

Crossing Phonetics-Phonology Lines

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Edited by

Eugeniusz Cyran and Jolanta Szpyra-Kozłowska

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P U B L I S H I N G

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SPELL-OUT, POST-PHONOLOGICAL

TOBIAS SCHEER

1. Introduction

Spell-out is known to be the operation that converts morpho-syntactic information into phonological material (e.g., Marantz 1997, Embick 2010). The match between the input and the output of this translational process is achieved through a lexical access: a morpho-syntactic structure that describes, say, past tense of a weak verb in English is realized as *-ed* because there is a lexical entry stored in long-term memory that specifies this equivalence (past tense [weak verbs] ↔ *-ed*). Since lexical properties by definition do not follow from anything (at least synchronically speaking), the relationship between the input and the output of this spell-out is *arbitrary*: there is no reason why, say, *-ed*, rather than *-s*, *-et* or *-a* realizes past tense in English.

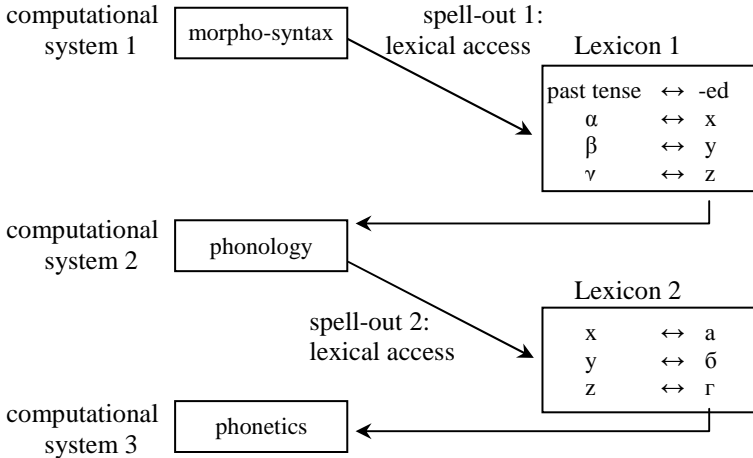
This is a trivial and consensual property of the upper interface of phonology. On the pages below, the modular approach and the way distinct computational systems communicate are applied to the other interface that phonology is involved in, i.e., the one with phonetics. Here the same spell-out mechanism produces quite a counter-intuitive prediction.¹ Everybody knows indeed that there is a more or less one-to-one relationship between phonological categories and the way they are realized in phonetics: something that is [+labial] in phonology (almost) always comes out as somehow phonetically labial, rather than, say, palatal or occlusive.

The goal of the article is to convince the reader that even though it may seem bewildering when it comes to the phonology-phonetics interface, in a modular perspective there is no alternative to the arbitrariness of translation. If you believe that phonology and phonetics are distinct computational systems (which you may not: there are various approaches, in OT for example, where everything is scrambled into one single system), you cannot escape the conclusion that translation at the lower end of phonol-

¹ Note that this article only lays out the modular perspective on post-phonological spell-out. Space limitations preclude discussion of traditional and other currently entertained theories of the phonology-phonetics interface.

ogy (spell-out 2 under (1) below) is just as arbitrary as it is at its upper edge (spell-out 1).

(1) Fragment of grammar involving phonology



The goal, then, is to construe a consistent global picture where all interfaces respond to the same logic. Or, in other words, where linguistic-internal matters and competing (interface) theories are refereed by extra-linguistic constraints, in our case those imposed by cognitive science and modularity. This perspective is in line with minimalist and biolinguistic tenets: grammar-internal properties are shaped and explained by extra-grammatical, more generally cognitive constraints, typically relating to the interface(s).²

In such a perspective, the apparently obvious one-to-one relationship between phonological categories and their phonetic realization thus begs the question. I argue that it is merely accidental and has a diachronic origin: freshly grammaticalized phonological processes are phonetically faithful; only older processes may move away from the phonetic surface through aging. There are cases of the latter kind (known as crazy rules in the literature, which are further discussed in section 6.2), but not too many since they emerge only as the result of multiply telescoped rare events.

