

Chapter 1

A Point-Based Event-Ontology for the Phonetics/Phonology Interface

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ABSTRACT. Recent rethinking of the Phonetics/Phonology-Interface has come to drop the old notion of a syntactic relationship between both research domains and replaced it by a semantic one. However, it remained relatively unclear how this relationship ought to look like. Progress in diagrammatic reasoning provides a fruitful approach towards a mutually constraining interface description. But to utilise this tool we first have to argue that it is reasonable to suppose a common ontology of a certain variant for both fields of research. This is so, because the heterogenous logics-approach attempted here relies on the sharing of models.

1 Introduction

On June 13th 1998 Anna uttered, as an assent to a preceding utterance “Uh-hm”; this is often taken to be a positive feedback signal in German, which is her mothertongue. The sounds/air turbulences that left her mouth can be represented¹, at a low level of abstraction, as shown in Figure 1.1.

¹In this section we will talk a lot about representations. This is intended to be a kind of case study and we hope that much of what can be said about representations can also be said about theories. This hope is based upon the fact that representations are (licensed by) parts of theories and thus strongly connected to them. We will switch back to talk about theories in the subsequent sections.

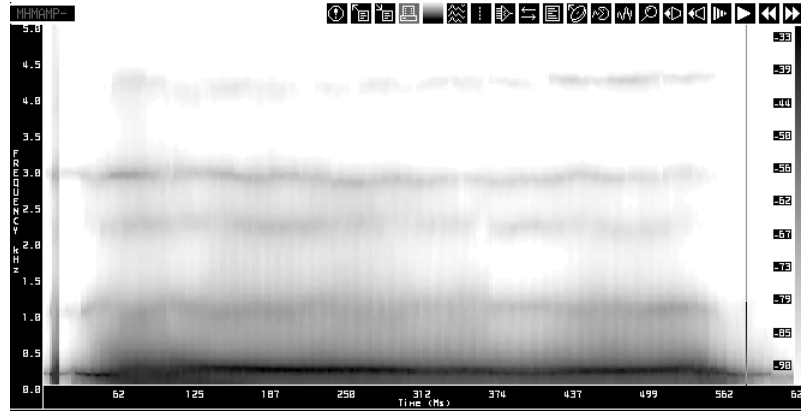


Figure 1.1: A spectral analysis of a sample utterance

Many alternative representations of the given utterance are possible, depending on the researchers' interest. An alternative phonetic representation is given in Figure 1.2.

LUNGS	subglottal pressure		decreasing s.gl.pr.	no s.gl.pr.
GLO-CD	closed	opening	periodic	closing closed
GLO-CTD	relaxing	tensing	tense	
VEL	open			
LIPS-CD	closed			
LIPS-CL	bilabial			

Figure 1.2: An articulatory representation of the same utterance as above

The representation in Figure 1.1 shows some properties of Anna's utterance in a different way than that in Figure 1.2, e.g., beginning and end of the utterance etc. Moreover, the representation in Figure 1.2 shows *other* properties than that in Figure 1.1, e.g. the articulators involved. However, what may not happen, and cannot happen if the representations are correct, is that they contradict one another in showing differing instantiations of the *same* property. The same holds if a representation from a different field of research is involved, say, phonology. (Figure 1.3 shows a simple phonological representation of Anna's utterance.) They can not contradict each other because they are about the same objects.

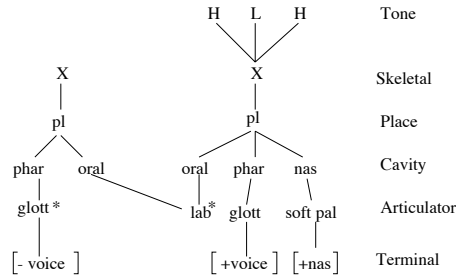


Figure 1.3: A phonological representation of Anna's utterance

This view is also expressed in Pierrehumbert's [11, 375] well-known paper:

Both phonology and phonetics have the aim of describing and explaining the sound pattern of human language. Insofar as both are exact theories, both must provide exact representations of the sounds of language. But the work done by these representations is different.

We agree with Pierrehumbert on this aspect. What ought to be kept in mind is that the differences in description do not lie purely on the level of granularity but on the level of perspective. It may be an acoustic, auditory, articulatory or functional perspective, respectively. Now that we know what the differences are, something needs to be said about what all those different representations viz. the theories licensing them have in common. If we know this, we maintain, we have an answer for the interface-problem. But before we can discuss the questions related to this problem, in turn, we first have to make clear what the shared ontological commitments at stake are.

