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On Deriving the Well-Formedness Condition

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One of the cornerstones of early autosegmental theory was the Well-Formedness Condition on autosegmental representations. Goldsmith (1976) formulated it as in (1).

(1) *Well-Formedness Condition* (WFC)
   a. All vowels are associated with at least one tone; all tones are associated with at least one vowel.
   b. Association lines do not cross.

Subsequent research has shown that (1) is too strong. Following Pulleyblank (1983), I assume a weaker form of the WFC in (2).

(2) *No-Crossing Constraint* (NCC)
   Association lines do not cross.

Goldsmith (1976) formalizes the WFC in terms of a notion of "connectedness." In light of the weakening of the WFC to the NCC, a new formalization is necessary, since the old one in terms of connectedness excludes violations of (1a) that are not excluded by the NCC. Here, I argue for a conception of association where autosegments are seen as issuing articulatory instructions to the slots or nodes they are linked to. This view, coupled with a natural interpretation of linear ordering on a tier, allows us to derive the NCC while allowing violations of (1a).

This squib is organized as follows. I begin by reviewing Sagey's (1986) demonstration of the paradoxicality of associ-

Thanks to D. Archangeli, E. Moravcsik, D. Pulleyblank, E. Sagey, and two anonymous reviewers for much useful feedback. This work builds on material first developed in Sagey (1986) and extended in Sagey (1988). References are to Sagey (1986).

ation viewed in terms of simultaneity. I then show how my proposal avoids both these paradoxes and certain problems facing Sagey's solution.

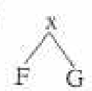
Sagey suggests that linear order of elements on a tier encodes temporal precedence. The properties of that ordering "need not be defined in [Universal Grammar], because they are part of our knowledge of the world" (p. 285). The properties Sagey assumes are transitivity, antisymmetry, and irreflexivity. She defines these as follows (p. 285).

(3) *Temporal Precedence* ("<")
  a. Transitivity: if $A < B$ and $B < C$, then $A < C$
  b. Antisymmetry: if $A < B$, then NOT $B < A$
  c. Irreflexivity: NOT $A < A$

Sagey shows that paradoxes result if association lines are interpreted as indicating simultaneity. Simultaneity, she assumes, has the following properties (p. 286).

(4) *Simultaneity* ("=")
  a. Transitivity: if $A = B$ and $B = C$, then $A = C$
  b. Symmetry: if $A = B$, then $B = A$
  c. Reflexivity: $A = A$
  d. Substitution: if $A = B$ and $B < C$, then $A < C$

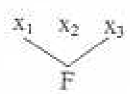
Sagey presents three paradoxes. Consider first the representation in (5).

(5) 

Assume that F and G are distinct melodic elements linked to the same timing unit on the skeletal tier. From the ordering of elements on the melodic tier, it follows that F precedes G ($F < G$). From the simultaneity interpretation of association lines, it follows that F is simultaneous with x ($F = x$) and G is simultaneous with x ($G = x$). From these three propositions and substitution, it follows that x precedes x ($x < x$), which contradicts (3c).

A second paradox can be constructed from (5) as well. By symmetry, $x = F$ follows from $F = x$. By transitivity, $G = F$ follows from $G = x$ and $x = F$. This contradicts the fact that F precedes G ($F < G$).

A third paradox can be shown to arise from discontinuous linking, as in Semitic morphology (McCarthy (1979)). Consider the representation in (6).

(6) 

On the skeletal tier linear precedence gives $x_1 < x_2$ and $x_2 < x_3$. From the simultaneity interpretation of association, it follows that $F = x_1$ and $F = x_3$. By substitution on $x_1 < x_2$, $F < x_2$ follows. From $x_2 < x_3$, NOT $x_3 < x_2$ follows by antisymmetry. Finally, by substitution, NOT $F < x_2$ follows from NOT $x_3 < x_2$, a logical contradiction with respect to $F < x_2$.

To deal with these paradoxes, I depart from Sagey's view and propose that association encodes a different relation than cotemporaneity. If association lines are instead interpreted as issuing an articulatory instruction to the slot or node, the paradoxes above can be avoided straightforwardly.

If this is assumed, then many of the properties in (4) are simply inapplicable to association. For example, symmetry (4b) says that if A is simultaneous with B ($A = B$), then B is simultaneous with A ($B = A$). If an autosegment is conceived of as issuing instructions to a slot, the slot does not issue instructions to the autosegment. Hence, association is asymmetric. Reflexivity (4c) would say that an autosegment issues articulatory instructions to itself. This is nonsensical; hence, association is irreflexive. Finally, substitution would say that if an autosegment issues instructions to a slot and the slot precedes a second slot, then the autosegment precedes that second slot. This is also nonsensical; hence, association does not exhibit substitutivity. Finally, there is transitivity, which does appear to hold of association. For example, if an autosegment issues instructions to a node that is issuing instructions to a timing slot, then it seems reasonable to say that the autosegment is issuing instructions (indirectly) to the timing slot.

This all results in a set of properties identical to the similarly asymmetric temporal precedence relation.

(7) *Association* ("$\Rightarrow$")
   a. Transitivity: if $F \Rightarrow G$ and $G \Rightarrow x$, then $F \Rightarrow x$
   b. Antisymmetry: if $F \Rightarrow G$, then NOT $G \Rightarrow F$
   c. Irreflexivity: NOT $F \Rightarrow F$

If association has this set of properties, then none of the simultaneity paradoxes apply. This is because these paradoxes rest on certain properties of simultaneity not exhibited by association: substitution and symmetry.

The first paradox of (5) rested crucially on the substitutability of association. Association in (7) is no longer substitutable. The second paradox of (5) relied on symmetry, and association in (7) is asymmetric. Last, the paradox in (6) also relied on substitution, which is no longer a property of association (7).

