THE PHONETICS OF GEMINATES: AN OVERVIEW

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"Geminate consonants across the world"

A satellite workshop for ICPhS

This version is near-final, and may be different from the final version.

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- The aim of this talk is not so much as to present results of new experiments, let alone new theories of geminates.

- I instead intend to provide an overview of the phonetics of geminates, focusing on cross-linguistic similarities and differences.

- What are the issues which should be addressed by the phonetic studies of geminates?

INTRODUCTION: GEMINATES AS LONG CONSONANTS

WHAT ARE GEMINATES?

- What are geminates? This question is not as simple as it first sounds.

- The working hypothesis: “consonants that are longer than corresponding singleton consonants.” Lahiri & Hankamer’s (1988) thesis: “the primary acoustic correlate of geminates (in Bengali and Turkish) is closure duration”. But:

  - Consonant duration is usually not the only cue.

  - It may not even be the “most noticeable” cue (e.g. Norwegian).

LET'S FIRST HEAR THEM!

(Egyptian) Arabic

- Frame sentence: [ʔælwælæd _ ɪdærs]
- [hatag] vs. [hattag]

Hindi

- Frame sentence: [ramni _ deka]
- [kata] vs. [katta]

(Kansai) Japanese

- Frame sentence: [hona _ de ikoka]

- [nito] vs. [nitto]

Norwegian

- Frame sentence: [əsɔ ___ ɪgɔr]

- [bate] vs. [batte]

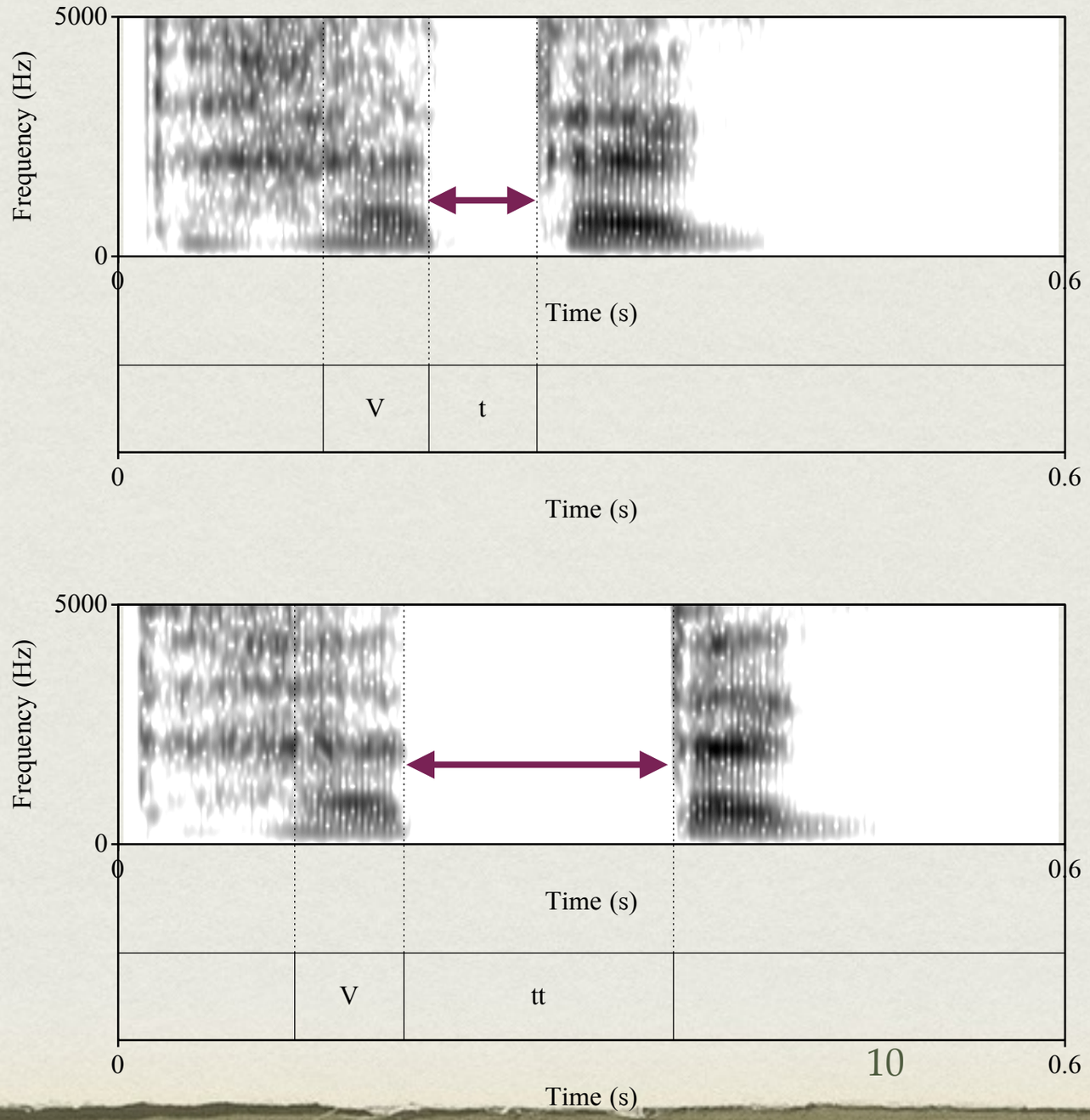
Do geminates sound long to you?

Swedish

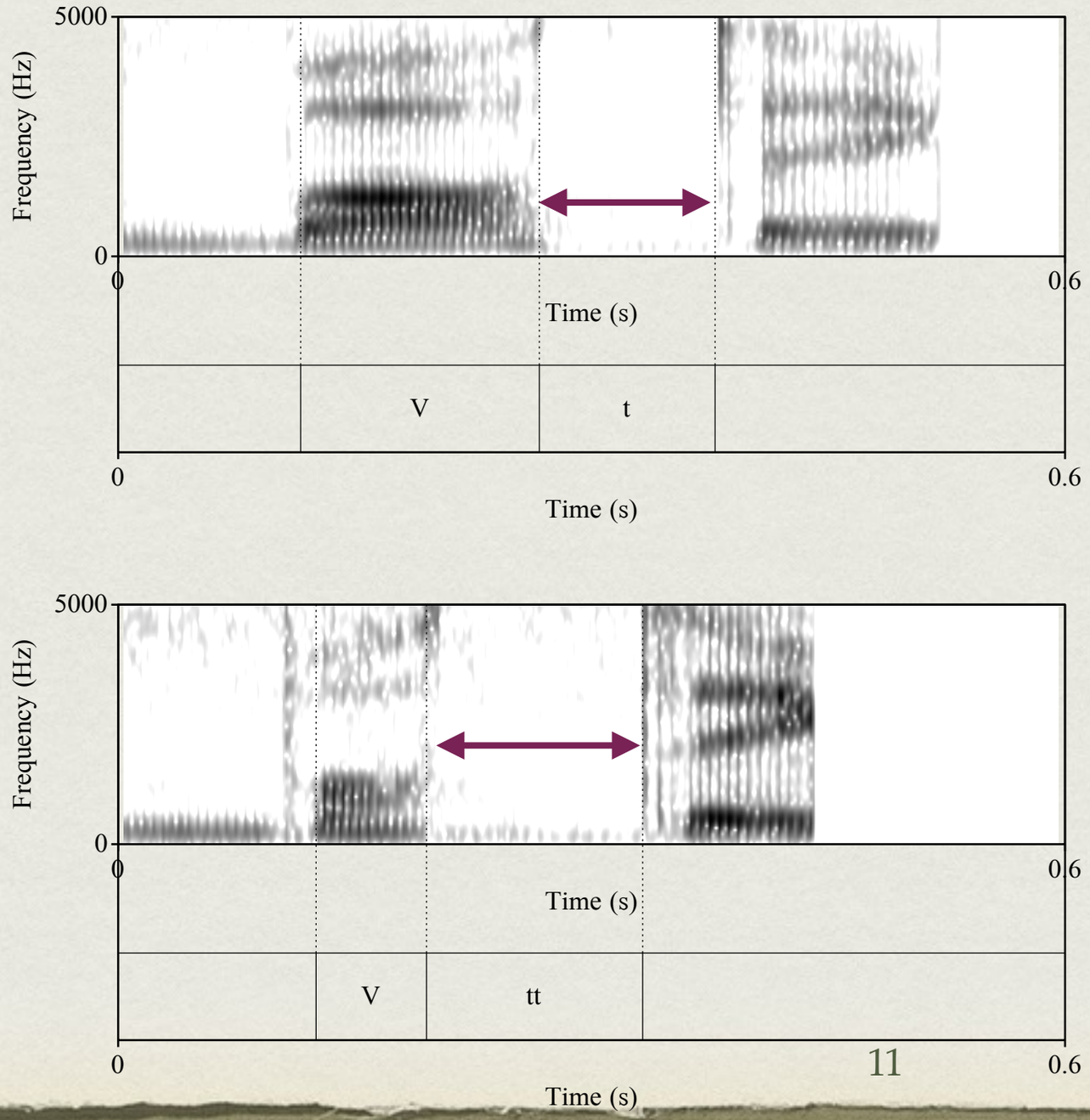
- Frame sentence: [ɪsɔgɛm ___ ɪgɔr]
- [bate] vs. [batte]

Note the change in preceding vowel quality. This is a general closed syllable phenomenon in Swedish phonology.

GEMINATES AS LONG CONSONANTS (ARABIC)



GEMINATES AS NOT-SO-LONG CONSONANTS (NORWEGIAN)



C ratio: 1.4
V ratio: 2
Fintfont (1961)

CROSS-LINGUISTIC VARIATIONS

Language	ratio	Sources
Norwegian	1.22-1.38	Fintfoft (1961)
Cypriot Greek	1.4~1.9	Arvaniti (1999)
Madurese	1.5	Cohn et al. (1999)
Icelandic	1.51	Pind (1986)
Trique	1.54	DiCanio (2008)
Buginese	1.7	Cohn et al. (1999)
Guinaang Bontok	1.9	Aoyama & Reid (2006)
Toba Batak	2.0	Cohn et al. (1999)
Finnish	2.14	Ham (2001)
Japanese	ca. 2-3	Kawahara (2015)
Persian	2.41	Hansen (2004)
Italian	ca. 2-2.5	Pickett et al. (1999)
Malayalam	ca. 2.5	Local & Simposon (1999)
Bengali	2.67	Hankamer et al. (1989)
Turkish	3	Hankamer et al. (1989)

segmental effects not controlled.

