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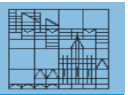

How attention to speech pitch is guided by its linguistic function

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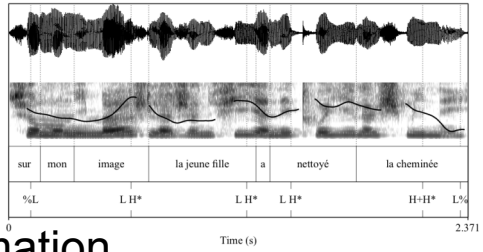
The puzzle



- Speech stream contains
  - segmental information (cued by spectral changes)
  - suprasegmental, prosodic information (cued by duration, intensity, pitch)
- How are these two layers of information processed and integrated?
  - in production
  - in perception
  - in first language acquisition

Research question

- How do listeners process and attend to segments and pitch information?

- Is processing of pitch information influenced by language experience
  - listeners from tonal and non-tonal languages

Previous work on pitch processing

- Similarities between listeners from tonal & non-tonal languages
  - segments weighed more heavily than pitch (Cutler & Chen 1997, Ye & Connine 1999)
  - classification rate for non-speech f0-variation (Bent et al. 2006)
  - orthogonally varied pitch slows down speed of segmental classification (Repp & Lin 1990, Lee & Nusbaum 1993)
  - ...
- Differences regarding
  - processing of pitch level vs. contour tones (Gandour 1983)
  - lateralization of pitch processing (Wang, Jongman & Sereno 2001)
  - mismatch negativity in tone processing (Chandrasekaran et al. 1997)
  - perception of tones from another tone language (Francis et al. 2008)
  - ...

Do we need yet another study?

- Yes: Tacit assumption that lexical tones are *meaningless* (= non-linguistic) for listeners from an intonation language
- Is that really the case?

Different results for different tones ...

- No, pitch movements may be interpreted as
  - postlexical (question vs. statement, cf. Broselow 1987)
  - paralinguistic (ignorance, sadness, cf. Braun et al. 2010)

Research question *refined*

- How do listeners process and attend to segments and pitch information?

- Is processing of pitch information influenced by language experience
  - listeners from tonal and non-tonal languages

- Is processing of pitch information influenced by the role pitch plays in a given stimulus?
  - lexical information (lexical tone)
  - postlexical information (e.g., sentence type)
  - non-linguistic information

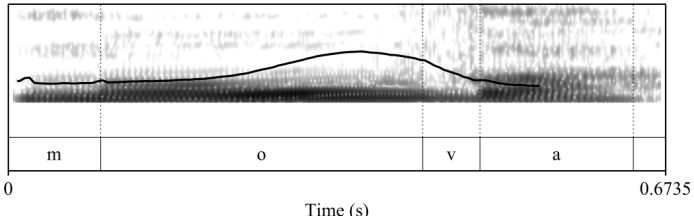
Current study

- When in conflict, do listeners rely more on segments or on pitch information?
- Is there a difference in reliance on these sources if pitch signals
  - potential lexical information
  - postlexical information
  - non-linguistic information

- ABX match-to-sample task (Dupoux et al. 1997)
  - **congruent** trials: X matches one of standards in segments *and* pitch (different token of same type)
  - **incongruent** trials: X matches one of the standards in pitch and the other one in segments

Experiment 1

- Processing of pitch rises that
  - are non-linguistic (Dutch listeners)
  - signal potential lexical information (Chinese listeners)



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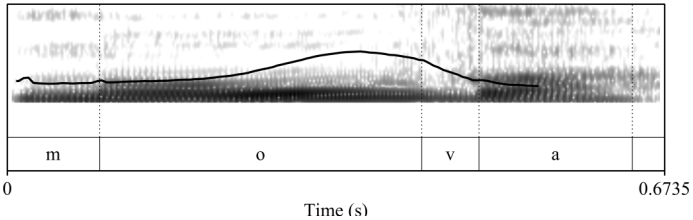

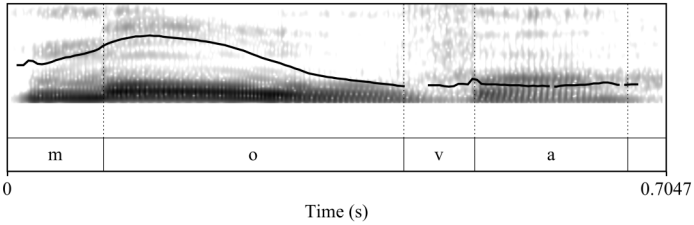

Experiment 1

- Processing of pitch rises that
  - are non-linguistic (Dutch listeners)
  - signal potential lexical information (Chinese listeners)
- Two listener groups
  - 8 native Dutch listeners (non-tonal dialects)
  - 8 native Mandarin Chinese listeners
- Two segmentally similar nonword pairs:
  - denu - zemu
  - mova - noba

