Consonant and Tone Interaction in Cantonese

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Introduction

- Two subfields of Linguistics
    1. Phonetics: the study of the universal properties of human speech
    2. Phonology: the study of how sounds are systematically organized in individual languages
- Often thought of as distinct subfields, but the interrelationship between them is itself an active research area

Project Goals

- This project explores this interrelationship by addressing how consonants and tone interact with each other
- Do they do so in a universally similar way or does it depend on the specific language?

Specific Research Questions:

1. Does tone affect the length of stop consonants in Cantonese, a language with 6 tones (4 of which are relevant)?
2. If so, how?
3. Is this purely a **phonetic** effect (based on universal constraints) or is it also influenced by (language-specific) **phonological** contrasts?

Stop Consonants

- Sounds produced by a closure somewhere in the mouth. Ex: /p/, /b/, /t/, /d/, /k/, and /g/.
- Put a piece of paper in front of your mouth.
- Say the words <pan> and <span>.
- The /p/ in <pan> is aspirated, but the /p/ in <span> is not.
- **Phonetically** different but not **phonologically** different for English speakers.
- But in some languages, they ARE **phonologically** different
  - Ex: In Thai, [p^ha] means ‘cloth’, [pa] means ‘aunt’, [ba] means ‘crazy’

Voice Onset Time (VOT)

- Acoustic measurement of stops (roughly equivalent to how long they are produced)
- Three types of stops defined by VOT:
  - Voiced: VOT < 0
    - Ex: /b/
  - Voiceless Unaspirated (short-lag): small positive VOT
    - Ex: /p/
  - Voiceless Aspirated (long-lag): large positive VOT
    - Ex: /p^h/
- VOT values (**phonetic**) can vary without changing stop categories (**phonological**)

F0 vs Pitch vs Tone

- Fo (fundamental frequency) is **phonetic**
- Pitch is perceptual
- Tone is **phonological**
  - not based on absolute Fo values but rather on relative Fo values that vary between speakers
  - not measured directly

F0 (phonetic) vs Tone (phonological) Illustrated

Fo Contour	English	English Meaning	Tone	Mandarin Meaning
High level	Ma.	Declarative	55	‘mother’
Rising	Ma?	Questioning /uncertainty	25	‘hemp’
Falling	Ma!	Anger	51	‘to scold’

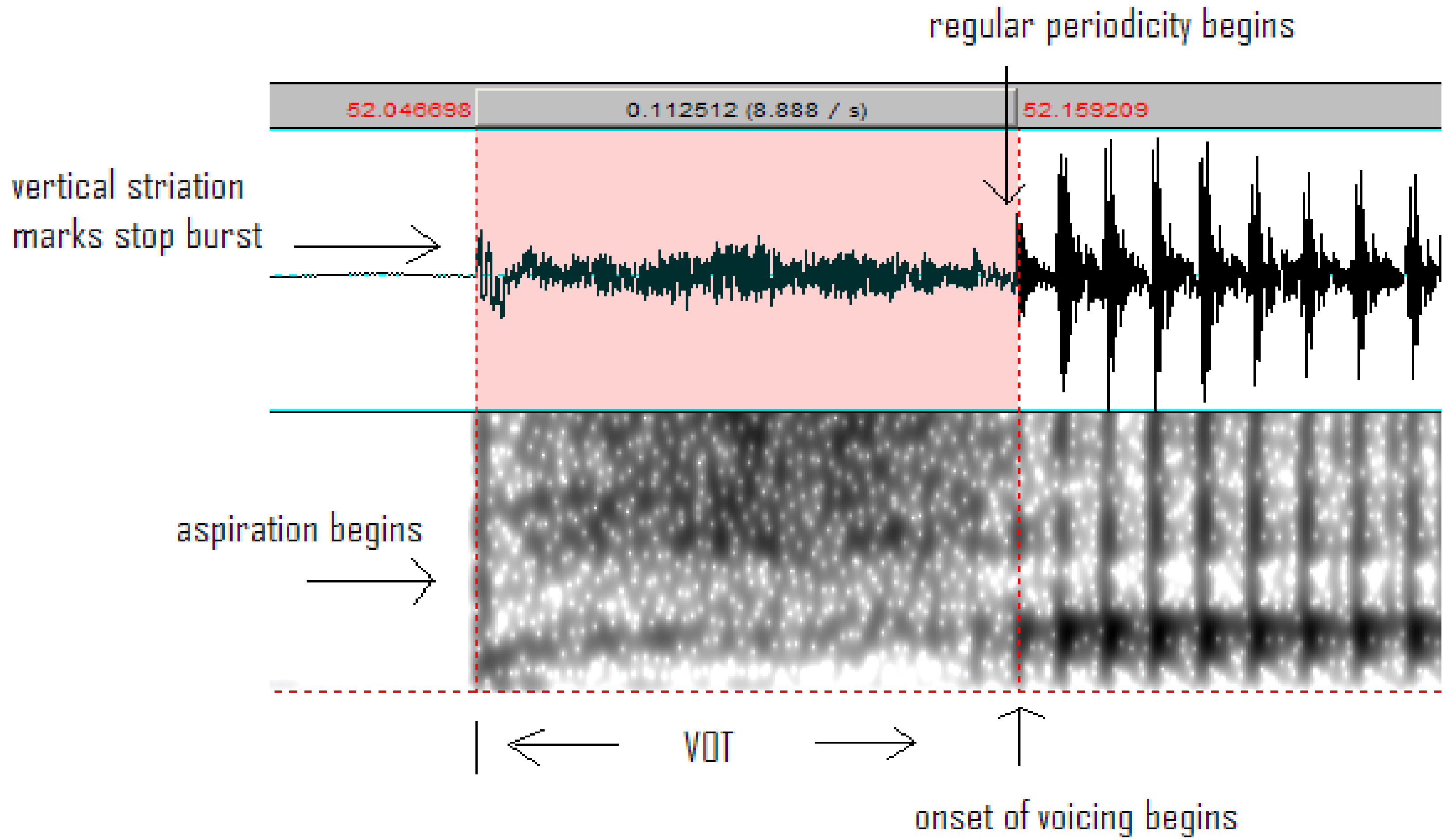
- English and Mandarin pronunciations are **phonetically** identical, but only in Mandarin is this considered tonal and **phonological**

