

# Overview & Aim

Investigating common properties of across-channel processing in time, space and speech perception

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JSPS Kiban A Grant Kickoff Workshop

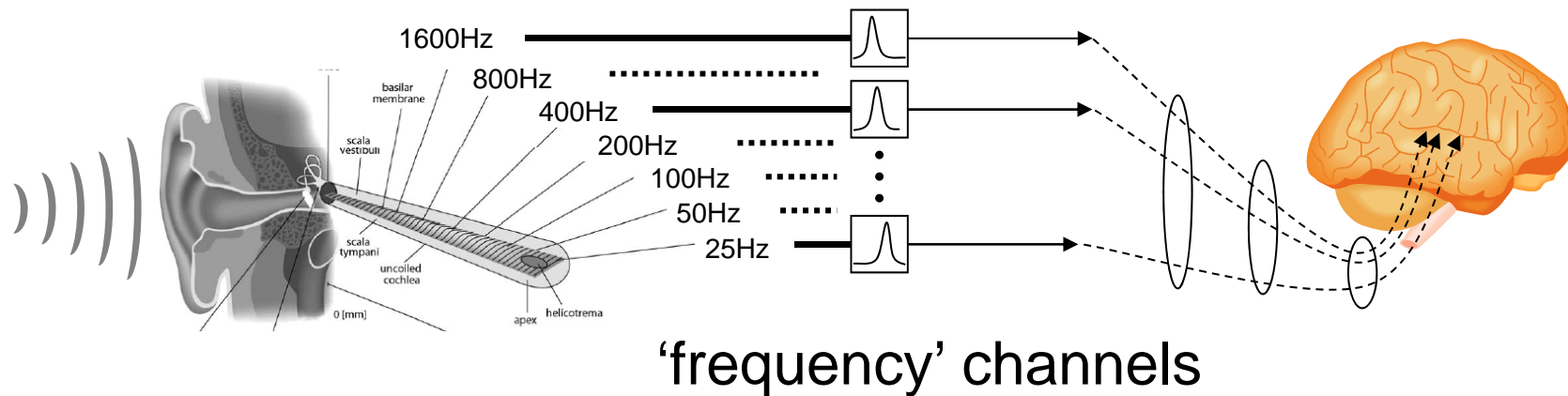
August 2, 2013



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# Across-channel processing

## Channel – Independent information pathway



## Auditory processing across channels

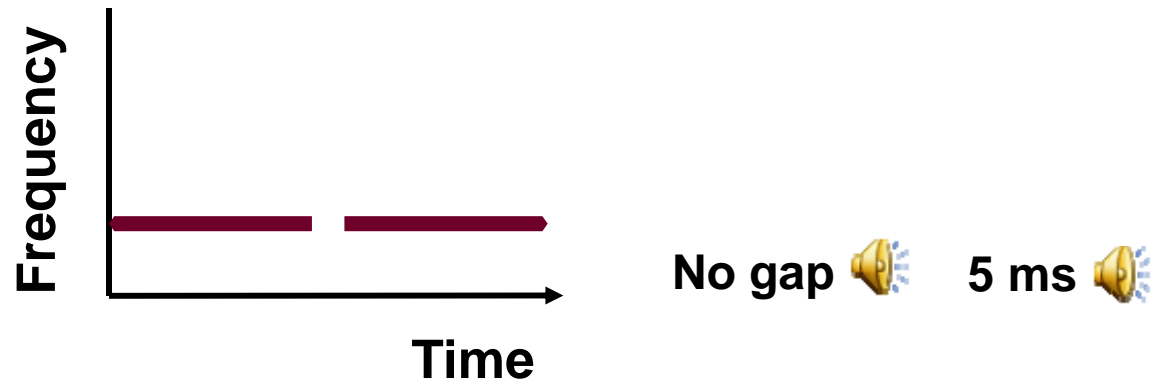
- Time: between-frequency gap detection
- Space: between-ear gap detection
- Speech: voiced-voiceless categorical boundary

# Between-frequency gap detection

## Gap detection

Measurement of auditory temporal resolution (Moore & Glasberg, 1988; Plomp, 1964, etc.)

