How abstract are features?

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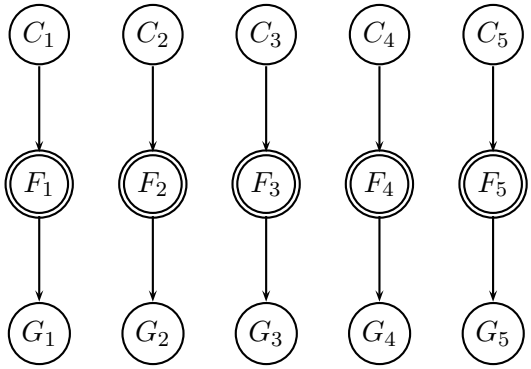
1 Where we are now

We looked at Hale, Kissock & Reiss. Main claims:

- There is a universal and probably very rich set of distinctive features.
- These features map deterministically and invariantly onto the phonetics by a set of transducers which can translate one type of representation into a different type of representation.
- As features are universal and transducers are invariant, all differences between languages – and within a language – must be phonological in nature.
- Differences in the phonetic realisation of a segment always mean that the phonological representation of these segments must also be different.

In short, the mapping between phonology and phonetics is straightforward and automatic. The relationship between features, articulatory gestures and articulatory cues in the Hale & Reiss model can be summarised graphically like this:

(1) The Hale & Reiss view of feature-to-phonetics mappings (F=feature, C=cue, G=gesture, motor command)



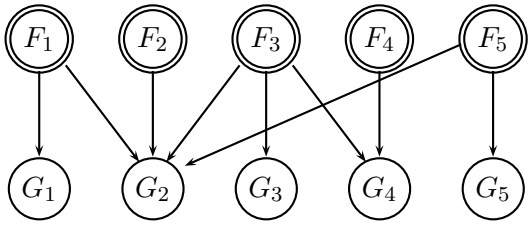
The view from phonetics (Ladefoged 1980, Kingston & Diehl 1996) does not support this view, however.

- Features and phonetic parameters are in an indirect, many-to-one relation (Ladefoged 1980).
- Phonetic transduction is not automatic but controlled (Kingston & Diehl 1996).

- Both conclude: If phonologists are interested in sound patterns, it is not helpful to think too much about phonetics. Phonology could – and should – be more abstract.

The mapping between features and articulatory gestures might thus be better described like this:

(2) A messed-up view view of feature-to-phonetics mappings (F=feature, G=gesture, motor command)



So which one is it? Today: Looking in some more detail in how abstract we should go. Here are some questions to guide us:

- Can what is phonetically same segment have different phonological representations?
- Can the same phonological representation map onto distinct phonetic segments?
- What are the effects of many-to-many relations between features and phonetic parameters? Are they a problem – or are they actually a good thing that can help us explain (a) diachronic change and (b) why the hell people cannot decide on uniform analyses, let alone a uniform set of features?

Two things to look at today: Rhotics and their antics and the interactions between features that can in some way be referred to as guttural (for lack of a better word).

2 Arr, arr

A classic problem for those who want to maintain a link between phonology and phonetics: the class of rhotics, conveniently transcribed as /r/ (see also and especially the insightful discussion in Chabot 2019 which I happened to speed-read last night (ahem)). The range of phonetic variation not just between languages but also within the same language (or even within a speaker) can be perplexing. /r/ can be

- alveolar: a trill [r] or a fricative trill [r̆] or a flap [ɾ] or an approximant [ɹ],
- a retroflex approximant [ɻ] or flap [ɽ],
- a velar approximant [ɣ] (sometimes voiceless [x]) (e.g. Brazilian Portuguese),
- a uvular trill [ʀ] or fricative or approximant [ʁ] (sometimes voiceless [χ]),
- a pharyngeal fricative or approximant [ʕ] (regional German)
- a labiodental approximant [ʋ] (regional English and Italian)
- a bilabial trill [ʙ],

- vocalized, usually towards [ə,ɐ,ɔ],
- and a lot of other things contextually, like [ðʲ] as an allophonic variant in Scots Gaelic

Research has so far failed to pin down a consistent phonetic correlate to the range of variation for /r/.

