Modularity

1. Modularity: I-language consists of multiple modules that interact in specific ways
2. Module: a collection of specific data types, data, and operations that operate only on module-internal data types, data, and operations except where an explicit interface is defined with other modules
3. Interface: a specification of the relation between objects and operations from different modules. Interfaces are ideally as simple as possible, preferably a simple mapping between objects and operations from different modules

Modularity applied to Syntax and Phonology

4. Linguistic domains
   (a) Syntax: a (pre-theoretical) set of phenomena related to the rules, principles, and processes that govern the structure of sentences in language(s) (and the study thereof)
   (b) Phonology: a (pre-theoretical) set of phenomena related to the systematic organization of sounds in language(s) (and the study thereof)
   (c) Morphology: a (pre-theoretical) set of phenomena related to the rules, principles and processes that govern the structure of words in language(s) (and the study thereof)
5. Modules
   (a) Syntactic Module: covers many (but not all) aspects of syntax
   (b) Phonological Module: covers many (but not all) aspects of phonology
   (c) NO morphological module: morphology split out over the syntactic module, the phonological module and the interface between them
6. Syntactic and Phonological Module

Property	**Syntactic Module**	**Phonological Module**
Feature names	Case, number, gender, exception features, ...	coronal, anterior, voice, obstruent, accentable, exception features,...
Feature Values	nom, acc, gen, sg, pl, +, -, ...	+, -, 1..n, ...
Atoms (composed indivisible units, set of features)	formatives	phonemes
Larger units	words, phrases with idiosyncratic properties	morphs, phonological words with idiosyncratic properties (e.g. accent, inflection class, ...)
combinatorial operations	SUBCAT principle, MOD principle, Edge Feature Principle, ...	phonotactic rules
transformational operations	movement, deletion, ...	assimilation rules, final devoicing, vowel harmonisation, ...
module-specific principles	subjacency, relativized Minimality, ...	Sonority Sequencing Principle, ...

7. Interfaces
   - between the syntactic module and the phonological module
   - interface with the semantic module: either via the syntactic module (T-model), or triplet interface between the 3 modules (sem, syn, phon)
8. There are now multiple 'lexicons' :
   (a) module-internal lexicons (phonemes, idiosyncratic morphs in the phonological module; formatives, idiosyncratic words/phrases in the syntactic component)
   (b) interface lexicons: mappings between objects of different modules

Structure Building

9. Phonology and Syntax do share some things, in particular *structure building* but
   - structure building is not part of the syntactic module or the phonological module
   - structure building is not shared only by phonology and syntax
10. Structure Building (SB)
    (a) SB is specific to humans but not to (narrow) syntax or even language (hence not part of the narrow faculty of language (FLN))- contra [HCF 2002])
    (b) SB cannot combine two objects into a new object on its own

(c) SB accounts for unbounded recursion but unbounded recursion is not its only diagnostics

(d) A major use of SB is alleviating the limitations of short term memory in production/analysis by providing a systematic procedure to do "chunking" in the sense of [Miller 1956]. Hence, alleviated short term memory restrictions are also a diagnostics for structure building.

Part A

11. Chomsky has *Merge* as structure building operation and claims that it is:

    (a) an operation in the syntactic component

    (b) binary (2 arguments)

    (c) set formation (no order)

12. However, Chomsky acknowledges or even suggests himself that *Merge* is used outside of syntax or the language faculty:

    Generally [Chomsky 2010a:53], [Chomsky 2010draft:4]

    Natural numbers [Chomsky 2004] [Chomsky 2005:6]; see also [Chomsky 2010a:53])

    Vision [Jackendoff & Pinker 2005: 217-218]; [Chomsky 2010a:53]

    Music [Fitch 2010:121]; [Katz & Pesetsky 2011]; [Chomsky 2011: 22'53"-23':26"] (perhaps)

    Morphology / Lexicon [Chomsky2010draft:4]

    Planning [Chomsky2010draft:4]

13. Chomsky of course does not want multiple Merge operations, and is therefore forced to consider these as a derivative of / 'parasitic on' / 'an offshoot of' the language faculty [Chomsky 2011: 22'53"-23':26"]):

    (a) "There is no other possible explanation for its existence",

    (b) "otherwise, again, it would be very hard to explain".

