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this handout and some of the references quoted at
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WHY MODULARITY PREDICTS THAT THE RELATIONSHIP BETWEEN PHONETICS AND PHONOLOGY IS ARBITRARY

DAY 1
Brainstorming

(1) answer (short version)
- a. computational systems are domain-specific: they process units that belong to a specific vocabulary and hence cannot understand the vocabulary of the neighbour.
- b. hence they can only communicate through translation: spell-out.
- c. translation is done through a lexical access, e.g. at the upper interface {synt|phon}.
- d. consequence of lexical access: the relationship between the two items {X|Y} is arbitrary.
- e. the modular architecture governs all of the mind (and hence of grammar). Therefore the lower interface (phonology-phonetics) must also follow its workings.
- f. spell-out, post-phonological
  the output of phonology and its exponents in phonetics {phono|phonet}are related by a lexical access – hence their relationship is arbitrary.

Some issues

(2) grammar
- a. what is in, what is out?
  Minimalist definition (third factor): all and only those things that are specific to language.
- b. where exactly does the red line run?
- c. what exactly is non-grammar? Still a computational system in the modular sense?
- d. is phonetics a computational system? If so, what is its proprietary vocabulary?

(3) how do non-grammar and grammar communicate?
- a. non-grammar cannot be modular, can it?
- b. categorization in psychology:
  transforms a gradient (real-world) reality into a discrete mental object
  Harnad (1987, 2003)
- c. grammaticalization is categorization in language
- d. all items that are manipulated by grammar are grammaticalized real-world items:
  syntax: time, person, number, inalienability, animcay etc.
  phonology: labial, occlusion, palatal etc.
  semantics: quantification, negation, etc.
- e. can phonetics be a computational system given that it manipulates gradient objects?

(4) regularity
   a. produced by grammar = result of a rule system
      vs.
      produced by non-grammar = result of physical (real-world) regularities
   b. for any given regularity, how can we tell of which kind it is?
   c. physical origin
      no exception, no compromise possible
   d. origin in grammatical computation
      exceptions possible:
      - lexical marking
      - morphological restriction
      - diachronic "rule aging" (the life cycle of rules):
      exceptionless (phonetic) > morphological conditions > lexical conditions > ø

The Holy Grail

(5) size of phonology
   a. big is beautiful vs. small is beautiful
   b. SPE
      (and Hale & Reiss, see Maxime's class)
      any alternation you see is the result of phonological computation
      including *eye* - *ocular* or *sweet* - *hedonistic* etc.
      ==> big is beautiful
   c. post-SPE (70s)
      seeds in SPE's ninth chapter (=typology, markedness)
      we need to somehow restrict SPE because it wildly overgenerates: it can describe all phenomena that occur, but also all those that don't occur.
      ==> *generative* linguistics 101: "all and only".
      Result:
      the number of alternations covered by phonology is constantly decreased, in order to constrain the generative power of SPE
      - the abstractness debate (internal revision): Kiparsky (1968-73) and following
      - Natural (Generative) Phonology (revolution)
   d. compromise in the early 80s: Lexical Phonology
      tries to maintain the basic SPE system but imposes restrictions on the "distance" between underlying and surface forms.
   e. extreme version of anti-SPE: Government Phonology
      ==> small is beautiful
      ==> phonological theory must not be able to account for phenomena that are not phonological in kind.

(6) what is "natural"?
   a. innocent rule $k \rightarrow \widehat{ts} / \_\_i,e$
   b. suspicious rule $k \rightarrow s / \_\_i$
   c. crazy rule $k \rightarrow m / \_\_ŋ$

(7) example
English velar softening
a. k,g → s,d͡ʒ / __ i *electri*[k] - *electri*[s]-*ity*, *analo*[g]*ue* - *analo*[d͡ʒ]-*y*
b. cross-linguistic (and also diachronic) experience leads us to mistrust k → s:
typical results of palatalization are t͡s and t͡ʃ, or possibly [c]
c. velar softening also is riddled with restrictive phonological and morphological conditions
d. it occurs only before i, rather than before all front vowels
e. it is restricted to a number of suffixes, such as *-y*, *-ity* and *-ism* (which Kiparsky 1982:40f identifies as belonging to class 1):
- velar softening does not occur morpheme-internally (*king* is not pronounced *[s]*ing*)
- or before i-initial class 2 suffixes (*hik-ing* is not **hi*[s]-*ing*, etc.).
f. exceptions: *monar*[k] - *monar*[k]-*ism*, *patriar*[k] - *patriar*[k]-*y*.
g. productivity
while the alternation may be productive with recent loans, it fails the productivity test with words like *Iraq*: native speakers seem unable to even parse *Ira*[s]*ity* ("the property of being typically like Iraq"), but are able to make sense of *Ira*[k]*ity*.
h. summary
characteristics that arouse suspicion:
- limited regularity
- limited productivity
- morphological conditioning
- questionable phonetic/phonological plausibility.

(8) Small is beautiful
an alternation cannot be the result of phonological computation
a. if it is not 100% regular, i.e. surface-true OR
[Natural Generative Phonology, Government Phonology]
b. if it has conditioning factors that are morphological (i.e. non-phonetic) OR
[Natural Phonology, Natural Generative Phonology, Government Phonology]
c. if there is no plausible causal relationship between the change observed and the triggering context
[Natural Phonology, Government Phonology]

(9) Small is beautiful
If an alternation is not phonological in kind, what is it then?
==> outsourcing where to?
a. no computation I: the lexicon
electricity (and *electric*) is one single lexical item
b. no computation: post-phonological spell-out
no option for electricity, see below for examples.
c. non-phonological but grammatical computation I: allomorphy
stored (allomorphs): 1) electri[s], 2) electri[k]
morphological computation: -ity selects electri[s]
d. non-phonological but grammatical computation II: morpho-phonology
an independent computational system, traditional since structuralism, revived by Natural (Generative) Phonology, GP (Gussmann 2007)

e. non-phonological and non-grammatical computation: analogy
[today called Output-Output, paradigm uniformity]
you start with electric and construct the -ity suffixation by following what you know from other pairs such as opaque - opa[s]ity. Hence the [s] in the result electri[s]ity is a consequence of the [s] in opa[s]ity.

(10) post-phonological spell-out
a. introduced in Government Phonology under the label of
phonetic interpretation:
Harris & Lindsey (1995: 46ff), Harris (1996), Gussmann (2007: 25ff)
b. in the Cognitive Science context:
Scheer (2014)
c. its role
1. a player in Small-is-Beautiful (here)
2. but when placed in a CogSci context, enforcing arbitrariness of the relationship between phonology and phonetics (to come)

(11) example
of how labour is shifted from phonological computation to post-phonological spell-out (phonetic interpretation)
(9)b
a. in Polish, [ɛ] behaves in three different ways

1. palatalizing e	lot - loci-e	"flight Nsg, Lsg"
2. non-palatalizing e	lot - lot-em	"id. Nsg, Isg"
	rak - rak-iem	"crab Nsg. Isg"
3. post-velar e in recent loans	kelner "waiter", kemping "camping"	

b. classical analysis (Rubach 1984)
1. one-to-one match between phonological behaviour and phonetic substance:
- any item that is phonologically [+front] (or [-back]) palatalizes
- only items that are phonologically [+front] (or [-back]) palatalize
2. consequences
– palatalization is only triggered by [+front] (or [-back]) items
– in case a phonetically [+front] (or [-back]) item fails to trigger palatalization, it cannot be [+front] (or [-back]) by the time the palatalization process applies.
3. ==>
– Isg -em is /-ɤm/ (where /ɤ/ is a back unrounded vowel, distinct from /ɔ/ through roundness).
– rule ordering:
1. palatalization (/-ɤm/ has no effect)
2. context-free transformation of /-ɤm/ into /-ɛm/ *by phonological computation*
– hence there is an additional vowel in the inventory of Polish, /ɤ/,
which is absolutely neutralized
c. Gussmann (2007: 56ff)
1. there are three phonologically distinct [ɛ]'s
– palatalizing e (lot - loci-e "flight Nsg, Lsg"): I--A
– non-palatalizing e (lot - lot-em "id. Nsg, Isg"): __--I--A
– post-velar e in recent loans (kelner, kemping): A--I
2. which all bear the palatal agent I, though in different function (no automaticity of palatalization in presence of the palatal agent)
3. I palatalizes only when it is the head (underscored) of the segmental expression.