2 Ontology

So the question arises how the basic entities phonetics or phonology talk about should be construed. As it is up to now quite unclear which entities *the* scientific ontology has to comprise it is worthwhile to discuss the consequences of different commitments. A popular view (*inter alia* [4, 3, 2] postulates *events* as the basic ontological entities for both phonetics and phonology.) Events are elegant because they appear to capture important features of (interpretations of) both phonological and phonetic diagrams, like the beginning and ending of some represented unit. When interpreting a spectrogram, we talk about *simultaneity* of formant movements or of an occlusion phase *preceding* a release phase. When interpreting autosegmental diagrams, those constituents related via association lines are usually (unless they are subsegmental units) interpreted as being *temporally overlapping*, while units represented on the same tier, are conceived of as standing in a

relationship of *precedence*². In [6], the temporal interpretation of phonological representations is somewhat different. In this description, phonological heads (e.g. syllable nuclei) are temporally interpreted before non-heads (e.g. syllable onsets) and temporally overlap with those constituents they dominate. This interpretation also results in an event-based description of phonological entities.

Two strategies concerning the status of events are possible. One is to say that events are entities in their own rights, the other to say they can be derived if other entities are assumed, most prominent among them instants. We vote for one version of the second option, a definition of events on the basis of beginnings and ends contra Bird [2] and in accordance with Coleman [6]. Bird's *formal* account is otherwise very much like our own, already rendered in Wagner [13].

The following discussion of viewing events as derivative of instants can be regarded as an answer to Bird's discussion of the issue.

2.1 Different notions of time

One reason for viewing events as ontological primitives is the need for phonological descriptions to remain temporally under-determined as opposed to phonetic events ([5, 2]). The necessity of defining different knowledge domains on the basis of different time domains has been defended by Carson-Berndsen [5]. She introduced the concept of *relative time* (typically) holding between phonological units as opposed to *absolute time* holding between phonetic units. We would not like to see a phonological description of an utterance to include information that a specific autosegment starts holding 200 milliseconds after the beginning of that utterance. In an approach where points of time stand in an ordinal relation to each other, this demand can be fulfilled. The argument for viewing an instant-based ontology not useful for phonological descriptions therefore seems to be based on a misconception of instants as necessarily referring to some point on an interval time scale. In many phonetic domains and applications (speech synthesis, labelling of speech signals), however, exact beginnings or endings of phonetic events need to be specified (even this may often be empirically difficult). In phonetic representations the (absolute) beginnings or endings cannot be ignored. Using a point-based ontology and leaving the temporal scale unspecified can thus serve for both descriptive levels.

²For a detailed description of the temporal interpretation of the hierarchical and linear information inherent in autosegmental diagrams in terms of precedence and overlap, see [2]

2.2 Instants vs. atomic events

It seems to us that most of the arguments against point-based ontologies rely on the assumption, that points of time are temporally extended units, some kind of *atomic events* that cannot be further divided. However, if they are rather regarded as *cuts* or *instants* without having a temporal extension themselves—a view which was already put forward in Ducasse [7] against Russell [12]—at least part of these difficulties can be avoided³.

2.3 Dynamic vs. stable events

Phonological event representations often abstract away from the dynamic movements of articulators, formants etc., which are a necessary ingredient in most phonetic descriptions. One could argue that those phonological events regard stable target configurations. An event-based description runs into problems when it tries to capture dynamic events that can be characterized by a constant change rather than a stable position.⁴

2.4 Cognitive Plausibility

Another argument mentioned by Bird is the apparent lack of cognitive plausibility of a point-based approach. According to him, it would take infinite processing time to recognise two events as preceding one another if they consisted of an infinite sequence of points. It is not clear, though, whether cognitive plausibility

- **is relevant**; after all we are engaged in determining the *nature* of (phonetic/phonological) events. It needs to be explained why their nature ought to be equivalent to the way they are cognitively processed.
- **is in favour of event-based ontologies** at all. One reason for our doubts is that it could very similarly be argued that it would take infinite processing time to recognise an event without ever determining the instant of its beginning or end or to produce one without ever starting to give motor commands.

3 Non-Reduction

Now that we have made clear what the basic entities in our ontology are, we have to explain how it happens that phonology and phonetics so often coincide in their predictions, or, to put it weaker, do not contradict each other.

³For a more detailed discussion of this point, cf. [13].