14. Other domains Chomsky does not mention but others have brought up:

    Discourse [Levinson & Evans 2010] and references there; [Koschmann 2010]

    Artificial languages Logic, Mathematics, Programming languages, Number notation systems[1]

    Thinking (under the assumption that it can be done without syntax)

[1] We mean here the unconscious capacity of humans to produce and analyze an indefinite number of expressions from such artificial languages. Our scientific understanding of the concept of 'recursion' is irrelevant here.

Phonology syllable structure, phonological phrases, metrical structure, metrical grids. See below

15. Conclusions:

    (a) *SB* must be (part of) an independent component interacting with other modules, among them the syntactic and phonological modules.

    (b) I agree that they must be due to the same mechanism (which is the case if (15a) is assumed)

    (c) if SB is not specific to the syntactic module, there is no reason to assume that the syntactic module is the only generating module (with the semantic and phonological modules interpretive in nature).

    (d) instead: 'language comprises a number of independent combinatorial systems, which are aligned with each other by means of collection of interface systems' [Jackendoff 2002:111]

Part B

16. SB cannot combine two objects into a new object on its own: a combinatorial principle/rule is required as well, cf.

    (a) *This annoys me very

    (b) *The the the

    (c) *John John John

    (d) *book the read boy the

17. [Chomsky 2005:6] does mention that

    (a) 'for an LI to enter into a computation,[...], it must have some property permitting this operation'.

    (b) 'an LI has a feature that permits it to be merged' (the 'edge feature' (EF))

    (c) 'The fact that *Merge* iterates without limit is a property at least of LIs - and optimally, only of LIs, as I will assume. EF articulates the fact that *Merge* is unbounded, that language is a recursive infinite system of a particular kind.'

18. What is implicit here is that *Merge* requires a combinatorial principle (say, the 'Edge Feature Principle'), and this combinatorial principle requires an LI to have an edge feature for *Merge* to be applicable)

19. so this is completely uncontroversial, except for the interaction between SB and the combinatorial principles/rules

20. Signature of Structure Building (SB):

    (a) SB: [OC] $\rightarrow$ OPC $\rightarrow$ OC where

(b) OC is an object of component C

(c) [X] is a sequence of objects of type X

(d) OPC is a combinatorial operation for objects of component C

(e) OPC: [OC]→ {OC} where {X} is a sequence, a set, or a multiset of objects of type X depending on your favorite theory or on component C

21. Examples of combinatorial operations for syntax

    (a) Universal principles such as

        i. 'Edge Feature Principle',

        ii. syntactic selection principles (strict subcategorization), e.g. [Stabler 2011] word1::=X Y word2::X → word1::Y word2::X

        iii. modification principles, e.g.

            A. $[X1_{MOD=[Y]}, X2_{CAT=Y}] \rightarrow \{X1_{MOD=[]}\ X2\}$

            B. *very* with property MOD=[A] can modify a syntactic object of syntactic category A but not of syntactic category V

    (b) language-specific or even construction-specific combinatorial rules

    (c) or whatever your favorite combinatorial principles/rules are

Part C

22. Unbounded recursion in natural language is real and must be accounted for. *SB* indeed can in special cases account for unbounded recursion, but unbounded recursion is just a side effect that can occur if the combinatorial principle/rule happens to allow this.

23. Recursive rule application is severely limited in many cases. e.g., in syntax, complementation, numerical expressions for integers [Odijk 2013]. Here another example, inspired by [Yang et al. 2017:114]):

24. Possessive structures in Dutch with genitive-marked nouns (limited recursion, probably caused by limitations of genitive case assignment):

    (a) Jans moeder (Jan's mother, 'Jan's mother')

    (b) vaders moeder (father's mother , 'father's mother')

    (c) ???vaders moeders vader (fathers mothers father, 'father's mother's father')

25. Possessive structures in Dutch with possessive pronouns (unbounded recursion):

    (a) Jan z'n moeder (Jan his mother. 'Jan's mother')

    (b) de vader z'n moeder (the father his mother, 'the father's mother')

    (c) de vader z'n moeder d'r vader (the father his mother her father, 'the father's mother's father')