Finally, it needs to be made explicit that the view of the phonology-phonetics interface promoted in this article develops and puts a cognitive name on what is known as *phonetic interpretation* in Government Phonol-

² For the so called third factor explanations, see Chomsky (2005).

ogy (Harris and Lindsey 1995: 46ff, Harris 1996, Gussmann 2007: 25ff). Also, what is exposed below converges with much of Boersma's (1998) and Hamann's (2014) ideas on the phonology-phonetics interface.

2. Background: Modularity in Cognitive Science and in Language

In Cognitive Science, modularity holds that the mind (and ultimately the brain) is made of a number of computational systems that are specialized in a specific task, non-teleological and symbolic (Fodor 1983, Coltheart 1999, Gerrans 2002, Carruthers 2006). Modules are also domain-specific, which means that they work with a specific symbolic vocabulary that is distinct from the vocabulary of other modules. 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. Based on their domain-specific input vocabulary, modules perform a computation whose output is structure. Hence 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.

A necessary consequence of domain-specificity is translation (or transduction): since different modules speak mutually unintelligible idioms, intermodular communication must rely on translation of items from one vocabulary into another.

Participating in what is called the cognitive revolution of the 50s-60s (e.g., Gardner 1985), generative linguistics applies modularity to language. Language-internal modular structure that is standard since Chomsky (1965: 15ff) is made of three units: one system where items are concatenated (morpho-syntax)³ and two interpretational systems that provide a meaning (LF) and a pronunciation (PF) to the output of the concatenative module. In current minimalism, the way morpho-syntax transmits information to PF has come to the fore: spell-out, late insertion, linearization and PF-internal activity become more and more prominent. Lexical insertion (or spell-out) converts (portions of) the hierarchical morpho-syntactic structure into phonological material. This implies a lexical access: the phonological material inserted is stored in the lexicon (long-term memory),

³ Talking about morpho-syntax in this context does not imply any specific view on the old question whether morphology and syntax are the same or two distinct computational systems (e.g., Lieber and Scalise 2007, Williams 2007). What they have in common is concatenative activity.

and the units stored are morphemes. Reiss (2007) offers an overview of the modular approach applied to phonology/phonetics.

The assignment of a morpheme to a portion of the morpho-syntactic structure depends on its morpho-syntactic properties, but an account of its phonological characteristics is unpredictable and arbitrary: there is no reason why, say, *-ed* realizes past tense in English (rather than *-eg* or *-a*). This is because we are dealing with a lexicon, and lexical properties are arbitrary.

3. Scrambled Phonology and Phonetics or Two Distinct Computational Systems?

The first thing that needs to be settled is the fact that phonology and phonetics are two distinct computational systems. Otherwise there is no interface in the first place, and hence no point in applying the workings of the other interface. The question whether phonetics is just low-level phonology, rather than ontologically distinct, is the subject of a long-standing debate.

Coming from connectionism (Smolensky 1988), OT is typically 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. An overview of how morphology is scrambled with phonology in OT is available in Scheer (2011: §523); implementations of the scrambled view of phonology and phonetics include Steriade (1999) and Flemming Flemming (2004).

The alternative view upholds a modular distinction between phonology and phonetics, as for example in Zsiga (2000). Kingston (2007) provides an overview of the two orientations. The pages below assume that phonology and phonetics are distinct computational systems.

4. Modular Constraints on Translation

Given thus two distinct modules, phonology and phonetics, communication can only occur through some kind of translation. Assuming modular standards and especially what we know from the morpho-syntax - phonology interface, there must be a spell-out operation that converts the output of phonology into units of the phonetic alphabet. As was shown, modular

spell-out has a number of properties that then must also apply to its post-phonological instantiation. These are made explicit below.

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 α is assigned to a phonological item x .
- 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.

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 is based on an independently stored list of instructions and modifies one in order to produce the other.
- b. Nothing is said about the nature and the size of the phonological structure x and its phonetic exponent α . Namely, there is no segment-based assumption: the phonological units that are screened by the spell-out mechanism may comprise one or several timing units (x -slots). 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.