WHERE DOES THIS CROSS-LINGUISTIC VARIATION COME FROM?

- Ham (2001): syllable-timed languages tend to show smaller geminate/ singleton ratios than mora-timed languages (e.g. Norwegian vs. Japanese).

- (Is it straightforward to define syllable-based languages vs. mora-timed languages for all languages?)

- Engstrand and Krull (1994): Geminates are longer than singletons to the degree that these two categories are sufficiently distinct perceptually.

- Could it be that different languages phonologically represent geminates differently? Double C-slots, moraic consonants, simply [+long] consonants, [+tense] consonants, fortis consonants, etc…(cf. Broselow et al. 1997).

EFFECTS ON PRECEDING VOWELS

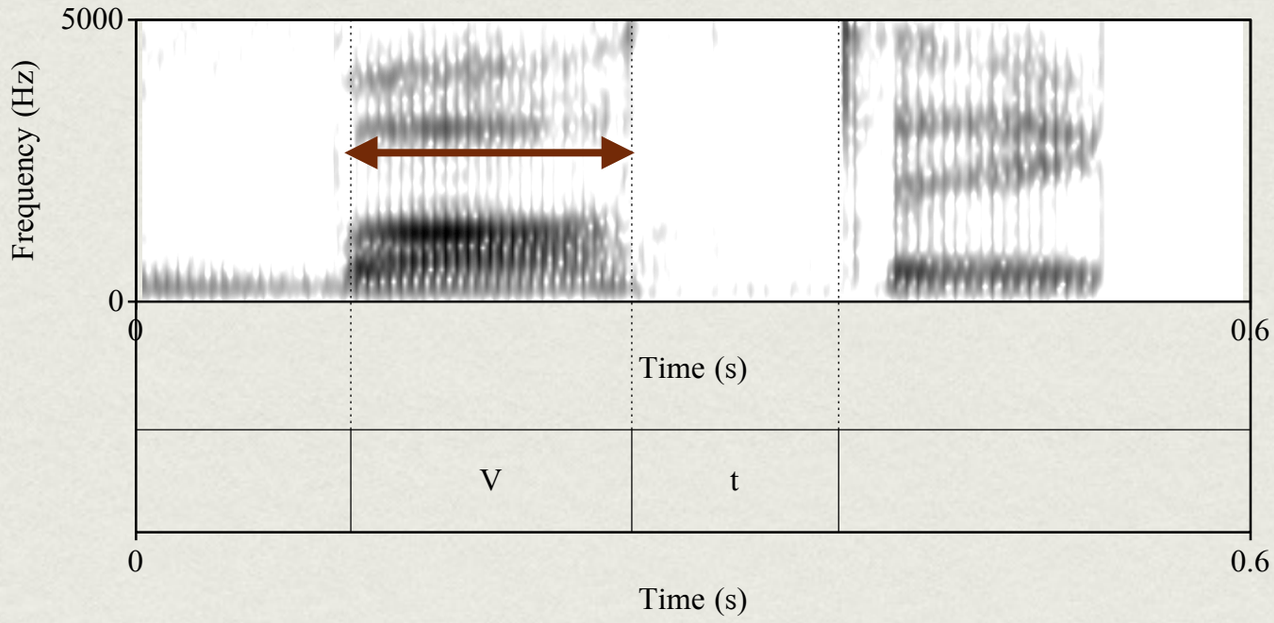
- Geminates are usually assumed to close the preceding syllable; e.g. [kat.ta].

- Vowels in closed syllables are usually shorter than vowels in open syllables (Maddieson 1985) (this is not a universally accepted view, though).

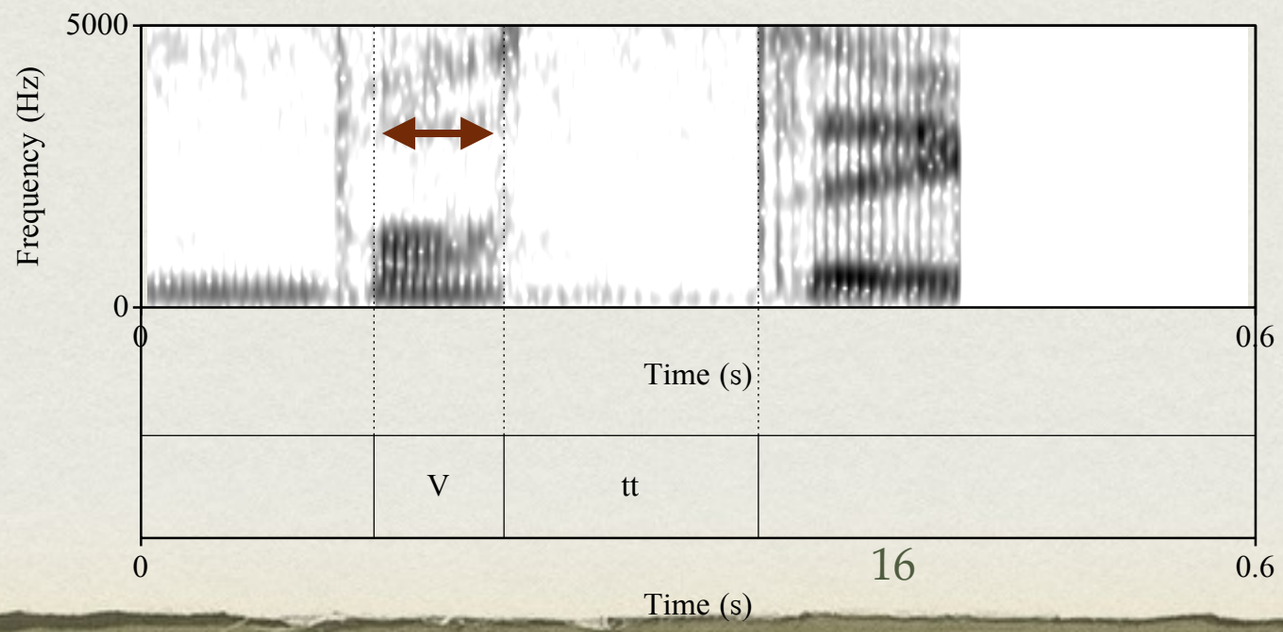
- Geminates are therefore expected to shorten preceding vowels.

- This expectation fails when it comes to geminates…

PRE-GEMINATE SHORTENING (NORWEGIAN)

