Second-Language Processing of Prosodic Information

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Aix Summer School on Prosody

September 8, 2016

Introduction

- Prosodic information is **crucial** to the successful comprehension of language

Introduction

- Stress placement in Spanish word recognition

Descansó toda la mañana.
'(He) rested all morning.'

Descanso '(I) rest' (penultimate stress)

Descansó '(s/he) rested' (final stress)

Introduction

- Pitch accents in French speech segmentation

Le chat lépreux s'endort doucement.
'The cat leprous falls asleep slowly.'

chat 'cat'

chalet 'cabin'

Introduction

- In the native language (L1), the speech processing system is maximally efficient and makes use of those prosodic cues that are informative for recognizing words
- Listeners approach the task of recognizing words in a second language (L2) with these processing biases (for discussion, see Cutler, 2012)
- How does that affect their use of prosodic information in L2 word recognition?

Introduction

- Focus: **Effect of the L1 on the use of prosodic information in L2 word recognition**
  - How the *functional load* (or degree of informativeness) of prosodic information in the L1 modulates the learning and use of prosodic information in the L2...
  - ... above and beyond similarities and differences between the L1-L2 prosodic systems

Roadmap

1. Use of stress in L2 word recognition
2. Use of pitch accents in L2 speech segmentation

1. Use of Stress in L2 Word Recognition

Peperkamp & Dupoux's (2002) Stress Parameter Model

- L2 learners' ability to use stress in L2 word recognition is determined by whether they have encoded stress **in their L1 phonological representations** (i.e., in their first 2 years of life)

Peperkamp & Dupoux's (2002) Stress Parameter Model

- Listeners encode stress in their L1 phonological representations only if...
  - ... **stress is not "fixed"** (i.e., it does not always fall on the same syllable in the word); and
  - ... **stress is not completely predictable** (i.e., it has to be memorized/lexicalized at least for some words)

Peperkamp & Dupoux's (2002) Stress Parameter Model

- **Spanish**
  - Stress falls on the penultimate syllable unless the last syllable ends with a consonant other than /n/ or /s/, in which case it falls on the last syllable **(e.g., Harris, 1983)**
    - *maÑAna* 'tomorrow/morning,' *aniMAL* 'animal'
  - Several exceptions that do not follow this rule and thus need to be memorized/lexicalized
    - *PLÁtano* 'banana,' *diFÍcil* 'difficult'
- Prediction
  - Spanish listeners **should not be "stress deaf"** when processing new words

Peperkamp & Dupoux's (2002) Stress Parameter Model

- **French**
  - Does not have lexical stress (i.e., "stress" is "fixed")
  - Prominence is instead phrasal, with words at the end of the phrase receiving a pitch accent
    (e.g., Jun & Fougeron, 2000, 2002)
    - *le CHAT, le chaLET, le chat léPREUX*
      'the cat,' 'the cabin,' 'the cat leprous'
- Prediction
  - Listeners who do not encode stress in their L1 phonological representations (e.g., French listeners) **should be "stress deaf"** when processing new words

Dupoux, Sebastián-Gallés, Navarrete, & Peperkamp (2008)

- **Dupoux et al. (2008)** tested these predictions with
  - Native Spanish listeners
  - French "late" L2 learners of Spanish (age of first Spanish instruction: 16.9 years) at three proficiencies in Spanish (beginner, intermediate, advanced)
  - Native French listeners who did not know Spanish

Dupoux, Sebastián-Gallés, Navarrete, & Peperkamp (2008)

- **Sequence recall task** (see also Dupoux et al., 2001)
  - Association training
    - Experimental condition: **initial stress = 1; final stress = 2**

      NUmi...1 *nuMI*...2 *nuMI*...2 *NUmi*...1 etc.

    - Control condition: **/k/ = 1; /t/ = 2**

      fuki...1 *futi*...2 *futi*...2 *fuki*...1 etc.