4. the "surface neutralization" of the three e's occurs during post-phonological spell-out (phonetic interpretation), rather than *in* the phonology (by phonological computation).
5. spell-out
   I-A ↔ [ɛ]
   _-I-A ↔ [ɛ]
   A--I ↔ [ɛ]

(12) Inuit
Dresher & Compton (2011)

a. if a non-palatalizing front vowel lacks the phonological prime for frontness, how come it is pronounced front?
   ==> spell-out may decide so.
b. Inuit dialects
   two [i]'s:
   1. palatalizing ("strong" i)
   2. non-palatalizing ("weak" i)
c. strong i < Proto-Eskimo i
   weak i < Proto-Eskimo schwa
d. weak i
   1. does not palatalize
   2. but also is also subject to other processes such as assimilation, dissimilation and deletion
e. conclusion:
   1. weak i has no phonological substance: it is synchronically empty (= "_") just like it was in Proto-Eskimo
   2. the diachronic change is only in the spell-out relation:
      the modern ([i]) and the ancient ([ə]) pronunciation realize the same phonological unit, schwa.
      _ ↔ ə > _ ↔ [i]
      while nothing has changed for strong i: I ↔ [i] > I ↔ [i]
   3. synchronic situation
      _ ↔ [i]
      I ↔ [i]
f. the phonology of the modern dialect and Proto-Eskimo is exactly the same, nothing has changed. The only thing that changed is the way the output of phonological computation is pronounced: spell-out.

(13) big is beautiful
may be compelling but is dangerous: it opens Pandora's box
==> the island problem

a. following its logic, there are no grammatical restrictions at all that a human investigator could ever identify based on the empirical record.
b. there could be a language hidden on an island, dead or not yet born where
   - binding is the reverse of what it is everywhere else
   - stress is assigned to prime-numbered syllables
   - open syllable shortening occurs

c. prime-numbered syllables
Hale & Reiss have tried to find the most outlandish conditioning possible, but by doing so behave exactly like the small is beautiful people who also reject outside of grammar what appears outlandish to them.
Outlandishness is a matter of taste…

(14) the Holy Grail
[says Ricardo Bermudez-Otero]
a. will be found the day phonologists are able to determine exactly which alternations are the result of phonological computation, and which ones are not.
b. unless we are able to do that, we are fishing blind:
like, say, geologists who want to make a theory of geology and for that purpose analyze stones, but are unable to distinguish plastic from stone.
Guess what competing theories look like that
- analyze 10% plastic
- analyze 30% plastic
- analyze 70% plastic
- analyze 90% plastic

The locus of arbitrariness

(15) A → B / C__D
what exactly is arbitrary / interchangeable
a. Substance-free phonology (Hale & Reiss) says:
no restriction on A, B, C, D
- any segment can instantiate any letter
- anything and its reverse is possible
b. "→" is not arbitrary
1. possible: [αX] → [-αX] / __[αX]
describes a dissimilation
2. impossible: [α{X,Y,Z,…}] → [-αX{X,Y,Z,…}]
describes a dissimilation that requires the two segments to be distinct, but not with respect to a specific feature [X]. Rather, with respect to any feature: which one does not matter: {X,Y,Z,…}.
==> the segments need to be different, no matter by which property.
==> this does not occur in natural language, hence phonological computation must not be able to do that.
Reiss (2003)
3. again: there could be a language on an unknown island where the "impossible" rule occurs.
Reiss is doing for "→" what he says should not be done for substance: reasoning about typology and "existing" vs. "non-existing" patterns.
c. A, B, C, D are only arbitrarily distributed in case they stand for substance = melody = features.
If they stand for other items in phonology they are NOT arbitrary
1. example: syllable structure
closed syllable shortening VV → V / __Coda
2. VV, V and Coda cannot be flipped around / are not interchangeable:
impossible: V → VV / __Coda
impossible: VV → V / __Onset

(16) locus of arbitrariness

a. substance-free phonology also says:
   1. only melody (substance, A, B, C, D above) is arbitrary
   2. other things in phonology are not: e.g. syllable structure

b. why not?
   ==> the island problem
   1. there could be a language on an island that has closed syllable lengthening
   2. there could be a language on an island that has reverse Binding
   etc.
   ==> nothing can ever be excluded in grammar, there is no UG and language slavishly follows whatever the environment provides. See (13).

c. Hale & Reiss' answer:
   substance abuse
   Hale & Reiss (2000)
   1. Occam: phonology must not replicate what phonetics is in charge of anyway.
   2. syllable structure is not taken care of anywhere else, hence it's the job of phonology
   3. that's one possible way to locate arbitrariness, i.e. here to restrict it to melody (=substance).
   4. but this does not get the island problem out of the way:
      see b).

d. Maxime's answer (first week class)
   Artificial Language Experiments
   1. whatever can be learned is a possible grammatical process
   2. only what cannot be learned lies outside of grammar (ex.: #__ - __# dependencies)
   3. well, learning and grammar are two different things
   4. the fact that something can be learned does not imply that it is run by grammar
   5. you can learn to memorize 10 different items, but that has got nothing to do with grammar.
   6. critical period: we know for sure that adults don't use the same mechanisms as infants when they learn a language.

==> we need an independent way of locating / restricting arbitrariness.

(17) locus of arbitrariness by modularity

a. modularity makes a precise prediction regarding the locus of arbitrariness:
   1. computational systems are not arbitrary
   2. the lexicon is. The lexicon is THE home of arbitrariness.

b. the modular architecture has a lexicon whenever there is spell-out
   1. vocabulary insertion (converting morpho-syntactic into phonological vocabulary)
   2. phonetic interpretation (GP term, converting phonological into phonetic items)

c. lower spell-out
   1. relates the output of phonology with phonetics = substance – this relationship is therefore arbitrary.
   2. spell-out = A↔ B
   2. Syllable structure (or Binding etc.) in itself is not related to any lexicon in any way: it is a regular bottom-up construction where basic units (phonemes) project structure.

d. hence
   _ ↔ [i]
   I ↔ [i]

e. but what about
   I ↔ [e]
   I ↔ [u]
   k ↔ [y]
   p ↔ [o]

DAY 2

1. Modularity in Cognitive Science

1.1. Workings

(18) general description
the mind (and ultimately the brain) is made of a number of **computational systems** that are
a. specialized in a specific task
b. non-teleological
c. symbolic
Fodor (1983), Coltheart (1999), Gerrans (2002), Carruthers (2006)

(19) core properties of cognitive modules according to Segal (1996: 145)
a. **domain specificity**
b. **informational encapsulation**
c. obligatory filtering
d. fast speed
e. shallow outputs
f. limited inaccessibility
g. characteristic ontogeny
h. dedicated neural architecture
i. characteristic patterns of breakdown

(20) modules are **domain-specific**
a. they work with a specific symbolic vocabulary that is distinct from the vocabulary of other modules.
==> different languages of the mind
b. for example, the input to visual and auditory computation is made of distinct items, which will be unintelligible by modules that they do not belong to.
c. That is, an auditory input to the visual system will provoke no reaction at all: the data are simply ignored since they cannot be parsed.
d. ==> every module can only parse items that belong to its own proprietary vocabulary.

(21) modular computation
a. based on their domain-specific input vocabulary, modules perform a computation whose output is structure.
b. for example, syntactic computation (whose central tool is Merge in current minimalism) takes as its input features such as gender, number, person, tense etc., and outputs hierarchized syntactic structure, i.e. trees.

(22) domain specificity requires **translation**
   a. a direct consequence of the fact that different modules speak different languages (of the mind) is their inability to understand each other. Modules can only parse objects that belong to their own language, i.e. which are part of the domain-specific vocabulary that they are designed to process.
   b. "'Mixed' representation[s] should be impossible. Rather, phonological, syntactic and conceptual representations should be strictly segregated, but coordinated through correspondence rules that constitute the interfaces." Jackendoff (1997:87ff)
   c. ==> intermodular communication must rely on translation of items from one vocabulary into another.