Example of the Procedure

- ABX task – order of A and B counterbalanced
  - congruent condition (16 trials)
    e.g., mova-fall denu-rise mova-fall
  - incongruent condition (16 trials):
    e.g., mova-fall denu-rise denu-fall

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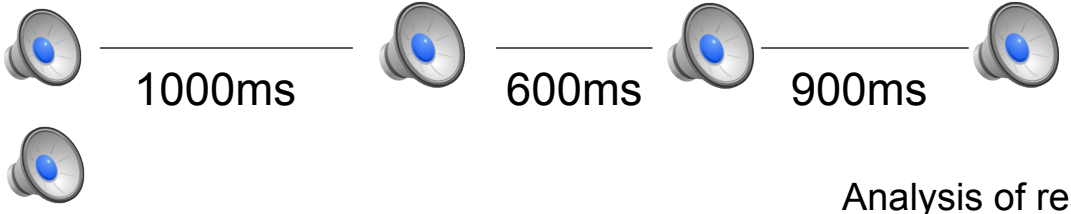


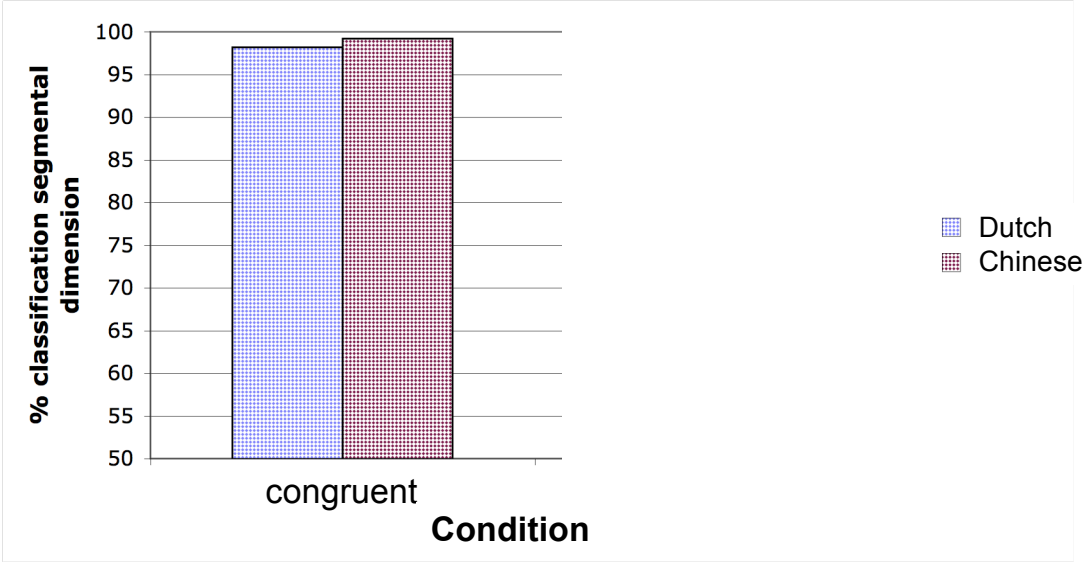
Analysis of response type
(A or B) and reaction time

Rationale and Hypothesis

- **Responses**:
  - most responses along segmental dimension
- **Reaction times (RTs)**:
  - RTs in congruent trials as baseline
  - increase in RT in incongruent trials suggests that pitch is attended to and competes with segmental information (interference)
- **Hypothesis:**
  - the more linguistically relevant pitch, the stronger the interference

