Sources of variability in consonant perception and their auditory correlates

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**Sources of variability in consonant perception and their auditory correlates (2pSC27)**

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**BACKGROUND AND OBJECTIVE**

Responses obtained in consonant perception experiments typically show a large variability across stimuli of the same phonetic identity (Phatak at al., 2008; Sing & Allen, 2012; Toscano & Allen, 2014). The present study investigated the influence of different potential sources of this response variability. It was distinguished between source-induced variability, referring to perceptual differences caused by acoustical differences in the speech tokens and/or the masking noise tokens, and receiver-related variability, referring to perceptual differences caused by within- and across-listener uncertainty. It can be demonstrated that any physical change in the stimuli had a measurable effect. This holds even for slight time-shifts in the steady-state masking-noise waveform. Furthermore, responses obtained with identical stimuli differed substantially across different normal-hearing listeners, while individual listeners were able to reproduce their responses fairly reliably. To determine how well the source-induced variability is reflected in different auditory-inspired internal representations (IRs), the corresponding perceptual distances were compared to the distances between the IRs of the stimuli. Several variants of an energy-based IR and a modulation-based IR were considered. The results suggest that a normalized modulation-based representation provides the best match to the perceptual data.

**EXPERIMENTS**

- 15 CVs: /bi, di, gi, hi, ji, ki, li, mi, ni, pi, si, ti, vi/
- Presented in white noise @ 12, 6, 0, -6, -12, and -15 dB SNR
- 8 young normal-hearing native Danish listeners

**Experiment 1: Speech variability**

- 3 speech tokens of each CV spoken by a male talker (A)
- 3 speech tokens of each CV spoken by a female talker (B)
- Each token mixed with different frozen noise waveforms at 12, 6, 0, -6, -12, and -15 dB SNR
- Three observations per stimulus and listener

**Experiment 2: Noise variability**

- 1 speech token of each CV spoken by a male talker
- Each mixed with:
  - Frozen noise “A”
  - Frozen noise “B” (noise “A” shifted by 100 ms)
  - Random noise
- At 12, 6, 0, -6, -12, and -15 dB SNR
- Different frozen noises used for the different tokens
- Re-test with a subset of 4 listeners
- Five observations per stimulus and listener

**SELECTED RESULTS**

**Perceptual distance definition**

To quantify the perceptual effect of the considered factors, a measure of the perceptual distance between responses was defined. The responses of a given listener, obtained with a given stimulus, were treated as vectors \( r = [p_1, p_2, \ldots, p_n] \), where \( p_i \) denotes the proportion of response “i”. The perceptual distance between two such response vectors \( r_i \) and \( r_j \) was defined as the normalized angular distance between them:

\[
D(r_i, r_j) = \arccos \left( \frac{\sum_{k=1}^{n} r_i(k) r_j(k)}{\sqrt{\sum_{k=1}^{n} r_i(k)^2} \sqrt{\sum_{k=1}^{n} r_j(k)^2}} \right) \times 100\%
\]

**Perceptual Distance calculation across six factors**

**Source-induced factors**

- across CVs
- across noises

**Receiver-related factors**

- across listeners

Apart from the across-CV factor, only responses obtained with stimuli of the same phonetic identity were compared. For each considered factor, the perceptual distance was calculated across all pairwise comparisons of response vectors representative of that factor. The calculation was performed for each SNR condition separately and the individual distance values were averaged across the considered response pairs and across listeners.

**ANALYSIS**

**QUANTIFICATION OF FACTORS**

**MODELING**

**REFERENCES**


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