- Articulatorily, its realizations span almost all possible places of articulation and most manners (although usually not obstruent, never a stop).
- Acoustically, a lowered F_3 has been suggested as a unifying trait but this also does not capture the whole range of possible variations (Ladefoged 1975, Lindau 1985).
- "The overall unity of the group seems to rest mostly on the historical connections between these subgroups, and on the choice of the letter 'r' to represent them all" (Ladefoged und Maddieson 1996: 245).

Moreover, it is not the case that one phonological segment /r/ maps unambiguously onto a range of possible phonetic exponents. These same phonetic exponents (or at least some of them) can also map onto a variety of underlying phonological segments.

- The alveolar flap [ɾ] is not always a rhotic. It also occurs as a contextual allophone of coronal stops in Low Saxon and in varieties of English.
- [ʁ] actually is a (phonological) fricative in a range of languages.
- The same holds for [ʕ] and [ʋ] (which is an approximant in many languages).
- This actually raises the question whether [r] itself is always a 'rhotic'.

Is there actually any reason to assume that all these different sounds do form a phonological unit in a language?

2.1 The unity of /r/

And now for some arguments in favour of such a phonological unity. Firstly, there are, of course, historical and dialectal correspondences between languages and varieties. English *three*, German *drei*, Italian *tre* all contain a different rhotic, but the words are related.

- But does this mean that these sounds are synchronically the same or members of the same phonological class?
- Then how about [ʃ] in Polish *trzy*?

We need to look a bit more systematically.

2.1.1 Intra-speaker variation

The observable variation is not just variation between dialects or idiolects. There can be striking intra-speaker variation,

- e.g. in Dutch /r/ (e.g. Sebregts 2014),

- e.g. Cote d'Ivoire French (Turcsan and Boutin 2007).
- A single speaker may have a whole range of different /r/-sounds at their disposal, some of which are contextually determined but some of which also appear in free variation.
- For a speaker who alternates between coronal and uvular realizations of /r/, between trilled and approximant realizations, it makes no sense to assume different underlying representations.

2.1.2 Loanword adaptation

Another argument for the psychological unity of the different /r/-sounds comes from loanword adaptation (and also from second language acquisition): Borrowers readily identify an /r/-sound in a foreign language and adapt it to the rhotic found in their own language. Phonetic similarity does not play a role in such adaptations (for details, see LaCharité & Paradis 2005):

- Arabic borrows French /r/ as /r/=[r], despite the fact that (standard) French /r/ is phonetically uvular [ʁ] and Arabic has uvular fricatives.
- Japanese borrows English /r/ as /r/=[r], despite the fact that the nearest perceptual match in the inventory is [w] and the two are frequantly confused in L2 acquisition.

2.1.3 The stability of phonological processes

Where phonological processes are triggered by /r/, it doesn't seem to matter which kind of /r/ is involved, sometimes with perplexing results.

Intrusive /r/ in English: In non-rhotic dialects of English, /r/ is used as a hiatus breaker after low/mid vowels (in RP, this is [ə, ɑː, ɔː], in some Southern English dialects this also includes [ɛː] (corresponding to RP [aʊ])). Typically, intrusive /r/ occurs between words but can also occur word-internally.

(3) Examples of intrusive /r/

idea of	[aɪdɪəɹəv]
China and India	[tʃaɪməɹəndɪndɪə]
the spa is	[ðəspɑːɹɪz]
law and order	[lɔːɹəndɔːdə]
now and then	[nɛːɹənðən]
kafkaesque	[kæfkəɹɛsk]
drawing	[drɔːɹɪŋ]

- The standard analysis of this alternation treats intrusive /r/ as the result of spreading (spreading of [low] or [-hi]), analogous to glide insertion next to high vowels.
- Phonetic 'grounding': The pharyngeal constriction in English /r/ = [ɹ, ɻ] (see Gick 1999 for measurements). Could allow for diurect feature-phonetics mapping?
- A wrinkle: Spread of labiodental /r/=[ʋ] across England (e.g. Foulkes & Doherty 2000; Britain 2002). This does not affect the insertion pattern.