non-linguistic ◄► lexical

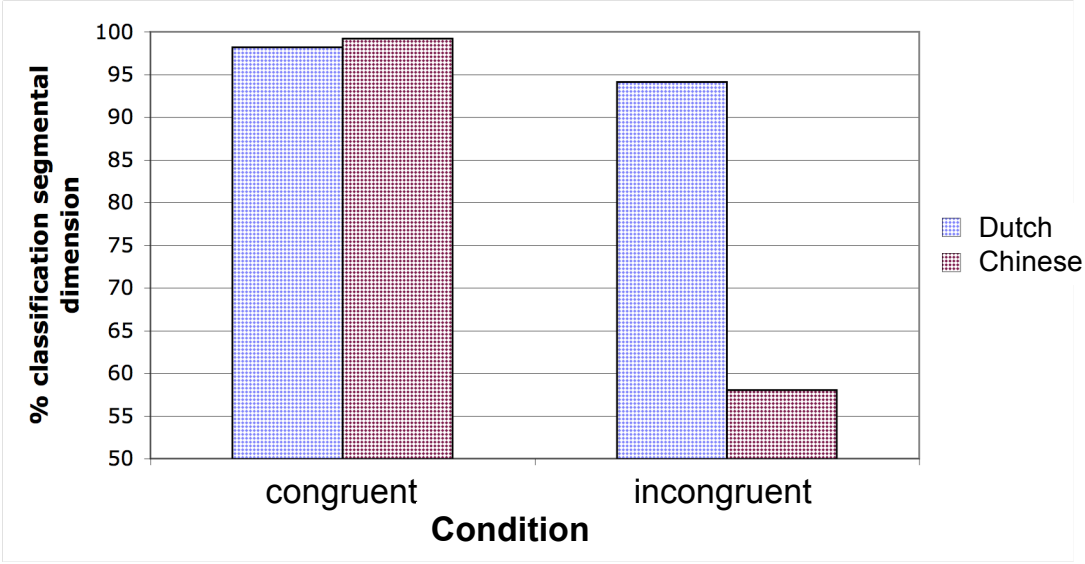
Results: response type



➛ in congruent trials, no difference across languages

non-linguistic ◄► lexical

Results: response type



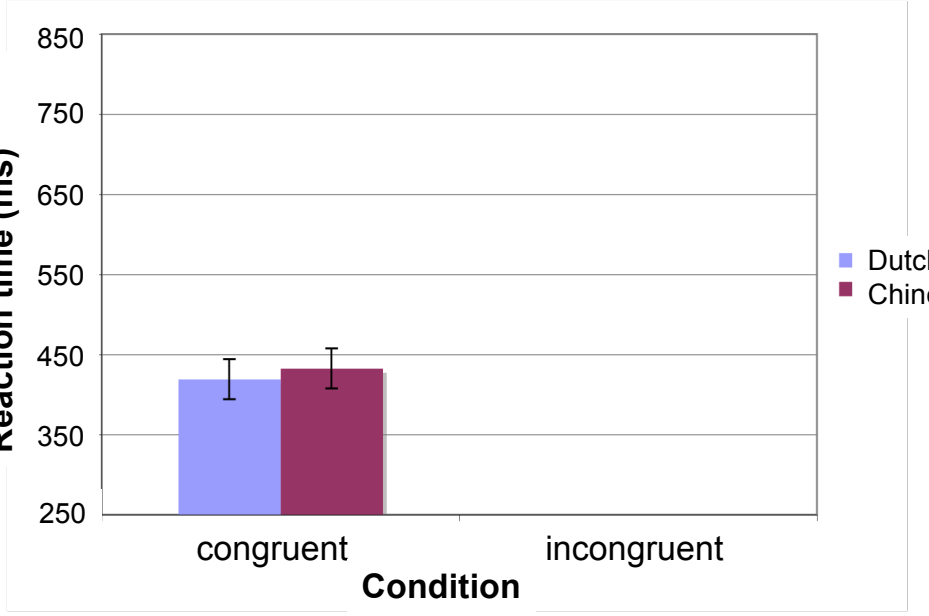
➛ in congruent trials, no difference across languages

➛ in incongruent trials, Chinese listeners responded less along segmental dimension

non-linguistic ◄► lexical

Results: reaction times

(only responses along segmental dimension)