(23) how do we identify modules?
   a. **domain specificity**
   b. **informational encapsulation**
   c. based on pathologies: double dissociation

1.2. History and the connectionist competitor

(24) history
   a. Franz-Josef Gall (1758-1828), phrenology
   b. implicit in the Turing - von Neumann model that underlies the so-called cognitive revolution of the 50s-60s (Gardner 1985)
   c. Chomsky & Halle's (1968) description of the phonological rule system:

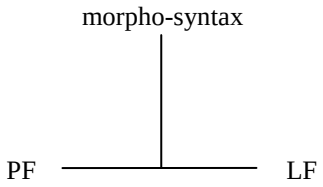
      "The rules of the grammar operate in a mechanical fashion; one may think of them as instructions that might be given to a mindless robot, incapable of exercising any judgment or imagination in their application. Any ambiguity or inexplicitness in the statement of rules must in principle be eliminated, since the receiver of the instructions is assumed to be incapable of using intelligence to fill in gaps or to correct errors." Chomsky & Halle (1968:60)
   d. modern and explicit incarnation: Fodor (1983) and following

(25) competing model of the mind: connectionism
   a. Rumelhart *et al.* (1986) and following
   b. issues:
      – parallel, instead of serial computation
      – colourless (content-free) computation: computation is all-purpose, rather than (domain) specific
      – consequence: computation is non-symbolic
      – non-distinction between storage and computation: rule-list fallacy
      – reductionsim (eliminativism): there is no mind, the brain is the only relevant entity
   c. in linguistics: "Cognitive" Linguistics, Langacker (1987) and following, see e.g. Taylor (2002) for an overview.
   d. overview literature:
      Pinker & Mehler (eds.) (1988), Dinsmore (1992), Pylyshyn (1999), Rumelhart (1989), Stillings *et al.* (1995:63ff), Thagard (2005:111ff)

2. Modularity in language

(26) the standard model: inverted T

a. three independent and domain-specific computational systems:
1. (morpho-)syntax = the concatenative system, whose output is interpreted by
2. phonology (PF) = assigns a pronunciation
3. semantics (LF) = assigns a meaning
Chomsky (1965: 15ff)



(27) **phonology vs. the rest**

a. if we go by domain specificity,
the major ontological gap in language is between phonology and the rest.

Vocabulary used in syntax, morphology, semantics:	phonology:
number	
person	labiality
gender	friction
animacy	voicing
quantification	occlusion
aspect	

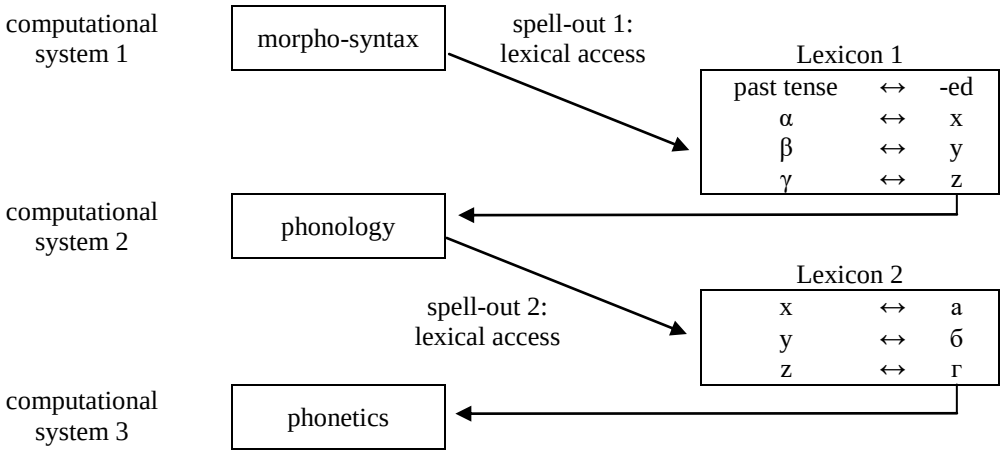
b. Jackendoff's (1987, 1992, 1997) Representational Modularity
(called Structure-Constrained Modularity today, Jackendoff 2002: 218ff)

> "The overall idea is that the mind/brain encodes information in some finite number of distinct representational formats or 'languages of the mind.' Each of these 'languages' is a formal system with its own proprietary set of primitives and principles of combination, so that it defines an infinite set of expressions along familiar generative lines. For each of these formats, there is a module of mind/brain responsible for it. For example, phonological structure and syntactic structure are distinct representational formats, with distinct and only partly commensurate primitives and principles of combination. Representational Modularity therefore posits that the architecture of the mind/brain devotes separate modules to these two encodings. Each of these modules is domain specific.
> […] The generative grammar for each 'language of the mind,' then, is a formal description of the repertoire of structures available to the corresponding representational module." Jackendoff (1997: 41)

c. Chomsky (2000)
"The phonological component is generally assumed to be isolated in even stronger respects: there are *true* phonological features that are visible only to the phonological component and form a separate subsystem of FL [the Faculty of Language], with its own special properties." Chomsky (2000: 118, emphasis in original)

d. Late Insertion = segregation of phonological vocabulary
while up to Government & Binding (80s), morpho-syntactic computation was done on the basis of complete lexical information that included syntactic, morphological and semantic features as much as phonological material (sealed suitcases), Late Insertion is the idea that phonological material is absent from morpho-syntactic computation

(28) fragment of grammar involving phonology



3. Communication between morpho-syntax and phonology

(29) derivational and representational communication
morpho-syntax may influence phonology through two distinct channels
a. representational
b. derivational
==> Interface Dualism, Scheer (2011)

(30) representational: **translation**
a. a morpho-syntactic object is translated into a phonological object, which is then inserted into the phonological representation.
b. this is called **vocabulary insertion**, or **Spell-Out**
(today done somewhere at PF)
Spell-out converts portions of the morpho-syntactic structure into phonological material.
c. vocabulary insertion is done through a **lexical access**:
items stored in long-term memory (morphemes) compete for insertion of relevant portions of the morpho-syntactic structure
d. example for the translation of morphemes
in English, the morpho-syntactic object
- <number = sg>
- <person = 3>
is translated into phonological vocabulary and appears in the linear string as
-s (he live-s)

(31) derivational: the cycle (phase theory)
   a. since Chomsky *et al.* (1956: 75), morpho-syntax may also impact phonology through cyclic derivation, today called **phase theory**
   b. nothing is translated
   c. there is no lexical access
   d. workings
      [[[A] B] C] is interpreted successively from inside out:
      1st round: [A] is interpreted (by PF and LF)
      2nd round: [AB] is interpreted (by PF and LF)
      3rd round: [ABC] is interpreted (by PF and LF)

      ==> hence [[[A] B] C] and, say, [[A] BC] produce different results

      "[ ]" is called a phase and the distribution of phases over syntactic structure is a currently debated question.