Traditional, 'within-frequency' task

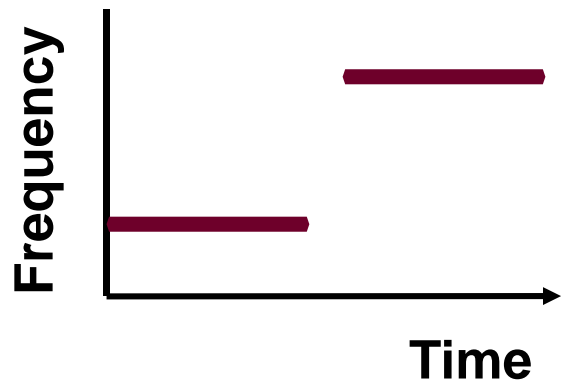


Gap thresholds below 5 msec (Scharf & Buus, 1986)

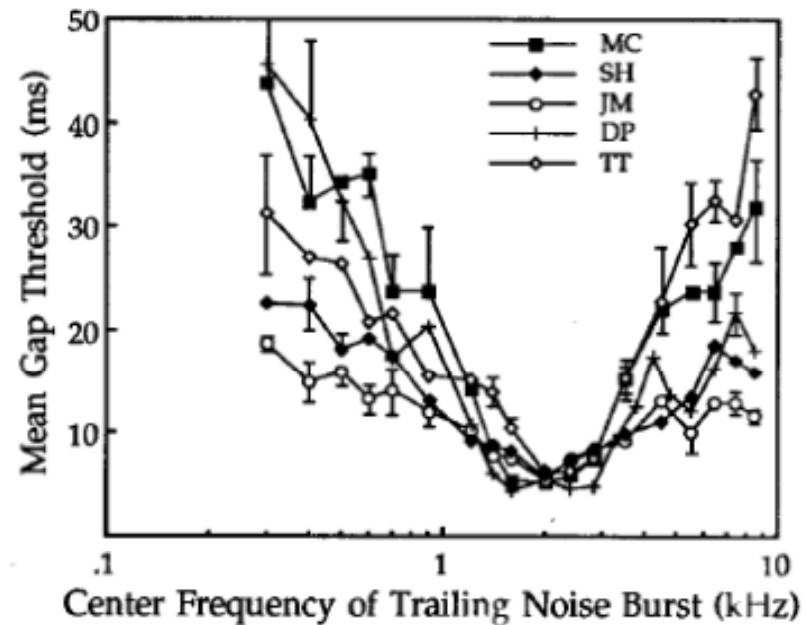
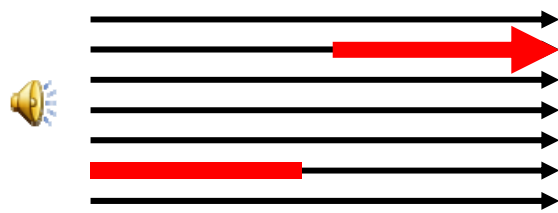


# Between-frequency gap detection

## Between-frequency task

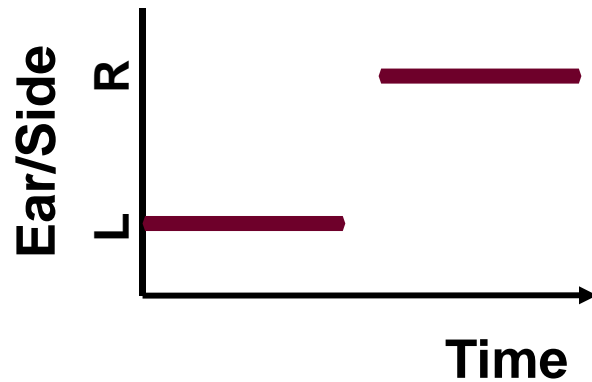


No gap 📣  
5 ms 📣 10 ms 📣 80 ms 📣

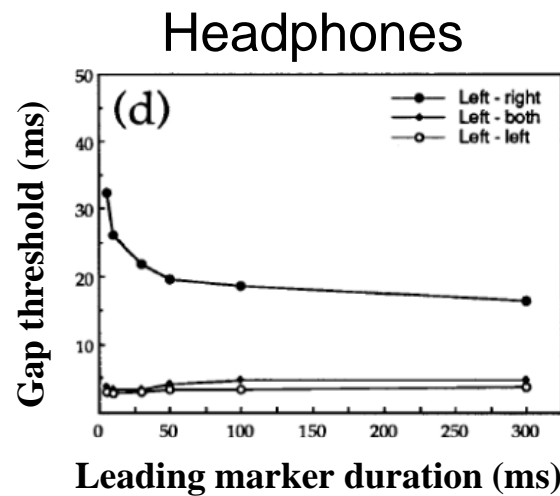


(Phillips et al., 1997, JASA, pp.3697, Fig.2)

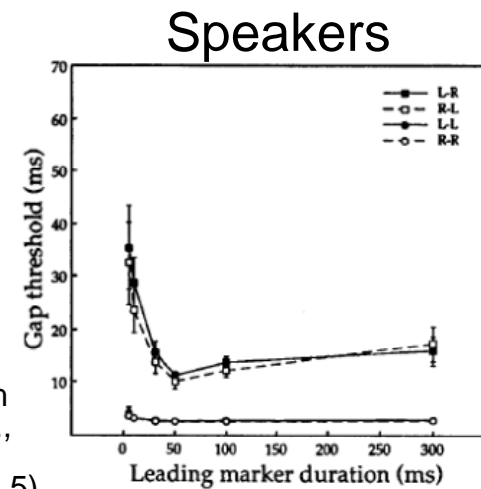
# Between-ear gap detection



Dependence on leading marker duration (Phillips et al., 1997, 1998)



