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Canonical phonology and criterial conflicts: relating and resolving four dilemmas of phonological typology

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Abstract: Typologists strive to compare like with like, but four dilemmas make this challenging in phonology: (1) the non-uniqueness of phonological analysis; and the existence of (2) multiple levels of analysis; (3) multiple theories of phonology; and (4) analytical interdependencies between phonological phenomena. Here I argue that the four dilemmas can be coherently related, and then addressed together. I introduce the concept of criterial conflicts, derived from notions in canonical typology. Criterial conflicts arise in the presence of an unexpected pairing of properties that pulls an analysis in two directions. This contradictory pull and its resolution in different directions leads by various paths to the four dilemmas. Concrete strategies are then discussed for countering the common, underlying problem. I observe that criterial conflicts are well handled by factorial analysis (i.e., multiple normalization) and multivariate analysis, but not by simple normalization. Illustrative examples are taken from the canonical typology of segments.

Keywords: canonical phonology; canonical segment; canonical typology; criterial conflict; levels of analysis; non-uniqueness; phonological typology; segment typology

1 Introduction

Four dilemmas confront the phonological typologist, each of them complicating the task of typologizing by giving rise to multiple, conflicting versions of phonological "facts": (i) the non-uniqueness of phonological analysis; and the existence of (ii) multiple levels of phonological analysis; (iii) multiple theories of phonology; and (iv) interdependencies between phonological phenomena, such that the analysis of

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phenomenon A will depend on how phenomenon B is analysed.[1] Resolving these dilemmas, or even reducing the magnitude of the challenge that they present, is difficult, in no small part because it is not obvious how they relate to one another. Here I argue that the four dilemmas can be coherently related. Relating them to one another reduces the magnitude of the challenges they appear to present and leads to a clearer view of how to respond to them. At the centre of the argument, I introduce the concept of criterial conflicts, which I derive from notions in canonical typology (Bond 2013; Brown and Chumakina 2012; Corbett 2005; Round and Corbett 2020). In a nutshell, criterial conflicts arise when a phenomenon has an unexpected pairing of properties that pulls its analysis in two directions. This contradictory pull, and its resolution in two different directions, is the immediate source of non-unique solutions. It is also a key motivation for the positing of multiple levels of representation, so that different levels can pull in different directions; and its very existence is a problem that theories may commit to solving, and then solve differently, leading to a proliferation of theories out of a single body of phonological typological facts. Finally, the interconnectedness of many phonological phenomena means that conflicts can arise across different phonological domains. The primary contribution I wish to make here is methodological. It will help, though, to focus on a specific case study, and for this purpose I examine the problem of segmentation.

The paper is organized as follows. Section 2 provides some preliminary remarks on segments. Section 3 discusses canonical typology, proposes some canonical criteria for segments and introduces the central notion of criterial conflicts. Section 4 considers the four dilemmas of phonological typology and builds up the argument that by relating these dilemmas to criterial conflicts, we can reduce the magnitude of the challenge they appear to pose, and moreover, that it becomes clear what the desiderata are, for viable responses. With this in mind, Section 5 examines strategies of phonological typologizing and highlights how far they succeed in meeting our needs. Section 6 summarizes the argument and discusses some implications for priorities in phonological typology.

2 Segments

Most approaches to phonology have posited segments of some kind, from classical phonemes to nuanced notions like feature-geometric root nodes.[2] Many theories

1 In this paper I restrict myself to phonology. In future work it would be valuable to determine what is specific to phonology and what generalizes to other parts of grammar also.

2 This is not to say that segmentation is uncontroversial, either in its particular details or in the fundamental correctness of the assumptions that stand behind it (e.g. Firth 1948). Segmentation entails a discretization of the temporal unfolding of speech. Particularly in phonetics, where asynchronous events unfold in continuous time and exhibit continuous variability in other dimensions,

posit the existence of segments at multiple levels of representations, such as phones, phonemes and morphophonemes (e.g. Trubetzkoy 1969); or underlying, lexical and surface segments (e.g. Kiparsky 1982). In addition, segments are often incorporated into hierarchically complex representations in which they may dominate other structural elements such bundles, vectors, or geometries of features (Bloomfield 1933; Chomsky and Halle 1968; Clements 1985), or be dominated by other elements in prosodic structures (Nespor and Vogel 1986; Selkirk 1986). Common to these is that segments are the product of a fundamental analytic task of segmentation: a division of the speech stream into, or a mapping of the speech stream onto, a sequence of distinct, discrete units. Though much about segmentation is treated as uncontroversial (Ladd 2011), there remains a rump of cases in which the segmentation task is less straightforward: are affricates one segment or two? Does an epenthetic vowel qualify as 'a segment' to the same extent as a non-epenthetic vowel? When does a segment count as 'the same' across two environments, and when does it count as different? These are questions to which phonological theory has generated very many answers (Bradfield 2014; Cser 2013; Devine 1971; Gouskova and Stanton 2021; Martinet 1939; Pike 1947; Round 2013; Shih and Inkelas 2014; Trubetzkoy 1969 among many others), but has not settled upon any of them unanimously. For phonological typologists, this means that constructing typologies of segments demands an ongoing reckoning with multiple solutions to segmentation, and the diversity of analysis that results. Notwithstanding these challenges, segment typology is a vibrant and important field (Maddieson 1984; Maddieson and Precoda 1990; Moran and McCloy 2019; Nikolaev and Grossman 2020). Consequently, for present purposes, segmentation will furnish us with a good, topical illustration for the ideas about typological methodology which will be my main focus.