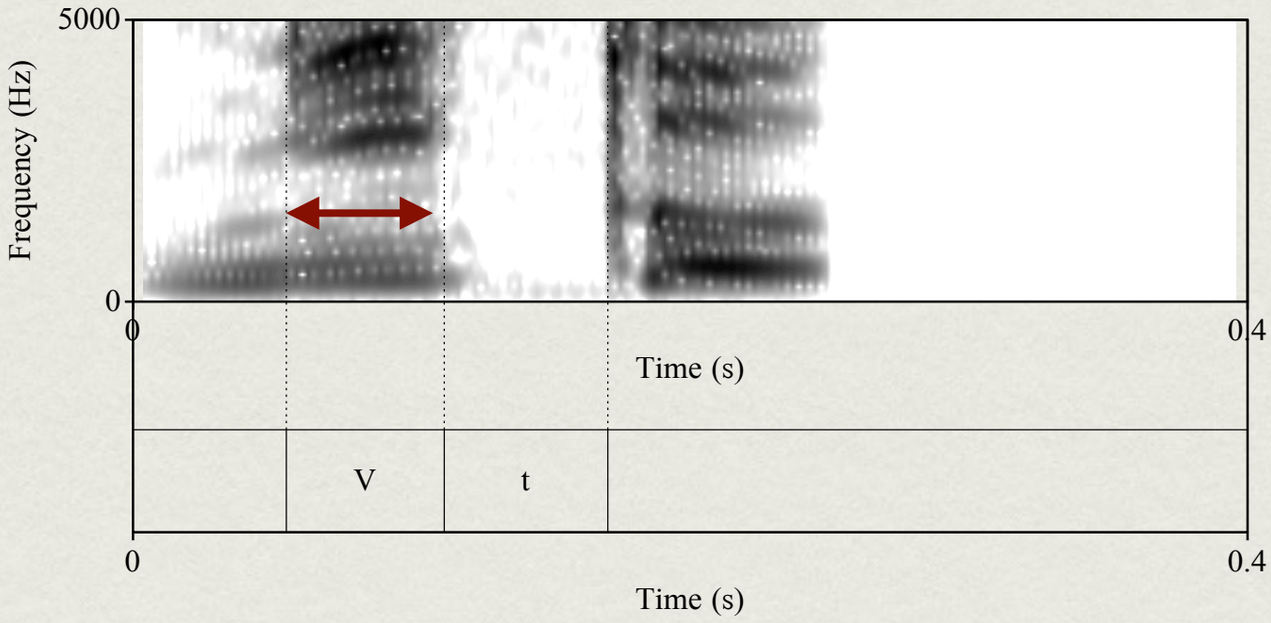


- singleton
- open syllable

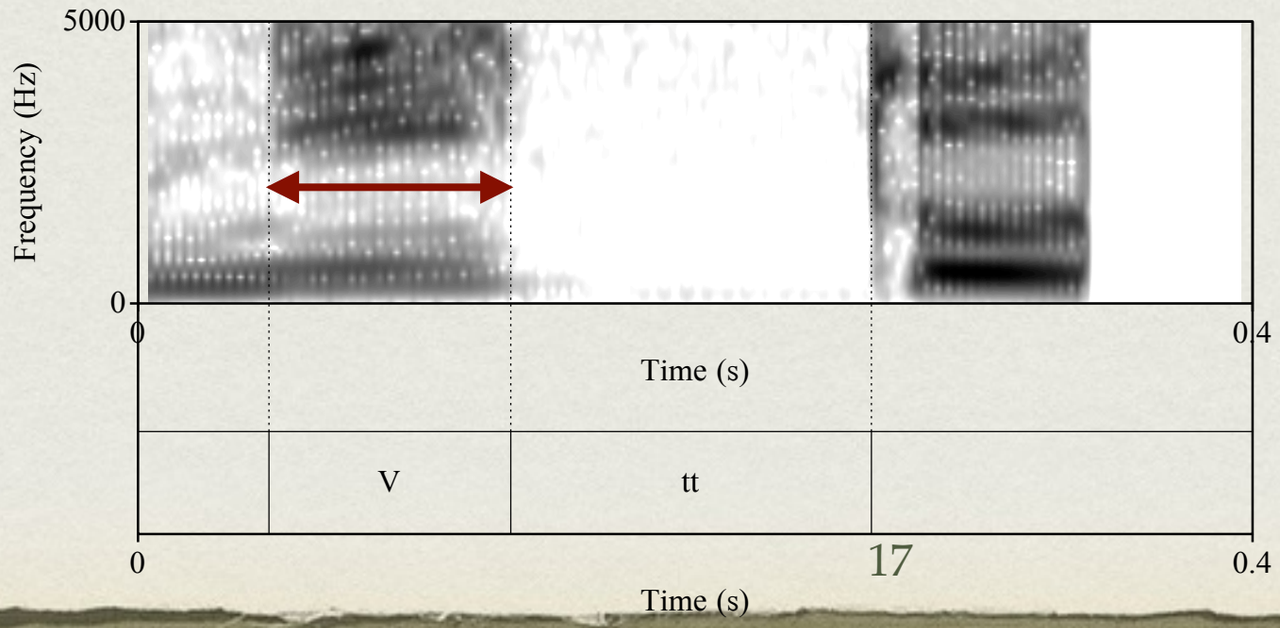


- geminate
- closed syllable

PRE-GEMINATE LENGTHENING (JAPANESE)

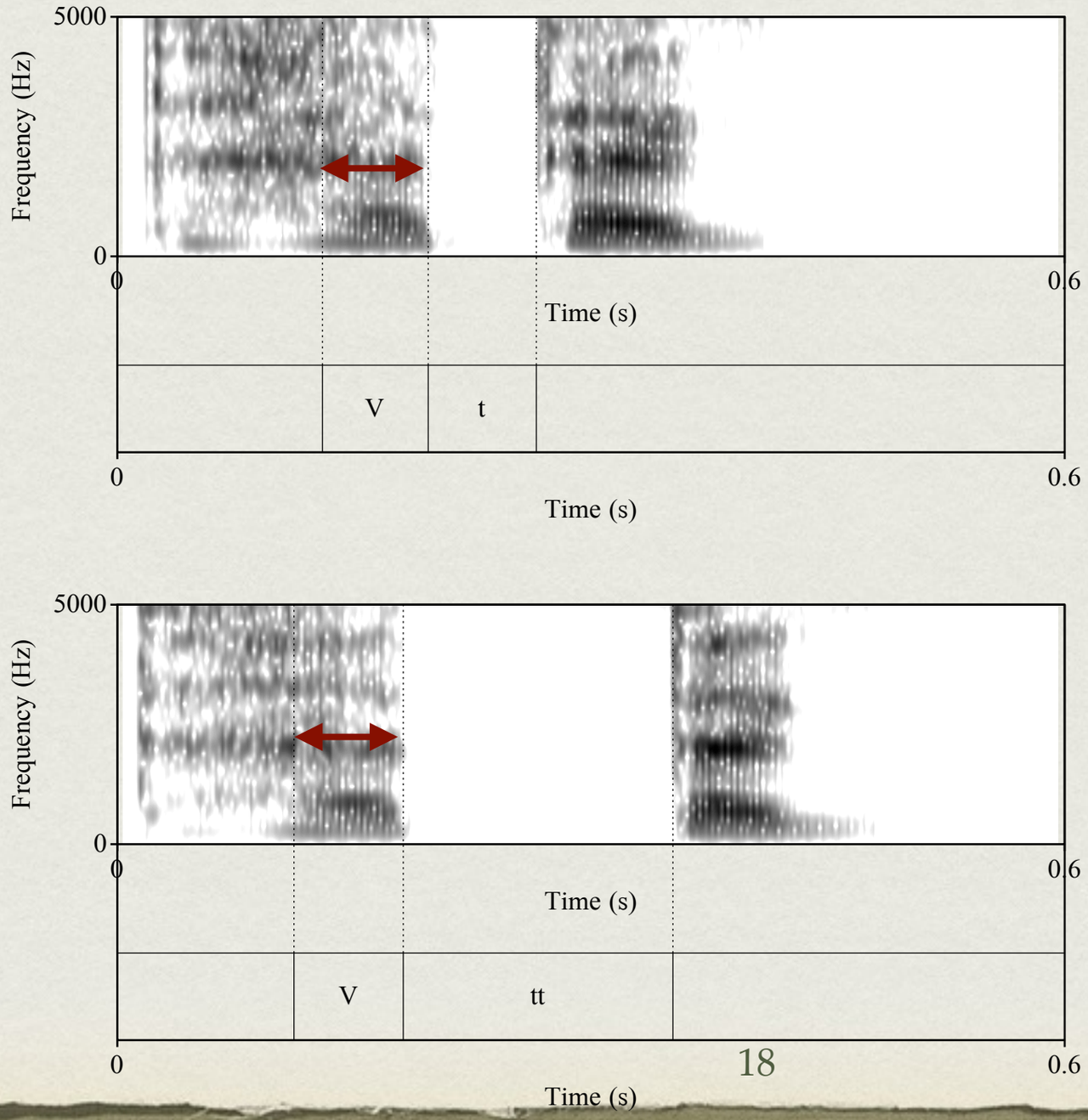


- singleton
- open syllable



- geminate
- closed syllable

NO EFFECTS ON PRECEDING VOWELS (ARABIC)



- singleton
- open syllable

- geminate
- closed syllable

CROSS-LINGUISTIC VARIATIONS: A SUMMARY

- Shortening-languages
  - Bengali (Lahiri & Hankamer 1988)
  - Norwegian (Fintfont 1961)
  - Italian (Esposite & Di Benedetto 1999)
- Lengthening-languages
  - Japanese (Kawahara 2015)
  - Turkish (Jannedy 1995)
  - Finnish (Lehtonen 1970; Yoshida et al. 2015)
  - Shinhara (Letterman 1994)
- No-effect-languages
  - Arabic (Norlin 1987)—in Labanese Arabic, only long vowels shorten (Khattab & Al-Tamini 2014).
  - Estonian (Engstrand & Krull 1994)

Not a comprehensive list.

THE QUESTION

- Where does this cross-linguistic variation come from?
- Differences in phonological representations, especially syllabic affiliations?
- Or perceptual explanation?

1. Short V can enhance the long duration of C-duration (C/V ratio: Kingston & Diehl 1994; Port & Dalby 1982).

2. V and C together can constitute a perceptual unit (Kato et al. 2003; Kingston et al. 2009).

OTHER ARTICULATORY/ SPECTRAL CORRELATES

VOT AND/OR BURST

- We would expect higher air pressure rise behind the closure (i.e. high P_0) after geminates, resulting in longer VOT and/or strong, clearer burst (cf. Oral 1983).

- This expectation is met in Berber (Ridouane 2010), Hindi (Shrotriya et al. 1995) and Cypriot Greek (Arvaniti & Tserdanelis 2000)

- But not so in other languages, including Japanese (Ham 1994), Trique (DiCanio 2008), and three Indonesian languages discussed in Cohn et al. (1999).

- Turkish even has shorter VOT for geminates (Lahiri & Hankamer 1988).

SPECTRAL FEATURES OF GEMINATES

- Preceding vowels can be (but are not always) creaky before Japanese geminates (Idemaru & Guion 2008).
- Preceding vowels are more often breathy before geminates than before singletons in Trique (DiCanio 2008) (i.e. pre-aspiration).
- F1 is lower after geminates in Japanese (Kawahara 2006).
- Sonorant geminates in Malayalam show palatal resonance with higher F2 (Local & Simpson 1999). There are formant differences in surrounding vowels.
- No obvious effects of geminacy on formant frequencies in Italian (Esposito & Di Benedetto 1999) or Trique (DiCanio 2008).

EFFECTS ON THE PRECEDING C AT A DISTANCE

- Effects on C1 in C1VC(C)V. C1 is founded to be longer before geminates in Hindi (2007) and Japanese (Han 1994).

- This long-distance effect is a bit surprising, given C-to-C coarticulation is unexpected (Öhman 1966 *et seq.*; Gafos 1998).

THE FOLLOWING VOWELS

- The effects of geminacy on the *following* vowels (not the *preceding* vowels) are less well studied.

- In Japanese, vowels are slightly shorter after geminates, and this shortening affects the perception of geminates (Idemaru & Guion-Anderson 2010; Ofuka et al. 2005).

- A similar shortening occurs in Finnish, but as a part of the general shortening of CV syllables after CVC/CVV syllables (Yoshida et al. 2015).

- How about other languages?

SUMMARY SO FAR

- Some sad (or challenging/exciting) conclusion: the only universal acoustic/articulatory feature that we can identify about geminates with confidence is constriction duration.

- This feature could even be challenged by the Norwegian geminates.

- A singleton/geminate contrast shows the typical "multiplicity of acoustic cues" of a phonological contrast (Kingston & Diehl 1994).