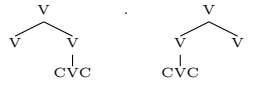
26. It is therefore not unreasonable to assume SB also operates in domains even if they are finite in nature, e.g. for syllables:

    (a) we assume (for the sake of the argument) that a syllable is always headed by a syllabic element

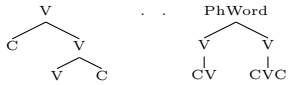
    - no syllable without a syllabic element
    - a syllabic element is (often) enough to form a syllable

    (b) Phonotactic constraints restrict recursion (with perhaps the Sonority Sequencing Principle [Selkirk 1984a,Clements 1990] playing a role)

    (c) (where V=[+syllabic], C=[-syllabic]) excluded structures:

    (d) not excluded structures:

    (e) which structures that are not excluded are actually justifiable I leave to the phonologists

27. Phonological phrases, metrical structure, metrical grids

    - are generated independently by the phonological module
    - resemble syntactic structures to some degree due to the alignment by the interface between the syntactic and the phonological modules
    - but are not necessarily isomorphic to syntactic structure [Selkirk 1981[1978]:138], [Nespor & Vogel 1986], [Scheer 2011:sec 146]:
        - portmanteau words might be separate formatives in the syntactic module, but a single morph in the phonological module
        - clitics might be independent in the syntactic module but form part of a word in the phonological module
        - in fact often a sequence of structures rather than a single structure [cf. Jackendoff 2002:118-119] as in [Chomsky & Halle 1968:371-372]'s example:
            * [This is [the cat that caught [the rat that stole [the cheese]]]] v.
            * This is the cat / that caught the rat / that stole the cheese
    - though almost none of this is fully uncontroversial (see e.g. [Samuels 2011:289])

Part D

28. Merge [based on Chomsky 2005:5]

    - *Merge*: an operation that takes n SOs already formed, and constructs from them a new SO.

29. Chunking: Miller (1956:11)
    - "grouping input events and apply a name to the group, and then remember the new name rather than the original input events".
30. A major use of SB is alleviating the limitations of short term memory by providing a systematic procedure to do "chunking" in the sense of [Miller 1956]. SB is an operation of Short Term Memory, which organizes the input sequence into chunks in the sense of Miller (1956:11).
31. elaboration here:
    (a) Working Memory (WM), which includes Short Term Memory(STM)
    (b) STM can contain only a small number of item (7+/- 2 [Miller 1956])
    (c) Elements in WM can only be accessed via a slot in STM
    (d) if a combinatorial rule is not applicable, it leads to overflow of STM for long sequences:

STM	m	n	g	l	s	a	a	*o*	*i*
WM									

32. combinatorial rules applicable:

STM	[+syll]	[+syll]	[+syll]	[+syll]					
WM	man	ga	li	so					

33. If, for an object sequence, a combinatorial rule exists and is applicable, SB can be applied. A combinatorial rule can be
    (a) automatic : fast, no external memory needed, few errors
    (b) not-automatic: slow, requires additional memory (pen and paper; keyboard and screen), and error-prone.
34. Examples
    (a) Phonology (automatic): Cf. /mnglsaaoi/ v. /mangaliso/ 9 phonemes v. 4 syllables
    (b) Orthography (automatic): Cf. mnglsaaoi v. mangaliso
    (c) Syllable sequences: perhaps rules for foot formation (perhaps even a foot within a foot [[Martínez-Paricio & Kager 2015,Kager & Martínez-Patricio 2018]), perhaps only grouping of a short sequence of syllables into a phonological word
        i. Long sequence of syllables processed with difficulty or not at all and only if you learn them by heart
        ii. Llanfairpwllgwyngyllgogerychwyrndrobwyll-llantysiliogogogoch
        iii. → each morpheme consists only of a small number of syllables
    (d) Decimal number notation (3458472748903), Roman number notation (MCMLXXXIII), programming languages: all not automatic

(e) Morphology (automatic)

(f) Syntax (automatic), cf. (34(f)i) v. (34(f)ii):

i. Get by of tired the sitting beginning was very on sister bank her Alice to

ii. Alice was beginning to get very tired of sitting by her sister on the bank

(g) C-I component (automatic)