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the concept has met with significant criticism. Articulatory Phonology (Browman and Goldstein 1986), which primarily (though not exclusively) deals with articulatory phonetics, dispenses with segments. Port and Leary (2005) mount a critique of formal phonology in general and the segment in particular, in favour of a segment-free phonetics. Ladd (2011) critiques the theoretical coherence of systematic-phonetic segments as characterizations of the speech stream, while admitting that the notion seems useful and perhaps even necessary for phonetic typology. Delving further into these debates would take us beyond the remit of the present paper, though they are certainly connected to the topics of concern here. The existence of non-canonical segments and criterial conflicts – whose implications for *segmental* typology are discussed here – are not unlinked to the motivations that are cited in favour of *non-segmental* approaches, especially with respect to canonical criteria that refer to phonetic segmental properties (cf. Section 3).

3 Canonical phonology

Canonical Typology was developed by Greville Corbett and colleagues and has been applied primarily in morphology and morphosyntax[3] but also in phonology (Hyman 2009; Hyman 2012; Kwon 2017; Kuznetsova 2018; Uchihara 2021). Here I introduce its basic concepts (Section 3.1), applying them briefly to segments (Section 3.2), before turning to the central notion of criterial conflicts (Section 3.3).

3.1 Dimensions of variation and canonical criteria

Like other multivariate approaches to typology (Bickel and Nichols 2002; Bickel 2007, 2015), canonical typology breaks down a domain of investigation into the multiple dimensions of variation that are exhibited by linguistic phenomena within it. Specific instances of the phenomenon can then be measured along each dimension, independently of the others. To study segmentation, I will define the domain of investigation[4] as 'objects corresponding to the pretheoretical notion of a single speech sound'. This definition is intentionally broad, since my intention is to cover phenomena that may be analysed within a wide variety of theoretical approaches. In canonical typology, the statements that define the dimensions of variation in a domain have a specific, technical format. Firstly, they focus on a logically extreme end of the dimension.[5] Secondly, one end of the dimension of variation is given the label 'canonical', for reasons that I return to shortly. These definitions are termed 'canonical criteria'. Thus, the first dimension of variation I use here is defined in terms of the canonical criterion in (1).

(1) Canonical single segments[6] have an internally uniform sound quality – They have no discrete sub-intervals and no continuous, gliding changes.

3 Applications include: agreement (Corbett 2006), negation (Bond 2013), quotation (Evans 2013), phonaesthemes (Kwon and Round 2015), morphological complexity (Stump 2017) concurrent feature systems (Fedden and Corbett 2017; Round and Corbett 2017), compounding (Spencer 2017) and signed languages (Cormier et al. 2013). For a recent overview concentrating on morphology, see Bond (2019), and for further examples of the value of canons see the bibliography at: http://www.smg.surrey.ac.uk/approaches/canonical-typology/bibliography/.

4 Also referred to as a *canonical base* (Bond 2013).

5 There are well-established reasons for this. For an extended discussion in relation to typology, see Round and Corbett (2020); in other sciences consider examples such as absolute zero (the extreme of temperature in thermodynamics), the 'rational actor' (an extreme of decision making in economics) and point masses, elastic collisions and frictionless planes (extremes in physics).

6 Or, in the case of more abstract segments, the phonetic intervals to which they correspond.

In (1), the dimension of variation is the internal uniformity of a segment. The extreme end referred to is total uniformity, and that end of the dimension is labelled as 'canonical'. The canonical ends of dimensions are those that correspond best to an existing body of (often pretheoretical) thought about the domain of study. For instance, the traditional and pretheoretical notion of a segment accords better with 'a uniform piece of sound' than 'a highly nonuniform piece of sound', and thus it is complete uniformity (and not complete lack of uniformity) which is labelled as canonical. The labelling of one end of a dimension as 'canonical' is not intended to make any theoretical claim, nor to be prescriptive or to make any evaluation of correctness, but rather, it anchors the typology to pre-existing thinking.