This interpretation of association has the additional consequence of allowing us to derive the NCC as a consequence of the following natural assumption.[1]

[1] Thanks to an anonymous reviewer for pointing this out to me.

(8) *Ordering Principle*
Given two autosegments on a single tier, A then B, instruction B cannot be issued before instruction A.

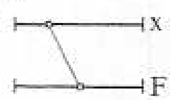
In a configuration (9), which would violate the NCC, the realization of B on x_1 would precede the realization of A on x_2.

(9)


Principle (8) is, in effect, the residue of substitutability, but it avoids the paradoxes stated above while simultaneously providing a rationale for the NCC.

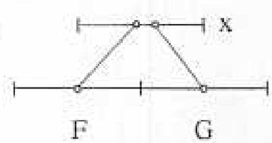
Sagey offers an alternative solution to the paradoxes by replacing simultaneity with overlap. Thus, a representation like (10) does not imply that F and x are simultaneous (F = x). Rather, it is interpreted to imply that "at least one instant of time be shared between the feature and the x-slot. When F overlaps x, that means that at least one point P(F) in F and one point P(x) in x are simultaneous" (p. 290). Sagey diagrams this relationship as in (11).

(10)


(11)


Elements linked by association lines must therefore be interpreted as (line) segments of time where the association line connects at least one point in that segment.

Sagey shows how this interpretation of association lines allows her to avoid the above contradictions. Consider, for example, the paradoxes associated with (5). These disappear when (5) is replaced with (12).

(12)


From the melody tier it follows that all points of F precede all points of G (All P(F) < all P(G)). From the association lines it follows that some point of F is simultaneous with some point of x (Some P(F) = some P(x)) and that some point of G is simultaneous with some point of x (Some P(G) = some P(x)). Invoking substitution allows us to conclude that some point of x precedes some point of x (Some P(x) < some P(x)). This is now entirely consistent with the interpretation of x as a line segment.

The second contradiction resulted from symmetry and transitivity. Transitivity is inapplicable now because the points that are multiply linked to melody units are not (necessarily) the same point. Hence, transitivity will not allow us to establish any overlap between F and G, the source of the paradox.

The paradox associated with (6) is avoided because the contradiction NOT $F < x_2$ and $F < x_2$ is reduced to the claim that some point of F does not precede x_2 (NOT some $P(F) <$ all $P(x_2)$) and some point of F does precede x_2 (Some $P(F) <$ all $P(x_2)$). Since F contains more than one point, no paradox is entailed.

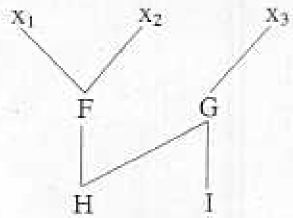
Under this proposal the NCC can be derived, as well; crossed lines create a paradox. In (9) x_1 precedes x_2 (All $P(x_1) <$ all $P(x_2)$) and A precedes B (All $P(A) <$ all $P(B)$). From association, A overlaps x_2 (Some $P(A) =$ some $P(x_2)$). Substitution on All $P(x_1) <$ all $P(x_2)$ results in Some $P(B) <$ some $P(A)$, which contradicts All $P(A) <$ all $P(B)$ (p. 294).

Sagey claims that "the points of time within a feature or x-slot are accessible only at the late level of phonetic implementation, where quantitative rules may apply and . . . they are not manipulable or accessible by phonological rules" (p. 293). Interpreted literally, this would seem to imply (contrary to our assumption above) that phonologically these elements are points rather than line segments. This is impossible, however. The simultaneity paradoxes arise in the phonology and the NCC must hold in the phonology. Therefore, in order for overlap to produce the results intended, the elements must contain more than one point in the phonology; hence, they would have to be line segments in the phonology.

This results in a number of problems for this solution. First, in principle, it permits one to vary the length of the segments in the phonology. This would multiply the number of ways phonological length could be represented. Second, in principle, the degree of overlap could be manipulated phonologically. This would result, for example, in a potentially infinite number of contrasting contour segments in the phonology.

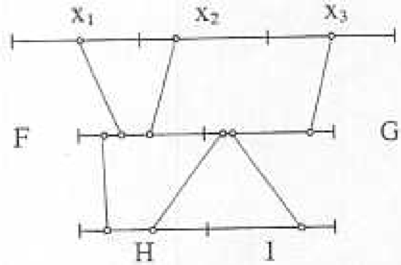
Third, this view makes indeterminate claims concerning multiple tiers. Consider, for example, a situation such as the one shown in (13). Here there is an autosegmental tier (H and I) linked to the timing slots (x_1, x_2, and x_3) through another tier (F and G). This sort of situation arises in segmental feature geometry (Steriade (1982), Clements (1985), and Sagey (1986)).

(13)



Presumably, such a representation would be interpreted as follows.

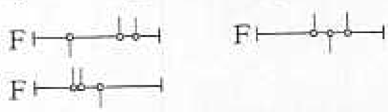
(14)



Such a structure gives rise to several related problems. First, what features percolate down to the timing slots? For example, x_1 is linked to some point of F that is linked to nothing on the second tier. Points on G are linked to points on H and I, but neither of these points is linked to x_3.

A second problem with (14) is the relative order of linked points in F or G. The following are all legitimate, but it is unclear whether they have empirical consequences.

(15)



Given these indeterminacies in the overlap solution, I conclude that the analysis in terms of issuing instructions is to be preferred.[2]

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[2] Under any conception, it is unclear what should be said if, in (13), G is also linked to x_2. How is the contour value H–I to be transferred to the slots x_2–x_3?

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LARDIL PHONOLOGY

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