Methodology

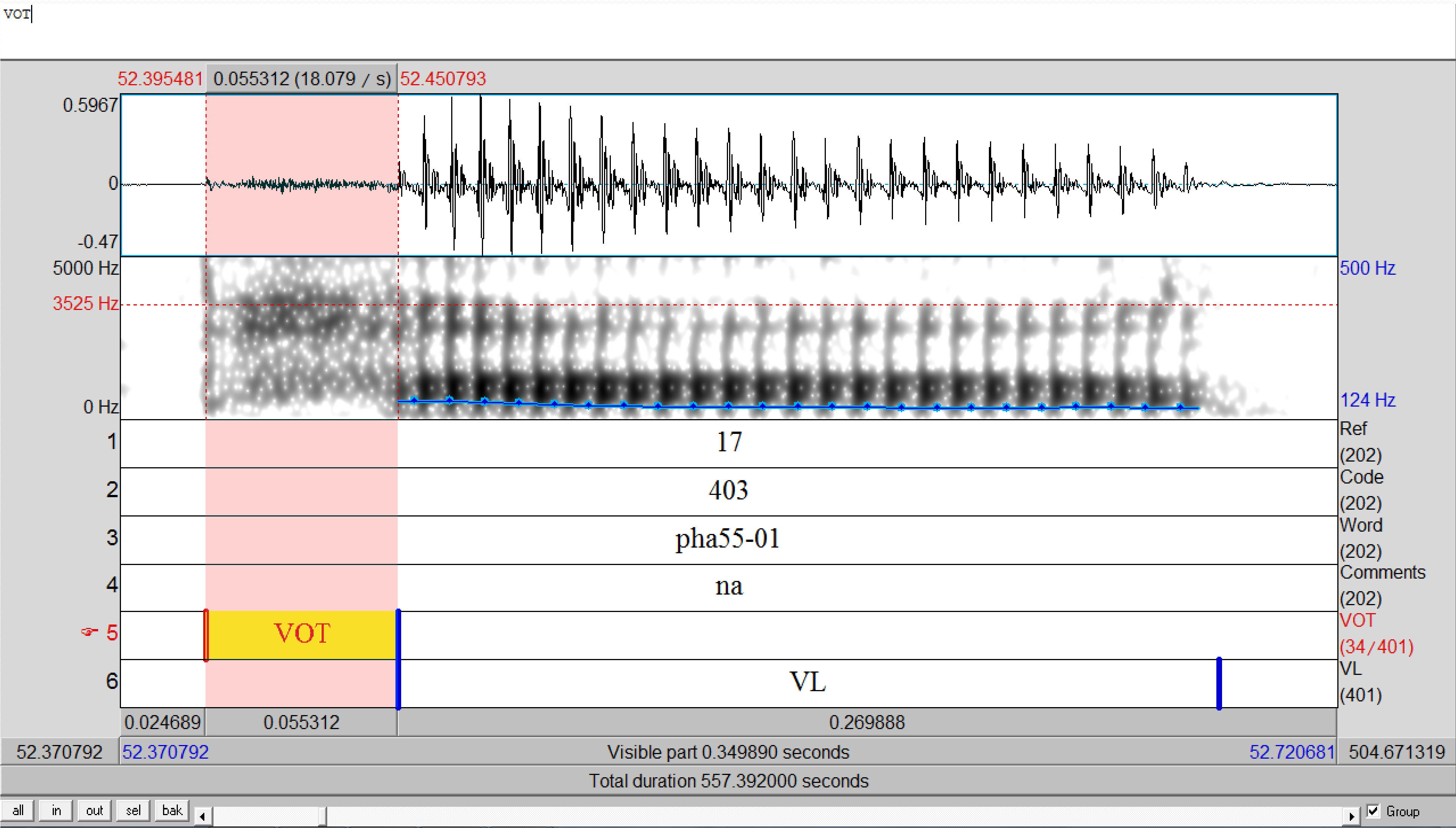
6 subjects (5 male, 1 female)
- native Hong Kong Cantonese speakers in their early 20's
- Less than 4 years in the U.S. at the time of recording.