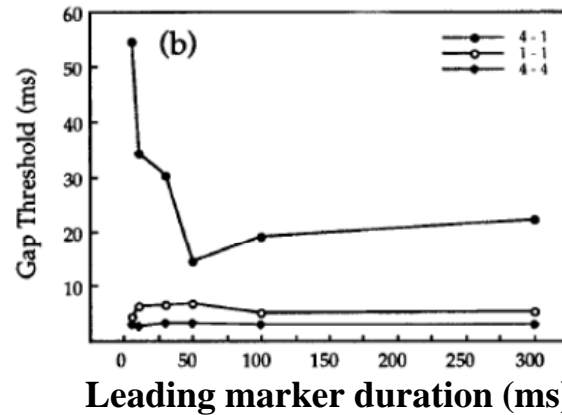
(Adapted from Phillips et al., 1997, JASA, pp.3702, Fig.5)



(Adapted from Phillips et al., 1998, JASA, pp.2066, Fig.2)

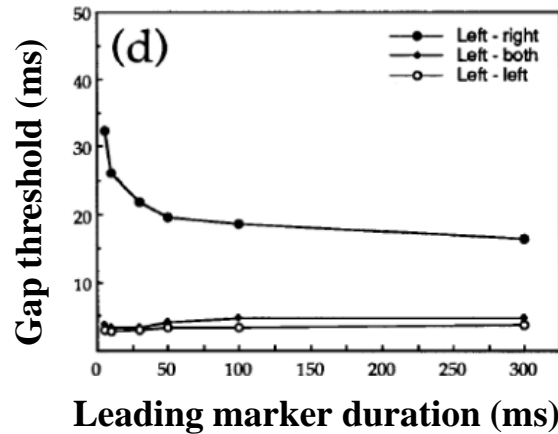
# Between-ear gap detection

Similarity to between-frequency thresholds (Phillips et al., 1997)



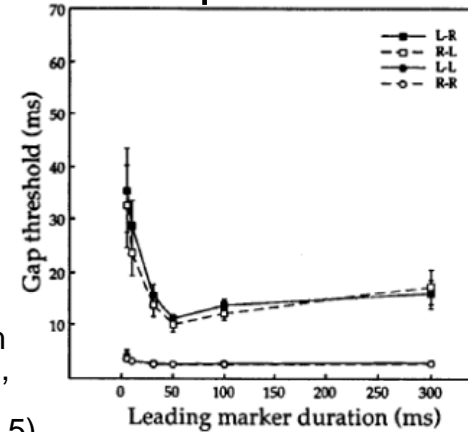
(Adapted from Phillips et al., 1997, JASA, pp.3698, Fig.3)

## Headphones



(Adapted from Phillips et al., 1997, JASA, pp.3702, Fig.5)

## Speakers



(Adapted from Phillips et al., 1998, JASA, pp.2066, Fig.2)

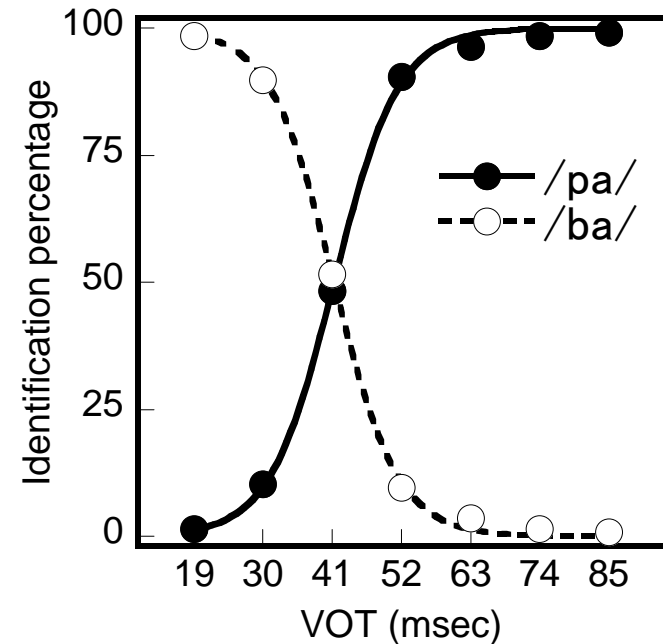
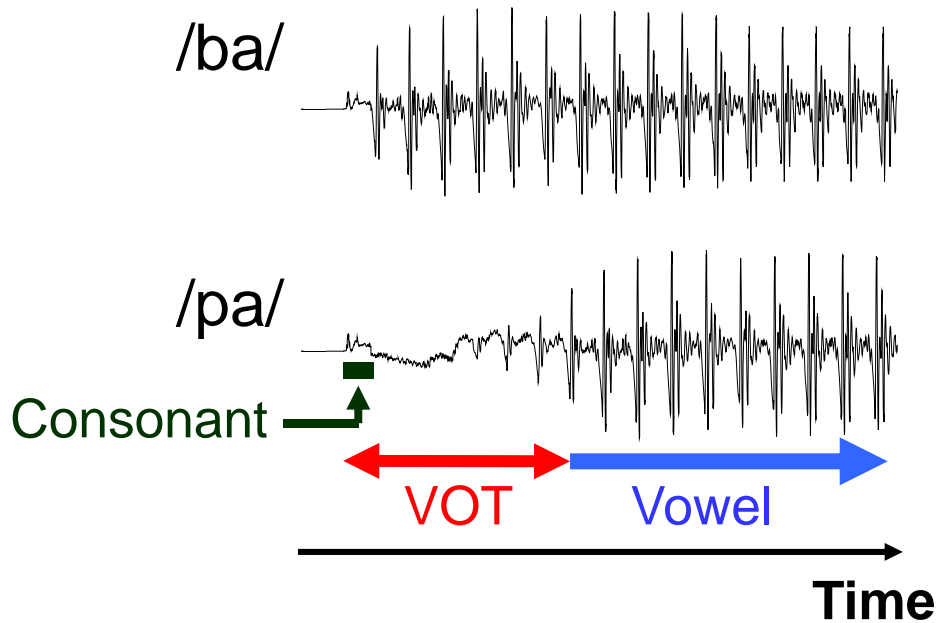