(32) we will only look at representational communication
   a. **domain specificity** marshals representational communication
   b. **encapsulation** is relevant for derivational communication (and phase theory has modified the picture quite a bit, but this is another story…)

4. History of translation and its violation in generative phonology

(33) definition
   domain specificity and hence modularity is violated when phonology makes reference to **untranslated** morpho-syntactic information

(34) SPE
   [The Sound Pattern of English, Chomsky & Halle 1968]
   a. boundary information
      there is a translation procedure: **non-morphemic** morpho-syntactic information is translated into so-called boundaries #

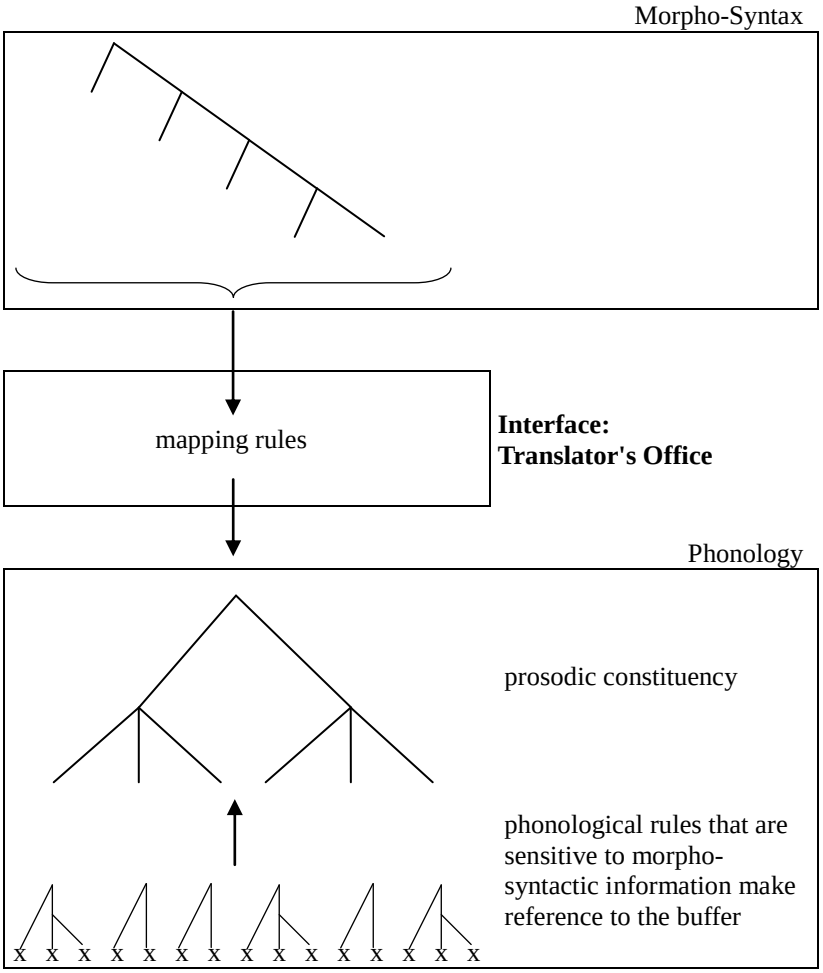
      example: class 1 vs. class 2 affixes in English:
      párent = bare root, penultimate stress
      parént-al = root + class 1 affix, penultimate stress
      párent # hood = root + class 2 affix, root stress (stress assignment blocked)
   b. but there is also reference to untranslated information:
      labelled brackets
      $[[\text{electric}]_{\text{Adj}}\ \text{ity}]_{\text{Noun}}$
      - brackets are aliens: non-parsable by the phonology
      - labels (Adj. etc.) are untranslated information

(35) 80s: Prosodic Phonology
Selkirk (1981 [1978], 1984), Nespor & Vogel (1986)

a. emerged from the conflict with the so-called Direct Syntax approach that proposes to make direct reference to untranslated morpho-syntactic information, hence to
==> abandon translation altogether
Kaisse (1983, 1985, 1990), Chen (1990), Odden (1987, 1990), Pyle (1972), Rotenberg (1978), Clements (1978)
==> the conflict was decided in favour of Prosodic Phonology in the mid-80s.

b. domain specificity is called **Indirect Reference**
[but strangely enough, no reference is made to modular theory]
==> the architecture is perfectly modular:
   1. phonological computation makes reference only to translated information
   2. translation is done in **modular no-man's land** (neither morpho-syntax nor phonology)
   3. translation is **computational**: mapping rules are RULES, i.e. carry out a computation in its own right.

(36) general architecture of Prosodic Phonology



(37) Optimality Theory (OT): massive violation
since the 90s
[Scheer 2011:§523]
a. constraint-based mapping with ALIGN: translation is done IN the phonology, and this is a permanent violation of domain specificity.
b. so-called interface constraints: a modern version of Direct Syntax
c. sometimes modularity as such, in language and elsewhere in the mind, is declared wrong: Burzio (2007)
d. OT has roots in connectionism, and hence a scrambling trope: one of its founders, Paul Smolensky, was also at the forefront of the development of PDP:
e.g. Smolensky (1987)

(38) current minimalist syntax has created a monster: PF
[Chomsky 2000 and following]
a. empty (narrow) syntax, pump up PF: clean syntax, dirty phonology?
b. PF used to be coextensive with "phonology", or "phonological computation"
c. it has now become an agora for all kinds of operations that have got nothing to do with phonological computation.
==> one of them is a strong modularity offender: PF Movement
[Embick & Noyer 2001 and following]
PF Movement moves items along the syntactic tree, but the movement is triggered by phonological properties.

5. Core properties of translation

(39) translation is **selective**
partial homology (Jackendoff 2002)
a. only a subset of the properties of the sending module is made available to the receiving module.

> "Correspondence rules perform complex negotiations between two partly incompatible spaces of distinctions, in which only certain parts of each are 'visible' to the other." Jackendoff (1997: 221)

> "The overall architecture of grammar consists of a collection of generative components G_1, …, G_n that create/ license structures S_1, …, S_n, plus a set of interfaces I_{jk} that constrain the relation between structures of type S_j and structures of type S_k. […] Typically, an interface I_{jk} does not 'see' all of either S_j or S_k; it attends only to certain aspects of them." Jackendoff (2002: 123)

b. the amount of structure that is visible for interface processors in a given module may be small or big, and this is unpredictable: the translational channel between two modules may have a more or less narrow "information bottleneck" (Jackendoff's 2002: 229 term).
c. well supported in language:
morpho-syntax and melody (i.e. items below the skeleton) are incommunicado in both ways

(40) translation is **arbitrary**
Jackendoff (2002)
a. which pieces of the structure of the sending module are translated cannot be predicted.
b. well supported in language:
the mapping puzzle (Scheer 2011): all efforts at finding cross-linguistic patterns of translation have been by and large vain. That is, phonologists could not come up with natural classes of boundaries.

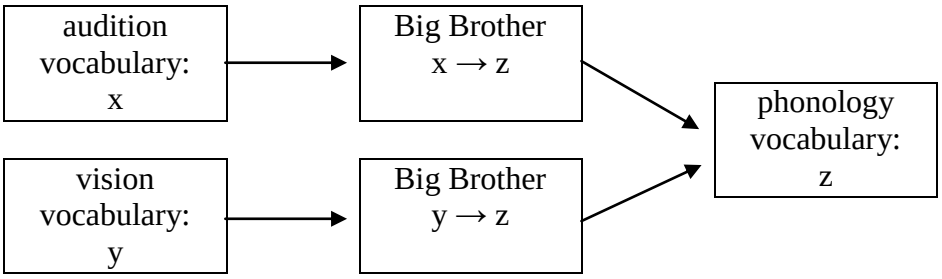
(41) modules receive variable inputs, but produce a uniform output
a. many-to-one
modules may draw on information that comes from a range of other modules
1. example: in perception, phonology is fed at least by acoustic-phonetic and visual information.
==> McGurk effect (McGurk & MacDonald 1976, Ingleby & Azra 2003)
2. The circuitry of visual stimuli that reach grammatical processing appears to be different from auditory stimuli, but processed by the auditory cortex (Calvert & Cambell 2003).
3. interestingly, the McGurk input into the phonological module appears to be the complementary set of what morpho-syntax can provide: melodic primes.
b. one-to-many
the output of a given module may be used as the input to a range of other modules
audition
provides information for a number of very different modules: sound is processed by
- all-purpose audition (e.g. the perception of sound that is produced by animals)
- voice recognition (the identification of humans according to their voice)
- auditory affect perception (emotion detector)
- perception of linguistically relevant phonetic material
c. consequence
variable input vocabularies that are all mutually unintelligible must be translated into the proprietary vocabulary of the receiving module.