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non-linguistic ↔ lexical

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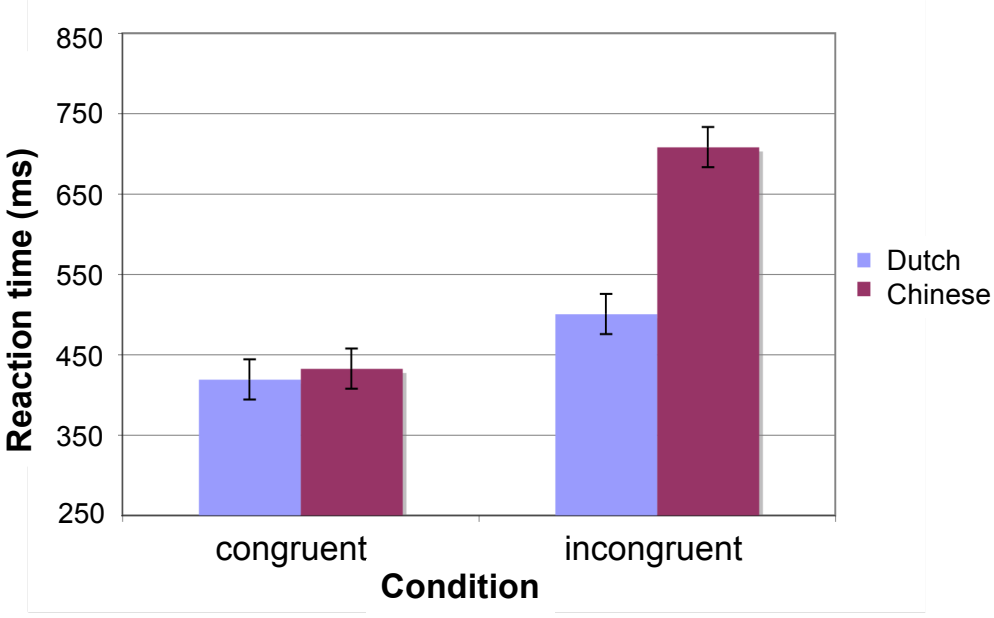
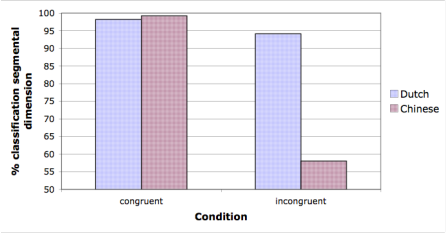
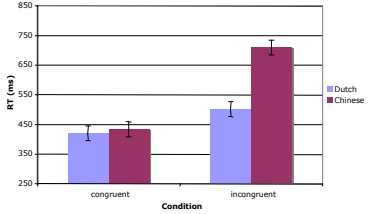


➛ in congruent trials, no difference across languages

➛ in incongruent trials, Chinese listeners slowed down more than Dutch listeners



Interim Summary



- Chinese listeners (pitch is potentially lexical)
  - significant decrease in responses along segmental dimension in incongruent stimuli
  - increase in RTs in incongruent stimuli

- Dutch listeners (pitch is non-linguistic)
  - no difference in responses across conditions
  - increase in RTs in incongruent stimuli (but less than for Chinese listeners)

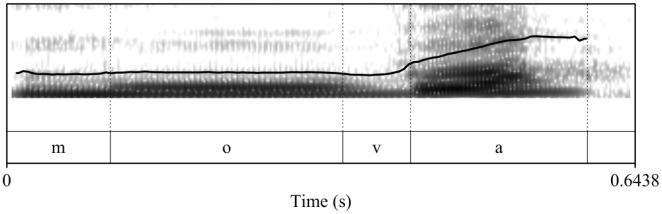
Follow-up question

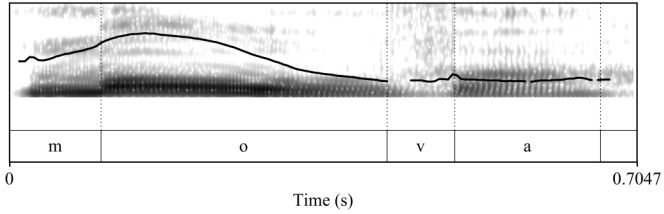
- Is processing of postlexical pitch information (also linguistically meaningful) comparable to processing of potential lexical information?

- Replication of Experiment 1 with modified materials and another set of
  - 8 Dutch listeners
  - 8 Chinese listeners