    - Non-words uttered by 6 different speakers
    - Passing criterion: 7 correct items in a row

Dupoux, Sebastián-Gallés, Navarrete, & Peperkamp (2008)

- **Sequence recall task** (see also Dupoux et al., 2001)
  - Main experiment
    - Experimental condition (**stress**): Recall sequences

      nuMI NUmi NUmi nuMI OK (Answer: 2112)

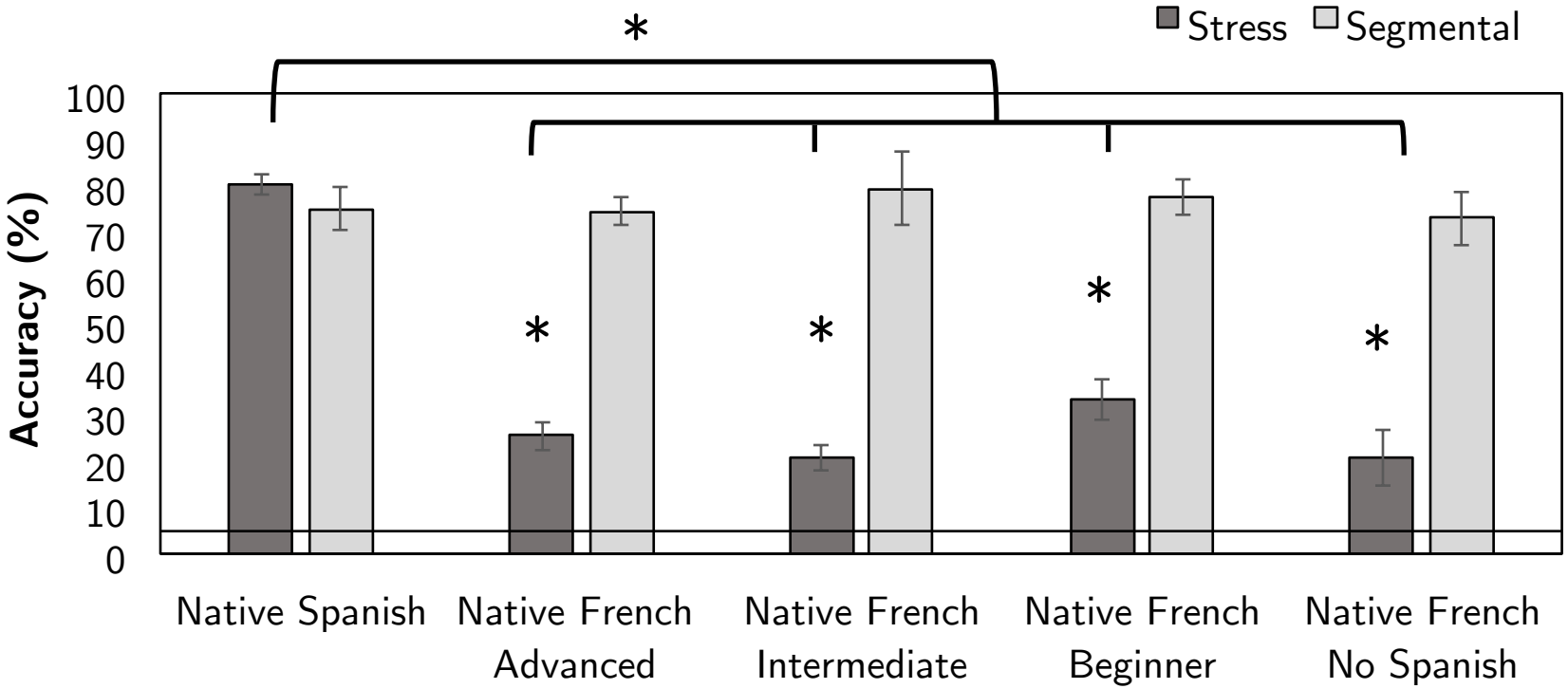
    - Control condition (**segmental**): Recall sequences

      fuki futi fuki futi OK (Answer: 1212)

    - Inter-stimulus interval (ISI): 50 ms

Dupoux, Sebastián-Gallés, Navarrete, & Peperkamp (2008)