6. Computational translation (in general)

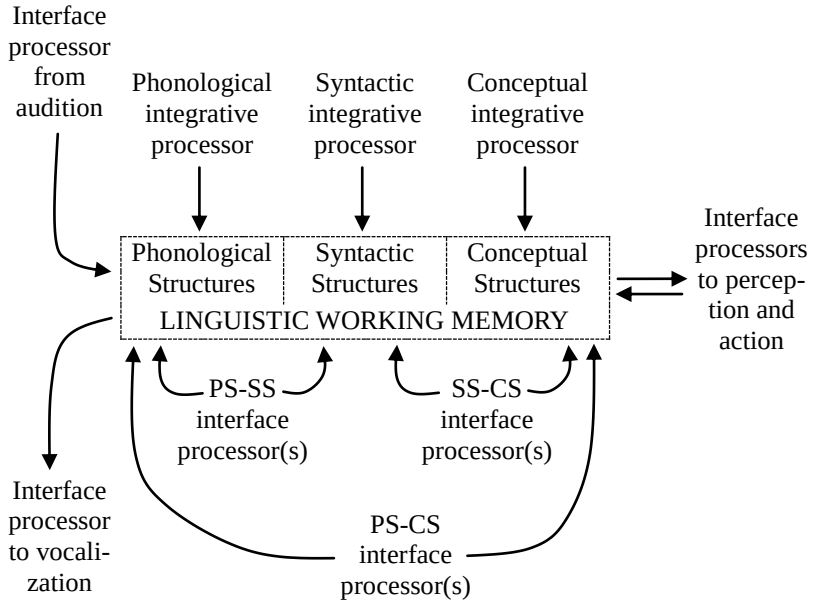
(42) computational translation
a. translation has always been conceived of as computational
- readjustment rules (SPE)
- mapping rules (Prosodic Phonology)
- correspondence rules (Jackendoff)
all are a computation in its own right, i.e. distinct from either the sending or the receiving module.
b. **Big Brother**
translation by computation requires the Translator to have access to both the vocabulary of the sending and the vocabulary of the receiving module.
==> violation of domain specificity
c. Jackendoff (2002: 229) tries to discuss away this contradiction with the help of the word "bi-domain specificity": interface modules are domain-specific like all others, but they are super-modules and therefore can be specific to two domains.
==> contradiction in terms

(43) which status do computational devices have that do translation?
   a. ==> they can only be modules, since there is nothing in modular theory that carries out computation apart from modules.
   ==> but they cannot be modules because they violate domain specificity.
   b. in Jackendoff's model (where modules are called processors):
   1. inferential processors (Fodor's central systems)
   2. integrative processors (Fodor's modules)
   3. interface processors
   integrative processors are related by interface processors.

(44) reduction of variable inputs to a uniform output
   a. no trouble for computational translation: on their input side, modules have a Big Brother for each different vocabulary that they are fed with.
   b. example [audition, vision] → phonology

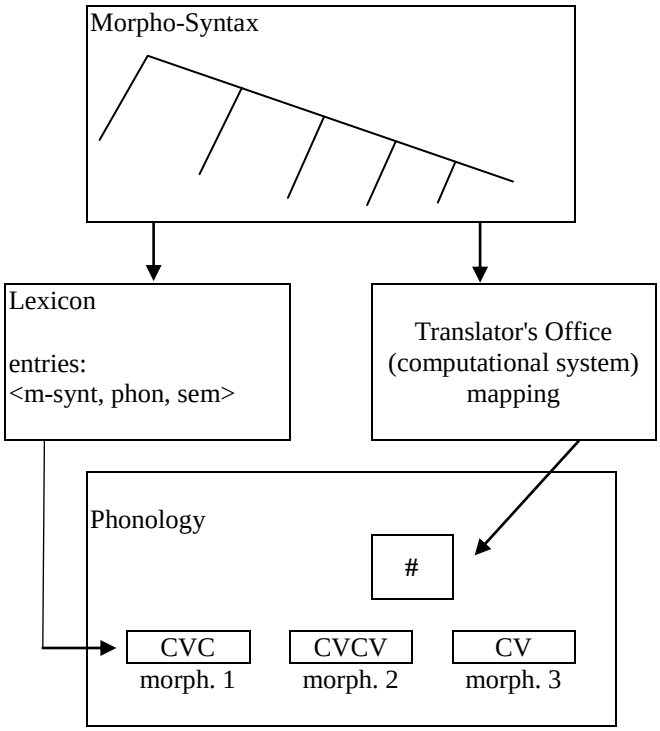


(45) modular structure of language according to Jackendoff
(reproduction of a chart from Jackendoff 2002: 199)



7. Computational translation (in language)

(46) translation in generative interface thinking
Two Channel



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(47) mixed lexical and computational translation
a. lexical translation
morphemic information is transformed into phonological material through a lexicon:
- <number = sg>
- <person = 3>
==> morpheme injected into phonology: -s
3sg ↔ -s
b. computational translation
non-morphemic (boundary) information is transformed into phonological objects by a computational process:
párent = bare root, penultimate stress
parént-al = root + class 1 affix, penultimate stress
párent # hood = root + class 2 affix, root stress (stress assignment blocked)

(48) major difference
both lexical and computational translation insert an item into the phonological string, but
a. lexical translation
the origin of that item is the lexicon: there is **a lexical access**
==> morphemic information (vocabulary insertion)
b. computational translation
the origin of that item is not the lexicon: there is **no lexical access**
==> boundary information (i.e. non-morphemic: #, ω etc.)

(49) linearisation
   a. is a complicated and debated problem
      e.g. Kayne's (1994) Linear Correspondence Axiom (LCA), Richards (2004, 2007), Bobaljik (2002), Embick & Noyer (2001, 2007) and Embick (2007).
   b. somebody must decide the linear order in which objects that represent morphemic and non-morphemic information are pieced together.
      ==> what is for sure is that the input to phonological computation is a linearly orderd string: linearisation is done prior to phonology.

8. One-Channel Translation (i.e. only lexical)

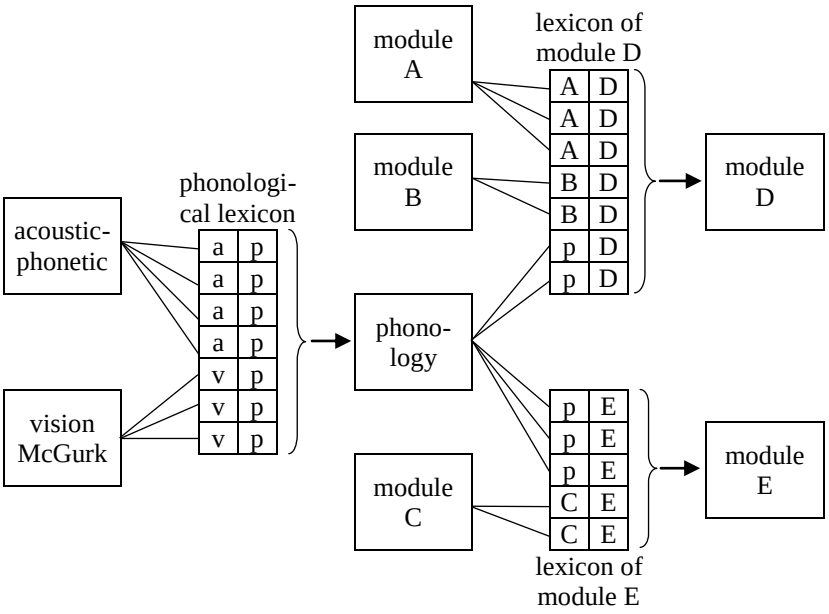
Scheer (2012)

(50) translation bears the signs of **lexical** activity
   a. arbitrary relations of an input and an output
   b. refusal to obey cross-linguistic lawful behaviour

(51) other arguments for **lexical translation**
   a. Big Brothers violate domain specificity
   b. economy / Occam's Razor: lexical translation uses the resources of modular theory that are needed anyway.
      Modularity knows only
      1. modules
      2. lexica
      3. eventually central systems

(52) reduction of variable inputs to a uniform output
   a. instead of having a number of Big Brothers, modules have a proprietary Lexicon on their input side.
   b. this Lexicon has variable inputs (i.e. written in the distinct vocabularies of the different inputs), but a uniform output, i.e. only into the phonological vocabulary.
   c. in this perspective, lexical entries are pairs of arbitrarily associated items which belong to two different domains.