The match is arbitrary

- a. This follows from the fact that translation is list-based (or lexical): 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.
- b. A consequence of arbitrariness is what Kaye (2005) calls the *epistemological principle of GP*: 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. 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. Therefore they must not be taken seriously when phonological identities are established. For example, if an /u/ is pronounced [i], it will not palatalize despite its being front phonetically. Relevant examples are discussed below.

Conversion is exceptionless

A basic criterion for classifying alternations as morpho-phonological, allomorphic, phonological, analogical, lexical or phonetic is the presence of exceptions. 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., to the application of an algorithm that transforms X into Y. 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. 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.

This is indeed what we know from the morpho-syntax - phonology spell-out: there is no variation and there are no exceptions in the assignment of phonological material to morpho-syntactic structure. The exponent of past tense in English weak verbs is *-ed*, always *-ed* and only *-ed*.

This means that among all alternations found in language, only those that are exceptionless qualify for being the result of post-phonological spell-out. The idea that exceptionlessness and “proximity” to phonetics are strongly related is a long-standing insight: exceptionless alternations are often called “low level”, “surface palatalization” (in Polish: Rubach 1981) or, quite aptly (for bad reasons, though), “late”. Consider for example the way Paul Kiparsky (1968-73: 18) defines his Alternation Condition: “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^holir^hícian*) is of this kind: automatic, exceptionless and *hence* close to phonetics. If on the route towards phonetics exceptionless alternations are rather close towards the phonetic end, they remain phonological in kind, though: “late” means “towards the end of the application of ordered rules” in SPE. By contrast in the present modular approach, “late” means “outside of the phonology”: the alternations in question arise during post-phonological spell-out, i.e., have got nothing to do with phonological computation. That is, 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.

Exceptionlessness also played an important role in the division of grammar that was operated by Natural Generative Phonology (e.g., Hooper

1976): only exceptionless alternations could be truly phonological. Following the structuralist track, alternations riddled with exceptions were rejected into a distinct computational system, morpho-phonology. Alternations that were called phonological in NGP, or rather, some of them, are located in the post-phonological area in the present approach. Only some are since there is no prohibition for phonological computation to produce fully regular patterns. The only red line that is drawn by post-phonological spell-out is that it could not possibly produce alternations which are not 100% surface-true.

5. Arbitrary Spell-Out: Some Cases in Point

5.1. How much of the alternation basket is phonological?

One issue that post-phonological spell-out addresses is the question how much of the alternations that we observe on the surface is exactly the result of phonological computation. In SPE, the answer was close to 100% (including “alternations” like *eye – ocular* or *sweet – hedonistic*, Lightner 1981) and since the shock-waves of Kiparsky (1968-73) has constantly decreased. Government Phonology is on the far “small is beautiful” end, i.e., where a relatively small amount of labour is left in the phonology. This perspective is worked out and theorized by Gussmann (2007), especially for Polish.

Alternatives to phonological computation may or may not be computational in kind. The lexicon falls into the latter category (*electric* and *electricity* are two distinct lexical entries), while non-phonological computation includes allomorphy (the root has two allomorphs, *electri[k]-* and *electri[s]-*), analogy, and phonetics. Bermúdez-Otero (2012) tackles the age-old question of how these alternation-drivers are distributed. Post-phonological spell-out shows that there is also life after all phonological computation is done, explains how this life is constrained and defines its organization.

Let us consider the following example from Polish, showing how a given alternation can be either attributed to phonological computation, or to post-phonological spell-out. Table 0 below illustrates that the vowel [ɛ] in Polish behaves in two different ways.⁴

⁴ There is actually a third *e* that appears in recent loans such as *kelner* ‘waiter’ and *kemping* ‘camping’. This *e* is noteworthy since elsewhere Polish prohibits the sequence velar+*e* altogether: the result is *k^he*, *g^he* as e.g., in *sok – sok-iem* ‘juice nom.sg., instr.sg.’. This third type of *e* is orthogonal to the demonstration.