PERCEPTION OF GEMINATES

CLASSIC EXPERIMENT

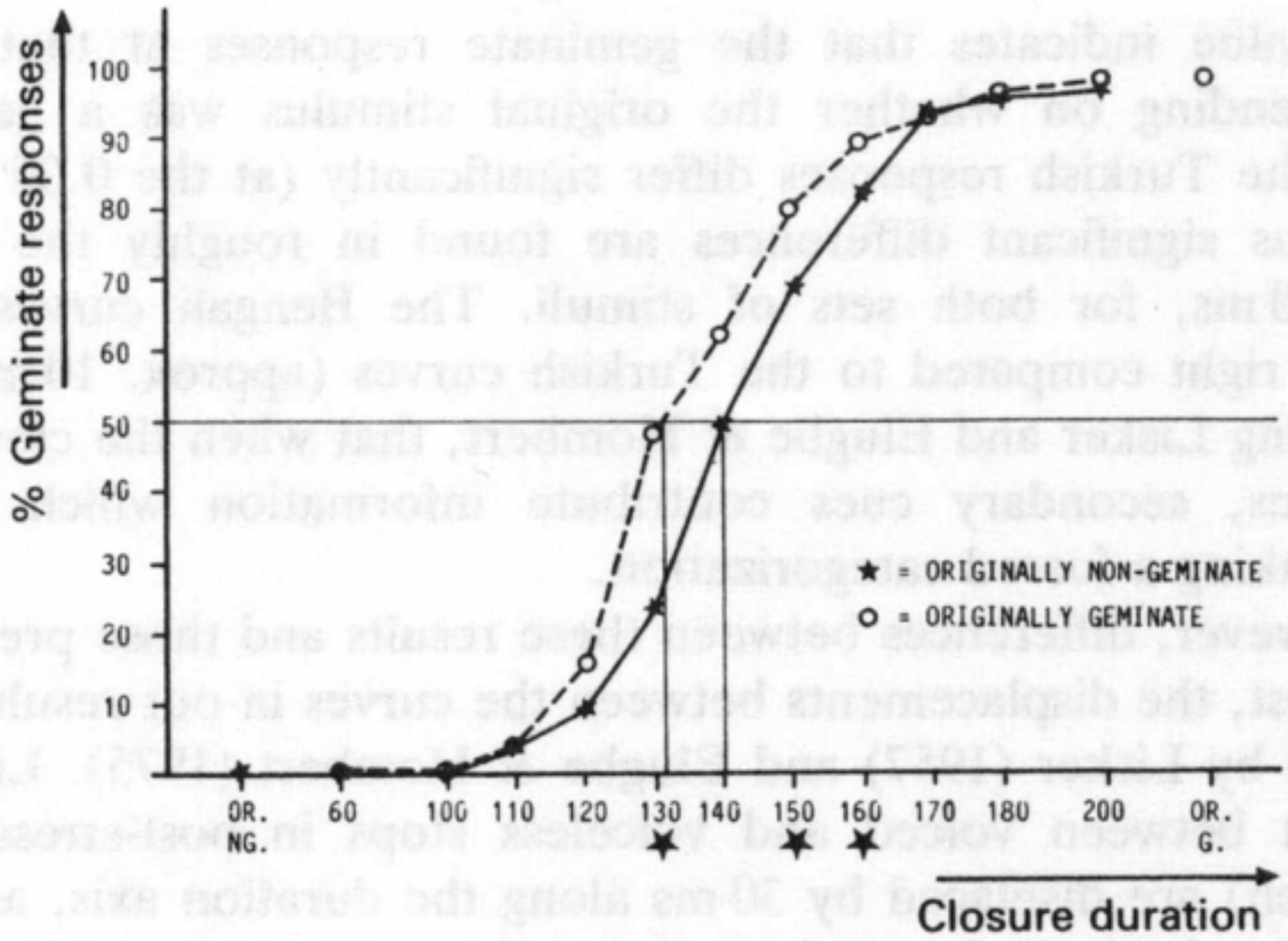


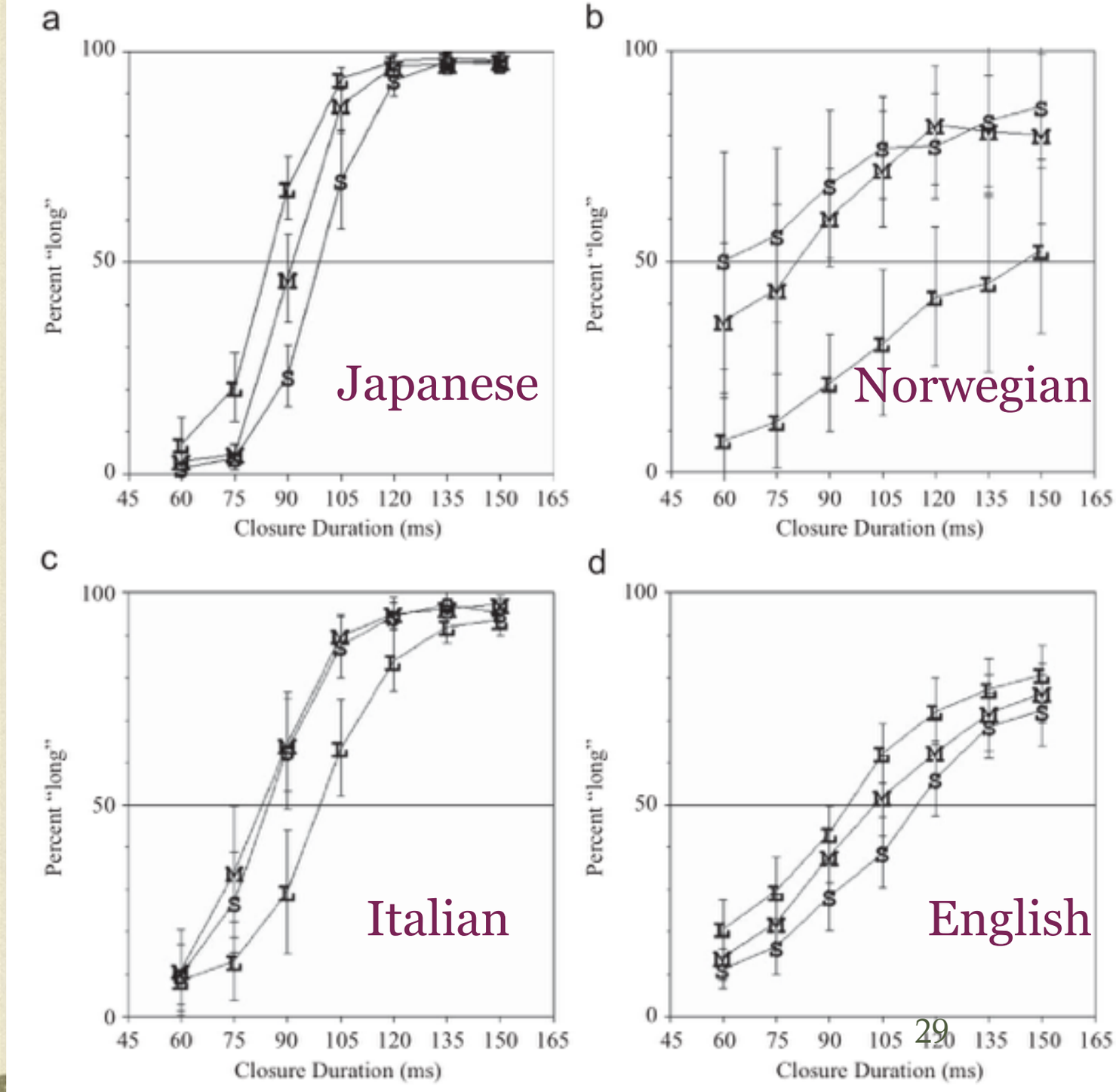
Figure 2. Mean percentage geminate responses at different closure durations to Bengali stimuli. The solid line is the curve indicating geminate responses to stimuli created from original non-geminates; the broken line is the curve indicating geminate responses to stimuli created from original geminates.

From: Hankamer, Lahiri & Koreman (1989)

There are cues for geminacy beside closure duration.

A similar paradigm conducted in many other languages (Pattani Malay: Abramson 1987; Finnish: Yoshida et al. 2015; Japanese: Fukui 1978; Tamil: Lisker 1958; Turkish: Hankamer et al. 1989).

THE EFFECTS OF PRECEDING VOWELS

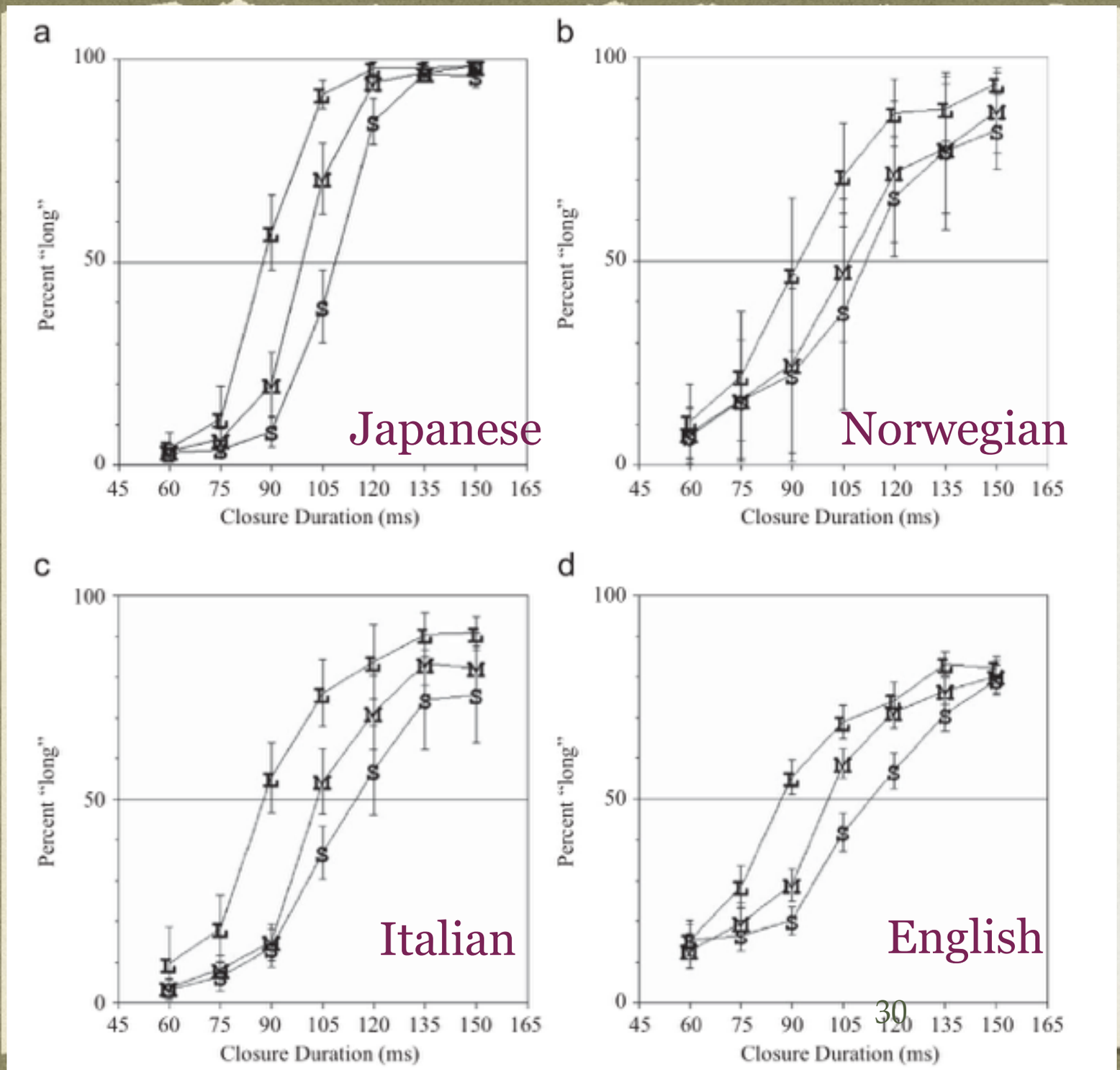


From Kingston et al. (1999)

Preceding vowel duration affects the perception of geminates, in ways expected from their production patterns.