# Voiced-voiceless categorical boundary

Phoneme contrasts of stop consonants

/b/ - /p/, /d/ - /t/, /g/ - /k/

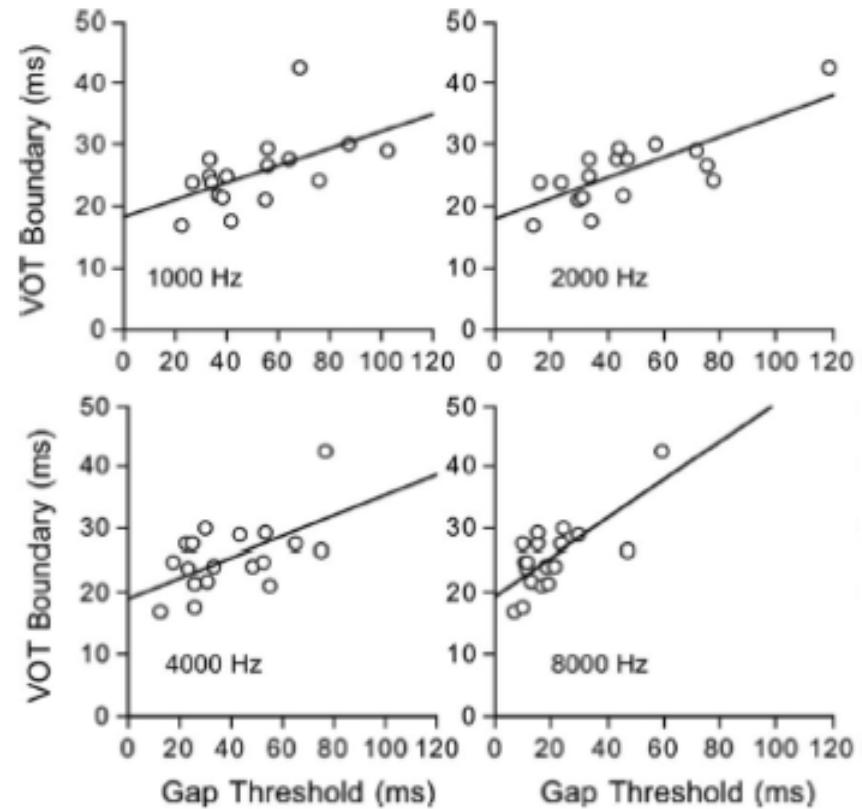
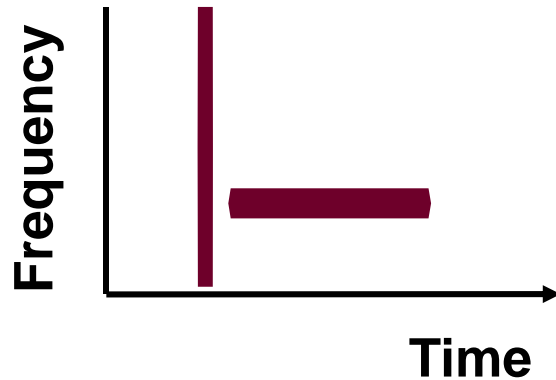
Voice onset time (VOT) as perceptual cues (Liberman et al., 1957; Lisker & Abramson, 1964)