(2) Two *e*'s in Polish

- | | | |
|------------------------------|----------------------|---------------------------|
| a. palatalizing <i>e</i> | lot – loci- <i>e</i> | flight nom.sg., loc.sg. |
| b. non-palatalizing <i>e</i> | lot – lot-em | flight nom.sg., instr.sg. |

Represented by Rubach (1984), the classical analysis of the pattern under 0 is based on a one-to-one match between phonological behaviour and phonetic substance: any item that is phonologically [+front] (or [-back]) palatalizes, and only items that are phonologically [+front] (or [-back]) palatalize. That is, 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. Therefore the instr.sg. morpheme *-em* is /-ɣm/ underlyingly. /ɣ/ is a back unrounded vowel (distinct from /ɔ/ through roundness) which does not exist on the surface (in the vocabulary of the 70s, it is absolutely neutralized). Rules then apply such that palatalization is ordered before the context-free conversion of /ɣ/ into [ɛ]: when /lot-ɣm/ undergoes palatalization, there is no palatal agent yet, and hence no palatalization. A later rule transforms /ɣ/ into /ɛ/, but the palatality of the latter cannot bite because there is no palatalization rule anymore.

Gussmann (2007: 56ff) follows a different track: if there are two *e*'s with different behaviour, they must be distinct phonological objects. And they must be distinct all through phonology. This methodology is along the lines of Kaye's (2005) aforementioned principle: the identity of phonological objects is determined by their behaviour, and by nothing else. Hence in Gussmann's view the palatalizing *e* of the loc.sg. suffix is (I-A), while the non-palatalizing *e* of the instr.sg. suffix is (_-I-A). Both segmental expressions contain the palatal agent I, which however is head (under-scored) in the former, but only operator in the latter (empty-headed) case ending. A piece of the phonology of Polish, then, is that only headed I triggers palatalization. When phonological computation is completed, the output structure thus contains instances of both (I-A) and (_-I-A). Spell-out then assigns a phonetic identity to whatever is provided by phonology, and it so happens that both segmental expressions receive the same pronunciation, [ɛ] (I-A ↔ ɛ, _-I-A ↔ ɛ).

In sum, then, the traditional and Gussmann's analysis share the idea that the non-palatalizing *e* is phonologically distinct from the palatalizing one in that it does not possess the palatalization-triggering configuration. In both cases, there is a conversion operation as well, which however is a piece of phonological computation on the traditional count, while on Gussmann's it occurs post-phonologically during spell-out. A spin-off of

the latter is that the serial effect is shifted from phonological computation (ordered rules) to the interface with phonetics: serial computation is disputed in phonology, but the serial ordering of phonology and phonetics (in production) is consensual and trivial (assuming the position discussed in section 3).

5.2. Virtual length

A typical pattern covered by post-phonological spell-out is so-called virtual length. 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 signalled by duration.

A trivial and consensual example is English (or German) *agma*: the velar nasal in *sing* comes along as short [ŋ] phonetically, but in fact identifies as the cluster /ng/ phonologically. There are a number arguments, including the fact that it occurs only after short vowels (*VVŋ) and never word-initially (*#ŋ) (e.g., Gussmann 1998 for English, Dressler 1981 for German). The discrepancy between the phonological and the phonetic situation of English *agma* is depicted under (3a) below.

(3)	a. English agma	b. length = non- reduction	c. length = shortness of the preceding vowel
after phonological computation	$\begin{matrix} x & x \\ \diagdown & \\ n & g \end{matrix}$	$\begin{matrix} x & x & x \\ \diagdown & & \\ \alpha & & \alpha \end{matrix}$	$\begin{matrix} x & x & x & x & x \\ & & \diagdown & \\ c & i & t & y \end{matrix}$
spell-out	↕	↕	↕
phonetic exponent	[ŋ]	[α] [ə]	[t]

Vowel length has been found to be expressed by ATRness in French (Rizzolo 2002) and vowel reduction in Semitic (Lowenstamm 1991, 2011) as well as in Kabyle Berber (Bendjaballah 2001, Ben Si Saïd 2011) and Apulian dialects of Italian (Bucci 2013, in press). The latter case is illustrated under (3b): in a language where vowel length is not distinctive on the surface, a melodic item *α* is spelled out as [α] iff associated to two timing units, but as schwa in case it is associated to only one x-slot. Such a language possesses short and long vowels at the phonological level, which however phonetically appear in the disguise of full vs. reduced vowels.