- But: Insertion of [ʊ] after [ə, ɑː, ɔː (ɛː)] is not phonetically motivated.
- Phonologically, the different types of /r/ in English do not seem to differ.
- And: In a more restricted context you also find intrusive /r/ in German, with yet different variants of /r/.
  - In Bavarian, an apical trill in hiatus position after low vowels (Ito & Mester 2007).
  - In High German, uvular [ʁ] optionally after low vowels in word-initial non-pretonic position, e.g. *Jena**r**er, Riga**r**er, algebra**r**isch, Kafka**r**esk* (all Google).

Retroflexion in Norwegian: A range of Norwegian dialects (including Standard Norwegian) have a process of postrhotic retroflexion: (Anterior) coronals become retroflex after /r/; /r/ subsequently deletes (see also Chabot 2019).

(4) Retroflexion of coronals after /r/: overview

$$/\text{r}/ + \left\{ \begin{array}{c} /\text{t}/ \\ /\text{d}/ \\ /\text{n}/ \\ /\text{s}/ \end{array} \right\} \rightarrow \left\{ \begin{array}{c} [\text{t}] \\ [\text{d}] \\ [\text{n}] \\ [\text{ʃ}] \end{array} \right\}$$

This process is found both morpheme-internally and across morpheme and word boundaries.

(5) Retroflexion of coronals after /r/

/bɑrn/	[bɑːɳ]	'child'
/sʉːr+t/	[sʉːʈ]	'sour (N. SG.)'
/sʉːr+nə/	[sʉːɳə]	'to become sour'
/for+deːl/	[fɔɖːeːl]	'advantage'
/mur+som/	[muʃːɔm]	'funny'
/muːtur+sykl/	[muːtuʃːʏkːl̩]	'motorbike'
/ver dɑːg/	[væː ɖɑːg]	'every day'
/ver nɑt/	[væː ɳɑtː]	'every night'
/jøːr de/	[jøːɖɛ]	'do it'

- In most Norwegian dialects, /r/ is trilled [r].
- Retroflexion can be motivated phonetically: [r] involves an apical gestures as well as retraction of the tongue, as does the production of retroflexes.
- Common acoustic property: lowering of F_3 (Hamann 2003).

The wrinkle: Dialects (found along the SW coast) that have uvular /r/, typically approximant [ʁ]. As might be expected, these dialects typically *don't* have postrhotic retroflexion (and neither do they delete /r/).

(6) No retroflexion of coronals after uvular /r/

/bɑrn/	[bɑʁn]	'child'
/sʉːr+t/	[sʉːʁt]	'sour (N. SG.)'
/muːtur+sykl/	[muːtuʁsʏkːl̩]	'motorbike'
/ver dɑːg/	[væːʁ dɑːg]	'every day'

The problem: Uvular /r/ is currently spreading across the SW of Norway, beyond its original confines of Sørland and the Bergen area. This has created (admittedly small) areas of overlap, e.g. the town dialect of Arendal (Stausland Johnsen 2012) which have both uvular [ʁ] *and* retroflexion.

- A sufficiently abstract representation of /r/ is necessary in order to capture this fact.

2.1.4 What can be done?

Given that /r/ seems to be phonologically uniform but phonetically variable, what can a possible solution look like?

- Positing an abstract feature [±rhotic] is generally shunned, as its only function would be to index unity of rhotics. Distinctive function? Phonetic correlates?
- Wiese (2000, 2001) proposes that the unity of /r/ can only be understood phonotactically. /r/ is a position on the sonority scale and whatever sound can go there (given aerodynamic constraints) will in some language.

While the sonority-based account looks promising, it still raises the question whether it is a universal solution.

- Many languages do not allow consonant clusters, many don't allow syllabic consonants.
- How would a learner of these languages know what a rhotic is in these languages?
- Or is the concept of rhoticity restricted to languages which have a more permissive phonotactics?
- Is every [r] a rhotic??

2.2 An alternative hypothesis: It's underspecification

Idea: A rhotic is an underspecified sonorant.