(Based on Oyama, 2013, pp.11, Fig. 6)

# Voiced-voiceless categorical boundary

Similarity to between-frequency thresholds (Phillips et al., 1997; Elangovan & Stuart, 2008)



(Adapted from Elangovan & Stuart, 2008, Ear & Hearing, pp.769, Fig.6)





# Research questions

1. Common properties in time, space, and speech
  - Does same processing mediate those three domains of auditory perception?
  - What really is across-channel processing?
2. Brain mechanism
  - Where in auditory pathway does across-channel processing take place?
3. Possible operation in other domains
  - Vision
  - Perception of geminate consonants



# JSPS Kiban A Grant

‘Investigating common properties of across-channel processing in time, space and speech perception’

- FY 2013 to 2017
- Shuji Mori (chief), Kaoru Sekiyama, Keiji Iramina, Nobuyuki Hirose, Willy Wong, Makiko Sadakata, Takako Mitsudo



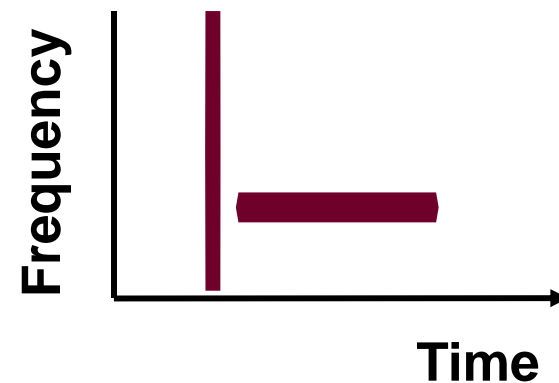
# Common properties

Oyama (2013)

Correlations of individual gap thresholds and /b/ - /p/ boundaries (cf. Elangovan & Stuart, 2008)

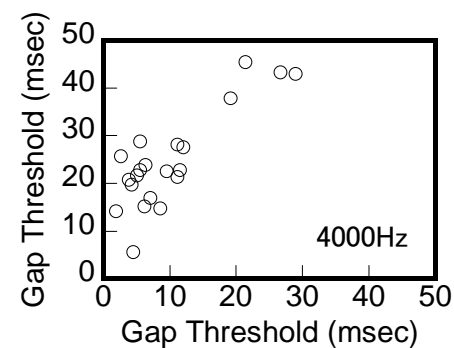
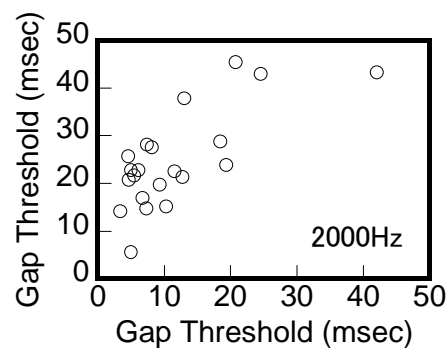
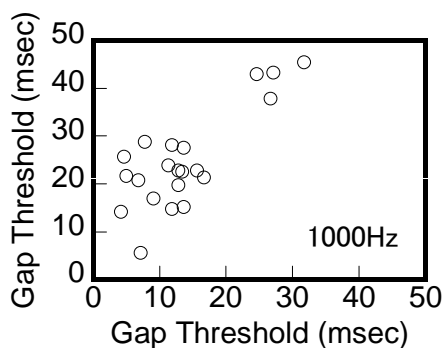
- Between-frequency
- Between-ear
- /ba/-/pa/ identification

21 native Japanese listeners

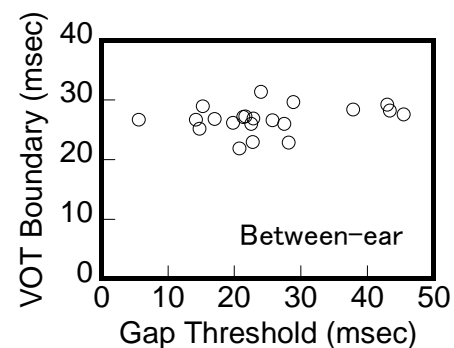
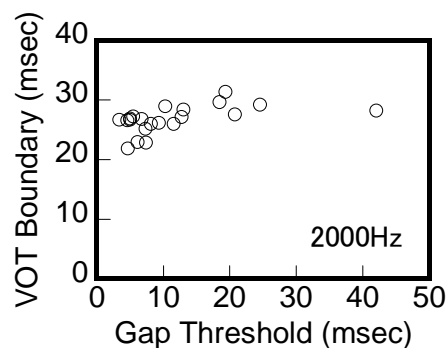