On the consonantal side, exponents of geminacy that are identified in the literature include the (non-)inhibition of a preceding vowel-zero alternation in Somali (Barillot and Ségéral 2005), aspiration in English (Ségéral and Scheer 2008) and preaspiration in Icelandic and Andalusian dialects of Spanish (Curculescu 2011). In Germanic languages, a typical exponent of phonological geminacy is the length of the preceding vowel: relevant analyses are available for German (Caratini 2009), Dutch (Hulst 1985), the Cologne dialect of German (Ségéral and Scheer 2001) and English (Hammond 2007). Given that the distribution of vowel length (or tenseness) in (American) English depends on whether the vowel stands in a closed or in an open syllable, Hammond (2007: 9) argues that this must also be true for the one single context where this appears not to be the case, i.e., in open syllables before singleton consonants. Here both short and long vowels occur: *Rita* [riitə] vs. *Minnie* [mimii], *city* [sitii]. Hammond's solution appears under (3c): (non-final) phonetically singleton consonants are in fact geminates when preceded by a short (lax) stressed vowel. In other words, rather than being marked on its own body, the phonetic exponent of English geminates appears on the preceding vowel. It is identifiable without ambiguity and hence recoverable by children as long as they know that vowel length is a function of syllable structure: a stressed short (lax) vowel cannot exist in open syllables – in case it does, the syllable is not open but closed, i.e., the following consonant must be a geminate.

5.3. Laryngeal realism: the “default” value is acquired during spell-out

Another issue is so-called laryngeal realism (Iverson and Salmons 1995, Honeybone 2005, Harris 2009). 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 involve two distinct sets of primes, [\pm voice] or [\pm spread glottis] in feature-based systems, L- or H-active systems in monovalent approaches. That is, there are systems (called voicing languages: roughly, Romance and Slavic fall into this category) where voiced consonants are “truly voiced”, i.e., where voicing is the result of explicit laryngeal action. 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). By contrast in other systems (called aspiration languages: roughly, Germanic languages are a case in point), it is voiceless consonants that are the result of explicit laryngeal action: a prime, [+spread glottis] or H, enforces voicelessness.

Here 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]). 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.

The question is how to find out, for any given system, whether voiced consonants are truly voiced, or only by default. 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): in voicing languages, “voiced” items are prevoiced (long lead-time, i.e., negative VOT), while “voiceless items” have a zero or slightly positive VOT. By contrast in aspiration languages, “voiced” plosives have a zero VOT, while their “voiceless” counterparts have a strongly positive VOT (long lag-time).

This type of universal phonetic correlate sits uneasily with post-phonological spell-out which, recall, is arbitrary in kind. In recent work, Cyran (2012, 2013) 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 as is standardly assumed (Rubach 1996). 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 (default voicing). When injected into the same computational system, these opposite representations produce the surface effect observed.

A consequence of Cyran’s analysis is that there is no cross-linguistically stable phonetic correlate for H- or L-systems. That is, they may not be identified by spectrograms, VOT or any other property contained in the phonetic signal: Warsaw and Cracow consonants are phonetically identical. The only way to find out which type of laryngeal opposition a surface voice-voiceless contrast instantiates is to observe its behaviour. This is what is also predicted by post-phonological spell-out: phonetic correlates of phonological structure are arbitrary.

5.4. Melodic primes: how much slack between a prime and its pronunciation?

Another issue of interest is the amount of slack that ought to be allowed between the phonological identity of a segment and its pronunciation. We know that the same phonetic object may have distinct phonological identities across languages: [ɛ] may be (I,A), (A,I) or (I,A) (using GP representations where the head of the expression is underscored – the same holds true for feature-based approaches). But may it also be I alone, or A alone?

Or even U alone? 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-flopped where [i] is the pronunciation of U, [a] of I and [u] of A. The arbitrariness of post-phonological spell-out enforces precisely this counter-intuitive position: yes, flip-flop is indeed a possible situation – not a very plausible one, though. This is because a flip-flop system will have to take the hurdle of transmission to the next generation. In order to reconstruct the phonological identities of the vowels, children need some kind of cue to understand that what they hear is not what they need to store. For example, if in the flip-flop system described [i] does not palatalize (because it is in fact an U) but [a] does (because it realizes I), children have evidence from processing that allows them to correctly identify phonological units. If there is no such evidence, though, the flip-flop system will be eliminated by the next generation: children will simply store what they hear. Hence the decay (or lexicalization) of palatalization in our flip-flop system can sign its death.