(53) intermodular communication through a lexical access



(54) well-known problem of translation by computation: all-powerfulness
Jackendoff defends all-powerful translation against the critique of overgeneration, i.e. the fact that unconstrained transmission of information allows for the description of existing as much as non-existing interface activity.

> "correspondence rules are conceptually necessary in order to mediate between phonology, syntax, and meaning. It is an unwarranted assumption that they are to be minimised and that all expressive power lies in the generative components. […] In other words, correspondence rules, like syntactic and phonological rules, must be constrained so as to be learnable. Thus their presence in the architecture does not change the basic nature of the theoretical enterprise." Jackendoff (1997: 40)

(55) lexical translation constrains translation: anything is not possible

a. anything that reaches phonology must originate in the lexicon.
Hence boundary information must qualify for being stored in the lexicon

b. **morpho-syntax has no bearing on phonological computation**
==> explanation
for the fact that morpho-syntax NEVER alters phonological computation: computational instructions cannot be its output. By contrast, there is nothing wrong with that in principle if translation is computational.

c. **diacritics are outlawed**
the output of the translation of boundary information are necessarily pieces of the proprietary phonological vocabulary: only such vocabulary can be stored in the lexicon.
==> diacritics are outlawed
this is a valuable benefit since the output of translation of boundary information has always been diacritics: "+", "#", "ω", "φ" etc.
==> diacritic-free Interface is the gist of Direct Interface: Scheer (2008b, 2012).

d. **morpho-syntax has no bearing on morpheme-internal phonology**
however linearisation works, the linear input string to phonology is made of pieces that represent morphemic as well as non-morphemic information. Since both have the same origin – the lexicon –, boundary information must have exactly the same linear identity as morphemes: it must incarnate as identifiable pieces of the linear string.
   1. ==> there is no linear requirement when translation is computational: prosodic constituency does not have any linear identity (it is a tree structure erected over morphemes)
   2. ==> explanation
   of the observation that morpho-syntax has no bearing on morpheme-internal phonology: only edges may be modified.

DAY 3
Spell-out, post-phonological

1. The modular view of the phonology-phonetics interface

(56) two distinct computational systems?
   a. are phonology and phonetics two distinct computational systems?
   b. if they are not, there is no interface in the first place, and hence no point in applying the workings of the other interface.
   c. the question whether phonetics is just low-level phonology, rather than ontologically distinct, is the subject of a long-standing debate.
   d. coming from connectionism (Smolensky 1988), OT is genetically endowed with a **scrambling tropism** that blurs or does away with modular contours, on both ends of phonology: morphological and phonetic constraints are typically interspersed with phonological constraints in the same constraint hierarchy, and characteristics of two domains (phonology-phonetics, phonology-morphology) often co-occur in the formulation of constraints.
   e. The alternative view that upholds a modular distinction between phonology and phonetics is also represented in the literature, though (see the overview in Kingston 2007), see Silke's class.
   f. we proceed on the assumption that phonology and phonetics are
      - two distinct computational systems
      - hence that can communicate only through translation

(57) consequence
   a. there must be a **spell-out** operation that converts the output of phonology into units of the phonetic vocabulary.
   b. as was shown, modular spell-out has a number of properties that then must also apply to its post-phonological instantiation, and which entail a number of consequences:

(58) the phonology-phonetics interface conceived of as

post-phonological Spell-Out

i.e. the spell-out of the result of phonological computation (phonological structure) as vocabulary items of the phonetic module.

2. Post-phonological spell-out: four core properties

(59) #1
Lexical access: list-type conversion
   a. the match between phonological structure and phonetic exponents thereof is done through a **lexical access**. That is, the conversion is list-type, or one-to-one: a phonetic item X is assigned to a phonological item A.
   b. the dictionary-type list in question is hard-wired, i.e. stored in long-term memory and not subject to any influence from (phonological or any other) computation. It does undergo diachronic change, though.

(60) #2

No computation

a. the difference between list-based and computational conversion is the absence of an input-output relationship in the former: the two items of the correspondence are not related by a computation that transforms one into the other.
b. nothing is said about the nature and the size of the phonological structure A and its phonetic exponent X.
    1. Namely, there is no segment-based implicit: the phonological units that are screened by the spell-out mechanism may comprise one or several timing units (x-slots).
    2. Basic autosegmental principles apply: only those melodic items that are associated to timing/syllable structure are transmitted to the phonetics (i.e. floating melody is not). This property of the spell-out mechanism is universal.

(61) #3

The match is arbitrary

a. recall that a fundamental property of translation is the arbitrariness of the two items of distinct vocabularies that are related.
b. This follows from the fact that translation is list-based: like in a multilingual dictionary, there is no reason why "table" has the equivalent "stół" in Polish, "Tisch" in German or "udfirk" in some other language.
c. A consequence of arbitrariness is what Kaye (2005) calls the "**epistemological principle of GP**"
    1. the only means to determine the phonological identity of an item is to observe its (phonological) behaviour. Its phonetic properties will not tell us anything.
    2. That is, in case spell-out "decides" to have a given phonological structure pronounced by a rather distant phonetic exponent, its phonetic properties may be opposite to its phonological identity and behaviour.
    3. For example, if an /u/ is pronounced [i], it will not palatalise despite its being front phonetically. Relevant examples are discussed below.

(62) #4

Conversion is exceptionless

a. A basic criterion for classifying alternations as morpho-phonological, allomorphic, phonological, analogical, lexical or phonetic is the presence of exceptions.
b. The whole notion of exception makes only sense when both alternants are related by computation: an exception is an exception to an expected result, i.e. the application of an algorithm that transforms X into Y.
c. If, say, *electric* and *electricity* are two distinct lexical items, it does not make sense to say that *antique* - *antiquity* is an exception to the k - s-ity pattern: there is no such pattern in the first place.
d. Hence talking about exceptions supposes computation. Since the match of phonological structure and its phonetic exponent does not involve any computation, it must be exceptionless.
e. This is indeed what we know from the morpho-syntax - phonology spell-out: there is no variation, there are no exceptions in the assignment of phonological material to morpho-syntactic structure.
f. ==>

    What that means is that among all alternations found in language, only those that are exceptionless can possibly be due to post-phonological spell-out.

(63) exceptionlessness = phonetic proximity
The idea that exceptionlessness and "proximity" to phonetics are strongly related is a long-standing insight:
a. exceptionless alternations are often called
1. "low level",
2. "surface palatalization" (in Polish) or,
3. quite aptly (for bad reasons though), "late"
4. post-lexical
b. Alternation Condition (Kiparsky 1968-73: 18):
"if a form appears in a constant shape, its underlying form is that shape, except for what can be attributed to low-level, automatic phonetic processes."
In English, the aspiration of voiceless stops (as in p^hólitics - p^holit^{h}ícian) is of this kind: automatic, exceptioneless and hence close to phonetics.

(64) "late": inside vs. outside of phonology
a. the literature in question
continues to place the processes and hand *in* the phonology: "late" means "towards the end of the application of ordered rules" in SPE.
b. in the present modular approach
1. "late" means "outside of the phonology"
2. the alternations in question arise **during post-phonological spell-out**.
c. in our English example there is no rule or constraint that converts p,t,k into p^h,t^h,k^h in appropriate (initial and stressed) contexts. Rather, aspirated and plain p,t,k are identical objects in the phonology: the result of phonological computation is p,t,k in all contexts; these consonants are then spelled out as aspirated in initial and stressed contexts, while they have a plain phonetic exponent elsewhere.