- **Sequence recall task** (see also Dupoux et al., 2001)
  - Results: Sequence recall accuracy



Dupoux, Sebastián-Gallés, Navarrete, & Peperkamp (2008)

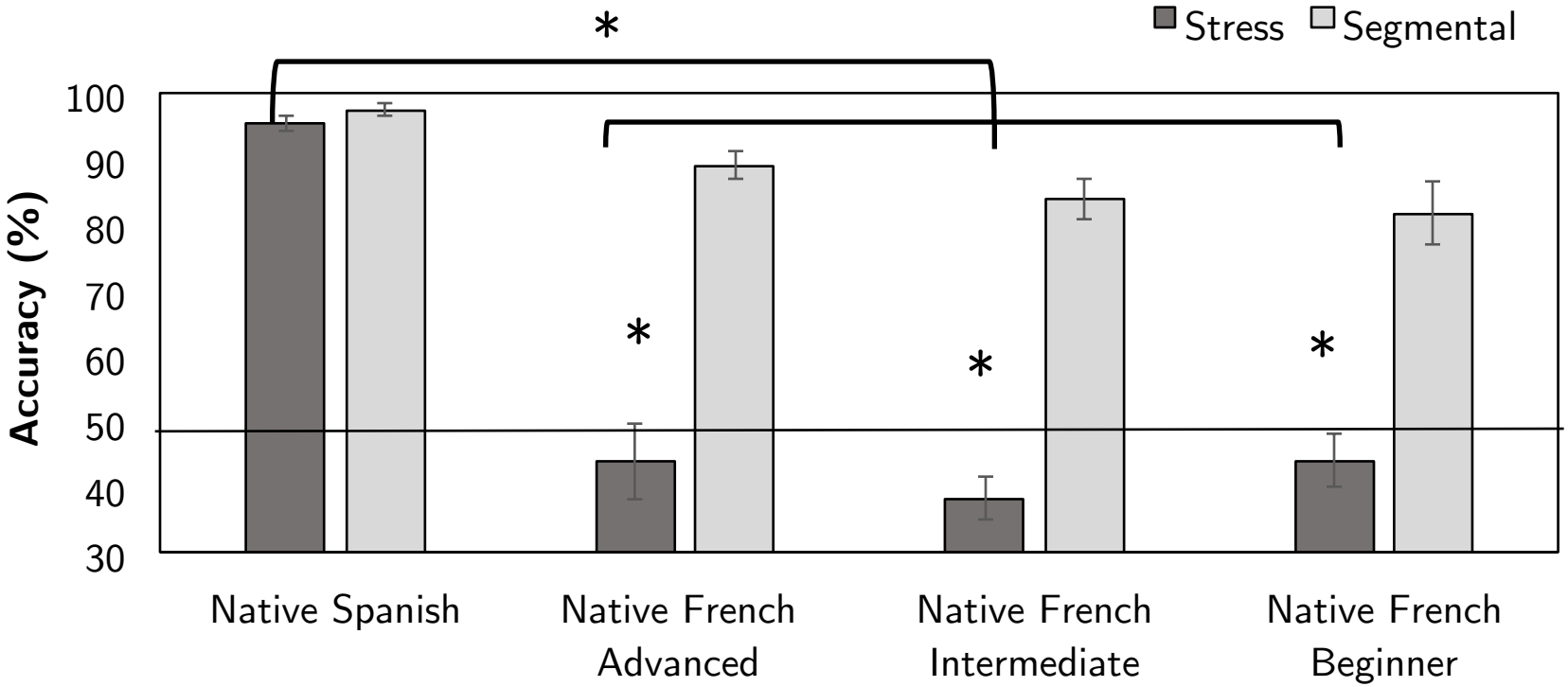
- **Auditory lexical decision task**
  - Experimental condition: Regular and irregular Spanish words whose non-word counterparts have the incorrect **stress**

    GOrro 'hat' vs. **goRRO* *FÁcil* 'easy' vs. **faCIL*
  - Control condition: Spanish words whose non-word counterparts have one incorrect **segment**

    año 'year' vs. **añi* *fuerte* 'strong' vs. **fuerbe*

Dupoux, Sebastián-Gallés, Navarrete, & Peperkamp (2008)

