Pitch, perceived duration and auditory biases: Comparison among languages

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Abstract. *In addition to fundamental frequency height, its movement is also generally assumed to lengthen the perceived duration of syllable-like sounds. The lengthening effect has been observed for some languages (US English, French, Swiss German, Japanese) but reported to be absent for others (Thai, Latin American Spanish, German). In this work, native speakers of Estonian, Finnish, Mandarin and Swedish performed a two-alternative forced choice duration discrimination experiment with pairs of complex tones varying in several acoustic dimensions. According to a logistic regression analysis, the duration judgements are affected by intensity, f_0 level, and f_0 movement for all languages, but the strength of these influences varies across languages and a pattern revealed by the relative strengths reflects phonological properties of the languages. The findings are discussed in the light of current hypotheses of the origin of pitch modulation of perceived duration.*

Introduction

Perceived duration of a sound is influenced by its pitch pattern

- Listeners judge sounds with higher f_0 as longer[1,2]
- Also, a tone with dynamic f_0 pattern is judged as longer by speakers of some languages[3-6] but not necessarily all[7]

Why? Hypercorrection theories:

1. Auditory: Pitch effect in duration is grounded in auditory system and subsequently used by production[4]
2. Production: Sound duration based on physiology, listeners over/under-estimate duration of normally short/ long sounds[6]

Methodological innovations:

- Stimulus pitch (almost) independent of spectral frequency; the "missing fundamental" illusion
- The effect *size* of f_0 influence on durational judgments rather than its mere presence
- Tonal and quantity languages

Methods

Procedure: A 2-alternative forced choice task "Which sound was longer? First or second?" with 400 pairs of stimuli for each subject.

Stimuli:

duration: 300 ± 75 ms
f_0 level: 150 Hz ± 4 st

Δf_0 (slope): 0 ± 4 st
intensity: 66 ± 2 dB
ons. diff.: 800 ± 20 ms

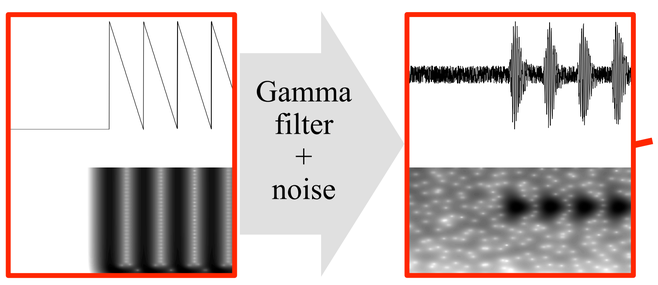
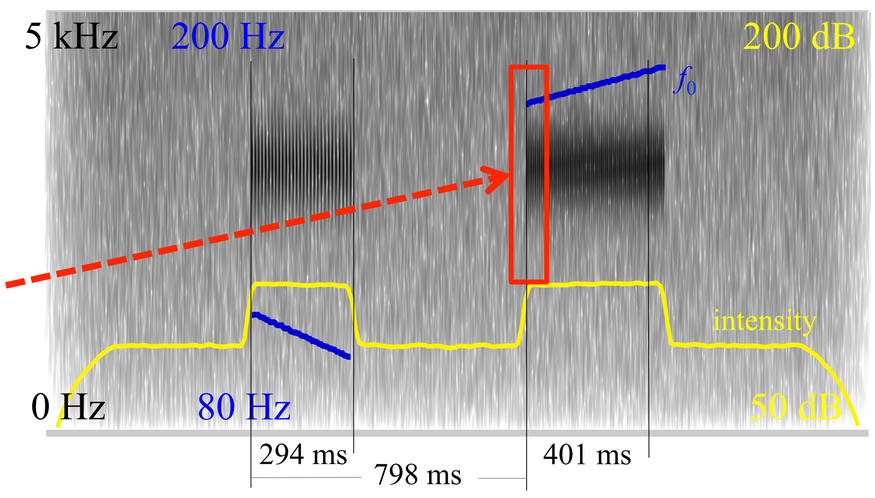


Figure 1. *An example of stimulus pair.*



Languages in the study:

	#	Quantity?	Tonal?
Mandarin	15	no	yes[9]
Swedish	6	partly	partly
Estonian	18	yes	no, but[10]…
Finnish	15	yes	no, but[11]…

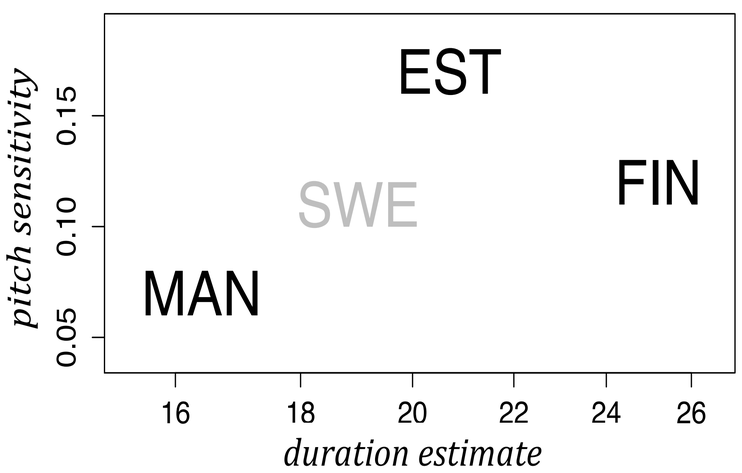
Table 1. *Languages investigated, number of subjects and relevant phonological properties.*

Results

	Mandarin	Swedish	Estonian	Finnish	
intercept	0.56***	0.25	0.20	0.18	➢ MAN >* EST, FIN
duration diff.	16.4***	19.0***	20.7***	25.2***	➢ EST, FIN >** MAN
f0 diff.	0.07***	0.11***	0.17***	0.12***	➢ EST >*** MAN, EST >* SWE EST >** FIN, FIN >** MAN
Δf_0 diff.	0.03***	0.03*	0.05***	0.04***	
$\lvert\Delta f_0\rvert$ diff.	0.06***	0.02	-0.01	0.05**	➢ MAN, FIN >** EST
intensity diff.	0.07*	0.09	0.15***	0.09**	➢ EST >* MAN

Table 2. *Coefficients of a mixed effect logistic regression model with binary response as dependent variable and fixed factors listed in the first column plus interactions between these and language (used for language comparisons, right). Random effects: slopes for individual subjects.*
*Significance: *: $p < 0.05$; **: $p < 0.01$; ***: $p < 0.001$*

Figure 2. *Distribution of languages based on estimates of duration and pitch (f_0 level) sensitivity.*



Discussion

- Pitch level, pitch movement, and intensity do influence durational judgments for speakers of all investigated languages
- The size of relative impact of acoustical dimensions on duration judgments is language specific
- The language specificity reflects phonological properties of languages in an expected way, see Fig. 2: speakers of quantity languages (EST and FIN) are better at duration discrimination but more strongly influenced by pitch in their judgments than MAN subjects, with speakers of SWE (with tonal and quantity elements) falling in between
- Some results support (production based) hypercorrection hypothesis (e.g., dynamicity effect for EST), but not all – FIN subjects didn't judge falling tones as shorter although they mark long quantity with falling pitch[10]
- Despite language differences, the expected biases are there for all groups and in the same directions; this provides some support for auditory based account (see also results of EEG measurements[12,13])
- Next steps: (1) collect data from more languages, (2) test different duration ranges, and (3) different sound types

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