Mutual Constraints at the Phonetics-Phonology-Interface

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Es soll gezeigt werden, daß die Darstellungen von Phonetik und Phonologie mit Hilfe *einer* Ontologie beschrieben und zueinander in Beziehung gesetzt werden können, welche Ereignisse als aus Zeitpunkten ableitbare Stukturen betrachtet. Der hier verfolgte Ansatz betrachtet beide Wissenschaften als sich gegenseitig einschränkend und ermöglicht Repräsentationen beider Domänen in contraint-basierten Grammatiken.

It is shown that phonological and phonetic representations can be formally described and interfaced using an ontology where events are taken as derivative of instants. The approach followed here regards both research domains as constraining each other and enables a representation of both domains in constraint-based grammars.

1 Introduction

Both phonetics and phonology are concerned with the description of the sound shape of language, but both strive for different kinds of generalisations. A view which has become popular though not yet formally expressed is that their relationship ought to be regarded as a semantic one rather than a syntactic one, and that it is misleading to expect there to be a set of rules deriving one description out of the other (e.g. [8]).

In this paper, a common description language based on a common ontology provides the basis for a formalisation of the relationship between phonetic and phonological representations that serves for an integration in a constraint-based grammar architecture.

2 Ontological Issues

A major step towards clarifying and formalizing the relationship between phonetic and phonological representations has been achieved by Bird and Klein [2] and Bird [1] with their logic of *Phonological Events* which serves to interpret *articulatory diagrams* as in [3] and *autosegmental diagrams* familiar from [5] as temporal event structures.

Following a definition by van Benthem [10], an event is *a period of time during which a certain property holds.* Events can stand in the relations of

precedence ($\prec$) and overlap ($\circ$) to each other. We propose two changes to this event ontology for phonetic/phonological representations:

1. Events are temporally extended units with a specific beginning and end, each marked by an *instant*, which is not temporally extended in itself.

2. During an event, either a certain property (*static event*) or the change of a certain property (*dynamic event*) does hold, where the end marks the instant where either *the property stops holding* or *the change stops holding*

This event definition[1] becomes necessary, because in the phonetic domain changes are at least as common as stable configurations. Furthermore, gestures, formants but also phonological categories (L,H) are often defined in terms of targets or points.[2] But a (phonetic) representation that abstracts away from the dynamic changes within its event representations (like a phonetic release phase), leaves gaps and is inadequate[3].

3   The Description of the Interface

Our solution for an integration of both constraint sets is to say that the set of models in which phonological theory is true must be identical with the set of models in which the phonetic theory is true. And this has to be the set of possible utterances of this language.[4] With the help of our point-based ontology which serves to describe both phonetic and phonological representations, we can further relate both representations, each contributing different aspects of information.

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[1] We vote for a definition of events on the basis of beginnings and ends against Bird [1], who views (temporally extended) events as being ontological primitives. Bird's formal account is very similar to the approach favoured here.

[2] It ought to be noted that Bird explicitly argues in favour of an event-based ontology for phonological and phonetic descriptions. However, these arguments are not convincing (cf. [11], [12])

[3] For the need of different time domains for phonetic/phonological knowledge domains, cf. [4]

[4] For a more detailed account of this cf. [12].

3.1   The definition of $\mathcal{L}$

$\mathcal{L}$[5] is a slight extension of Bird's language. We adopt from his paper the
operators used for expressing relevant relations, but define them differently
due to our different ontology (cf. 2). Phonological and phonetic events can
be defined within such a framework and one can talk of them as *preceding*
($\prec$), *overlapping* ($\circ$), etc. one another. The axioms that need to be satisfied
by events as derivative of instants can be sketched as such:

1. *Instants are linearly ordered on a scale*

2. *Events precede each other, if the beginning instant of the one follows
   the final instant of the other.*

3. *Events immediately precede each other, if the final instant of the one
   is the beginning instant of the other.*

4. *Two events overlap each other, if neither of them stops before the other
   one has started.*

5. *Events last until the property that holds during that event starts chang-
   ing (OCP) or as long as a property changes.*

3.2   Grammar Architecture

A framework such as HPSG [9] provides us with an instrument where any
descriptive level of grammar can be related to any other one via unification,
subsumption and structure sharing. The interaction between phonetic and
phonological constraints can be integrated into such a formalism by intro-
ducing a PHONCONT sort, where — in analogy to semantic situations
— "parametrized states of sound affairs" are stated as relations between
phonetic and phonological constraints, the phonetic context imposing re-
strictions upon the way of interpreting the phonological content and vice
versa. The PHONCONT-entry would thus serve as a semantic interpre-
tation of the $\circ$- and $\prec$-operators by integrating the empirical constraints
both sciences impose on models of the same linguistic unit. The insightful
work on two–level formalisms known from Kaplan and Kay [6], Kosken-
niemi [7] and others is based on a similar observation, namely that there
are two different sources of constraints which can be tied to each other
via *Finite–State Transducers*. These transducers describe exactly the set
of models satisfying both sets of constraints of the language in question.

