit artificial grammar learning paradigm. Thirty two healthy Dutch university students were recruited on which natural language data were already acquired. Based on previous findings, we predicted that artificial syntax processing would engage the left inferior frontal region (BA 44, 45) and that this activation would overlap with syntax-related variability observed in the natural language experiment. In contrast, claims that Broca's region is specifically related to syntactic movement or the processing of nested structures predict that Broca's region should not be involved. The main findings of this study replicate previous findings on implicit AGL in detail. First, the left inferior frontal region centered on BA 44 and 45 is active during the artificial syntax processing of well-formed (grammatical) sequence independent of local substring familiarity. Second, this region is engaged to a greater extent when a syntactic violation is present and structural unification becomes more difficult or impossible. The effects related to artificial syntactic processing in the left inferior frontal region (BA 44 and 45) were essentially identical when we masked these with activity related to natural syntax processing in the same subjects. Finally, the medial temporal lobe is deactivated during this operation, consistent with the view that implicit processing does not rely on declarative memory mechanisms that engage the medial temporal lobe memory system. We conclude that the left inferior frontal region is a generic on-line sequence processor that unifies information from various sources in an incremental and recursive manner, whether there are any requirements for syntactic movement or the processing of nested structures or not.

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The brain signature of syntactic architecture

26.02.2010, 12.30–13.00 Uhr, Raum 1.204

Introduction Like language, music appears to be organised in a syntactic architecture with hierarchical and recursive structuring between its elements. Anyway, it is not actually addressed how far syntactic relationships in music are defined from the merely psychoacoustic aspect of the sound. If music, as at the current evidence suggests, also related to an abstract syntactic system, are musical and linguistic syntax neurally independent or is there a significant overlap? The neuroscientific evidence on this question seems paradoxical. On the one hand, neuropsychology has provided well-documented cases of dissociations between musical and linguistic syntactic processing. On the other hand, neuroimaging points to overlap in the processing of linguistic and musical syntax. The aim of this study was to clear this debate.

Subjects and method We designed an fMRI experiment where nine German non-musicians had to judge the correctness of some musical phrases and language sentences. The stimuli presented either syntactic (i.e. grammatical or tonal) or psychoacoustic violations. In a second study 32 subjects were scanned with DTI sequences. Both experiments were performed on a 3 Tesla scanner. The analysis of the data used SPM5/8, DTI Toolbox (http://www.uniklinik-freiburg.de/mr /live/arbeitsgruppen/diffusion/fibertools_en.html) and dPC.

Results Violations of hierarchical rules in language involved a left hemispherical network, including the inferior and superior frontal, thalamus, supramarginalis, parietal and precentral gyrus. In music, we founded a bilateral activation of the inferior frontal gyrus, of insula, of the superior temporal and perolandic operculum, supramarginal, parietal and precentral gyrus, of the right thalamus and the left pallidum. The comparison between detection of hierarchical rules versus psychoacoustic violation as like the conjunction analysis showed in language and in music a preferential left hemispherical network, involving the inferior frontal gyrus (p. opercularis and triangularis), precentral gyrus and insula. DTI and dPC analysis individuated two functionally and anatomically pathways: a dorsal way along F. Longitudialis between p. opercularis and supramarginalis / precentral gyrus and a ventral along Capsula extrema between p. triangualris and insula. Only in language the ventral pathway *erreicht* girus frontalis superior and only in music a third pathway along temporal is involved. Psychoacoustic violation also used the same pathways, but without ereichen Broca's area.

Conclusions This study supports that the physical proprieties of the sound is a "necessary but not sufficient" basis for *the feeling of the tonality* (Lerdahl, 2001). Although linguistic and musical syntax involved distinct domain-specific networks, there is an overlap in the neuronal resources underlying hierarchic rule processing. Our results showed that Broca's area is pivotally involved in this human unique ability independently of its domain. Two parallel working pathways are related to this area: a ventral way *relating* to p. triangularis and a dorsal way to p. opercularis. In analogy with acoustic system, we supposed that the dorsal cortical pathway tracks time-varying events, then more related to expectancy, working memory and motor process. Conversely, the ventral pathway, which is thought to be specialized for invariant time-independent object properties, seems to be responsible for identification of real / natural structural dependences.