(65) post-phonological spell-out
puts a cognitive name on what is known in Government Phonology as *phonetic interpretation*
Harris & Lindsey (1990, 1995: 46ff), Harris (1996), Gussmann (2007: 25ff)

3. Issues addressed by post-phonological spell-out

(66) #1
how much of the alternations that we observe on the surface is exactly the result of phonological computation?
==> see DAY 1

(67) #2
virtual length
a. the length of phonologically long vowels and phonological geminates may be marked in the phonetic signal by duration, but also by other means: there is no reason why phonological length should always be flagged by duration.
Virtually long items do not betray their length by phonetic cues related to duration, but by other properties that can be read off the signal.

b. vowel length has been found to be expressed by
   1. ATRness in French
      Rizzolo (2002)
   2. vowel reduction
      - Semitic (Lowenstamm 1991, 2011)
      - Ge'ez (Old Ethiopian) (Ségéral 1996)
      - Kabyle Berber (Bendjaballah 2001, Ben Si Saïd 2011)
   3. stress
      in Apulian dialects of Italian (Bucci in press)

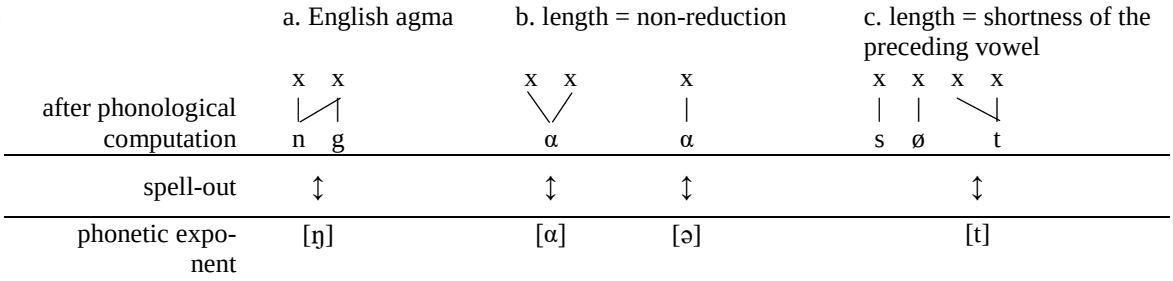
c. phonological geminates have been found to be expressed by
   1. the length of the preceding vowel
      - German (Caratini 2009)
      - Cologne dialect of German (Ségéral & Scheer 2001)
      - English (Hammond 2007)
   2. the (non-)inhibition of a preceding vowel-zero alternation
      Somali (Barillot & Ségéral 2005)
   3. aspiration
      English (Ségéral & Scheer 2008)
   4. preaspiration
      Icelandic and Andalusian dialects of Spanish (Curculescu 2011)

d. examples from English
   1. agma
      [ŋ] is /ng/:
      - it occurs only after short vowels
      - it does not occur word-initially
      Gussmann (1998), Dressler (1981) for German
   2. distribution of short/lax vs. long/tense vowels in English
      short/lax vowels occur in closed syllables, hence the phonetically simplex t in *city* must be a geminate. *NOT* an ambisyllabic consonant.
      ==> ambisyllabicity is the analysis of people back in the 70s where it could not be conceived that a phonetically simplex consonant is related to two skeletal slots. The unbreakable rule was a one-to-one mapping between x-slots and phonetic duration.
      Hammond (1997)

e. Norwegian

common gender	neuter	
peen	pen-t	pretty
stuur	stur-t	tall/big
søøt	søt	soft

(68)



(69) #3
laryngeal realism
the default value is determined during spell-out
Iverson & Salmons (1995), Honeybone (2005), Harris (2009)

a. it is fairly consensual today that there are two distinct systems of laryngeal, or voice-related oppositions: what is traditionally called a voice vs. voiceless contrast may in fact involves two distinct sets of primes,
   1. [±voice] vs. [±spread glottis] in feature-based systems
   2. L- or H-active systems in monovalent approaches

   hence there are two types of languages: voicing and aspiration.
b. voicing languages
   (e.g. Romance and Slavic)
   1. voiced consonants are "truly voiced", i.e. voicing is the result of explicit laryngeal action.
   2. a prime, [+voice] or L, provides voicing, while voiceless items are the default: they are produced by the absence of explicit action ([-voice], absence of L).
c. aspiration languages
   (e.g. Germanic)
   1. voiceless consonants are the result of explicit laryngeal action: a prime, [+spread glottis] or H, enforces voicelessness.
   2. voiced consonants are only voiced by default, i.e. because they lack the prime responsible for voicelessness/aspiration, H (or experience the minus value of [spread glottis]).
d. ==> in this setup, "by default" means "during phonetic interpretation": obstruents that are phonologically voiceless, i.e. which lack H (or are specified [-spread glottis]), are pronounced voiced.

(70) how to identify voice vs. aspiration languages?

a. the standard answer in the literature is that this may be decided by looking at the VOT of word-initial pre-vocalic plosives (e.g. Harris 2009).
b. voicing languages
   "voiced" items are prevoiced (long lead-time, i.e. negative VOT), while "voiceless items" have a zero or slightly positive VOT.
c. aspiration languages
   "voiced" plosives have a zero VOT, while their "voiceless" counterparts have a strongly positive VOT (long lag-time).

(71) a universal phonetic correlate is incompatible with post-phonological spell-out

a. because, recall, the match between phonological items and their phonetic exponents is arbitrary.
b. in recent work, Cyran (2012, 2014) has argued that a well-known peculiarity of voicing in external sandhi that is found in South-West Poland (so-called Cracow voicing, or Poznań-Cracow voicing) is not the result of phonological computation.
c. he shows that it may be derived by simply assuming that the Warsaw-type system is L-based (true voicing), while the Cracow-type system is H-based. When injected into the same computational system, these opposite representations produce the surface effect observed.

d. a consequence of Cyran's analysis is that there cannot be any cross-linguistically stable phonetic correlate for H- or L-systems.
   1. these systems may not be identified by spectrograms, VOT or any other property contained in the phonetic signal: Warsaw and Cracow consonants are phonetically identical.
   2. the only way to find out which type of laryngeal opposition a surface voice-voiceless contrast instantiates is to observe is behaviour.
   3. ==>
      This is what is also predicted by post-phonological spell-out: phonetic correlates of phonological structure are arbitrary.

e. a word of caution
   1. it may not be the case that Warsaw and Cracow consonants are phonetically identical.
   2. VOT is the most popular cue for identifying plosives (because it is easy to identify and to measure), but it may not be the only one that is present in the signal.
   3. pitch may also cue voicing
      Haggard *et al.* (1970)
   4. Geoff Schwartz (p.c.) reports that when tokens are doctored so that their VOT is identical (for Polish this means erasing the pre-voicing), the voice-voiceless contrast is still identified by natives.
   5. Schwartz (2012, Ms) proposes an alternative analysis of Cracow voicing in the framework of Onset Prominence.

(72) #4
how much slack ought to be allowed between the phonological identity of a segment and its pronunciation?

a. we know that the same phonetic object may have distinct phonological identities across languages: [ɛ] may be
   1. I.A,
   2. A.I or
   3. I.A
   (using GP representations where the head of the expression is underscored).
   But may it also be
   4. I alone?
   5. A alone?
   6. or even U alone?

b. recall (17)e:
   what about
   I ↔ [e]
   I ↔ [u]
   k ↔ [y]
   p ↔ [o]

c. intuitively, there must be limitations on how things can be pronounced, since otherwise a three vowel i-a-u system could in fact be flip-flop where [i] is the pronunciation of A, [a] of U and [u] of I.

d. the arbitrariness of post-phonological spell-out enforces a counter-intuitive position, though: yes, flip-flop is indeed a possible situation.

(73) confirmation of counter-intuitive arbitrariness I
South-East British posh girls
a. situations where a given vowel is pronounced as another vowel are real:
Uffmann (2010) reports that in the speech of this group,

"vowels are currently shifting quite dramatically, with back/high vowels fronting and unrounding, and a counter-clockwise rotation of most of the remainder of the system, leading not only to vowel realisations that are quite distinct from traditional Received Pronunciation, but also, at least for some speakers, to near-merger situations (e.g. /i:-u:, ey-ow, e-æ/)"
Also see descriptions by Henton (1983), Harrington *et al.* (2008)
b. hence posh girls will pronounce "boot" as [biit].
c. but: gliding in external sandhi
1. regular SE British English
see [ii j] it
do [uu w] it

2. posh girls
see [ii j] it
do [ii w] it
d. ==> the vowel in "do" is still underlyingly /uu/ (rather than /ii/): this is witnessed by the glide.