Using these techniques of canonical typology enables us to produce a catalogue of data and its variation, while also juxtaposing that data systematically against an existing body of thought about the domain. Like other multivariate methods, it draws attention to interesting, fine-grained variation in the data, but in addition, it highlights those cases which pose a challenge to prior understanding. In this sense, canonical typologizing prepares the ground for subsequent theoretical work, since it sets out the problems that need solving. Conversely, it can reveal the problems that *prior* theoretical research may have attempted to solve, even in cases where the theoretical literature itself is not explicit about the motivation that these problems originally provided. This can help us identify the shared typological problems that lie behind diverse and superficially unrelated theoretical solutions – a point which is expanded upon in Section 4.

3.2 Canonical criteria for segments

Ten canonical criteria for single speech sounds are set out below, in (1)–(10). Each criterion serves to define a dimension of variation among segments, and assigns the label of 'canonical' to one end of the dimension. For reasons of space, I introduce each in turn only very briefly. Recall that the intention here is not to produce a definitive canonical typology of segments, but to provide sufficient material to lend concreteness to the main discussion below. Short comments are provided to add extra context.

(1) Canonical single segments have an internally uniform sound quality – They have no discrete sub-intervals and no continuous, gliding changes.

(2) Canonical single segments exhaustively subdivide the speech stream – They are contiguous with, and have no overlap with, their neighbours; their boundaries are precisely locatable and occupy no space.

Criteria (1) and (2) refer to phonetic properties taken to extremes, to which no real segment is likely to correspond.[7] The utility of criteria like this lies not in the ability to distinguish strictly canonical segments from strictly non-canonical, but in the ability to distinguish the more canonical from the less canonical. For instance, a pure vowel will be more canonical with respect to (1) than a diphthong; and an intervocalic glottal stop will be more canonical with respect to (2) than an intervocalic glide. The ability to pick out especially non-canonical segments will aid in the prediction and understanding of criterial conflicts, discussed next in Section 3.3.

(3) Canonical single segments have similar, unremarkable durations – They are not unusually long or short.

(4) Canonical single segments are integrated into unremarkable prosodic structures – For example, a canonical segment is part of a canonical syllable.

(5) Canonical single segments are integrated into unremarkable linear phonotactic structures – They have a linear distribution commensurate with other, similar segments.

(6) Canonical single segments are contrastive with other single segments in the same system.

(7) Canonical single segments are not predictable from their contexts – Their presence contrasts with their absence.

(8) Canonical single segments are affiliated with a morph – They are not epenthetic.

(9) Canonical single segments persist across different contexts – They do not delete.

(10) Canonical single segments maintain the same sound quality across different contexts – They do not alternate.

3.3 Criterial conflicts

I now introduce a notion which will become crucial to understanding how the four dilemmas fit together. When we think of non-canonical single segments (like

7 See also fn. 2 on the generally controversial status of phonetic segments.

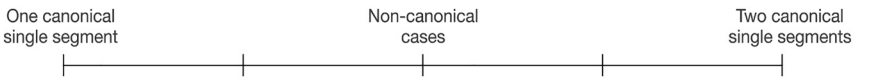


Figure 1: A misleading conceptualization of the problem of non-canonical cases, in which they are viewed as sitting mid-way along a single, linear dimension.

affricates for example), it is tempting to imagine them lying on a scale something like in Figure 1, situated mid-way between a single canonical segment and a sequence of two canonical segments. But this is not, in fact, what the crux of the typological challenge is like.

Instead, consider Figure 2, which displays not one but two canonical dimensions, set out schematically as the horizontal and vertical axes of a graph. Phenomenon A is a canonical single segment with respect to both of the dimensions, and B is a sequence of two canonical segments with respect to both. The real problem is C. Phenomenon C is canonically two segments with respect to the horizontal dimension but canonically one segment with respect to the vertical dimension. For example, an affricate may be canonically two segments with respect to criterion 1 (internal uniformity) but might pattern just like any other single consonant with respect to criterion 5 (linear phonotactics). Such phenomena possess what I call *criterial conflicts* – a contradictory combination of high canonicity with respect to some criteria, but also very low canonicity with respect to one or more others.

The central problem of a criterial conflict is that if we assert that phenomenon C must be analysed either as one segment or as two, then there is no good option.

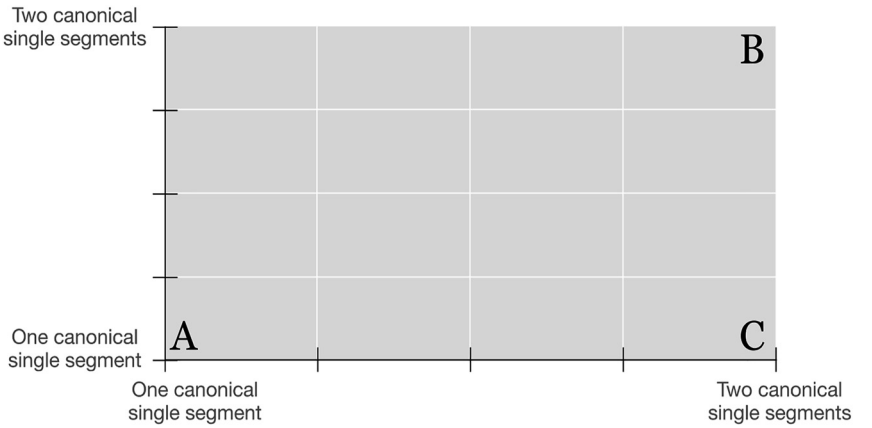


Figure 2: A diagram of two canonical dimensions (horizontal and vertical). Phenomena A and B are fully canonical. Phenomenon C has a criterial conflict.