Phenomena like the one that according to Uffmann (2010) is sociologically affiliated to South-East British posh girls (see also the descriptions by Henton 1993 and Harrington *et al.* 2008) show that 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 realizations 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/ (abstract of Uffmann 2010).

Hence the posh girls in question will pronounce *boot* as [biit]. There is good reason to believe, however, that the [ii] in question is still phonologically /uu/ since in external sandhi gliding it produces a back, rather than a front glide. In (certain varieties of) English a glide appears after word-final high vowels when the following word is vowel-initial and fulfils certain syntactic requirements (see e.g., Broadbent 1991). The glide then is front after front, and back after back vowels. Thus *see* [j] *it* comes with a yod, while *do* [w] *it* produces a [w]. Now Uffmann reports that in the latter u-fronting posh girls continue to introduce a [w] despite the fact that the preceding vowel is [ii] in their speech: *d[ii w] it*.

The kind of chain shift that South-East British posh girls are engaged in is not isolated or rare in the evolution of language (e.g., Hock 1991: 156ff, Labov 1994: 113ff, Gordon 2014). The Great Vowel Shift that occurred in

early modern English is a case in point (e.g., Wolfe 1972, Roca and Johnson 1999: 214ff). It ended up being grammaticalized and today is a legendary piece of English phonology, both diachronically and synchronically (it has left abundant traces in synchronic alternations, e.g., *dev[aj]ne* – *div[ɪ]nity* etc.). Whether our posh girls leave any trace in the phonology of further generations remains to be seen.

An example that is better known than the posh girl pattern and has baffled phonologists for quite some time is the fact that 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. In these languages, [ʁ,χ] undergo voice assimilation (they receive their voice value from adjacent obstruents, e.g., French [tχwa] *trois* ‘thee’ vs. [dχwa] *droit* ‘law’) and like all other obstruents devoice word-finally in case this process is present in the grammar (as in varieties of German that do not vocalize r). Phonologically, however, [ʁ,χ] “continue” to behave like a sonorant: only sonorants can engage in a branching onset, but the uvular fricative or trill does so happily. When looked at through the lens of post-phonological spell-out, there is nothing wrong with that: for some reason the languages in question have decided to pronounce the phonological item /r/ as a uvular (r ↔ [ʁ,χ]). This does not change anything to its phonological properties or behaviour. The transmission to further generations is no problem since children who know (via UG or some inference) that obstruents cannot occur as second members of branching onsets will automatically conclude that what they hear cannot be real: they will store [ʁ,χ] as the sonorant /r/.

A final example comes from “exotic” segments such as ingressives [β, d, ɡ] or clicks [ǀ, ǁ, ǃ, ǂ, Ǆ, ǅ]. Surface-bound classical phonological analysis has taken these articulatory artefacts seriously. Clicks for example are sometimes implemented with a specific melodic prime, [±suction] in Halle (1995: 8ff). In the perspective of post-phonological spell-out, ingressives and clicks are but funny pronunciations of regular phonological objects that occur in other languages as well (but of course it must be secured that there are enough distinct phonological representations for all items that contrast in such a language). Being a click is not a piece of phonological information, and phonological computation does not know what a click is. The specifics of clicks are only introduced when regular phonological representations receive a phonetic value upon spell-out.

6. If Spell-Out May be Arbitrary – Why is it Predictable Most of the Time?

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

It was shown that there are cases where the phonetic and phonological identities of an item are (dramatically) distant and unpredictable. It is true nevertheless that in the overwhelming majority of cases they are not. This is precisely why the minority of incongruent cases are so baffling. Probably in over 90% 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). How come?

Let us first recall the fact that 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% arbitrary. 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.