⁴For a more detailed event definition based on instants and an explicit differentiation between dynamic and stable events see [15]

A first proposal could be that phonology is reducible to phonetics and hence can not contradict the latter. Traditionally, a theory Θ_1 is called *reducible* to a (base-)theory Θ_0 iff the axioms of Θ_1 are (deducible from) theorems of Θ_0 . We write $\vdash_{\Theta_0} \Theta_1$ for this. If one defends the view that phonology is reducible to phonetics, and has not an exotic view on reduction, this means that $\vdash_{\Phi_0} \Phi_1$, where Φ_0 is phonetics and Φ_1 is phonology, is supposed.

What makes this view attractive is that it complies with the classical view of all sciences being unified with Physics as the base-theory for all the other special sciences. It is generally accepted that correctness of the assumption that the physical work is closed is the legitimation for doing sciences the way we do. Clearly, phonetics is more often than phonology engaged in numeric measurements, hence it seems that phonetics is in a way closer to physics. This accounts for the hierarchy of theories with phonetics as a base-theory for phonology.

On the other hand, there are lots of problems in this view a solution of which is not so easy. One of these problems is that phonology, e.g., has in its vocabulary the expression “means”, that is, at least one semantic expression, and it is not at all clear, how the bridge laws⁵ mapping semantic expressions onto phonetic ones could look like if there are any.

So, though the view of a reductive relation between phonetics and phonology surely is attractive, it is by far not clear how (or if!) the reduction should be done.

3.1 Semantic Cohesion

We defend another view on the relation; we hold⁶ that

$$\not\vdash_{\Phi_0} \Phi_1 \& \not\vdash_{\Phi_1} \Phi_0 \tag{1.1}$$

But of course we take it that there is *some* relation between both sciences that prohibits that one contradicts the other. This is, under no circumstances may one of both state a fact that does not hold following the other. Let us explain briefly: The idea is that there are models in which the laws of phonetics are true; if phonetics and phonology are correct and adequate (if their generalisations are right, or, as Pierrehumbert, p. 3 above, put it, if they are exact sciences) for the description of utterances, the set of models in which the phonetic laws are true is identical with the set of models in which the phonological laws are true. If this were otherwise, there were a

⁵We omit mentioning the bridge laws mapping the basic expressions of one theory onto that of the other from here on. It is clear that the reduction paradigm we have in mind is Nagel’s from [10].

⁶Indeed we do not hold a view quite as strong as what is defended here; we do not really want to say that we think that reduction is *impossible*, but only that it is *not necessary*. So what follows is too strong a claim and just put forward to take the strongest possible position here.

contradiction between phonetics and phonology and one of them, or possibly both, had to be corrected. Note that this is in compliance with Pierrehumbert's [11, 380] characterisation of the relation between the two theories as a semantic one.

What we write for the fact that each model that satisfies Φ_0 satisfies Φ_1 as well is

$$\bigwedge_{\mathcal{M}} (\mathcal{M} \models \Phi_0 \Rightarrow \mathcal{M} \models \Phi_1) \quad (1.2)$$

So, to sum up, what we want from phonetics and phonology, and what we are sure they give us, is

$$\not\models_{\Phi_0} \Phi_1 \& \not\models_{\Phi_1} \Phi_0 \& \bigwedge_{\mathcal{M}} (\mathcal{M} \models \Phi_0 \Leftrightarrow \mathcal{M} \models \Phi_1) \quad (1.3)$$

where \mathcal{M} is any standard Kripke model. This is what we talked about in the introductory remarks: Phonetics and phonology are about the same objects *and* they cannot contradict each other. If we conceive of events being modelled as relations between instants (the lesson from section 2), then it is clear how a language conforming to phonetics and phonology would look like.

It is interesting to see, what a reductionist account would say to our demand (1.2).

1. $\vdash_{\Phi_0} \Phi_1$ holds, i.e., Φ_1 can be deduced from Φ_0 ; hence it is necessarily the case that the set of models in which Φ_0 is true is not larger than the set of models in which Φ_1 is true: Theories are to be conceived of as conjunctions of axioms, hence each new axiom added will add new truth conditions to the previous ones.
2. Of course the other way round is not true on a reductionist's account, as $\not\models_{\Phi_1} \Phi_0$ holds. To require $\vdash_{\Phi_1} \Phi_0$ would be grotesque in the context of (1); it would mean that the two theories collapsed and turned out to be one and the same theory. This could be the case with some theories, but surely is not the case with phonetics and phonology. And the relation between the two theories would rather be identity than reduction.
3. Hence it is no guarantee that the two sciences are true in the same set of models. It is a matter of dispute whether one should require this, but it seems to us that correctness and completeness together are hallmarks for good theories. Completeness alone will not do, as the theory will render too many theorems as true.

So it seems to us, that our demands concerning identity of the sets of models is justifiable and that a reductionist account would do only half of the work⁷.