(h) Discourse (automatic): discourse coherence rules

(i) Music (automatic)

Encapsulation

35. Modularity implies encapsulation: a rule in module M only 'sees' objects of module M (except where interfaces allow otherwise)

    (a) ⇒ operations in the syntactic module are not sensitive to phonological properties (basically correct)

    (b) ⇒ operations in the phonological module are not sensitive to syntactic properties (not obviously correct)

36. Examples:

    (a) nouns converted from verbs have initial stress in English (permít v. pérmit)

    (b) Dutch past tense (if a purely phonological solution is not possible cf. [Trommelen & Zonneveld 1979]

    - [+past] → tə/ [-voice] __
    - [+past] → də

    (c) English compound stress rule: a compound of category N, A, or V consisting of two elements receives primary stress on the initial element [Chomsky & Halle 1968:92-93]

    (d) (French) *de* + *le* → *du*, but only if *le* is an article (not when it is a personal pronoun)

    (e) French *ce*

    - (French) *ce* → *cet* / __V if ce is a demonstrative determiner (*cet homme, *c'homme*)
    - *ce* → *c'* / __V if *ce* is demonstrative pronoun (**cet est, c'est*)

37. if possible we want to avoid introducing ad-hoc exception features in phonology to cover such cases

38. I would like to explore the option where some syntactic rules have a corresponding phonological rule, just as Controlled M-Grammar [Rosetta 1994:ch 17, esp. section 17.4] does for syntax and semantics. The interface then operates at the derivation level and creates a partial correspondence at the derivation level. Certain phonological rules only fire when there is a corresponding syntactic rule (and v.v.).

39. Examples:
    (a) Compound rule: [X, Y] ⇒ Y[X,Y] ⇔ Compound Stress Rule W ⇒ [1 stress] / __##Z
    (b) any rule that creates a noun ⇔ assign primary stress by the Main Stress Rule
    (c) Past formation: V ⇒ [+past] ⇔ ∅ ⇒ tə/ [-voice] __ else də
40. This is still to be explored further in detail.

References

Chomsky 1957 *Syntactic Structures.* The Hague: Mouton

Chomsky 2004 Chomsky, N. (2004), 'Biolinguistics and Human Capacity', lecture delivered at MTA, Budapest, May 17, 2004 http://www.chomsky.info/talks/20040517.htm. Also appeared as Chapter 7 of Noam Chomsky, Language and Mind, Third Edition, Cambridge University Press pp 173-185.

Chomsky 2005 Chomsky, Noam (2005), 'On Phases', unpublished manuscript, MIT.

Chomsky 2008 Chomsky, Noam. On phases. In Robert Freidin, Carlos P. Otero, and Maria Luisa Zubizarreta, editors, Foundational issues in linguistic theory: Essays in honor of Jean-Roger Vergnaud, pages 133166. MIT Press, Cambridge, Mass., 2008.

Chomsky 2010draft Chomsky, N. (2010), 'Some simple evo devo theses: how true might they be for language?', downloaded from http://www.people.fas.harvard.edu/ fs39x/readings/chomsky-evodevo.pdf

Chomsky 2010a Chomsky, N. (2010), 'Some simple evo devo theses: how true might they be for language?', in [Larson et al. 2010], pp. 45-62.

Chomsky 2010b Chomsky, Noam (2010), 'The Mysteries of Nature: How Deeply Hidden', in J. Bricmont & J. Franck (eds.) Chomsky Notebook, pp. 3-33. New York: Columbia University Press.

Chomsky 2011 Chomsky, N. (2011), Lecture on Linguistics, Leiden, the Netherlands, March 14, 2011.
accessible via URL http://media.fsw.leidenuniv.nl/getmedia.php?id=5119

Clements 1990 Clements, G. N. (1990). The role of the sonority cycle in core syllabification. In J. Kingston and M. E. Beckman (eds.) Papers in Laboratory Phonology I: Between the grammar and the physics of speech. Cambridge: Cambridge University Press. 283-333.

HCF 2002 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.

Hulst 2010 Hulst, H. van der (2010). 'A note on recursion in phonology'. in H. van der Hulst (ed.) *Recursion and human language*, chapter 17, pp. 301-341. Berlin: De Gruyter.

