# Study on the Perception of Tone and Intonation in Sesotho

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## 1. Aims

- Investigate the extent tonal perception interacts with vowel perception for word identification.
- Examine prosodic features that facilitate perceptual differences between statements and questions.
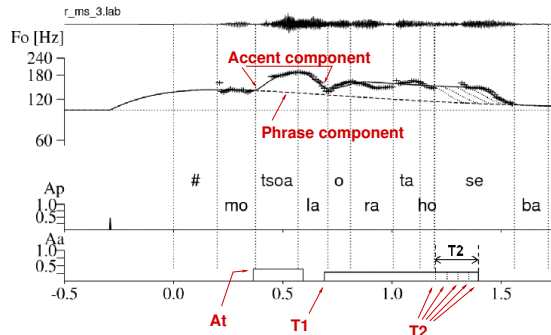
## 2. Background

- A tonal Bantu language.
- Spoken as an official language in Lesotho and South Africa.
- 2 tonemes – high (H) and low (L).



Lesotho

## 3. Fujisaki model

- Decomposes log F0 into:
  - phrase component capturing slower changes (phrase intonation).
  - accent component capturing fast changes (accents and tone).



## 4. Implementation

- Prosodically modify stimuli using the Fujisaki model.
- Increase/decrease the amplitude and duration of pitch excursion.
- Examine the effect of the modifications on:
  - word identification
  - statement vs. question distinction

In the table:
- 3 minimal pairs differ only in tone.
- One differs only in vowel.
- One differs both in tone and vowel quality.

| Word | Translation | Vowel | Tone | Modification |
|------|-------------|-------|------|--------------|
| lehata | skull | [e] | HHH | increase of value of T1 |
| | liar | [e] | LLL | T1 value later |
| seba | gossip | [e] | HL | variation of T2 value |
| | do mischief | [e] | LL | T2 value earlier |
| tena | is getting dressed | [e] | HL | variation of tone command location (both T1 and T2) |
| | is annoying | [e] | LL | T1, T2 values earlier |
| bolla | was circumcised | [o] | HHH | reduction of T2, reduction of At |
| | decayed | [O] | LLL | increase of At |
| ts'ela | crossed | [e] | HL | reduction of At |
| | poured | [E] | HL | only vowel difference |

## 5. Word identification

- What is the minimum duration (T1, T2) of a tone command associated with a high tone syllable?
- Does modifying the tone/duration using the Fujisaki model lead to a difference in the perceived meaning?
- Does reducing/raising the tone command amplitude (At) of a high/low tone syllable lead to perception of the low/high tone partner?
- What is the interplay between vowel quality and tone?
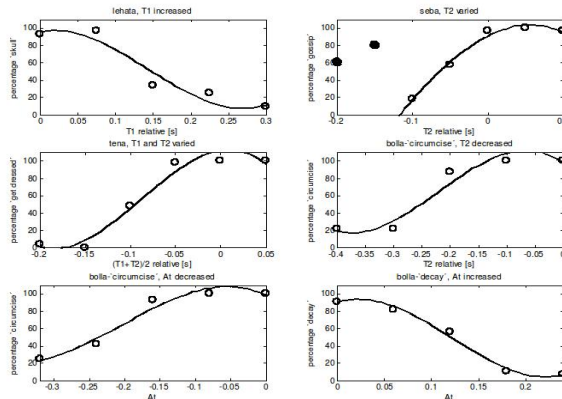


## Conclusions

- Reduction of At as well as reduction of T2 for high tone stimuli lead to the perception of low tone counterparts.
- Increasing At for a low tone word has the opposite effect.
- F0 modifications override vowel differences.
- For 'seba', the intended low tone stimuli were associated with the high tone meaning.

## 6. Question vs. Statement

- Questions are generally spoken at a higher pitch, i.e. increased phrase command, as well as with a shortened penultimate syllable.
- Examine which prosodic features facilitate the perceptual differences between statements and questions.
  - Does increasing the speech rate and/or the phrase command magnitude (Ap) lead to a perceived question?
  - Does shortening the penultimate syllable lead to a perceived question?

### Results

| Stimuli | Phrase magnitude (Ap) | Speech rate | Penultimate syllable | Outcome – identified as ... |
|---------|-----------------------|-------------|----------------------|------------------------------|
| Unmodified | Unchanged | Unchanged | Unchanged | Statement by 97.6% |
| Modified | Increased to max. | Unchanged | Unchanged | Statement by 84.8% |
| Modified | Unchanged | Increased | Unchanged | Statement by 86.9% |
| Modified | Unchanged | Unchanged | Shortened | Statement by 66.1% |
| Modified | Highest | Increased to max. | Present | Question by 89.3% |

### Conclusions

- Shortening the penultimate syllable, increasing the speech rate, and increasing the phrase command magnitude (Ap) all increase probability that an utterance is perceived as a question.
- Shortening of the penultimate syllable had the strongest impact.

## 7. Overall Conclusions

- The Fujisaki model can be used to model tone in Sesotho.
- F0 modifications override vowel differences in minimal pairs.
- F0 modifications are important in question/statement distinction.