# Common properties

Between-frequency and -ear positively correlated



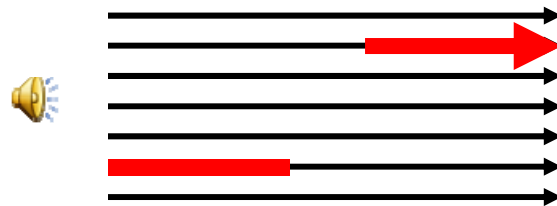
/b/-/p/ boundary correlated with between-frequency, but not with between-ear



# Across-channel processing

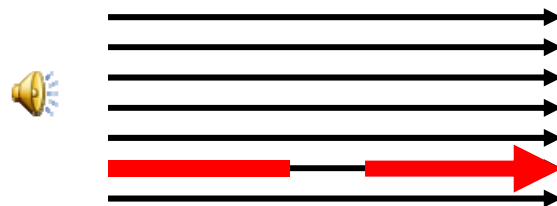
## Relative timing (Phillips, 1999)

Monitoring offset of leading and onset of trailing marker



Reflects central computation

## Discontinuity detection

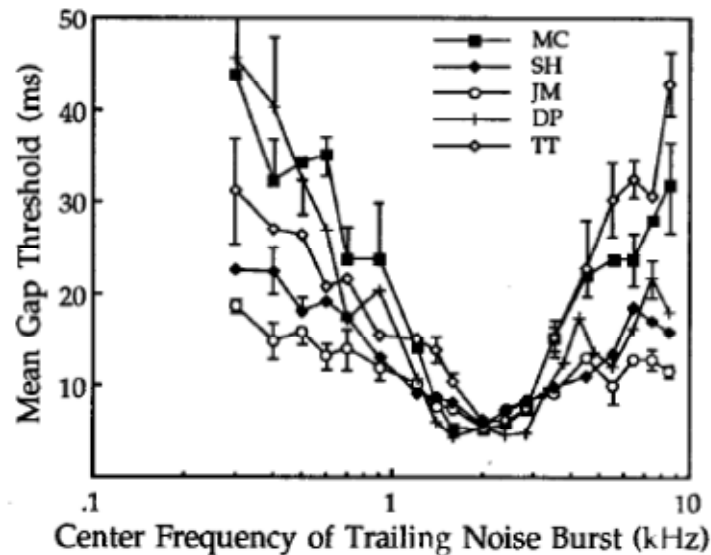


Performed peripherally



# Across-channel processing

Distinction between two operations?



(Phillips et al., 1997, JASA, pp.3697, Fig.2)

Why takes longer for larger separation?

# Across-channel processing

## Attention shift

Attention dwell time (Fitzgibbons et al., 1974)

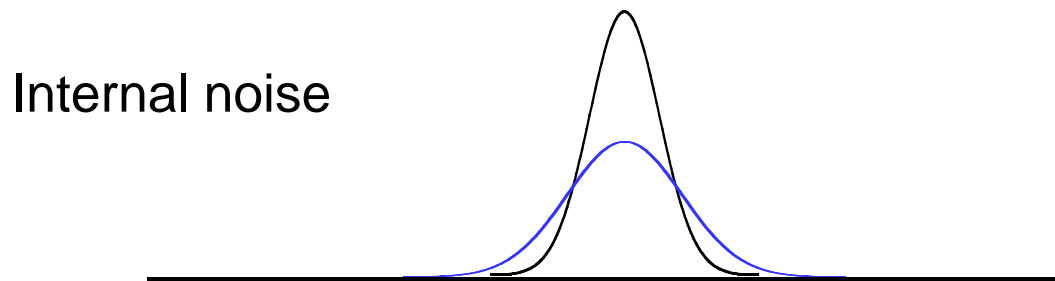
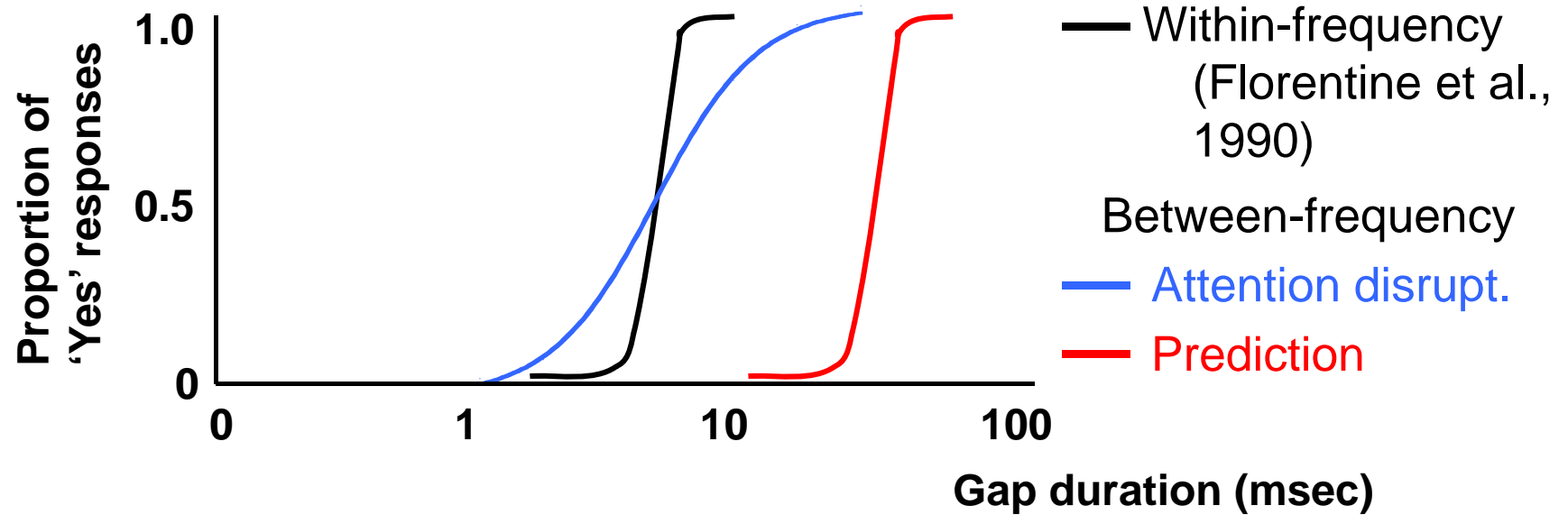
Imprecise time-stamping in unattended channel  
(Phillips et al., 1997)

