The Four-way Voicing Distinction in Bengali Infant Directed Speech

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BACKGROUND

- Infant directed speech (IDS) is typically thought to be hyperarticulated
- However, in languages with 3-way and 4-way voicing contrasts like Korean (Narayan & Yoon, 2011) & Nepali (Benders et al, 2019), IDS is reportedly ***hypo***articulated
- Two potential reasons for consonant ***hypo***articulation in IDS
  - A by-product of vowel contrast enhancement (e.g. Benders et al., 2019)
  - Variable f0 in IDS hinders its use for distinguishing contrasts (Dmitrieva & Dutta, 2020; Schertz & Khan, 2020)
- This study: Comparison of production of stops and affricates in Bengali connected IDS vs ADS
  - Crucially, Bengali has a four-way voicing and aspiration distinction with voice onset time (VOT) and potentially f0 as primary cues

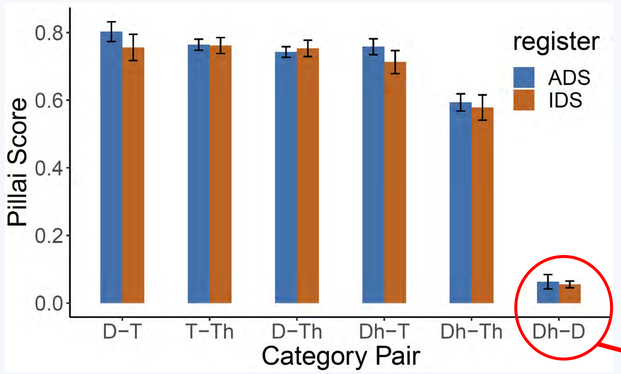
METHOD

- Connected speech from 10 native speakers (5 male, 5 female) of Bangladeshi Bengali (Yu et al, 2014)
- Excluded: Tokens with background noise, interruptions, speaker error, lenition of the closure, and creaky voice
- Analyzed: Stops and affricates - VOT and f0 at vowel onset
  - Target phones coded for place of articulation, prosodic position, lexical stress, prosodic focus and pitch accent
  - VOT measurement semi-automated using Dr. VOT (Shrem et al., 2019)
  - VOT rate normalized to average syllable duration in 500 ms window around target segment
- Dependent variable: Pillai scores (Hay et al., 2006) to evaluate overlap in VOT and onset f0
  - Hypoarticulation = greater overlap in distributions = lower Pillai scores

Stop type	IDS tokens	ADS tokens
[p, t, ʈ, tɕ, k] = T	1426	1517
[t^h, $ʈ^h$, $tɕ^h$, k^h] = Th	250	246
[b, d, ɖz, g] = D	646	643
[b^h, d^h] = Dh	116	147

RESULTS

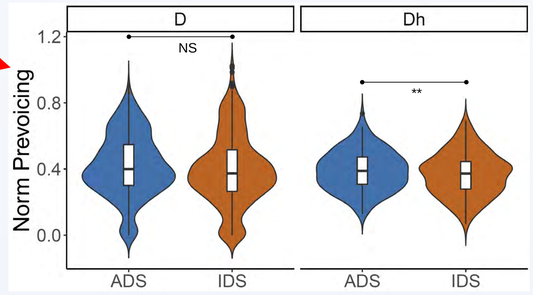
No hypoarticulation of voicing contrasts in Bengali IDS with raw VOT and f0



- No significant difference by register
- In Bengali, all voicing pairs are separated in both registers
- **Except**: Voiced aspirated and voiced unaspirated stops

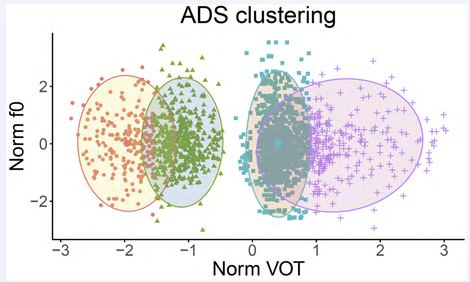
- After rate normalization,
  - Voiced aspirates are hypoarticulated, i.e. less prevoiced
  - Voiced, unaspirated stops are no longer hyperarticulated, i.e. more prevoiced

Bengali voiced aspirates hypoarticulated in IDS after rate normalization

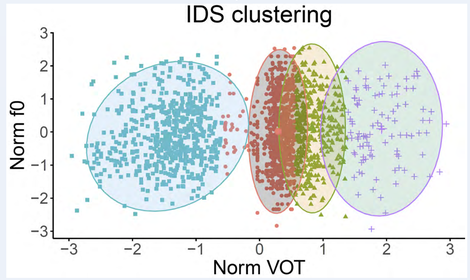


Can we rule out register differences in vowel expansion and the use of f0 as cue to voicing distinctions?

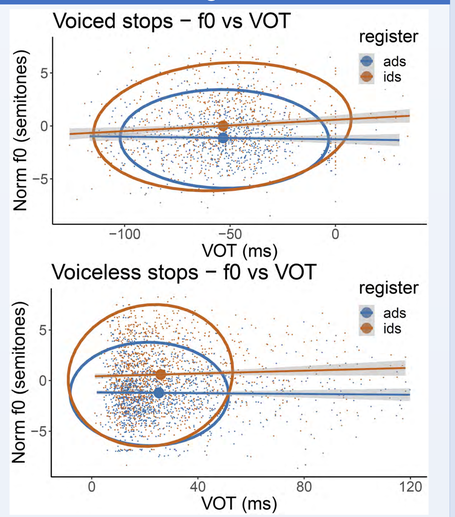
f0 is not a reliable cue for voicing in IDS or ADS



Voicing categories only distinguished by VOT: k-means clustering learns categories based on VOT but not f0

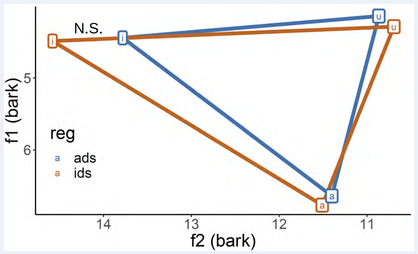


No clear relationship between VOT and f0



Vowels are not hyper-articulated in IDS

- No significant difference in vowel triangle area based on productions of [a, i, u]
- Hypo-articulation not due to syllable-internal compensation



CONCLUSIONS

- Bengali IDS is hypoarticulated only for voiced aspirates
  - This is not due to enhanced vowel contrasts
- No evidence for hyperarticulation of IDS
  - Voiced unaspirated stops appear *hyper*-articulated in IDS, but this is an effect of the slower speech rate of IDS
  - No hyper-articulation in IDS after rate normalization
- Bengali 4-way voicing distinction in neither IDS or ADS is signaled by f0 effects
  - Local f0 effects are likely overpowered by intonational effects in connected speech
- Broadly, IDS does not always facilitate phonetic learning

FUTURE DIRECTIONS

- Expand acoustic cues to 4-way voicing distinctions
  - Breathiness on the following vowel
  - Lenition, which is optional inter-vocalically in Bengali
- Extent of prevoicing as an index of passive or active voicing
  - [voice] is a “stronger” feature than [spread] (Shwarz et al., 2019) in Nepali
  - If also true in Bengali, hypoarticulation would result in neutralization of the spread contrast (Dh-D) rather than the voice contrast (Dh-Th)

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