English is like Japanese.

NON-SPEECH STIMULI



When the stimuli are converted to non-speech sounds, everybody turns into Japanese!—even Italians.

V+C as a perceptual unit? (Kato et al. 2003)

WHAT ABOUT…

- What about the impact of other spectral acoustic correlates on geminate perception?

- As far as I know, not many experiments have addressed this issue.

- Idemaru (2011) is a rare attempt (as far as I know), but with null results.

IDEMARU 2011: AMPLITUDE DROP

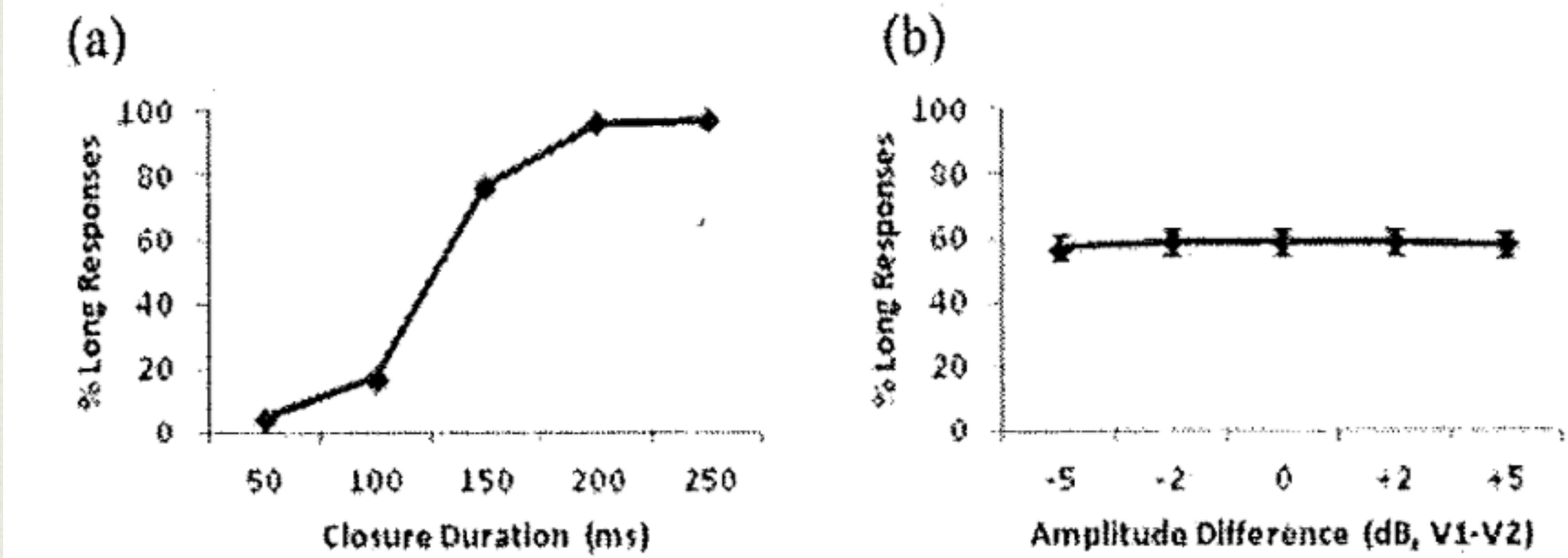


Figure 1. Effect of closure duration (a) and amplitude (b) in the perception of Japanese stop lengths.

IDEMARU (2011): F0

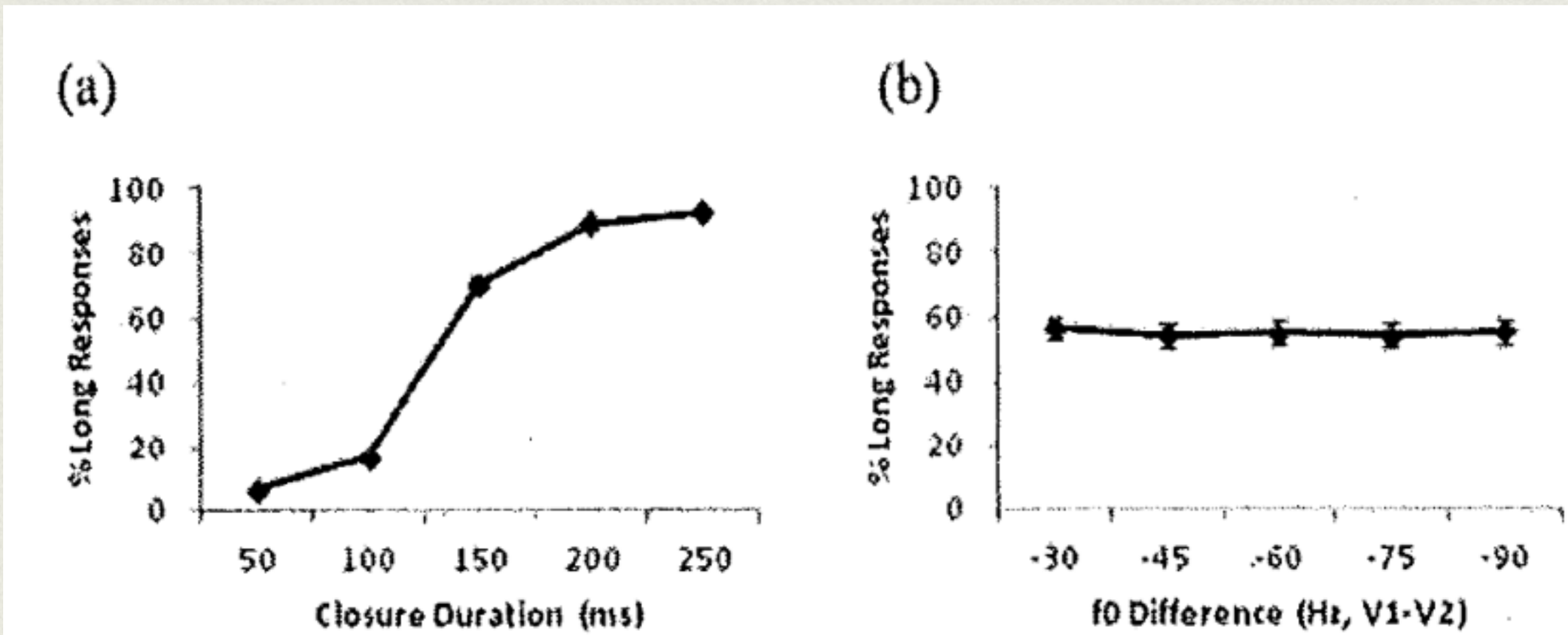


Figure 2. Effect of closure duration (a) and f0 (b) in the perception of Japanese stop lengths.

(SOME OF THE) MANY REMAINING ISSUES

REMAINING ISSUE 1: COPING WITH VARIATION

- The issue of invariance (Stevens & Blumstein 1979 *et seq*).

- To the extent that geminates (largely) depend on durational cues, how do listeners cope with speech rate effects?

- Geminates spoken in faster speech can be shorter than singletons spoken in slower speech rate.

JAPANESE DATA FROM HIRATA & WHINTON (2005)