Categorizing it in either way will result in an inconsistent category. For example, lumping C with A creates a category of 'single segments' whose members will differ significantly on the horizontal dimension. Nevertheless, criterial conflicts do arise and linguists have no option but to attempt to deal with them. In practice, there are telltale signs that hint at the places where linguists have been grappling with criterial conflicts. An individual linguist may respond to a criterial conflict by adding extra discussion at the relevant point in a descriptive grammar, that records the difficulties and contradictions of the analysis. Pairs of linguists, or pairs of schools of thought in linguistics, may enter into protracted disagreements over what the 'right' analysis is. Communities of linguists may settle upon one solution which becomes a convention – while the opposite solution is conventionalized in another community of practice. And theorists may propose innovations, such as multiple representations or complex representations, which allow both solutions to co-exist. Without entering into any judgements on the merits of such responses, we can recognize that all of these behaviours of linguists are symptoms of a common underlying cause: a criterial conflict.

4 Four dilemmas of phonological typology

With the concept of criterial conflicts in hand, I now turn to the four dilemmas of phonological typology.

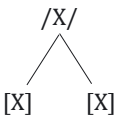
4.1 The non-uniqueness of phonological analyses

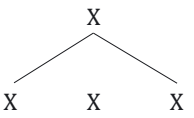
The non-uniqueness of phonological analyses was recognized early in the development of the field. Chao (1934) sets out a list of ways in which empirical facts can licence multiple analyses that "are not simply correct or incorrect, but may be regarded only as being good or bad for various purposes" (p. 38), and many similar observations have been made since (Dresher 2009; Lass 1984; Simpson 1999 inter alia). For instance, in a given language if one's purpose is to highlight sequences of 'pieces of sound', then an affricate is best analysed as two segments, while if the purpose is to highlight regularities of phonotactic patterning, then it may be analysed as one. The general issue is that we have multiple expectations of what a single segment – or for Chao, a single phoneme – should be like, yet phenomena exist for which different expectations point to different analyses, and neither analysis is merely correct or incorrect. Chao finds causes of non-uniqueness of analysis in many quarters: related to the lumping or splitting of segments; to questions over whether segments are present or absent; to phonetic variation; to symmetry and parsimony of

analyses, *inter alia*. The consequence of non-uniqueness is that the same linguistic system can be given multiple, different, defensible analyses. Troublingly, the analysis that it does receive will depend in part upon a choice that must be made by the linguist. Although the range of options that are available to choose from will follow from the facts of the language, the choice actually taken is determined by the author of the analysis. The dilemma for typology is that if a typological study takes analyses of languages as its observations (as it surely must, since there is no pure observation without analysis) then those observations will inevitably blend together facts about languages and facts about linguists (Hyman 2017).

4.2 Multiple levels of phonological analysis

Multiple levels of analysis are ubiquitous in phonology, both in description and in theory. For the moment it will suffice to observe that this is patently true, and I return to the question of why in Section 5.4. Multiple levels can take the form of distinct representations, such as phones, phonemes and morphophonemes (Trubetzkoy 1969), or complex representations with multiple hierarchical layers, such as Pike's (1947) hierarchical relationship of phonemes and segments as in (11a). Complex, hierarchical representations are convenient for capturing one-to-many correspondences, and perhaps one-to-zero correspondences if the formalism permits floating or unassociated elements as in (11b). Multiple, distinct representations can also capture these relationships and, depending on one's assumptions, are potentially more tolerant of linear re-orderings.

(11) a. 

b. 

Multiple levels are useful for allowing a given phenomenon to take on multiple guises simultaneously, for instance, counting as one segment on one level, and as two segments or as no segment on another level. As a consequence, multiple levels are particularly useful for representing phenomena that have criterial conflicts. Conversely, if a phenomenon lacks criterial conflicts and so has little need for multiple guises, then it will typically be represented as more or less identical across multiple representations, or will be connected by simple, one-to-one correspondences in a complex hierarchical representation. This too has implications for typology. The dilemma that is posed by multiple levels is the question of which level to

typologize on.[8] We should note that logically, the choice of which level to use will be most consequential for phenomena that have different guises across different levels. Thus, for the dilemma of multiple levels, just as for the dilemma of non-uniqueness of analyses, it is phenomena with criterial conflicts that will be the most problematic for typologizing.