- **Auditory lexical decision task**
  - Results: Performance on non-words



Dupoux, Sebastián-Gallés, Navarrete, & Peperkamp (2008)

- On the basis of these results, **Dupoux et al. (2008)** argued that French listeners are "stress deaf" because they did not encode encode stress in their L1 phonological representations
- Note, however, that in a replication of this study, **Dupoux, Peperkamp, & Sebastián-Gallés (2010)** found that French-Spanish **simultaneous bilinguals** were <u>also</u> "stress deaf"!!!

What about English Listeners?

- **Peperkamp & Dupoux's (2002)** Stress Parameter Model predicts English listeners **not** to be "stress deaf"
- **English**
  - Stress is not "fixed"
    - *REcord* vs. *reCORD*
    - *PHOtograph* vs. *phoTOgrapher* vs. *photoGRAphic*
  - Stress is not completely predictable **(e.g., Halle & Vergnaud, 1987)**
    - *CAnada* vs. *baNAna*

What about English Listeners?

- However, stress distinctions in English are often realized with a contrast between **strong** and **weak** syllables (i.e., between full and reduced vowels)
- Are English listeners "deaf" to the suprasegmental correlates (i.e., fundamental frequency (F0), duration, intensity) of stress?

What about English Listeners?

- Early research suggested that English listeners are **not** sensitive to suprasegmental cues to English stress
  - Segmentally-identical minimal pairs prime each other (e.g., *FORbear* ↔ *forBEAR*) (Cutler, 1986)
  - Mis-stressing words (e.g., *He's a conVERT; He needs to CONvert*) does not inhibit word recognition in the absence of a change in vowel quality (Cutler & Clifton, 1984; Fear, Cutler, & Butterfield, 1995; Small, Simon, & Goldberg, 1988)

What about English Listeners?

- However, the methods used in early research may not have been sufficiently sensitive to capture the effect of suprasegmental cues to stress
  - Responses were typically collected after the complete word had been heard
  - Very few English words that differ in stress but not in vowel quality (e.g., *FORbear* vs. *forBEAR*)

What about English Listeners?

- Several English words begin with segmentally similar but suprasegmentally distinct first syllables

CAMpus	vs.	*camPAIGN*
MYStic	vs.	*misTAKE*
RObot	vs.	*roBUST*
SURgery	vs.	*surPRISE*

What about English Listeners?

- Stress may be used **early** in the word recognition process
- If so:

prime	target	Effect
...*MYS-*	*MYStic*	facilitation
...mis-	*misTAKE*	facilitation
...mis-	*MYStic*	inhibition
...MYS-	*misTAKE*	inhibition

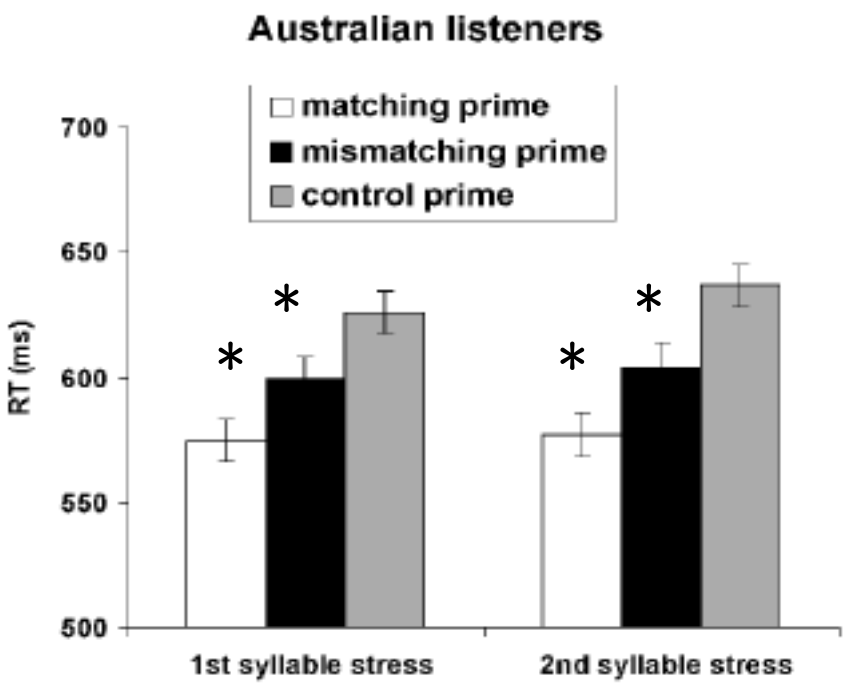
(e.g., effects found for Spanish in Soto-Faraco, Sebastián-Gallés, & Cutler, 2001, and for Dutch in Donselaar, Koster, & Cutler, 2005)