⁷An aside: What was said up to now is partially compatible with reductionism; if we wanted to help the reductionist, we could lend him the third conjunct, i.e. 1.2.

3.2 Interlingua

Barwise & Etchemendy [1] discuss the question, whether in such a case where two languages describe the same set of models it is necessary to have a third language translating the other ones in order to be able to co-ordinate the mutual constraints. Of course, Barwise & Etchemendy have some different problem in mind, namely co-ordinating diagrammatic inferences with inferences drawn in a propositionally represented format. But it is clear that, as the models used in the heterogenous logic paradigm are Kripke models for first-order logic and PL1 is complete for these models, all inferences drawn in the diagrammatic notation are expressible in PL1. Hence, if one chooses a proper weakening of PL1 with just the expressions necessary to formulate the diagrammatic inferences and another weakening of PL1 to capture what is written in the propositional format, there is a merge of both weakenings that is capable of expressing both of the theories and that is PL1-expressible. We consider phonetics and phonology as weakenings of a first order language. So, in this sense our problem is analogous to Barwise & Etchemendy’s. Now, the authors come to the conclusion that it is possible to find a translating language but that it is superfluous as it adds nothing—it is just the merge from the last paragraph.

Indeed, we as phoneticians or phonologists do not need an interlingua, either. We can do, say, phonology without looking over the fence. But as *theorists* and as people implementing linguistic knowledge we are bound to respect both fields of research. That is, we have a division between the *interface* that works without any interlingua and the *description of the interface* in our logical language.

As we understand Barwise & Etchemendy, one can look at formulae and depictions, together with their truth conditions, as being *restrictions over admissible models*. This, as they show, does all that is needed: Given inference rules for both notational systems, we can derive all valid formulae and, given the interpretations of the formulae, can find all the admissible models. No one working with constrained based grammars should be too surprised by this view⁸. So, let a language be a notational system plus interpretation. The set of models admissible for both notational systems plus their interpretations, i.e., for both languages, is just the intersection of both of the sets of models. In Tarski’s terminology, it is just the set of sequences of objects that satisfy both languages. The same holds *mutatis mutandis* for the models that satisfy singular expressions in either format. This is the skeleton of what we do with phonetics and phonology.

⁸Neither should anyone working with dynamic logics: Restrictions over admissible models accumulating during discourse is exactly the idea behind conjunction in DPL [8] and the construction algorithm in DRT [9]. E.g, the definition for the semantics of conjunction in DPL is $\llbracket \phi \wedge \psi \rrbracket =_{df} \{ \langle g, h \rangle \mid \exists k (\langle g, k \rangle \in \llbracket \phi \rrbracket \& \langle k, h \rangle \in \llbracket \psi \rrbracket) \}$, where k is a restricted assignment function relative to g .

4 Conclusion & Perspectives

We got

- from section 2 the result that we can have a common ontology for phonetics and phonology;
- from section 3 that if we have a common ontology, there are mutual constraints between both of them and the possibility to describe them in a unified format, the interlingua.

We did not yet exhaust the potential of the heterogenous logics; up to now we only concentrated on the basic feature of mutual restrictions between theories. The proposed view, however, can be augmented and fruitfully applied in phonology or phonetics alone: Heterogenous logics provide means to formalize the relation between the diagrams and text in both areas *themselves*. This, however can not be done here.

Another result of our treatment of the interface is that the relation between the representations in phonology and in phonetics can be described. One of the reviewers, to all of whom we are indebted for their inspiring comments, wrote that we could as an alternative to our methodology view phonetic representations as models for phonological representations. And, yes, this was what we had in mind when we chose the heterogenous logics approach. Unfortunately, due to restrictions by space, here, we cannot show what we achieved up to now in this area. In short, we include the representations in the set of models and get a fancy ontology for our descriptive apparatus.

In the end one might ask what is the practical outcome of such a relation on things for the working linguist? Basically, we say that phoneticians and phonologists need not work on conflating their theories into one or try to deduce representations of the other kind via complicated rule systems. All they need to take care of is to make sure that their descriptions of objects do not contradict the ones given by other theories concerned with the sound structure of the language in question. So, we can expect with the ongoing research of both disciplines that scientific progress will not only affect ones own but also the neighboring discipline. One could thus think of phonetics and phonology as mutually constraining each other and this insight may prove productive in constraint-based grammar architectures which want to concern themselves with speech as well as language. The core idea of this approach has already been applied to a practical implementation in the small domain of German Discourse Particles (see [14]) and will be extended to larger domains in the future.

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