Recordings
- made with solid state recorder in sound-proof booth
- 20 words spoken in a phrase
- 10 repetitions each, 200 samples per subject, but only 4 words (40 samples/speaker) used for present study, the rest used for different experiments/distraction

Sample VOT segmentation



Sample Textgrid labels



Results

Aspirated Stops

Tone	Normalized VOT Avg	Std. Dev. of Normalized VOT	VOT average (in seconds)	Std. Dev. of VOT	N
55	0.2487	0.06648	0.0627	0.19569	60
33	0.2619	0.06912	0.0657	0.02152	60
25	0.3002	0.06110	0.0771	0.01932	60
21	0.3240	0.07782	0.0785	0.02346	60
All Tones	0.2837	0.07476	0.0701	0.02202	240

Repeated Measure ANOVA test for tone and Normalized VOT for all tokens: $p < 0.001$, significant
ANOVA test for tone and actual VOT: $p < 0.001$, significant

Pair-wise analysis: aspirated stops

Tonal Pairs	p =	Significance
55 & 25	0.1118	n.s.
55 & 33	0.9816	n.s.
55 & 21	0.0046	**
25 & 33	0.1680	n.s.
25 & 21	0.8133	n.s
33 & 21	0.0219	*

General grouping: 55, 33, (25) < (25), 21

Tone vs F0 correlations

Subject	ANOVA p value	ANOVA significance	Pearson Coefficient	p value of correlation	Correlation Significance
1 (male)	< 0.000	**	-0.053	0.744	n.s.
2 (male)	0.001	**	-0.326	0.040	*
3 (male)	<0.000	**	-0.350	0.027	*
4 (male)	0.003	**	-0.001	0.997	n.s.
5 (male)	0.02	*	-0.313	0.049	*
6 (female)	0.469	n.s.	0.129	0.426	n.s.
All Subjects	<0.000	**	-0.210	0.001	*

Correlation test of actual VOT for all subjects: p = 0.249, n.s.

Effects of VOT on Tone

Language	Stop categories	Reported VOT effects
Kera (Chadic)	Voiceless (historically voiced/voiceless)	L < M < H
Mazatec	Pre-nasalized, short-lag, long-lag	L < H
Shanghainese	Voiced, short-lag, long-lag	LM, MM < H, HL
Korean (younger speakers)	Short-lag, medium-lag, long-lag	L < H
Mandarin	Short-lag, long-lag	213, 25 > 55, 51
Hakka	Short-lag, long-lag	Short tones < long tones
Taiwanese	(Voiced?), Short-lag, long-lag	LL, LR, LF > HL, HF
Cantonese	**Short-lag, long-lag**	**21 > 55, 33**

Discussion/Conclusion

- Tone has a significant effect on VOT for aspirated stops (w/o a loss in phonological contrasts)
- The effect is roughly (but not exactly) inversely correlated with Fo
- Tone is a stronger predictor of VOT than Fo
- A comparison with other languages suggests that this effect is language-specific
- VOT differences corresponding to tonal differences appear to enhance phonological contrasts between tonal categories