Cooper, Cutler, & Wales (2002)

- Cross-modal priming task (Exp. 2)

prime	target	
...MYS-/mis-	*MYStic/misTAKE*	(matching)
...mis-/MYS-	*MYStic/misTAKE*	(mismatching)
...[segmentally different]	*MYStic/misTAKE*	(control)

- Results



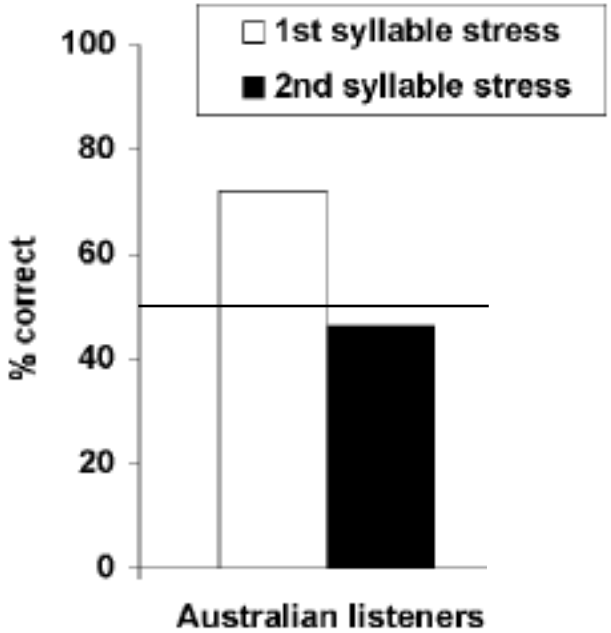
(cf. Donselaar et al., 2005; Soto-Faraco et al., 2001)

Cooper, Cutler, & Wales (2002)

- Forced-choice word-identification task (Exp. 3)

prime	target	
...MYS-	*MYStic* or *misTAKE*?	(1st syllable stress)
...mis-	*MYStic* or *misTAKE*?	(2nd syllable stress)

- Results



Cooper, Cutler, & Wales (2002)

- English listeners show some sensitivity to the suprasegmental cues to stress, but not as much as Spanish or Dutch listeners, who showed inhibition effects for the mismatching primes
  (e.g., Donselaar et al., 2005; Soto-Faraco et al., 2001)

Theory of L2 Word Recognition

- A theory of L2 word recognition needs to consider not only whether the L1 has a stress system that is not fixed and to some degree unpredictable, but also **what cues signal stress** in the L1

Cue-Weighting Theory of Speech Perception

- Multiple acoustic cues are simultaneously available to listeners, but these cues are weighed as a function of their informativeness for signaling linguistic contrasts (e.g., Francis et al., 2000; Francis & Nusbaum, 2002; Holt & Lotto, 2006)
- Cues are weighed differently across languages, and L2 learners transfer their L1 cue weighting to the perception of L2 linguistic contrasts (e.g., Invalgson et al., 2011; Iverson et al., 2003)

Cue-Weighting Theory of Speech Perception

- Suprasegmental cues to stress in English have a **weak functional load** (highly redundant with segmental cues, not very informative on their own)
- Does the functional load of suprasegmental cues to stress in the L1 predict the use of stress in L2 word recognition?