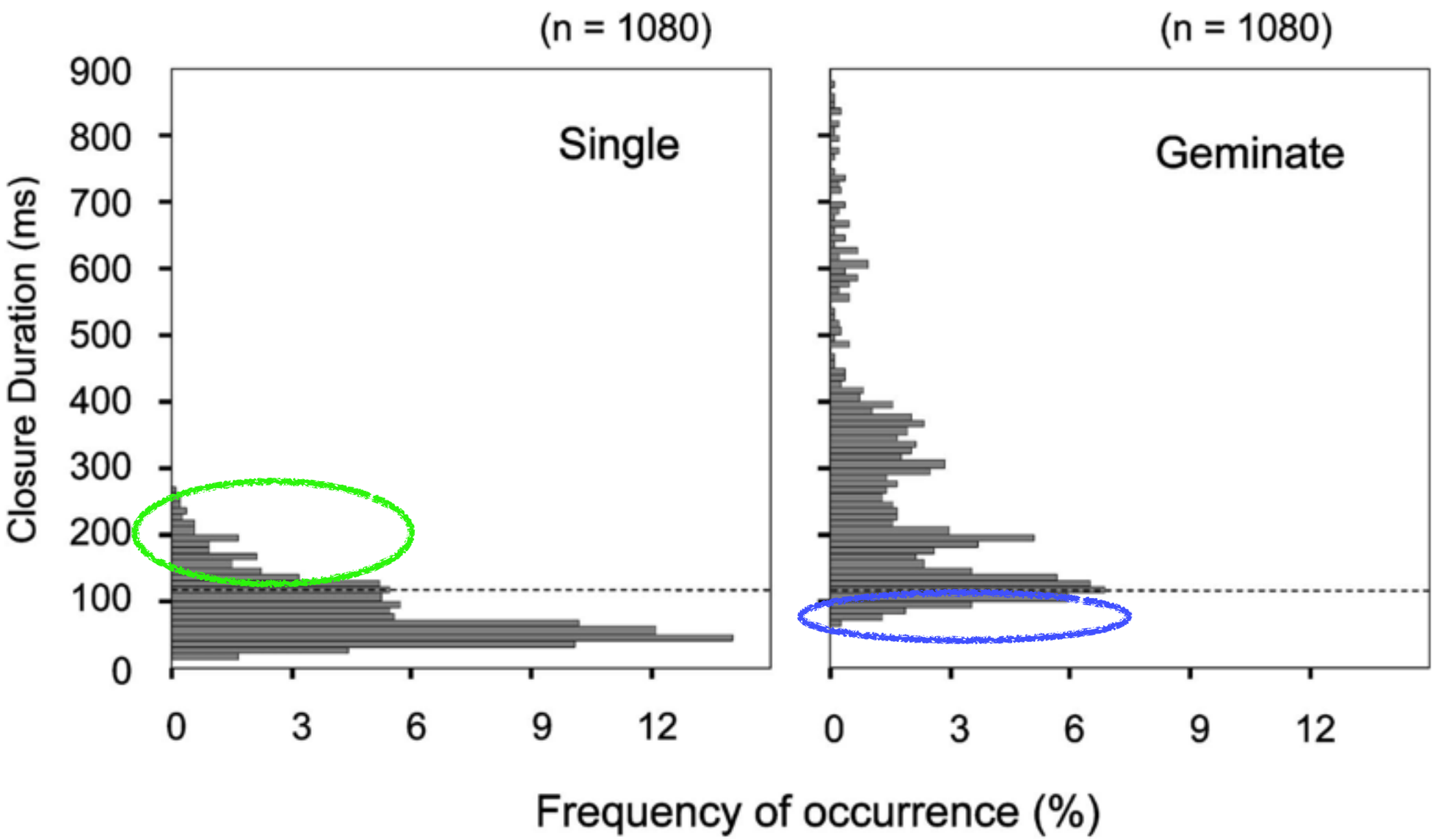
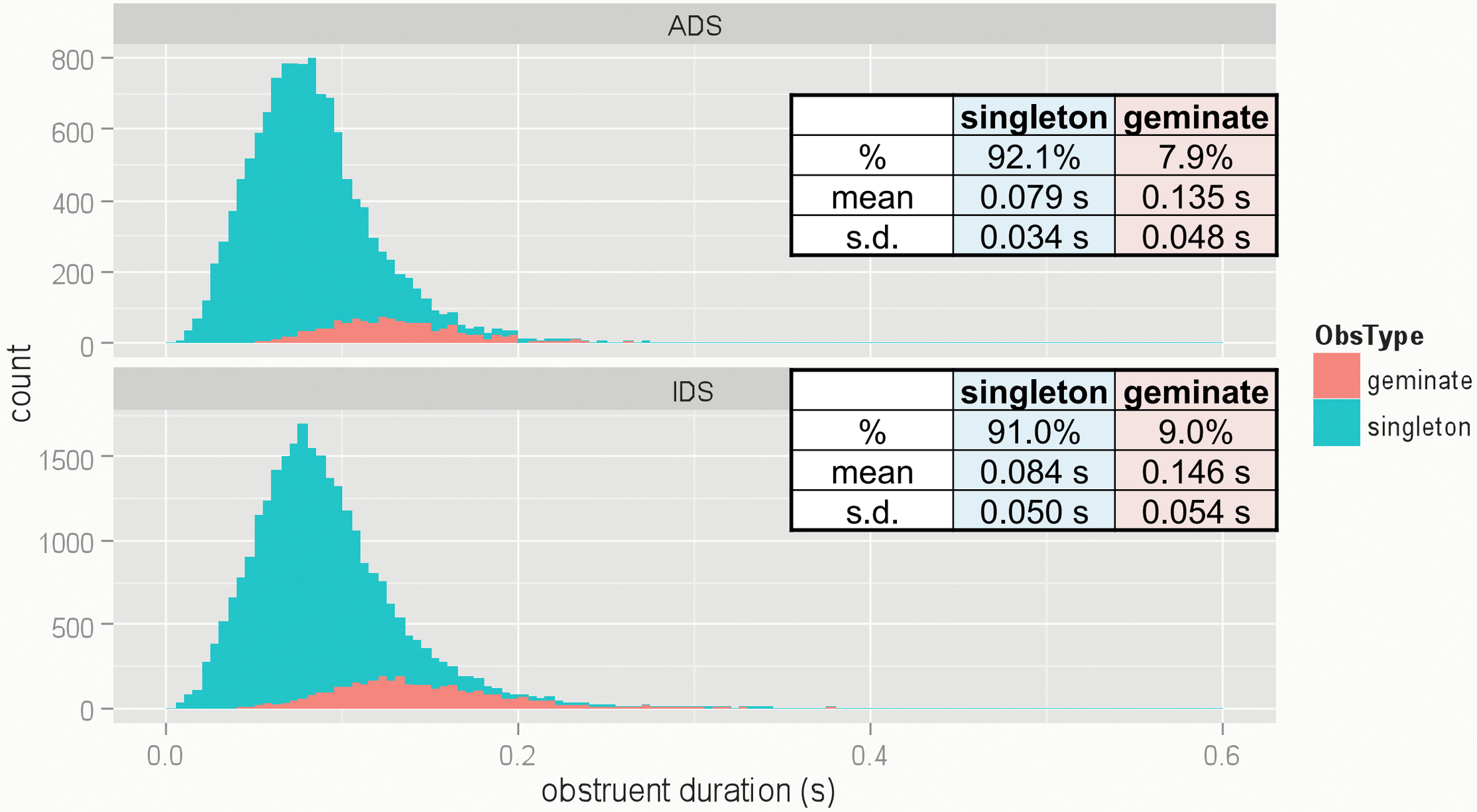


FIG. 1. Histogram of single versus geminate closure duration across all speakers and rates (set 2). Dashed line represents optimal boundary computed as 115 ms.

FURTHER PROBLEM IN TERMS OF LANGUAGE INPUTS (TAJIMA 2013)



	singleton	geminate
%	92.1%	7.9%
mean	0.079 s	0.135 s
s.d.	0.034 s	0.048 s

	singleton	geminate
%	91.0%	9.0%
mean	0.084 s	0.146 s
s.d.	0.050 s	0.054 s

SOME PROPOSED SOLUTIONS

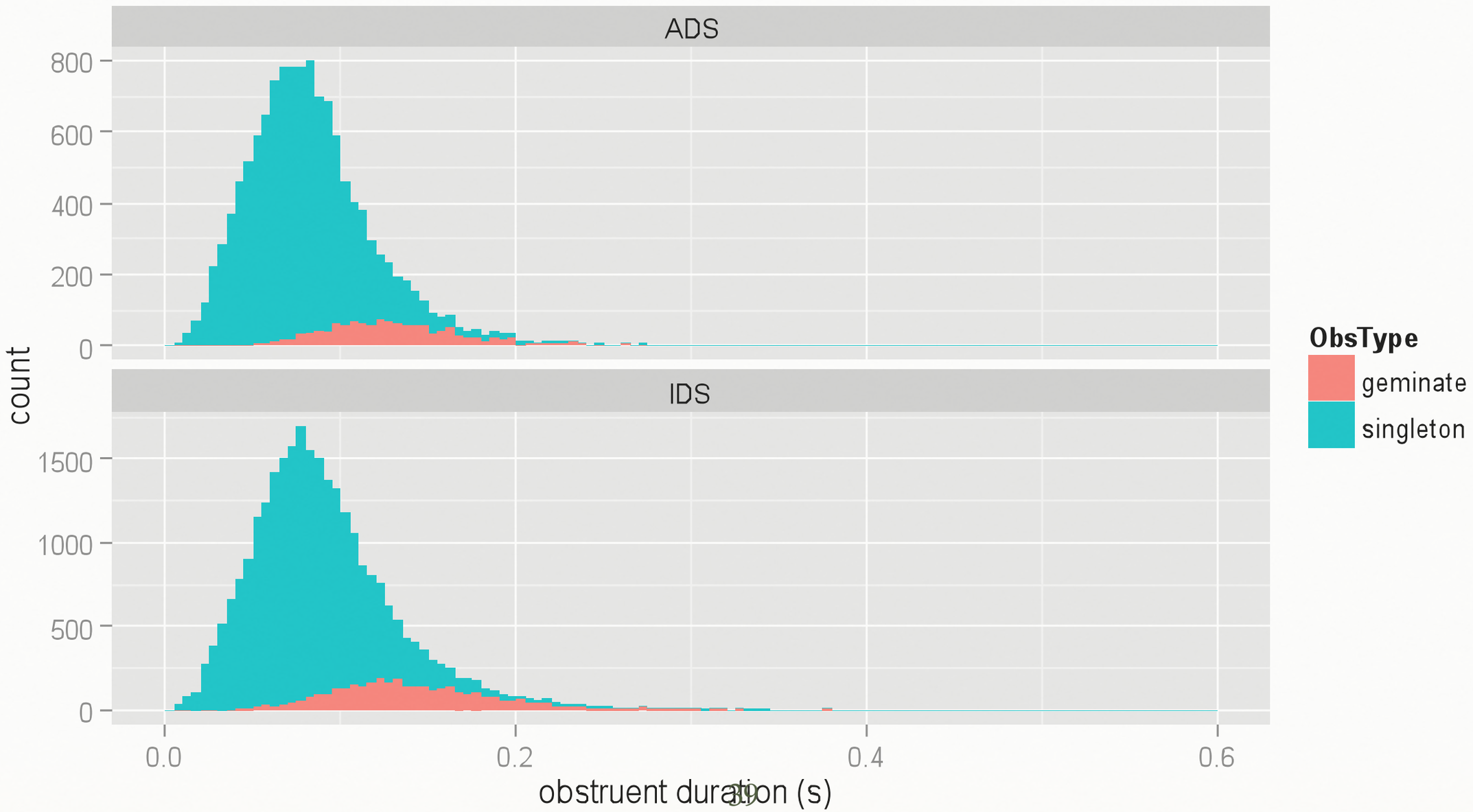
- Proposed relational measures: C/V1, C/Word, C/Foot, etc for Japanese; V/Rhyme for Icelandic, C/V1 for Italian…

- Any relational measure that works universally?