Another relevant observation is this: there is an intuitive similarity calculus for the input-output relation at the lower, but not at the upper interface. In order to see why this is so, let us have a look at the kind of vocabulary that is manipulated. It is fairly uncontroversial that the most important ontological gap within subcomponents of grammar is that between syntax, morphology and semantics on the one hand, and phon(-ology, -etics) on the other (e.g., Jackendoff 2002: 218ff, Chomsky 2000: 118). When items such as gender, tense, number, 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 set could be calculated: any match is as unmotivated as any other. 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. Therefore the calculus of a greater or lesser distance between phonological structure and its phonetic exponent is immediate and quite intuitive.

The reason for this situation is the ontological setup of grammar. Grammar is a cognitive system that codes real-world properties through a process known as grammaticalization (e.g., Anderson 2011). The real-world properties in question are of two kinds: semantic (eventually prag-

matic) and phonetic. The symbolic vocabulary of morpho-syntax and semantics is the grammaticalized version of real-world experience such as time, speakers, the difference between living and non-living items, between humans and non-humans, etc. On the other hand, phonetic categories are grammaticalized in terms of phonological vocabulary. 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. 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.

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.

6.2. Grammaticalization produces 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.

Phonological rules come into being through phonologization, i.e., the grammatical knitting of some variation that is present in the phonetic signal. This is the neogrammarian as well as the Saussurian take on language change,⁵ and the first step of what is known as the life-cycle of phonological processes (Baudouin de Courtenay 1895, Vennemann 1972, Bermúdez-Otero 2007, 2014). 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. 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.

⁵ Paul (1880: 32): “Die eigentliche Ursache für die Veränderung des Usus is nichts anderes as die gewöhnliche Sprechfähigkeit” [what really causes the change of usage is nothing else than ordinary speech activity]; Saussure (1916: 37) “c’est la Parole qui fait évoluer la Langue” ([it is Parole that makes Langue evolve].

Labov (1994, 2001) explains that grammaticalization in general and phonologization in particular have purely extra-grammatical causes: inherent phonetic variation that is present in the signal (i.e., which is produced by computation of the phonetic module) is arbitrarily selected for grammatical knighting in the interest of social differentiation that fosters group identity. Hence a village, or a group adhering to some urban culture, or any other socially defined community, seeks to be different and marks this difference with whatever variation offered by the signal. It does not matter in which way a group of speakers makes its speech different (by a spirantization, a palatalization etc.) – it only matters *that* it does.

Given the obvious correlation between the regularity of a phonological process and its age (the younger, the more regular) that follows from the life-cycle mentioned, phonetic variation that is knighted by grammar and freshly comes to stand under grammatical control is 100% regular. It also follows a clear causal pattern. This means that $k \rightarrow \widehat{tj} / _i$ for example is a possible product of grammaticalization, but $k \rightarrow \widehat{tj} / _u$ is not. The aging of a phonological process then implies its being gradually estranged from its real-world roots. This is what the Saussurian opposition *Langue* vs. *Parole* is about, and this is what we also know from the other types of grammaticalization: there is an obvious relationship between time (real-world) and tense (grammar), or between *dog* (real-world) and *dog* (concept), which however is intricate and anything but one-to-one (in his recent conferences, Chomsky insists on the fact that reference is poorly understood).

Phonological processes that were phonetically plausible at birth may thus undergo modifications in further evolution of the language, and after some time look quite outlandish, or even crazy. This is the insight formulated by Bach and Harms (1972): there are crazy rules, yes, but they are not born crazy – they have become crazy while aging (see Scheer 2014). For example, a context-free change that turns all *i*'s of a language into *u*'s may transform our phonetically transparent rule $k \rightarrow \widehat{tj} / _i$ into the crazy rule $k \rightarrow \widehat{tj} / _u$, which in its crazy guise may well continue to be present in the phonological computation of the language.

The take-home message is that it takes some historical accident and telescoping in order to produce a crazy rule. There is reason to believe that this insight not only applies to phonological computation, but more generally to the relationship between phonology and phonetics, i.e., also to spell-out: it takes the same kind of historical accident and telescoping in order to produce the distance between a phonological item and its phonetic realization that baffles the audience (posh girls, uvular /r/ etc.). That is, mapping relations between phonology and phonetics are not born crazy –

but they may become crazy through aging. Most of them do not, though, and this is the reason why the overwhelming majority of mapping relations show little slack.

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