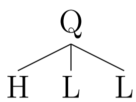
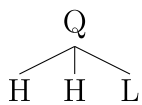
Continuous-Q-Theory: Representing Phonological Tone Contours as Continuous Functions

Lyndon Rey, University of Calgary

Introduction: Q-Theory, proposed by Shih and Inkelas (2018), is a model for representing subsegmental phonological variation. Specifically, it defines the number of subsegments within a segment Q to be 3. Using this model, single-segment early- and late-falling tones are represented in (1) and (2), respectively. This late- versus early-falling tonal distinction is phonemic; the contrast has been documented in South Dinka and Shilluk (Remijsen and Ayoker, 2014). The following theory will present a model which allows this contrast, but is agreeable under a usage-based paradigm (i.e. Exemplar Theory (Johnson, 1997)).

(1) 

(2) 

Proposal: This work proposes an extension on Q-Theory, called Continuous-Q-Theory. The premise of this theory is clear from its name: it proposes allowing the cardinality of Q (i.e. the number of subsegments within a segment) to be infinite, thus representing tonal contours as continuous functions on which phonemic analyses can be performed. The assumption made in this work is that the underlying form of any tonal contrast is a set of special points ($E = \{e_1, e_2, \ldots, e_n\}$), each containing a time q and a height f; i.e. $e_i = (q, f)$. They are connected by a curve, to create a continuous function. This function, $U(q)$, represents the underlying phonemic form. As a time×height plot, q represents the time axis, while f represents the height of the contour.

Implementation: Assume a hypothetical surface contour $Q(q)$, which is a continuous falling function. Two constraints are proposed: HeightPoint(Q(q), E) and Diff(Q(q), U(q)). HeightPoint(Q(q), E) requires that any tone contour sequentially pass through all the relative heights of each $e \in E$. However, HeightPoint(Q(q), E) does not consider the time axis q. This constraint ensures that a falling tone falls adequately. Secondly, Diff(Q(q), U(q)) requires that any surface tone contour function Q equal the underlying contour $U(q)$, in both time and height for every point. Thus, Diff(Q(q), U(q)) requires both tone height and timing to be considered. Both constraints are gradiently violable. In languages which do not show a subsegmental timing contrast for falling tones (most tonal languages, except for South Dinka and Shilluk (Remijsen and Ayoker, 2014)), these constraints are ranked with HeightPoint(Q(q), E) $\gg$ Diff(Q(q), U(q)); all a surface form has to do is pass through the correct tonal heights. In this case, Diff(Q(q), U(q)) is not relevant. In the aforementioned languages which show a timing contrast, the ranking is reversed, which forces surface forms to be faithful to both the timing axis q, and the relative height axis f. In order to calculate Diff(Q(q), U(q)), a simple function comparison is performed; the difference is the definite integral at every point q between two arbitrary timing points a and b.

Theoretical Implications: This theory is amenable to a usage-based theory of phonological perception (e.g. Bybee (2008) and Johnson (1997)), as it accounts for variation between inputs. An Exemplar Theory model strives to consider as much data as possible, and by representing a tone contour as a continuous function of time×height, it allows for quantifiable comparisons to be made between stimuli. This is in line with the constraints above, as they force the output to be quantified as most similar to previously-seen inputs. However, Continuous-Q-Theory can function with a prototype model as well; it simply depends on how the underlying phonemic form $U(q)$ is defined.

References

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