Inkelas & Zec 1990 Inkelas, S. & D. Zec (1990), *The Phonology-Syntax Connection.* Chicago: Chicago University Press.

Jackendoff 2002 Jackendoff, R. (2002). *Foundations of Language.* Oxford: Oxford University Press.

Jackendoff & Pinker 2005 Ray Jackendoff & S. Pinker (2005), 'The nature of the language faculty and its implications for evolution of language (Reply to Fitch, Hauser, and Chomsky)', Cognition 97, pp 211-225.

Kager 1993 Kager, René (1993). Alternatives to the iambic-trochaic law. *Natural Language and Linguistic Theory* 11(3), 381432.

Kager 1995 Kager, René (1995). On foot templates and root templates. In M. den Dikken & K. Hengeveld (Eds.), Linguistics in the Netherlands 1995, 125138. Amsterdam: John Benjamins.

Kager et al. 2018 Kager, René, and Violeta Martínez-Paricio (2018). The internally layered foot in Dutch. *Linguistics* 56(1), 69-114.

Katz & Pesetsky 2011 Katz, Jonah & David Pesetsky (2011), 'The Identity Thesis for Language and Music', unpublished paper, Version 2.1, revised January 2011.

http://ling.auf.net/lingbuzz?_s=wduLKOtIeLoKRVHS&_k=Rfc_6Rz7P-wfS6s9&3

Koschmann 2010 T. Koschmann (2010), 'On the universality of recursion', Lingua 120, pp. 2691-2694. [Larson et al 2010] Larson, R.K., V. Déprez, and H. Yamakido (2010), The Evolution of Human Language - Biolinguistic Perspectives, Cambridge: Cambridge University Press.

Larson et al 2010 Larson, R.K., V. Dprez, & H. Yamakido (2010), The Evolution of Human Language - Biolinguistic Perspectives, Cambridge: Cambridge University Press.

Levinson & Evans 2010 Stephen C. Levinson & N. Evans (2010), 'Time for a sea-change in linguistics: Response to comments on 'The Myth of Language Universals", Lingua 120, pp. 2733-2758.

Miller 1956 Miller, G. A. (1956). "The magical number seven, plus or minus two: Some limits on our capacity for processing information". Psychological Review 63 (2): 81-97. doi:10.1037/h0043158. PMID 13310704. (pdf)

Martínez-Paricio & Kager 2015 Martínez-Paricio, Violeta, and René Kager (2015). The binary-to-ternary rhythmic continuum in stress typology: Layered feet and non-intervention constraints. *Phonology* 32(3), 459504.

Odijk 1993 Odijk, J. (1993), 'Natural Language, Communication, and Man-Machine Interfaces, unpublished paper, IPO, Eindhoven.

Odijk 2011 Odijk, J. 2011, 'The CC-Theory of the Origin of Language', downloadable from http://ling.auf.net/lingbuzz/001337

Odijk 2013 Odijk, J. 2013, 'Structure Building', lecture at the 'TIN-dag', Utrecht, 9 February 2013.

Rosetta Rosetta, M.T. 1994, *Compositional Translation*, Dordrecht: Kluwer Academic Publishers.

Selkirk 1984a Selkirk, E. (1984). On the major class features and syllable theory. In Aronoff & Oehrle (eds.) Language Sound Structure: Studies in Phonology. Cambridge: MIT Press. 107-136.

Selkirk 1984b Selkirk, E.O. (1984), *Phonology and Syntax: The Relation between Sound and Structure*. Cambridge, MA: MIT Press.

Stabler 2011 Stabler, E. P., 2011. Computational perspectives on minimalism. In C. Boeckx (Ed.), Oxford handbook of linguistic minimalism (p. 617-641). Oxford: Oxford University Press.

Trommelen & Zonneveld 1979 Trommelen, M. & W. Zonneveld (1979). *Inleiding in de Generatieve Fonologie*. Muidenberg: Dick Coutinho.

Yang et al. 2017 Yang, C., et al., The growth of language: Universal Grammar, experience, and principles of computation. *Neurosci. Biobehav. Rev.* 81, pp.103-119 (2017),

http://dx.doi.org/10.1016/j.neubiorev.2016.12.023