- Idea goes back to Trubetzkoy (1939): the phonological 'content' (=specification) of a segment depends on the oppositions it enters, i.e contrast.
- Trubetzkoy also noted that German /r/ is poor in such content and mostly negative: not an onstruent, not a nasal, not a lateral. And this allows for phonetic variation.

But then 'rhotic' is not an a-priori concept but one that is emergent in languages with a specific type of inventory.

- Rhoticity is an emergent category in languages with a specific type of inventory.
- In other languages where the consonant system is differently organised it would not make sense to talk about a 'rhotic' when talking about /r/ – as this /r/ has different phonological properties.
- Underspecification to the rescue!

Let's look at some examples.

2.3 The non-unity of /r/

Now: a few brief case studies showing that /r/ also shows phonological diversity.

2.3.1 German

(7) The German consonant system

p b	t d			k g		
f v	s z	ʃ ʒ	ç	x		h
pf	ts	tʃ				
m	n			ŋ		
			(j)			
	l					
	(r)				*(ʁ)*	

- German /r/ contrasts with other consonants in its manner of articulation, but not in its place of articulation.
- Variation along the place dimension is thus predicted.
- Only constraint: It has to be an approximant (ish).
- Preference for uvular realisation: merely social convention, not phonological.
- A similar situation is found in other languages – with concomitant variability – e.g. English, French, Italian, Hungarian.

2.3.2 Kitharaka

- Kitharaka: Bantu language spoken in Kenya.
- /r/ is a trill [r]; no variation seems to be attested.
- /r/ also has a different position in the system of contrasts, though.

(8) The Kitharaka consonant system

p	t	c	k
	θ		
m	n	ɲ	ŋ
β	*r*	j	ɣ

- /β r j ɣ/ form a phonological class:
  - They become stops [b d ɟ g] after nasals
  - [r] alternates with [d] and contrasts with other sonorants in place.
- Phonologically /r/ is thus a [coronal] sonorant in Kitharaka— its phonological / systemic properties are quite different from those of /r/ in German or Norwegian.
- But note: variation between /r/ and /l/ in Bantu languages.
- A different effect of underspecification: place is specified, laterality isn't.

2.3.3 Rotokas

- Rotokas: Papuan language
- Famous for having the world's smallest consonant inventory (Lorentz 2006).

(9) The Rotokas consonant system (following conventions)

p	t	k
		g
v		
	r	

Is /r/ a rhotic in Rotokas?

- Looking at the phonetic realisation of the consonants gives a different picture:

(10) The Rotokas consonant system (phonetically accurate)

p	t∼s	k
b∼β∼v∼m	*d*∼*r*∼ɹ∼*n*∼*l*	g∼ɣ∼ŋ

- Three places of articulation: labial, coronal, dorsal.
- Two manners: voiceless stops and underspecified.
- Small inventory – few contrasts – great variation, but only in one member of the opposition.
- This also supports the view that features are privative: the voiceless stops are specified for place and manner, the other consonants are only specified for place.

2.4 Discussion

- In German, /r/ is specified for manner, not for place.
- In Rotokas, /r/ is specified for place, not for manner.
- How meaningful is it to assign both to a universal class of rhotics?

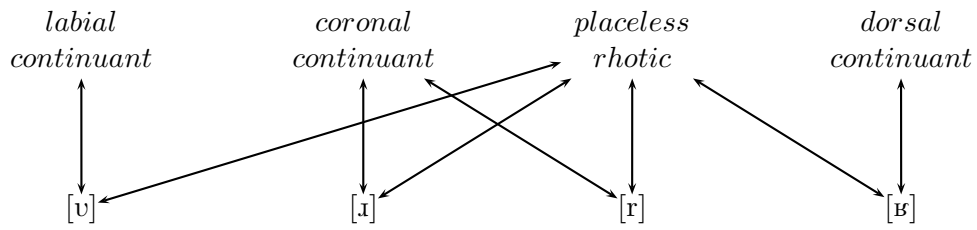
Conclusion: An /r/ is not an /r/ is not an /r/.

If we want to know what the phonological status of one of the segments is which are usually subsumed under the heading of 'rhotics', it is necessary to look at the whole system of contrasts to see where that segment slots in.