4.3 Differing theories of phonological analysis

As Hyman (2007) has observed, theory and typology have always been closely linked in phonology. Nevertheless, there is plenty of diversity among theories even though they are tethered to the same typological facts. This existence of multiple theories presents the third dilemma for typologists, because the analyses that they licence are not easily compared and equated. However, let us ask why there are so many theories to begin with. Theories are formulated to solve problems of explanation.[9] It is phenomena with criterial conflicts that often cause problems for pretheoretical bodies of thought, and thereby become the focus of theorizing. As mentioned just above, a common solution is to posit multiple levels, but when doing so there are different ways to go about it. At minimum, there is a choice between multiple representations and single, complex representations. In addition, theories may have other desiderata, especially parsimony. Consequently, supposing that criterial conflict #1 has been solved by positing theoretical device A (such as a particular level of analysis), then if conflicts #2 and #3 can also be solved using device A, parsimony would encourage doing so. As a result, device A will have the virtue (theoretically speaking) of being a parsimonious solution to three problems, but the fact that there is just one device can hide the fact that its existence was motivated by three separate problems. As different theories attempt different solutions to different problems in different sequences over time, it is only natural that they might assign solutions to devices in different ways. For instance, suppose that two theories each use two parsimonious devices to solve six criterial conflicts, and they do so as in Figure 3. In this case, there is no simple answer to the question 'which device in theory 2 corresponds to device A in theory 1?'. For a typologist who was, for example, hoping to typologize over 'comparable' devices (such as levels of analysis) in the two theories, this is disappointing, since there may simply be no comparability. However, while theories may have conflated their solutions to multiple problems in different, conflicting, parsimonious ways, it does remain the case that all theories, broadly speaking, are responses to the same empirical typology. All are solving similar problems. Consequently, though differences do arise as they innovate differently, the theories will have

8 This is exacerbated when different analyses use different numbers of levels or put levels to different uses (more on which in Section 4.3).

9 Theories do many things, but this is their relevant role here.

Criterial conflicts	1	2	3	4	5	6
Theory 1	A	A	A	B	B	B
Theory 2	C	C	D	D	D	C

Figure 3: Hypothetical use of two theoretical devices in each of two theories, to solve six criterial conflicts.

innovated in response to certain shared problems, and thus if we are aware of the common problems, we can be forewarned about the points on which theories' differences may be the sharpest. Given all of this, a reasonable expectation is that theories will differ most sharply in their treatment of phenomena with criterial conflicts, since this is where they have needed to innovate. So yet again, it is phenomena with criterial conflicts that will prove most challenging to typology: not only due to non-uniqueness and the general fact of multiple analyses, but also owing to how they feed into the development of different theories.

4.4 Contingency of phonological analysis

In phonology, as in all domains of grammar, the analysis of one phenomenon is often dependent upon the analysis of another. For instance, a decision about whether or not a language tolerates consonant clusters in syllable onsets may determine whether a word-initial nasal+stop is analysed as a single segment or a cluster (Pike 1947). Similarly, decisions about the morphological affiliation of a segment may affect whether its variable presence/absence is analysed as deletion or epenthesis, and thus whether it is present or absent on certain representational levels. The dilemma here is that analyses of phenomena in a domain that is currently under study may be affected by choices that linguists must make in other domains that are not directly under study. Again, the dilemma relates especially to criterial conflicts, for instance, conflicts between a criterion on canonical segments and a criterion on canonical syllables, or between criteria on canonical segments and canonical morphs. Consequently, for this fourth dilemma, as for the previous three, the crux of the problem lies in phenomena with criterial conflicts.

4.5 Relating the four dilemmas, the first step to their resolution

The four dilemmas discussed above are important to grapple with, because when left unaddressed, their effect is to weaken the validity of phonological typologies, by

allowing similar languages to appear different to us and different languages to appear similar. By doing so, they frustrate our adherence to the fundamental desideratum of comparing like with like.

Moreover, phenomena with criterial conflicts may wind up being systematically categorized together with phenomena that lack conflicts. If this occurs, then criterial conflicts may get systematically hidden from view. This is particularly regrettable, since it is criterial conflicts that are a key source of empirical challenges to received bodies of thought. One of the benefits of phonological typologizing ought to be that it allows empirical phenomena that challenge existing thought to be highlighted, not hidden away.

All four dilemmas relate principally to phenomena with criterial conflicts. This is welcome news, since it means that really, there is only one core challenge to be dealt with, not four as it appeared initially. Moreover, it is clear how good progress can be made. Developing an inventory of known criterial conflicts and the phenomena that have them would help map out phonological typology into areas where extreme caution must be exercised when interpreting data and results, and areas where we can proceed with more certainty.[10] Moreover, if my argument has some validity, and it is true that we have simplified the bulk of the four dilemmas by relating them principally to criterial conflicts, then the next step is to identify effective strategies specifically for dealing with criterial conflicts. This will be the main concern of the remainder of the paper.

