

Amodal Complements, Natural Classes and the Poverty of the Stimulus

Morris Halle's 1978 paper 'Knowledge untaught and unlearned' contains an Argument from the Poverty of the Stimulus (PoS), although he does not use that term. This observation is particularly relevant now since several scholars have recently denied the PoS for phonology [1, *inter alia*]. Halle's main point is that rules refer to natural classes defined by shared features, and not to sets of atomic segments. His argument relies on predicting that an English speaker exposed to the pronunciation of *Bach* as [bax], with a voiceless velar fricative, can form the plural [baxs] despite never having encountered the devoicing of underlying /z/ applying after /x/. The implicit reasoning is that a speaker has learned a rule that devoices /z/ after *p,t,k,θ,f* and that *x* falls into the natural class that contains those segments. So, the pronunciation [baxs] is just normal rule application, if one thinks at the level of features. In other words, the rule refers to a natural class that is defined *intensionally*, but the *extension* of the set of relevant trigger segments changes when [x] is introduced. It turns out that the PoS argument from the plural can be pushed further, and the relevance of the intensional characterization of rules can be made even more apparent.

The English plural form [-iz] occurs in a natural class of environments, as expected, because the vowel insertion is triggered 'between coronal stridents.' The form [-z] does *not* occur in a natural class of environments, because it is the 'elsewhere' case, identical to the underlying form. However, the form [-s] arises by a devoicing rule, but it does *not* occur in a natural class of environments on the surface—the voiceless coronal stridents [s,f,(tʃ)] are in the natural class that contains [p,t,k,f,θ] (assuming [f] is +STRIDENT). The well-known solution is that the vowel insertion rule precedes and **bleeds** the devoicing rule. Intensionally stated, the devoicing applies after a natural class of segments (all the voiceless obstruents), but the data available to the learner contradicts this. We argue for an interpretation of PoS that not only *allows* the learner to posit rules in terms of natural classes despite the surface patterns, but actually *forces* them to do so.

Throughout the history of generative phonology, the treatment of segments, like /i/ or /ʊ/, as *sets* of valued features, as in (1), has been implicit, and even, occasionally explicit, as in [6, 2] who use Russell's type theory. We adapt and slightly modify such discussions.

(1) A *segment* is a set of valued features:

$$/i/ = \{+Hi, -BK, -RD, +ATR\} \text{ and } /ʊ/ = \{+Hi, +BK, +RD, -ATR\}$$

Consider a language with +HIGH vowels *i,y,I,ʊ,u,ʊ*, distinguished by combinations of the features BACK, ROUND, ATR. Since segments are sets of valued features, a natural class is one level up in type. A natural class is a set of segments (so, a *set of sets* of valued features) each of which includes a certain set of valued features:

(2) The natural class containing just *i* and *y* is the set of segments that are supersets of the set of all features those two share. The only such segments are *i* and *y* since $\{i,y\} = \{x : x \supseteq \{+Hi, +BK, +ATR\}\}$.

Not every set of segments constitutes a natural class. A natural class is defined intensionally by **generalized intersection** which finds the common members of the (set) members of a set of sets:

(3) The smallest natural class containing the segments in a set *S* is defined by the *generalized intersection* of *S*. So the smallest natural class defined by $S = \{i,Y\}$ must also contain *I,y*:

$$\cap S = \cap \{i,Y\} = \{x : x \supseteq \{+Hi, +BK\}\} = \{i,I,y,Y\}$$

There are several advantages to this formalization: (i) It is explicit and it is discrete—no natural class is *more* natural than any other; (ii) Unlike traditional definitions that require the class description to have fewer features than each of its members, this one can handle underspecification; (iii) Unlike previous definitions, it can handle natural classes with a single member. **Normal intersec-**

tion requires two arguments: $T \cap S$ is defined, but $\cap T$ is not defined. **Generalized intersection** takes a single argument, a set of sets (recall that a segment is a set): $\cap T$ is well defined, even if T has only one member segment, as in $\cap\{y\} = \{y\}$.

Much of the literature says that rules ‘typically’ refer to natural classes, and work like [5] proposes that the existence of rules that don’t rely on natural classes constitutes an argument against a universal feature set. In contrast, we propose that natural classes are defining properties of rules. **If a statement cannot be made in terms of natural classes, then it cannot be a rule.** We argue that it is only possible for linguists to study the range of possible rules if one stipulates that rules are based on natural classes. By defining rules in terms of natural classes, one severely restricts the hypothesis space for an acquirer—only processes definable in terms of natural classes can be part of the target phonological grammar. As pointed out above, the [-s] form of the plural does not occur in a natural class of environments, but the devoicing rule *intensionally* applies in a natural class of environments. If UG determines that rules must be stated in terms of natural classes, then a learner formulates such rules even in light of contradictory evidence—this is a PoS argument.

The view of natural classes developed here parallels the phenomenon of ‘amodal completion’ [4] in visual perception and other ‘masking’ effects . Fig. 1 is interpreted by the visual system as two objects, a magenta one partially

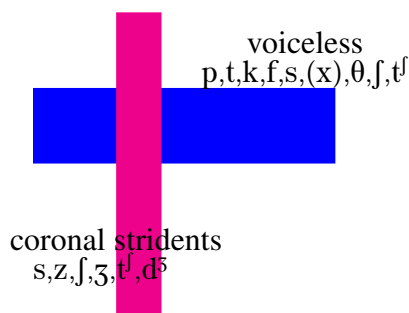


Fig.1: Amodal completion

occluding a blue one, despite the lack of continuity between the two blue regions. The visual system infers the part of the blue rectangle missing from the signal. Similarly, in acquiring ‘English’, the LAD infers a single voiceless obstruent class as a trigger of devoicing, even in the absence of direct evidence. As the IPA symbols in Fig. 1 show, we can think of the magenta region as representing the natural class of coronal stridents, which trigger vowel insertion. Because of the bleeding order, this rule ‘occludes’ some members (s, f, tʃ) of the intensionally defined natural class which triggers devoicing, the set of all voiceless obstruents. Just as our visual systems infer a single blue object, our phonological acquisition systems infer a single voiceless obstruent natural class.

If learners could make a separate rule for each segment that devoices /z/, then Halle’s claim about devoicing after /x/ would not be justified. We propose that even in the face of contradictory evidence (the partial ‘occlusion’ by coronal stridents of the natural class of voiceless obstruents), a learner constructs a single rule for devoicing. Without this insight—the centrality of feature-based natural classes, despite the poverty of the stimulus—it is impossible to develop a universal theory of rule formulation and rule interaction.

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- [4] A Michotte and L Burke. Une nouvelle enigme de la perception: le “donné amodal” dans l’expérience sensorielle. In *Proc. of the 13th Int Cong of Psych*, pages 179–180, 1951.
- [5] Jeffrey Mielke. *The emergence of distinctive features*. Oxford University Press, Oxford, 2008.
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