- We know that [ʁ] is not necessarily a rhotic but very often a fricative. The evidence comes from alternations, class behavior, phonotactics. This is old news.
- Curiously, however, it seems to be common belief that whenever we find an [r], that this segment should be a rhotic. This myth should be abandoned.

- Consequently, we also need no unifying feature for rhoticity. The concept of rhoticity itself probably is not a primitive of phonological description and representation, but rather a derived concept which is grounded in the systemic properties of inventories.
- This looks like a research program worth following. We will not present a typology of rhoticity here but would rather like to leave you with the feeling that things are pretty messed up.

(11) The messed-up situation with 'rhotics' (simplified)



Take-home message:

- The same phonetic sound [r] can be very different things phonologically.
- The same phonological unit /r/ can be very different things phonetically.
- We need a looser relationship between phonetics and phonology to allow for atht – no automatic transduction.
- Underspecification can help us if we don't want to give up completely on the idea that features are ultimately interpreted by the phonetics.

3 Tales from the guttur

Guttural features (in the broadest sense) are perhaps best known for the multitude of confounding factors when it comes to establishing clear phonology-phonetics mappings. We will review some of the problems here, try to provide an explanation and discuss the impact that it has on feature specifications.

3.1 Voice

Voicing is commonly described as vibration of the vocal folds, and the feature [±voice] is defined thus: Sounds which involve vocal fold vibration are [+voice]. Conversely, [+voice] should indicate vocal fold vibration. We have already seen in this course, however, that the situation is not that simple.

- Multiple cues for [voice] in English: closure duration, preceding vowel duration, F_0 drop, vocal fold vibration, etc.
- Evidence that speakers and listeners are aware of these multiple cues and use them (Kingston and Diehl 1996).
- This multiplicity of cues is not restricted to English – and can lead to phonological change. For example, languages may change from a laryngeal to a tonal system (historically in Mandarin, synchronically in Kera (Ebert 1976 vs. Pearce 2006) . In Swiss German, the voicing contrast became a length contrast (gemination).

3.2 ATR

An illuminating paper about the multiple phonetic exponents of [ATR] is Local & Lodge's (2004) discussion of the Tugen dialect of Kalenjin, a Southern Nilotic language. In Tugen Kalenjin, [±ATR] has the following phonetic correlates:

- [+ATR] vowels are higher than [−ATR] vowels.
- [+ATR] vowels have a somewhat longer duration than [−ATR] vowels.
- There is a slightly higher open quotient (period of glottal opening) for [−ATR] vowels (breathiness).
- Voicing bleeds over into consonants after [+ATR] vowels ('mixed excitation' in Local & Lodge's terms).
- Consonants sound tenser' after [+ATR] vowels, including a more salient release.
- Consonants are subsequently 'laxer' after [−ATR] vowels, often lenited (e.g. stops becoming continuants).

Local & Lodge see this as evidence for very abstract phonological features, which have no connection to the phonetics.

- A step too far? It seems to be evidence instead that there are many and diffuse phonetic correlates, but there are correlates.
- In fact, the seemingly surprising range of phonetic effects [ATR] has in Kalenjin is found in other languages as well, may even be phonologized to some degree. For example,
  - Vowel length and [ATR] pattern together in English and German. Long vowels are tense [+ATR], short vowels are lax [−ATR].
  - Vowel height effects can also be phonologized: In Oowekyala high vowels are lowered to mid after uvulars and laryngeals, analyzed typically as an effect of [ATR] (Howe 2000, Pulleyblank 2003).
  - The impact of [ATR] on consonantal place is also seen elsewhere: In Manchu (Dresher & Zhang), dorsals are velar before [+ATR] vowels, uvular before [−ATR] vowels. The same holds for Khalkha Mongolian (Staroverov 2015), and a similar effect can be observed with the dorsal fricative in German (Wiese 1996).
  - The relationship between [ATR] and [voice] has been independently established (Vaux 1996) with evidence from Armenian that [+ATR] vowels cause consonant voicing (Vaux proposes that voiced consonants are [+ATR]).
  - Laxer consonant articulations in the context of [−ATR] are also not unheard of: In colloquial Northern High German, voiceless stops lenite intervocalically only after [−ATR] vowels.
- It may be no surprise, then, that many traditional (structuralist) descriptions used the labels 'tense' and 'lax' as some kind of macro-features to classify distinctions between voiced and voiceless consonants, singleton and geminate consonants, [±ATR] vowels, etc, thus providing a unified descriptive label for the many different phenomena encountered here.