Experiment 2

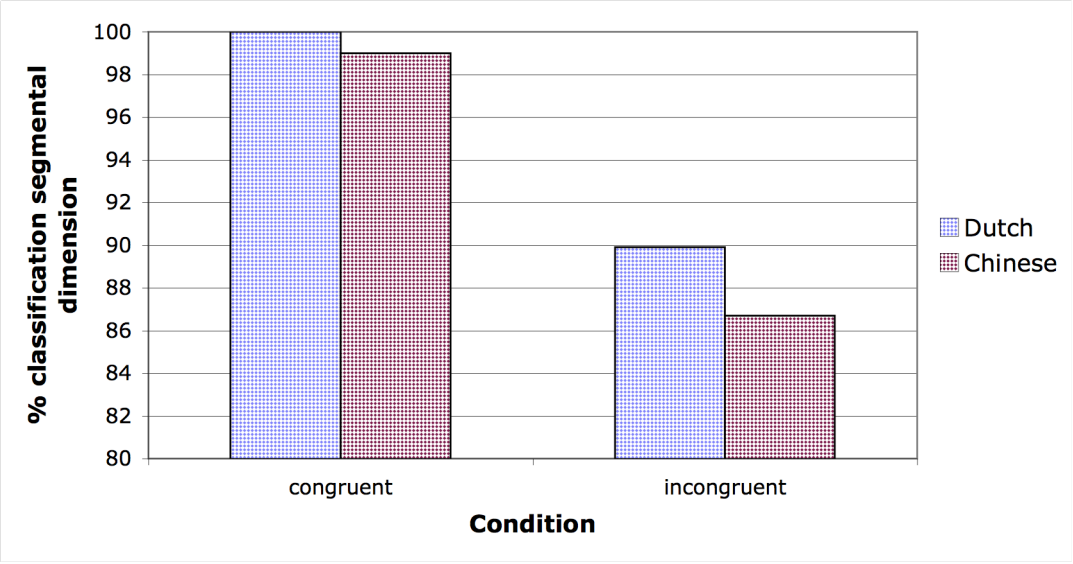
- Processing of pitch rises that signal
  - paralinguistic information (Dutch listeners)
  - potential lexical information (Chinese listeners)





paralinguistic ◄► lexical

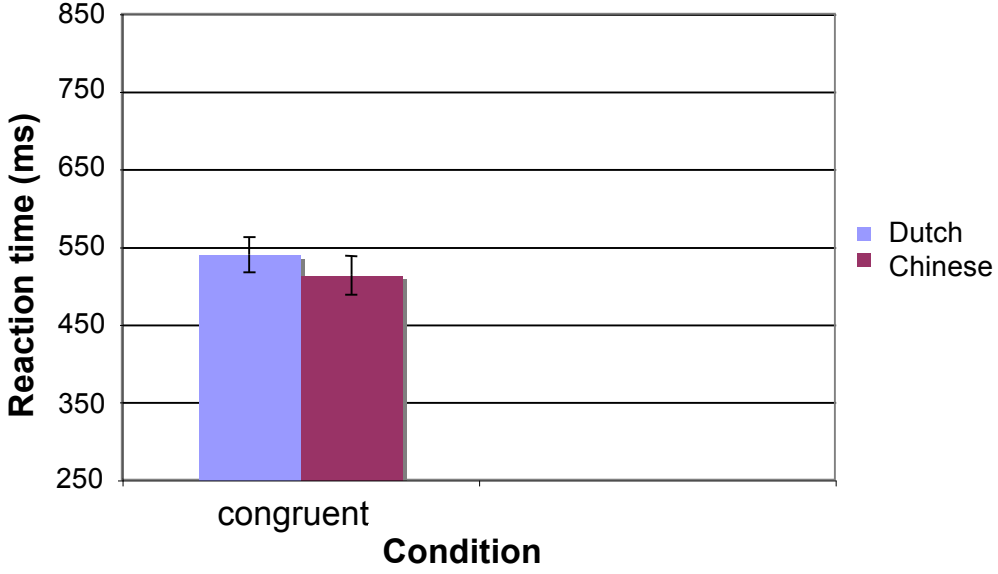
Results: response type



➛ significant interaction: Chinese listeners show effect of trial type (congruent vs. incongruent), Dutch listeners not