Attention shifts fast to a cued frequency (Scharf et al.,  
2007)

Attention disruption does NOT explain prolonged gap  
thresholds

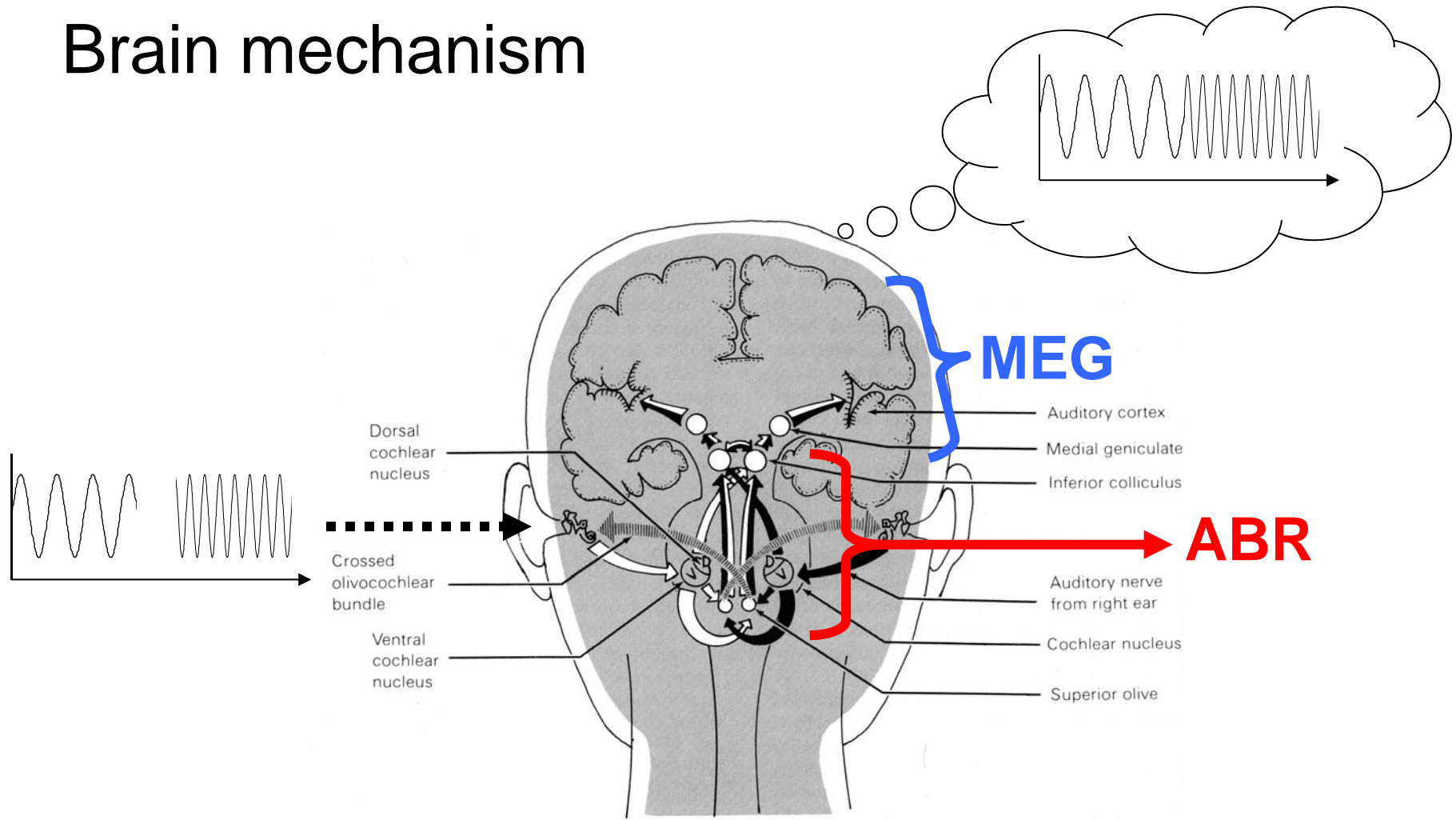


# Psychometric function





# Brain mechanism



(Coren et al., 1994, Sensation & perception, pp.204, Fig.6-17)

# Other domains

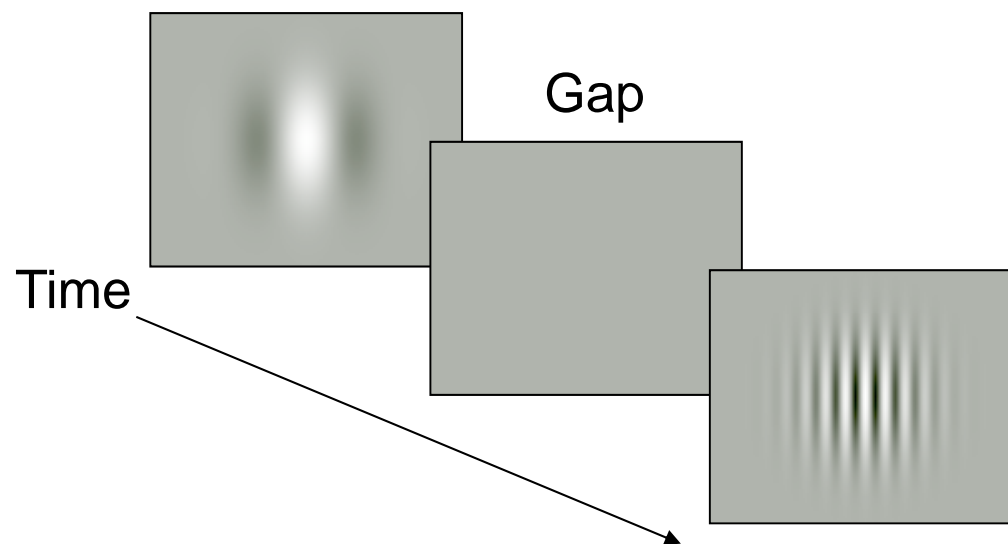
## Perceptual channel

Frequency, ear/side, phoneme (vowels, consonants), ...

## Vision

Spatial frequency, color, orientation, ...

Temporal gap detection task (Yeshurun, 2004)

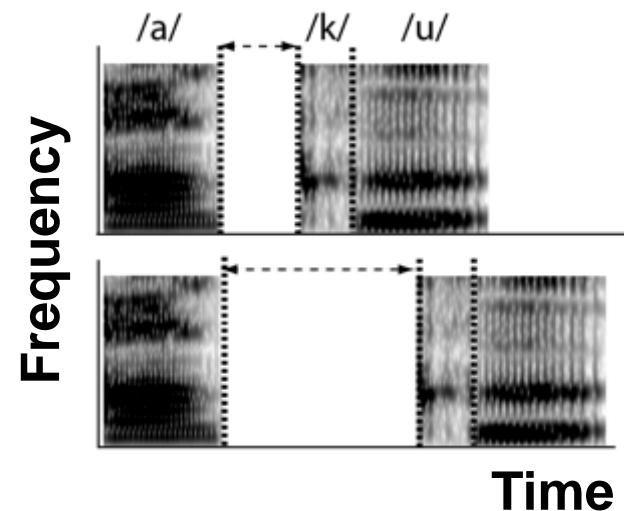


# Other domains

## Geminate consonants

/kk/, /tt/, /ss/, ...

Stop geminates contain silent intervals of over 100 msec



Largely cognitive (Sadakata & Sekiyama, 2011) but ...



# Next ...

## Psychophysical theory of speech perception

Speech is special (Liberman & Mattingly, 1985; Fowler, 1986)

Natural psychophysical boundary (Kuhl & Miller, 1978)

VOT boundary identical for humans and nonhumans

All phonetic contrasts are psychophysical in nature

## Identifying psychophysical correlates of phonetic contrasts



# Ultimately ...

## Psychophysics of language

Psychophysics of Japanese reading (with K. Sekiyama,  
W. Teramoto)

Combining psychophysical studies of speech and  
reading



Thank you for your attention