5 Strategies for phonological typologizing

5.1 Normalization

One approach to the dilemmas of typologizing is to typologize over normalized data (Kiparsky 2018; Maddieson 1984; Van der Hulst 2017). There appear to be two main ways in which normalization could be carried out: shifting data to the same level of analysis, or shifting data to reflect the same choice of solution to certain problems.

In the first kind of normalization, data in each language should be examined at the same level of analysis (for example, Kiparsky 2018 advocates analysing data at the Lexical level in order to compare it). There are three main problems to this approach though. First, the desired levels of analysis may not be available for much of the data, and the task of reanalysing the phonological systems of multiple languages may be

10 For instance, we would expect a typology of plain nasal segments to be relatively less exposed to these challenges, since plain nasal segments are generally highly canonical across many of the criteria in Section 3.2, compared to a typology of pre-nasalized stops for example.

impractical to undertake. Second, even if levels of analysis are available which are called by the same name, e.g. 'phonemic', the actual levels themselves may be significantly different: consider that in some theories, a phonemic level is one of two levels (the other being phonetic) where in others, is it one of three (the third being morphophonemic).[11] Third, given that levels tend to conflate the solutions of different problems in idiosyncratic ways (Section 4.3), it is not clear that a level is a natural object to study, as opposed to an artifactual and potentially idiosyncratic one.

A second approach to normalization is to normalize the solutions adopted to certain phonological problems, for instance, always treating affricates as one segment, or always as two. An advantage of placing phonological problems at the centre of normalization is that we know that these problems are the true, ultimate cause of much of the disparity that bedevils typology via the four dilemmas. The practical feasibility of performing this kind of normalization will depend in part on how well we understand the differing ways in which these problems have been solved in the analyses that make up our data: the better the understanding, the more effectively we can 'unpick' the analyses in the manner desired. One example of the application of normalization in this problem-centric sense is the set of 396 phonemic inventories of Australian languages by Round (2019a, 2019b), in which a set of phenomena known to have criterial conflicts are each accorded a normalized analysis, in an attempt to ensure that the remaining diversity across the inventories is most likely due to empirical differences in the languages rather than due to different choices of analysis made by the linguists who studied them.

5.2 Factorial analysis

Factorial analysis is an approach described briefly in Round (2017). The idea is to undertake multiple normalizations – for instance, to normalize the data using both solutions to a particular problem – and then to analyse each of the resulting datasets. The first major implementation of the method is Yin's (2021) analyses of sonority sequencing (see also Yin et al. 2023, this volume). Yin examines sonority sequencing violations in 496 languages, and makes two sets of assumptions: firstly, that affricates and homorganic nasal+stop are single segments, and then secondly, that they are sequences. Factorial analysis allows one to examine how the adoption of contrasting analytical choices can change the results of a typology. For instance, Yin finds that the cross-linguistic frequency of sonority sequencing violations appears more symmetrical in codas and onsets when affricates and homorganic nasal+stop are treated

11 The differences among levels called 'phonemic' stretch far beyond this, of course (Anderson 1985; Dresher 2011; Fischer-Jørgensen 1975; Twaddell 1935).

as sequences, and less symmetrical if they are treated as single segments. If factorial analysis is to be feasible as a general methodology, it will be prudent to assemble a stock of problems which are known to have multiple possible solutions, and which can then be normalized in multiple ways during the typological analysis of the data.

5.3 Multivariate analysis

A constant topic of discussion throughout this paper has been phonological phenomena which are not easily categorized into dichotomous traditional notions, such as one segment versus two. A potential drawback of normalization and factorial analysis is that their results are formulated directly in terms of these simple categorizations, which are known to be problematic. An alternative is multivariate analysis, in which the typology is conducted in terms of multiple dimensions of variation, such as canonical criteria. The results of multivariate analysis can appear quite different from those of traditional typological surveys, primarily because they do not take traditional categories as their units of measurement. We can expect multivariate analysis to be particularly insightful in the case of phenomena that are non-canonical, including those with criterial conflicts. For example, rather than asking 'how common are the various segments of the world', which presumes that we have already classified all phenomena as segments (whether one or two or more), the question in a multivariate analysis would be, what distributions and combinations of segment-like properties do we find in phenomena that correspond to 'a single speech sound'? (To make this concrete, a very short example study is given in Section 5.5 below.) In a multivariate analysis, the raw results will be multi-dimensional: each phenomenon examined will be rated as falling somewhere along each of the several dimensions investigated. Results of this kind, in a multivariate format, enable questions to be asked such as what the distribution of ratings is along a particular dimension (e.g. what percentage are near-canonical), but also what correlations, either positive or negative, might exist between the ratings on different dimensions. Multivariate analysis also enables us to discover criterial conflicts, to ask which are common or rare, and whether some criterial conflicts correlate with others, and how.