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The neural basis of recursion

26.02.2010, 13.00–14.00 Uhr, Raum 1.204

It has been argued that syntactic recursion is central to the human faculty of language (Hauser et al., 2002). Recent experimental work comparing the ability to process hierarchically structured sequences indicated that humans, but not non-human primates can learn and process hierarchical structures, although both easily deal with non-hierarchical sequences (Fitch & Hauser, 2004). For humans it was demonstrated that non-hierarchical structures are processed by a brain system which is phylogenetically older (frontal operculum) than the brain system supporting the processing of hierarchical structures, namely, Broca's area (Friederici et al., 2006). This latter study had used A^nB^n sequences of non-sense consonant-vowel syllables similar to those applied by Fitch and Hauser, but unlike Fitch and Hauser had not coded A and B category membership by pitch information. The syllable sequences used in these two studies (AAABBB) were criticised as they might allow processing and detection of "ungrammatical" strings simply on the basis of counting A and B elements, not necessarily requiring hierarchical structure building. In an additional brain imaging experiment stimuli were constructed such that hierarchical processing was required in order to be able to detect the dependencies between related elements ($A_3A_2A_1B_1B_2B_3$). The brain system supporting the processing of these hierarchical structures compared to non-hierarchical structures (ABABAB) again was Broca's area (Bahlmann et al., 2008).

Two further questions arose: first, does this hold even for embedded structures in natural languages and second, does it also hold for hierarchical structures in non-language domains. In a subsequent study we were able to show that Broca's area, in particular, the pars opercularis supported hierarchical processing in German sentences with multiple embedded structures, and, moreover, that another region (the left inferior frontal sulcus) holds responsible for the working memory demands resulting from the distance of the dependent elements, thereby indicating for the first time the principle neural independence of syntax and verbal working memory at the neural level (Makuuchi et al., 2009).

Additional brain imaging studies suggest that Broca's area itself and brain areas located anterior to Broca's area are involved to different degrees in processing hierarchical structures in the purely visual domain (Bahlmann et al., in press) and in mathematics (Friedrich & Friederici, 2009).

Together, these findings clearly indicate that Broca's area must be considered as the brain region subserving recursion.

Bahlmann, J., Schubotz, R.I., Müller, J.L., Köster, D. & Friederici, A.D. (in press). Neural circuits of hierarchical visuo-spatial sequence processing. *Brain Research*.

Bahlmann, J., Schubotz, R. & Friederici, A.D. (2008). Hierarchical artificial grammar processing engages Broca's area. *NeuroImage, 42*, 525-534.

Fitch, W.T., & Hauser, M.D. (2004). Computational constraints on syntactic processing in a nonhuman primate. *Science, 303,* 377-380.

Friederici, A.D., Bahlmann, J., Heim, S., Schubotz, R.I. & Anwander, A. (2006). The brain differentiates human and non-human grammars: Functional localization and structural connectivity. *Proceedings of the National Academy of Sciences of the USA, 103,* 2458-2463.

Friedrich, R. & Friederici, A.D. (2009). Mathematical logic in the human brain: Syntax. *PLoS ONE, 4(5),* e5599. doi:10.1371/journal.pone.0005599.

Hauser, M.D., Chomsky, N. & Fitch, W.T. (2002). The faculty of language: what is it, who has it, and how did it evolve? *Science,* 298,1569-1579.

Makuuchi, M., Bahlmann, J., Anwander, A. & Friederici, A.D. (2009). Segregating the core computational faculty of human language from working memory. *Proceedings of the National Academy of Sciences of the USA, 106,* 8362-8367.