- These labels were discarded also because of their lack of phonetic accuracy and their rather impressionistic nature, but perhaps there is a principled reason for such features.
- It's ok to use a feature like [tense] if you're not fussy about substance.

3.3 Nasals

Although less strongly, nasals can also participate in the mess, most famously in what is known as rhinoglottophilia; vowels can become nasalized in the context of aspiration (attested mostly diachronically in Indo-Aryan languages). Vowel lowering is also reported, at least phonetically, in may languages (House & Stevens 1956).

3.4 Whence the mess?

To summarize:

- Voicing has additional correlates in vowel duration, possibly vowel height, pitch (tone), consonant duration (gemination).
- [ATR] has additional correlates in vowel duration, vowel height, breathiness, consonant voicing, consonant release.
- Nasality has an additional correlate in aspiration and vowel lowering.

The reasons for this lie in the facts that (a) articulators are connected and influence one another and (b) that different articulatory gestures are possible to reach the same acoustic effect, with different side effects.

- For voicing to occur, the necessary prerequisite is adduction of the vocal folds. Additionally, the subglottal pressure must be higher than the supraglottal pressure to generate the necessary aerodynamic conditions for airflow through the glottis, which is a problem for obstruents, which raise the supraglottal air pressure.
- Several adjustments are possible to compensate for this,
  - e.g. by lowering the larynx – pitch depression effect, connection to low tones,
  - e.g. by widening the pharyngeal cavity, either by widening the pharynx itself or by advancing the tongue root – connection to [ATR].
  - The pressure-build up during the closure phase of stops can also be weakened by a shorter stop duration (for voiced stops) – connection to length.
- Tongue root advancement thus also has a number of side effects.
  - It interacts with voicing (by enlargening the pharyngeal cavity and thus diminishing supraglottal pressure);
  - It counteracts vocal fold adduction (hence the larger open quotient)
  - It allows for more precise ('tenser') consonantal articulations by stiffening the tongue root.
  - In contrast, tongue root retraction has the effect of narrowing the pharyngeal cavity. Pharyngealization effects are thus predicted.

  - This retraction is also necessary for the production of uvular sounds; one thus predicts (and finds) a correlation between uvular consonants and lax vowels.

- Nasals also interact with pharyngeal and laryngeal sounds for both perceptual and articulatory reasons.
  - Articulatorily nasality not only correlates with velic opening but frequently also with pharyngeal narrowing.
  - Perceptually, nasality has been shown to have very similar cues to breathiness (Arai 2006), including a higher open quotient (as is found for a retracted tongue root as well), low frequency spectrum flattening, raised F1.
  - Plus, the partially open glottis in breathy-voiced consonants generates an additional resonator (subglottally), which has the effect of producing antiformants, just like the additional nasal cavity resonator has for nasal sounds.

3.5 Consequences for feature theory

Languages make variable use of a large inventory of possibilities to encode basic phonological distinctions in the laryngeal and guttural area.

- The choice of primary and secondary cues seems to be language-specific. Not every language uses vowel duration as a cue for consonant voicing to the extent that English does. Languages use tongue height and tongue root advancement in different degrees to express vowel height distinctions, with consequences for secondary cues.
- Thus, features and cues/gestures are in many-to-many relations.
- This allows for phonologically change: a secondary cue becomes primary (e.g. [voice] vs. tone) as these cue clusters are reanalysed by learners.
- A consequence: Allowing for abstract, language-specific features. Why do we need to decide if some contrast is a contrast in [voice] or [ATR] or [spread glottis] ... if phonetically, all these things interact anyway?
- The only alternative: Going full Hale and Reiss, proliferate phonological features, trying to identify each small articulator that impacts on pronunciation, assign it a label, and live with massive redundancy, plus language specific feature clusterings.

Conclusion: An [F] is not an [F] is not an [F].