(74) confirmation of counter-intuitive arbitrariness II
"r"
a. in some languages the sonorant "r" is pronounced as a uvular fricative [ʁ, χ] or trill [R]. French, German, Norwegian and Sorbian are cases in point.
b. In these languages, like all other obstruents [ʁ] undergoes final devoicing (if present in the grammar), and voice assimilation.
c. Phonologically, however, it "continues" to behave like a sonorant: only sonorants can engage in a branching onset, but the uvular fricative or trill does so jollily.
d. When looked at through the lens of post-phonological spell-out, there is nothing wrong with this situation: for some reason the languages in question have decided to pronounce the phonological item /r/ as a uvular. This does not change anything to its phonological properties or behaviour.

(75) confirmation of counter-intuitive arbitrariness III
"exotic" segments: ingressives, clicks etc.
a. surface-bound classical phonological analysis takes these articulatory artefacts seriously and may implement corresponding melodic primes (a special feature for clicks for example: [±click]).
b. in the perspective of post-phonological spell-out, ingressives and clicks are but funny pronunciations (garden varieties as Jonathan Kaye would say) of regular phonological objects that occur in other languages as well.
c. but of course it must be secured that there are enough distinct phonological representations for all items that contrast in such a language.

DAY 4
So why do 95% of phonological items match their phonetic exponents?

(76) Why?
   a. if cases can indeed be found where the phonetic and phonological identities of an item are (dramatically) distant, it is true nevertheless that in the overwhelming majority of cases they are not.
   b. This is precisely why these few incongruent cases are so baffling.
   c. in something like 95% of all spell-out relations, the way a structure is pronounced is more or less closely related to its phonological value (i.e. there is little slack).
   d. this situation at the lower end of phonology stands in **sharp contrast** with the properties of the same spell-out mechanism at its upper end: the relationship between morpho-syntactic structure and its exponent phonological material is 100% unrelated.
   e. ==>
      At first sight, this dramatic difference does not speak in favour of the idea that both translating devices are identical, and that the only difference is the nature of the items involved.

1. Grammaticalization at the lower, but not at the upper spell-out

(77) intuitive similarity calculus
   a. for the input-output relation at the lower, but not at the upper interface
   b. why?

(78) key to the problem :
   the kind of vocabulary that is manipulated
   a. uncontroversially, the most important ontological gap within subcomponents of grammar is between syntax, morphology and semantics on one side, and phon-(-ology, -etics) on the other.
   b. when items such as gender, tense, number, case, person, animacy etc. are mapped onto items such as labial, occlusion, palatal etc., the relationship cannot be anything but 100% arbitrary.
      It is not even obvious how the degree of kinship between any item of one pool and any item of the other pool could be calculated: any match is as unmotivated as any other.
   c. by contrast, phonology and phonetics share a number of categories (which does not mean that the vocabulary items are identical). For example, labiality is certainly relevant on both sides.
   d. therefore the calculus of a greater or lesser distance between phonological structure and its phonetic exponent is immediate and quite intuitive.

(79) grammar works on grammaticalized real-world properties
  a. grammar is a cognitive system that codes real-world properties through a process known as grammaticalization.
     Anderson (2011)
  b. the real-world properties in question are of two kinds:
     1. semantic (eventually pragmatic) and
     2. phonetic.
  c. the symbolic vocabulary of morpho-syntax and semantics is the grammaticalized version of real-world semantic experience such as time, speakers, the difference between living and non-living items, between humans and non-humans, etc.
  d. on the other hand, phonetic categories are grammaticalized in terms of phonological vocabulary.
     1. It is therefore obvious and unsurprising that the output of the grammaticalization process that turns phonetic into phonological items is akin to the phonetic input, and also uses the same broad categories.
     2. by contrast, the relationship between the items related by the upper spell-out is not one of grammaticalization. Tense, person, number, etc., are not the grammaticalized versions of labial, occlusion, etc. Therefore there is no way to even imagine any similarity.
  f. the decisive difference between the upper and the lower spell-out that phonology is involved in is thus that the latter coincides with a grammaticalization that imports real-world properties into grammar, while the former is purely grammar-internal: it does not grammaticalize anything.

2. Discrete/gradient boundary crossed at the lower, but not at the upper spell-out

(80) Cue Constraints
     Bi-Phon Model (Boersma & Hamann)
  a. the lexicon is IN the Cue Constraints
     every Cue Constraint describes a mapping relationship between a phonological and a phonetic unit.
  b. this relationship is arbitrary
     /i/ ↔ 60 ERP
  c. Cue Constraints are ontologically distinct from regular constraints such as Faithfulness constraints (underlying to surface representations in phonology): the former describe a mapping relation, the latter do not.
     1. faithfulness constraints: input and output uses the same vocabulary
     2. Cue Constraints: input and output do not use the same vocabulary
  c. this is LEXICAL translation (not computational translation)
  d. these lexical statements are then computed by an OT grammar
     ==> why this additional step?
     ==> why is there no such thing at the upper interface?
  e. tentative answer
     because there is a transition discrete-gradient at the lower, but not at the upper spell-out.
     The lower spell-out needs to somehow produce and perceive gradience. But lexical mapping statements cannot be inherently gradient.
     ==> gradience = (non-grammatical) computation

3. When rules age

(81) complete identity
The fact that the lower spell-out also represents a grammaticalization boundary explains why the default relationship between a phonological category and its phonetic exponent is complete identity: this is what grammaticalization produces.

(82) life-cycle of phonological processes
Baudouin de Courtenay (1895), Vennemann (1972), Bermúdez-Otero (2007, 2014)
a. phonological rules come into being through phonologization, i.e., the grammatical knighting of some variation that is present in the phonetic signal.
b. alternations are born as phonetic regularities, then move into grammar where they are first phonological but at some point start to add morphological conditions, followed by lexical factors. Finally they are levelled out or eliminated from the language by some other means.
c. during this life-cycle, alternations become less and less regular: they apply to 100% of those items that satisfy the triggering conditions in their initial stage, but adding morphological and/or lexical conditions subtract more and more items from their influence.

(83) Crazy Rules
when rules age
a. when alternation patterns are born, i.e. when a phonetic variation is knighted by grammar and comes to stand under grammatical control, they are thus 100% regular, and follow a clear causal pattern.
b. that is,
$k \rightarrow \widehat{t\int} \,/\, \_\_i$
is a possible product of grammaticalization, but
$k \rightarrow \widehat{t\int} \,/\, \_\_u$
is not.
c. the aging of a phonological process then implies its being gradually estranged from its real-world roots. That is, rules that were phonetically plausible at birth may undergo modifications in further evolution of the language, and after some time look quite outlandish, or even crazy.
d. this is what we also know from the other types of grammaticalization
   1. relationship between time (real-world) and tense (grammar),
   2. *dog* (real-world) and *dog* (concept),
      which is intricate and anything but one-to-one (in his recent conferences, Chomsky insists on the fact that reference is poorly understood).

e. this is the insight formulated by Bach & Harms (1972): there are crazy rules, yes, but they are not born crazy – they have become crazy while aging.
==> typically through a context-free change that affects all segments of a certain type.
1. for example, a context-free change that turns all i's of a language into u's may transform our phonetically transparent rule
k → t͡ʃ / __i
into the crazy rule
k → t͡ʃ / __u.
2. hence it takes some historical accident and telescoping in order to produce a crazy rule (posh girls most certainly produce some).
3. example: l → ʕ/ʁ / V__V in external sandhi in Sardinian
Molinu (2009), Scheer (2015)
4. velar softening in English
k → t͡s / __i
then context-free innovation t͡s > s
k → s / __i

(84) spell-out mismatch
is only ever a product of diachronic evolution
a. it takes some historical accident and telescoping in order to produce the distance between a phonological item and its phonetic realization that baffles phonologists.
b. mapping relations between phonology and phonetics are not born crazy – they may become crazy through aging.
c. a faithful match is enforced by the real world - phonetics - before grammaticalization.
d. grammar does not care for whether or not the match is faithful.
It therefore opens the door for a non-faithful evolution.
e. ==>
non-faithful matches can only exist when an alternation is under grammatical control.

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