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[5] For a formal and more complete description of $\mathcal{L}$ cf. [11]
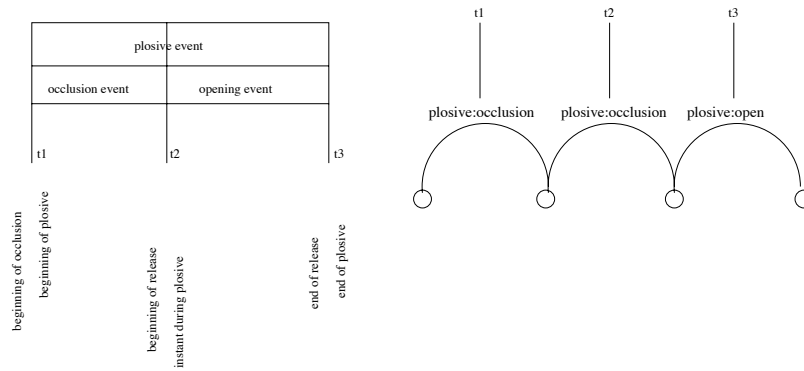
Figure 1: The mapping between a phonological and a phonetic plosive event expressed in an instant based FST.
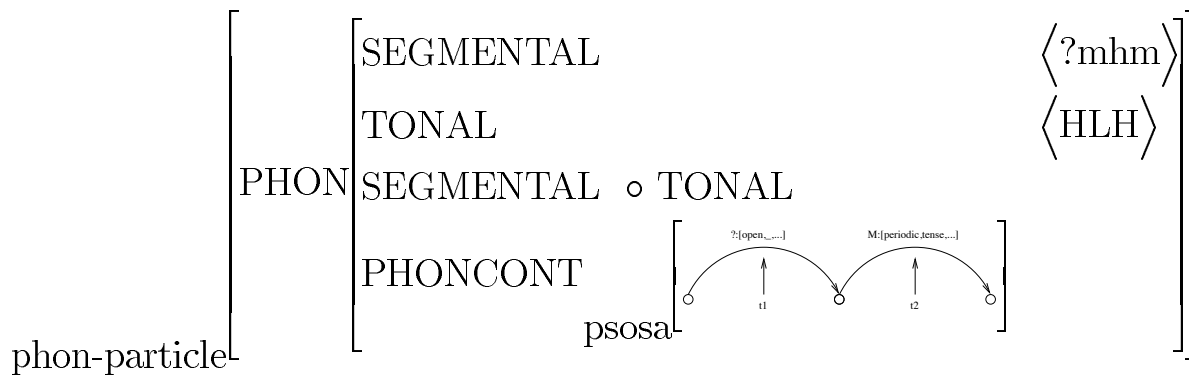

Figure 2: A PHON-entry integrating the mutual phonetic and phonological constraints

Thus, the (semantic) relation between phonetics and phonology can be expressed with the help of Two-Level Phonology, which provides us with useful tools by allowing to state mutual restrictions of different descriptive levels. Figure 1 exemplifies how a Finite–State Transducer can map a phonological plosive event onto a phonetic plosive event by expressing exactly the set of constraints that both representational levels impose onto each other. Figure 2 sketches an integration of such an approach into the PHON-entry of an HPSG sign (here: a German discourse particle).

4   Conclusion

The aim of this paper was to clarify the formal relationships between phonetic and phonological theories. In order to do this, a common ontology for both kinds of representations was introduced. This was further used as a basis for interfacing between the different kinds of diagrammatic representations that both sciences would give to a linguistic unit. Based on the assumption that descriptions of both sciences have to be true in the same

set of models, the empirical constraints that are introduced by regarding both sciences lead to a picture where both sciences are kept separate but not entirely unrelated and can be expressed within constraint-based grammars.

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