- Or even, is a relation measure the answer? (cf. Idemaru et al. 2012 who show that not every Japanese listener relies on relational cues.)

REMAINING ISSUE 2: ACQUISITION

How do Japanese children learn that there are two categories?



CHILDREN MAY NOT BE BORN TO BE READY FOR S/G CONTRAST (MAZUKA ET AL. 2012)

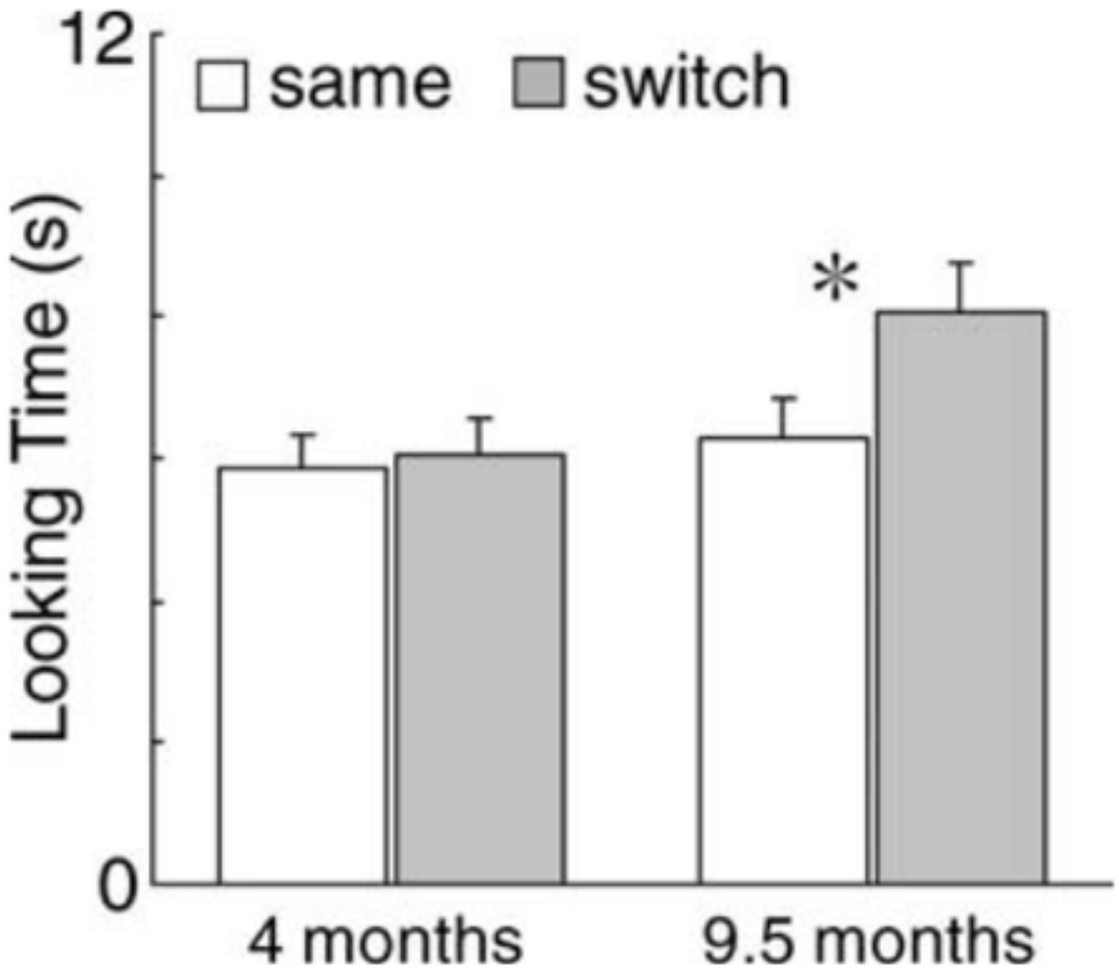


Figure 1. Mean looking times (with standard error bars) during the same and switch trials (see the Procedure section) for naturally uttered /pata/ and /patta/ in 4- and 9.5-month-old infants (redundant cues condition, Experiment 1). The 9.5-month-olds exhibited a significant difference in looking times between same and switch trials. * $p < .05$.

A habitation-dishabituation task.

The discrimination ability for a s/g contrast may not develop until 9.5 months.

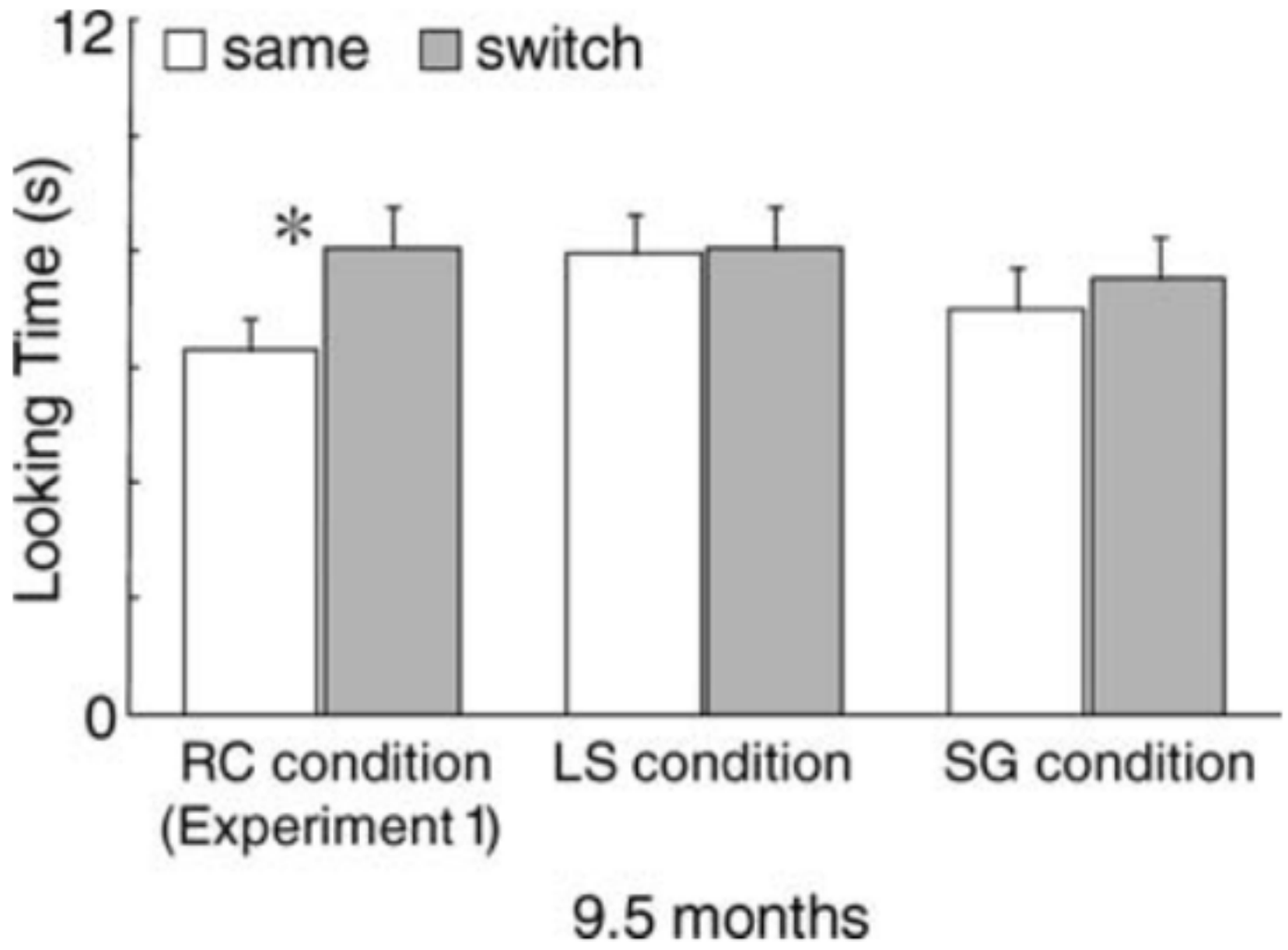


Figure 4. Mean looking times (with standard error bars) during the same and switch trials (see the Procedure section) in 9.5-month-old groups for the following word pairs: naturally uttered /pata/ and /patta/ (the redundant cues [RC] condition in Experiment 1), manipulated /patta/ and naturally uttered /pata/ (the lengthened single token [LS] condition), and manipulated /pata/ and naturally uttered /patta/ (the shortened geminate [SG] condition). The 9.5-month-olds exhibited a significant difference in looking times between same and switch trials only for the naturally uttered /pata/ and /patta/ pairs. * $p < .05$.

But they need secondary cues...

