The mental representation of ternary spreading: How are derived tones processed?

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Previous research on tonal processing in Mandarin Chinese, Cantonese, Taiwanese, and Thai show a number of significant findings including: (i) that there is integral processing of segments (and in particular vowels) and tones by tone language speakers (Braun & Johnson 2011, Repp & Lin 1990); (ii) there is a preference for vowel over tone information in vowel and tone monitoring tasks (Ye & Connine 1999); and (iii) there is more categorical processing (in particular identification) of tone by tonal listeners (Sun & Huang 2012), although alternative views on the latter do exist (Francis, Ciocca & Ng 2003). The integral processing of vowels and tone in Asian tone languages can be seen to follow from the dense tone-to-syllable association; the fact that nearly all syllables/morphemes are tonally specified; and that there are considerably few tonal (Sandhi) processes in Asian tone languages (Yip 2002: 173ff).

This paper investigates whether such findings hold in a different tonal language family, namely Bantu languages. In contrast to Asian language tone Bantu languages have few tonal contrasts (usually two); only a few syllables/morphemes are lexically specified for tone; and the surface tonal realization is derived from intricate tone spreading rules as, for example, discussed in the seminal works of Goldsmith 1976, and Clements & Goldsmith 1984. In addition, tone in Bantu is relative rather than categorical in terms of height.

The paper specifically investigates the mental representation of derived tones (i.e. non-lexical tones) in Bemba, testing whether native speakers can produce and perceive ternary High tone spreading in novel contexts. In a production task we test whether ternary spread can be extended to non-words. This is complemented with an AX discrimination task comparing binary v. ternary spread, which are phonologically contrastive, on the one hand, with a tonally similarly salient but non-phonologically relevant contrast, on the other. We show that in both the production and perception of non-words, ternary spread is distinct from binary spread, suggesting that derived tone is equally mentally represented as lexical tone is.

The paper will report results from two experiments conducted with twenty-three native speakers of Bemba (age: 18 to 66 years, 37.7 (mean) and SD 14.3 years; 15 male, 8 female). Experiment 1 investigates the application of ternary spreading processes (in contrast to unbounded spreading, see examples in 1-3) in the production of non-words, using a variant of the *Wug* test (Berko 1958, Ratner & Menn 2000). Specifically, participants heard real and nonce verb forms in one conjugation and had to conjugate them into another form (1st pl. to 3rd pl.). This task involves the application of a ternary spreading process in the participants' variety. If ternary spreading is a rule-based process, we expect speakers to produce ternary spreading in non-words as well. If it is lexically encoded, we expect fewer cases of ternary spread in the non-word condition than in the real-word condition.

Experiment 2 investigates behavioural results in a speeded AX discrimination task in which nonce stems with binary vs. ternary spread are contrasted with a long inter-stimulus interval (ISI) of 2 seconds. Such a long ISI allows us to tap into phonological representations (Babel & Johnson 2010, Cowan & Morse 1986, Crowder & Morton 1969). If ternary spread is cognitively specified, listeners should

be sensitive to the difference between a binary and a ternary spread. On the other hand, if ternary spread is just an allophonic variant of binary spread (attested in one variety of Bemba, see Bickmore & Kula 2013) or is simply the result of phonetic overshoot, we predict that listeners will have difficulties in perceiving the difference.

We used two kinds of control conditions in Experiment 2; one with a tonal difference that is equally salient but involves a paradigmatic contrast (High vs. Mid, Mid vs. Low) instead of the syntagmatic contrast between a binary and ternary spread. The second control condition involves real-words with a binary vs. ternary spread to address whether participants perform a dialect discrimination (in which case participants' sensitivity to the tonal contrast should be the same in the non-word and real-word condition) or not (in which case we would expect no or a smaller difference in the real-word condition than in the non-word condition due to lexical activation).

The production results show that native speakers of Bemba are equally able to produce ternary spreading in non-words; thereby suggesting inferential, rule-based processes (cf. discussion in Pinnow & Connine 2014). The perception results show more sensitivity to the binary-ternary contrast than to a non-contrastive paradigmatic contrast (High vs. Mid, Mid vs. Low), despite similar acoustic differences reflecting sensitivity to a phonologically relevant contrast. The results were analysed in R using linear-mixed effects regression models.

Thus while it may be a legitimate assumption that tone is part of a syllable's mental representation in Asian tone languages, this assumption is not tenable in Bantu tone languages, where the results show that both in production and perception speakers have a mental representation of derived tone and crucially that such representation can be as crisp as ternary spread. The results thus provide experimental evidence of treating tone as autosegmental in Bantu.

Examples (lexical highs are underlined, low tone unmarked)

(1) Unbounded Spreading

bá-ka-mu-londolol-a → *bá-ká-mú-lóóndólól-á*

2SM-FUT3-1OM-explain-FV

'They will introduce him'

(2) Binary Spreading (dialect 1)

bá-loondolol-é → *bá-lóondolol-é*

2SM-explain-SUBJ

'They should explain'

(3) Ternary Spreading (dialect 2)

bá-loondolol-é → *bá-lóóndolol-é*

2SM-explain-SUBJ

'They should explain'