paralinguistic ◄► lexical

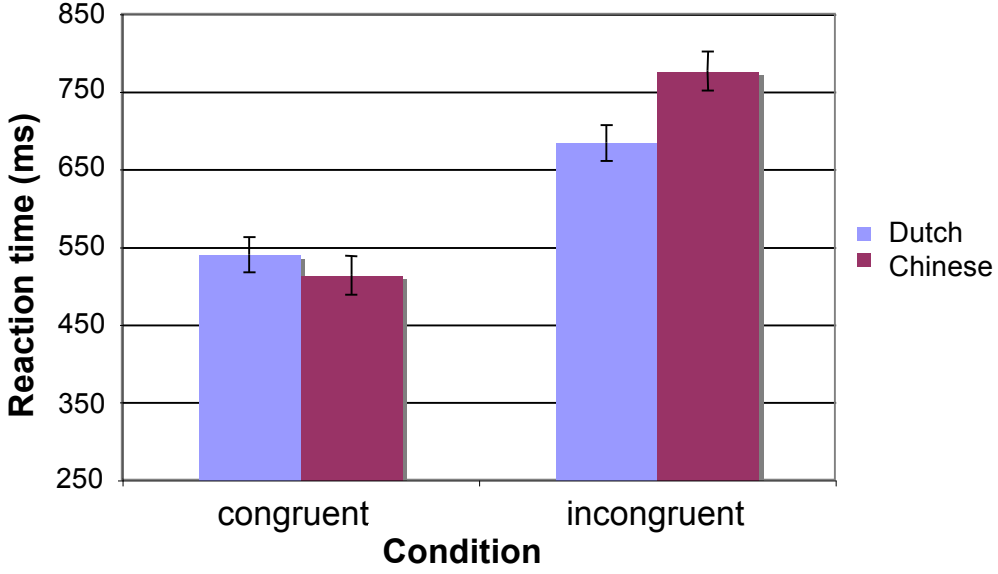
Results: reaction times



➛ in congruent trials, again no difference across languages

paralinguistic ◄► lexical

Results: reaction times



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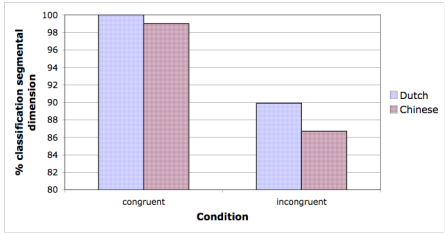

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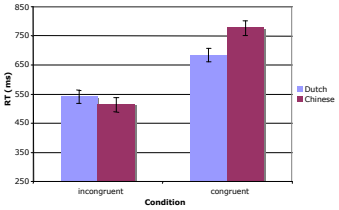

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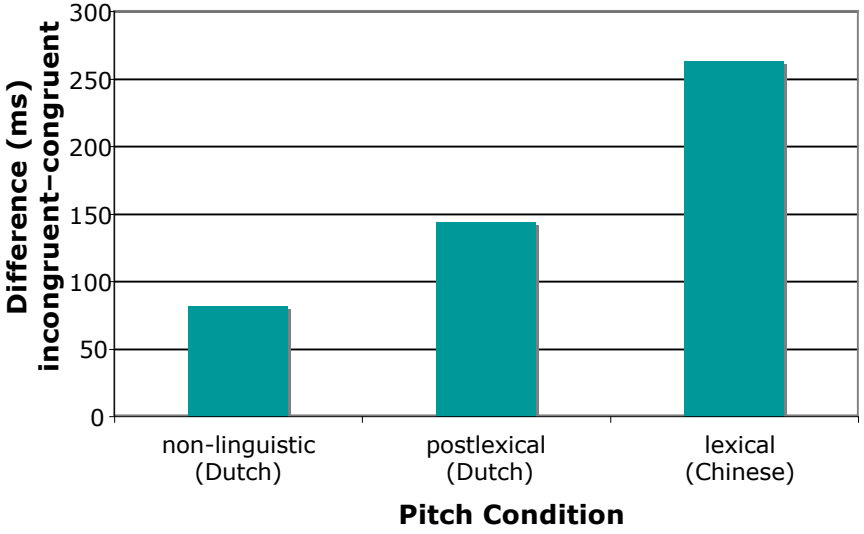
  - increase in RTs in incongruent trials

- Dutch listeners (pitch is postlexical)
  - no difference in responses across conditions
  - increase in RTs in incongruent trials
    - but less than for Chinese
    - more than for non-linguistic pitch rises (Experiment 1)

Conclusions

- Increase in RTs in incongruent trials is modulated by linguistic function of pitch in stimuli
  - non-linguistic < postlexical < lexical



Discussion

- Non-linguistic (unfamiliar) pitch movement also increases RTs and therefore
  - is attended to
  - is stored in short-term memory
  - interferes with processing

  ➛Dutch listeners not 'tone-deaf'

- Chinese listeners even *classify* stimuli along pitch dimension
- Even though stimuli are *nonwords*
  - pitch stored prelexically in Chinese? (Hallé et al. 2004, Lee 2007)

Discussion

- Ability to process and store pitch information in short-term memory is dependent on
  - linguistic experience
  - precise linguistic function of pitch in stimuli
- In conflict, segments outweigh pitch information
- Although meaningful, postlexical pitch information processed differently than potential lexical information
- Future work:
  - how does sensitivity to segments and pitch develop in L1?
  - can learners of tone language acquire native-like mechanisms?
  - how is paralinguistic information processed?

Thank you for your attention