LATERALIZATION NOT OBSERVED IN INFANTS: MINAGAWA-KAWAI ET AL (2007)

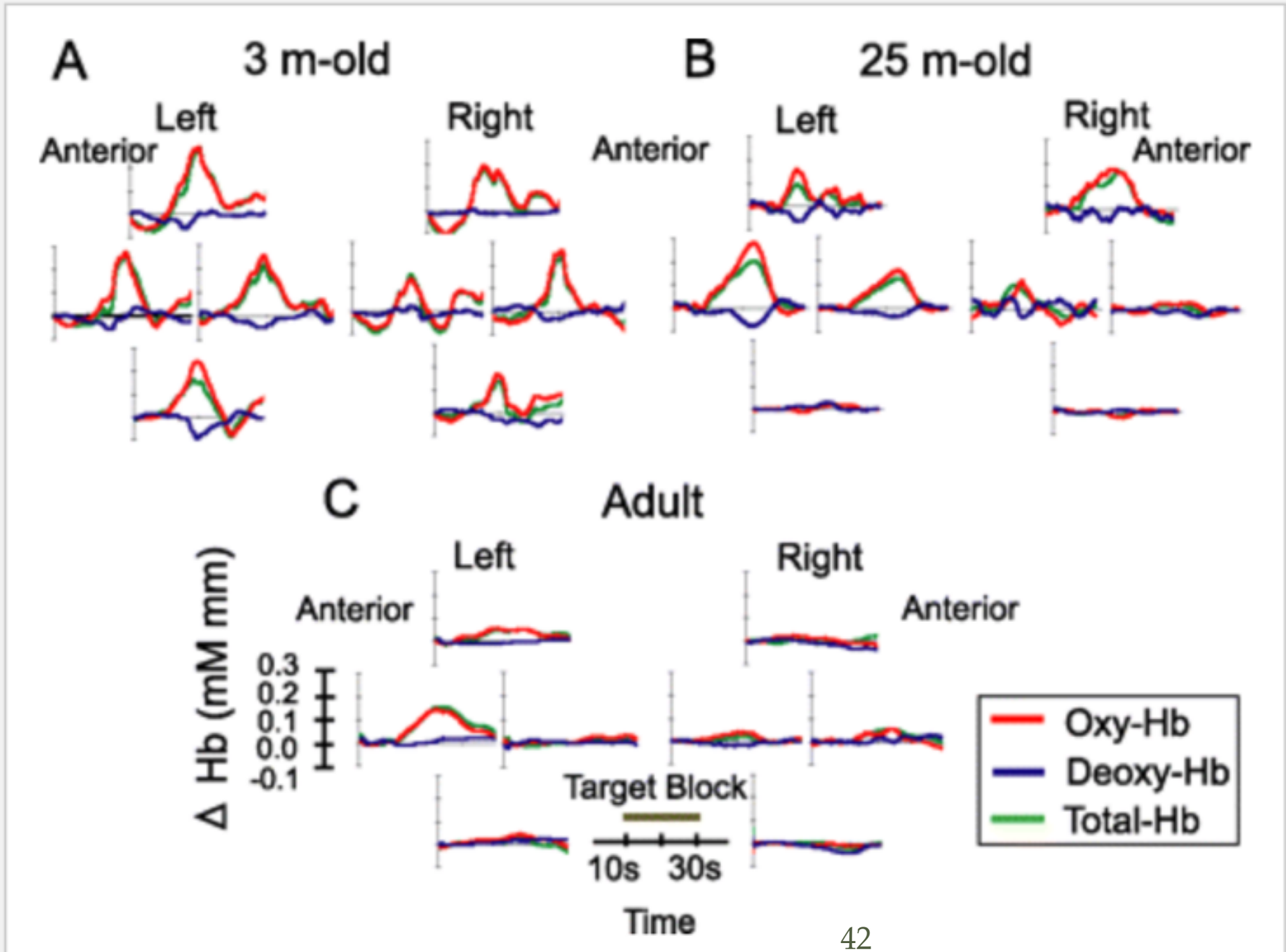


Figure 3.

Time course of NIRS responses for eight channels around the temporal areas (left and right) in subjects of different age groups: 3-month-old infant (***A***), 25-month-old infant (***B***), and adult data adapted from Minagawa-Kawai et al. (2002) (***C***). The younger infant showed bilateral and broad activations compared with the adult's pattern with left dominance.

View larger version:

THE PROBLEM IN A NUT SHELL

- Babies may not be born to be ready for a length contrast? (It is well known that babies are born to be ready for other contrasts.)
- How would they learn these two categories?
- Relatedly, how would L2 speakers learn these two categories?

REMAINING ISSUE 3: MANNER EFFECTS

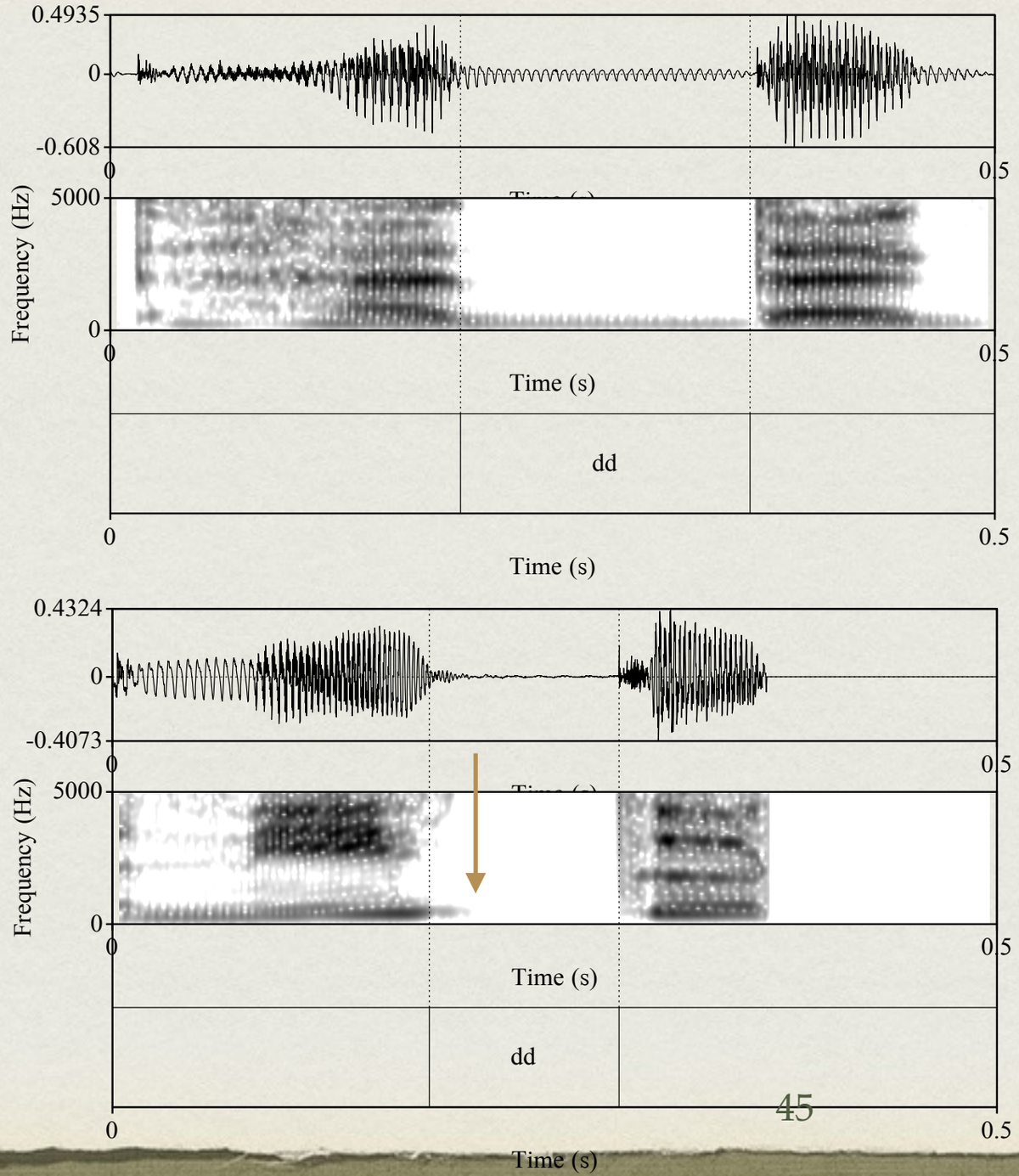
- Manner effects (e.g. fricatives are usually longer; consequently, gem/sing duration ratios are smaller).

- Many studies use stops (because they are most common types of geminates & they are easy to measure).

- Fricative geminates? Affricate geminates? Sonorant geminates?

- Voiced obstruent geminates? It is hard to keep voicing during geminate closure due to an aerodynamic problem. Japanese geminates are semi-devoiced; Arabic geminates are not.

VOICED GEMINATES



Arabic

Japanese

REMAINGINS ISSUE 4: DERIVED GEMINATES VS. UNDERLYING GEMINATES

- Lahiri & Hankamer's (1988) thesis: derived geminates and underlying geminates are phonetically identical (because they are phonologically identical).

- Challenged by some later work (Payne 1995; Ridouane 2010).

- A lurking theme: incomplete neutralization (Port & O'Dell 1985 *et seq*.)

REMAINING ISSUE 5: NON-INTERVOCALIC GEMINATES

- Geminates in many languages appear intervocalically; this distributional restriction makes sense perceptually (Kawahara & Pangilinan, to appear).

- However, there are languages that allow word-initial geminates (Muller 2001).

- There are languages that allow only word-initial geminates; e.g. Pattani Malay (e.g. Abramson 1987) and Kelantan Malay (Hamzah et al. 2011).

- Both in Berber and Swiss German, word-initial geminates are reliably longer than corresponding singletons (Kraehenmann & Lahiri 2008; Ridouane 2010).

THANK YOU

AND

LET THE WORKSHOP BEGIN!

IN LIEU OF REFERENCES

Shigeto Kawahara

1 The phonetics of *sokuon*, or geminate obstruents

Handbook of Japanese phonetics and phonology. H. Kubozono (ed.)

1 Introduction

Japanese has a phonemic contrast between short and long nasal and obstruent consonant series, as exemplified by minimal pairs like [ka**t**a] 'frame' vs. [ka**tt**a] 'bought' and [ha**t**o] 'dove' vs. [ha**tt**o] 'hat'.[1] Short consonants are generally called "singletons", whereas long consonants are called "geminates", geminate obstruents, or obstruent geminates (see also Kawagoe, this volume). In the traditional literature on Japanese phonetics and phonology, the first half of obstruent geminates is called "*sokuon*" for which the symbol /Q/ is often used; in the Japanese orthographic system, this coda part is represented by "small tsu". Nasal geminates or their coda portions are called *hatsuon*; in the traditional literature they are represented by /N/. This chapter focuses on obstruent geminates. Henceforth, the term "geminate" refers specifically to obstruent geminates or *sokuon*, unless otherwise noted. This chapter provides an overview of the acoustic, perceptual, and articulatory characteristics of

Most refs can be found in this paper!

Feel free to get in touch about other papers.