5.4 The kinds of findings that may result from studying criterial conflicts

Both multivariate analysis and factorial analysis furnish the means for studying criterial conflicts – either directly (in multivariate analysis) or indirectly, via the effects they have on multiple versions of typological results (in factorial analysis). It is worth considering for a moment some of the kinds of results that might emerge from

such studies, and here I take segments as an example. One conceivable result is that certain criterial conflicts are close to universal, affecting nearly all segments. This actually happens in the case of the conflict between criteria 6 (contrastiveness) and 10 (consistency of quality across environments). Virtually no concept of a segment which is reliably contrastive, such as the phoneme, will also have the same phonetic form in all environments; and conversely, no concept of a segment which has a constant phonetic form in all environments, such as a phone, will be the kind of unit that is reliably contrastive. This is one of the oldest findings of modern phonology (Anderson 1985; de Courtenay 1972; Ladd 2011), and the universality of it goes a long way to explaining why phonologists so unanimously embrace the recognition of multiple levels of analysis.[12] This is one possible outcome: a criterial conflict is found to be universal and so leads to an advance in phonological theory, that phonological segments have a fundamentally dual nature. Another conceivable outcome is that a criterion which frequently gives rise to conflicts comes to be regarded as ill-conceived, and accordingly, the original body of knowledge on which it was based is updated. A more radical possibility is that an entire pretheoretical concept such as 'segment' is rejected (cf. footnote 2, above). For typologists, what is most important here is that these are the cases in which the result of typologizing have the most significant ramifications for theory. Since those cases revolve around criterial conflicts, it would be fair to argue that criterial conflicts are precisely where theorists are most in need of reliable insights from typologists.

5.5 An example

Before turning to final discussion and conclusions, I first provide a very short example of multivariate analysis of the kind mentioned in Section 5.3. Here I report on a study by Round (2022) of homorganic stop+nasal intervals, which for convenience I will write as CN, in the Pama-Nyungan family of Australia.

Most language families of Australia permit homorganic and heterorganic stop+nasal clusters, but Pama-Nyungan languages generally do not permit any (Round 2022). Nevertheless, there are 18 languages in six subgroups of Pama-Nyungan which do possess homorganic CN in elevated numbers, where 'elevated' is defined for the purposes of the study as appearing in at least ten lexical items, and more than twice as frequently as heterorganic CN. These CN intervals have been analysed as single, complex segments or as clusters, as summarized in the column

12 Of course, once we posit two levels, it will be possible to use them to solve additional criterial conflicts (cf. Section 4.3), so it is not the case that we necessarily expect to see further proliferation of levels as soon as there are additional, universal criterial conflicts.

Table 1: Presence of simple nasal (N), clusters (CC) and homorganic stop+nasal (CN) in five phonotactic positions, and their analyses in the literature as prestopped nasals (^{C}N) or clusters (C+N).

	Analyses	V_V	#_V	V_#	C_V	V_C
Kulin	^{C}N	N CC CN	N	N CC	N CC CN	N CC
Karnic	^{C}N, C+N	N CC CN	N		N CC	N CC
Thura-Yura	^{C}N	N CC CN	N		N CC	N CC
Arandic	^{C}N, C+N	N CC CN	N CC CN		N CC CN	N CC CN
Paman	^{C}N, C+N	N CC CN	N	N CC CN	N CC CN	N CC CN
Yolngu	C+N	N CC CN	N	N CC CN	N CC	N CC CN

titled 'analyses' in Table 1, which is arranged by subgroup: Kulin, Karnic, Thura-Yura, Arandic, Paman and Yolngu.

CN intervals can be assessed in terms of the canonical criteria for single segments in Section 3.2. For brevity, I restrict myself here to a subset: criteria 1, 4 and 5. Criterion 1 states that a canonical single segment is internally uniform, which is not the case for CN. Criterion 4 states that a canonical single segment is integrated into unremarkable prosodic structures, such as a canonical syllable. Dixon (1980) shows that Australian languages have few clear diagnostics for syllable breaks, so this criterion is difficult to assess, and we set it aside. Criterion 5 will prove particularly interesting though. It states that single segments are integrated into unremarkable linear phonotactic structures. To investigate this property of Pama-Nyungan CN, Round (2022) uses a common strategy in multivariate typology, and splits this criterion into finer dimensions. For each subgroup, Table 1 compares the presence/absence of CN with the presence/absence of a simple nasal (N) and the presence/absence of other clusters (CC) in five phonotactic positions: intervocalically (V_V), word initially (#_V), word finally (V_#), post-consonantally (C_V) and pre-consonantally (V_C). In many positions, CN behaves like both N and CC, since either all three of N, CC and CN are permitted, or none are. In some positions, CN behaves like neither N nor CC, because N and CC are permitted but CN is not. Finally, only in the word-initial position in most subgroups does CN behave like clusters CC and unlike the simple nasal N, insofar as neither CN nor CC is permitted, while N is. These comparisons of CN versus CC and N are summarized in Table 2.

This very short study reveals that Pama-Nyungan CN is not unambiguously more like a single segment N or a cluster CC. It is marginally more cluster-like, though only with respect to canonical criterion 5, in word initial position, and not in all subgroups. More significantly though, the results illustrate the fact that merely assigning CN intervals to a segmental analysis, as one segment or two, does little to shed light on their actual nature and variation across subgroups, and moreover, that had we taken

Table 2: Similarity of phonotactic patterning of homorganic stop+nasal, compared to simple nasals, clusters, both or neither in five phonotactic positions.

	V_V	#_V	V_#	C_V	V_C
Kulin	BOTH	CLUSTER	NEITHER	BOTH	NEITHER
Karnic	BOTH	CLUSTER	BOTH	NEITHER	NEITHER
Thura-Yura	BOTH	CLUSTER	BOTH	NEITHER	NEITHER
Arandic	BOTH	BOTH	BOTH	BOTH	BOTH
Paman	BOTH	CLUSTER	BOTH	BOTH	BOTH
Yolngu	BOTH	CLUSTER	BOTH	NEITHER	BOTH

the existing segmental analyses, in the 'analyses' column of Table 1, at face value, our view of their typology would have been poorly informative at best and misleading at worst. More generally, this case study illustrates the fact that when criterial conflicts are at issue, it may be that the only avenue to a clear typological picture of the phenomenon is through the use of multivariate methods. Relatedly, if we were typologizing some other phenomenon (e.g. sonority sequencing) in which the analysis of these problematic phenomena would contribute to the findings, then at the very least, it would be prudent to use a factorial typological method, in order to be cognizant of the potential impact of adopting different analyses.

6 Consequences for phonological typology

Canonical typology offers powerful and principled tools for carrying out typological surveys. But it also offers more. Like other multivariate methods, canonical typology offers advantages over traditional methods, by identifying multiple dimensions of empirical variation and applying them to produce detailed and nuanced characterizations of phenomena and their diversity. But because canonical typology also labels one end of each dimension as 'canonical', it explicitly keeps track of the emerging typology with respect to previous bodies of thought, and therefore highlights aspects of the typology which challenge them. It also enables the discovery of criterial conflicts (whereas other multivariate methods typically do not). In the context of the four dilemmas of phonological typology in Section 4, this is invaluable, because criterial conflicts are the primary problem shared by all four dilemmas. Canonical typology enables us to systematically search for and identify phenomena with criterial conflicts, which we then know will be the major points of difficulty for non-uniqueness of analysis, choice between levels of analysis, multiple theories of analysis, and analyses contingent on other phenomena. In Section 5 I discussed

typological strategies to deal with these dilemmas, and emphasized the value of factorial analysis and multivariate analysis. Both methods are laborious, but as the example in Section 5.5 illustrates, a reliance merely on traditional analyses risks being uninformative or misleading. Moreover, we have every incentive to invest the effort in getting the typologies of these phenomena correct, because criterial conflicts constitute a primary source of the problems that explanatory theories of phonology will in turn seek to solve, and thus phenomena with criterial conflicts are precisely where the highest rewards stand to be reaped from good typologies. Canonical typology provides the means to first discover what these key phenomena are, and once they are identified, to analyse them effectively.

If the argument presented above is on the right track, then there are consequences for the work lying ahead in phonological typology, in the near and medium terms. In the near term, it will be invaluable to build up a stock of canonical analyses of domains in phonology, with particular attention to criterial conflicts that emerge. Thereafter, there will doubtlessly be work to do, refining the initial attempts. In the near and medium terms there will be ramifications to be figured out for typological databases. For instance, databases of segments are valuable, but if certain types of 'segment' are known to have criterial conflicts and therefore systematically to be the product of necessarily unsatisfactory analytical choices, then how should databases represent them more appropriately while continuing to integrate them with less problematic segments? Looking somewhat further ahead in this research program, once there exists a good inventory of criterial conflicts and a growing body of accounts of their typology, it is time to turn our attention to explanatory theories. By using the concept of criterial conflicts, we can begin querying which problems theories have solved, and compare how. For instance, which theoretical devices have been used, and what problems have been solved in similar or disparate ways? Does our analysis of theories lead us to believe that their differences are genuine and principled, or merely idiosyncratic and happenstance? Can we identify ways of integrating successes from one theory into others, and can we begin to demonstrate that some theories, despite appearing to differ, are actually essentially the same? In the best case, this will lead to a period of theoretical consolidation and tightening of focus in phonology. And it will be based on sophisticated typologizing of the most consequential phenomena for phonological theory.

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