Dutch

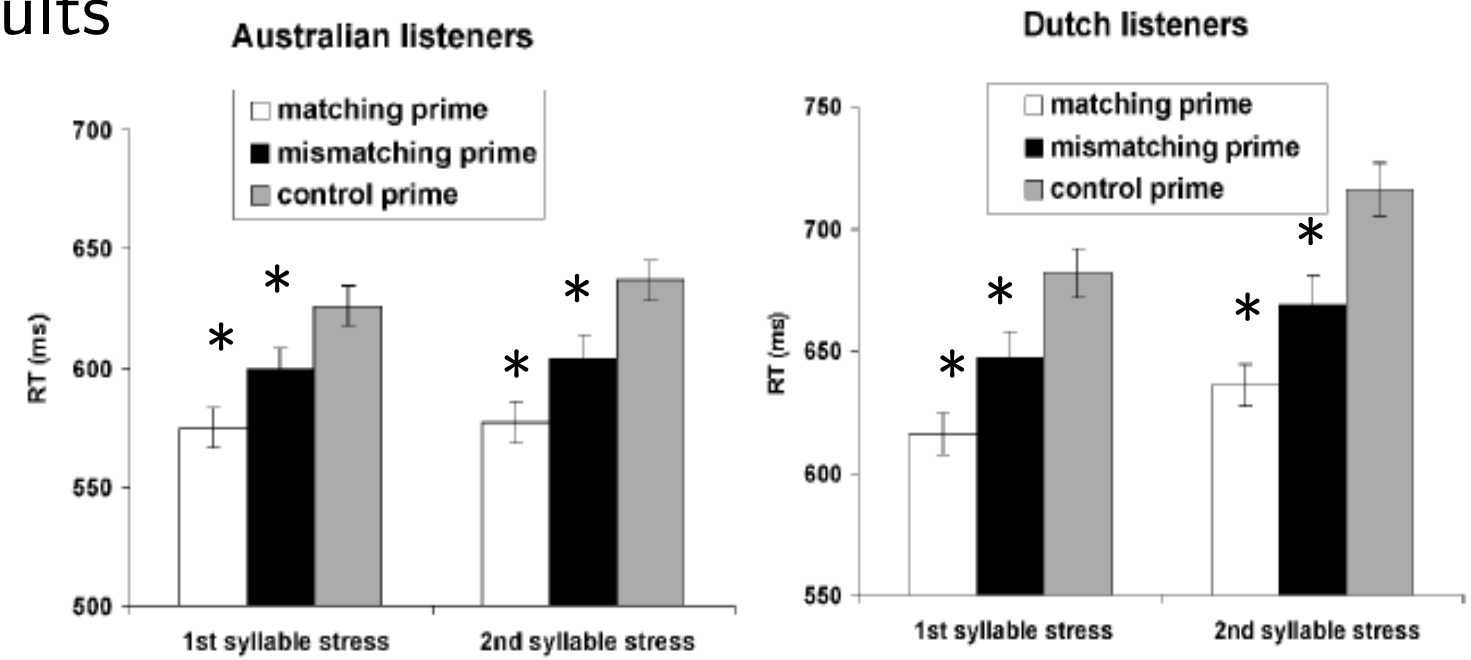
- Lexical stress in Dutch is very similar to lexical stress in English, with one important difference
  - Dutch has **less vowel reduction** than English does (Cooper et al., 2002)
  - Thus, suprasegmental cues to stress have a **higher functional load** in Dutch than they do in English (less redundant with segmental cues)
- Do Dutch listeners show greater sensitivity to the suprasegmental correlates of English stress than native English listeners?
  - **Cooper et al. (2002)**: Dutch L2 learners of English!

Cooper, Cutler, & Wales (2002)

- Cross-modal priming task (Exp. 2)

Prime	Target	
MYS-/mis-	*MYStic/misTAKE*	(matching)
mis-/MYS-	*MYStic/misTAKE*	(mismatching)
[segmentally different]	*MYStic/misTAKE*	(control)

- Results

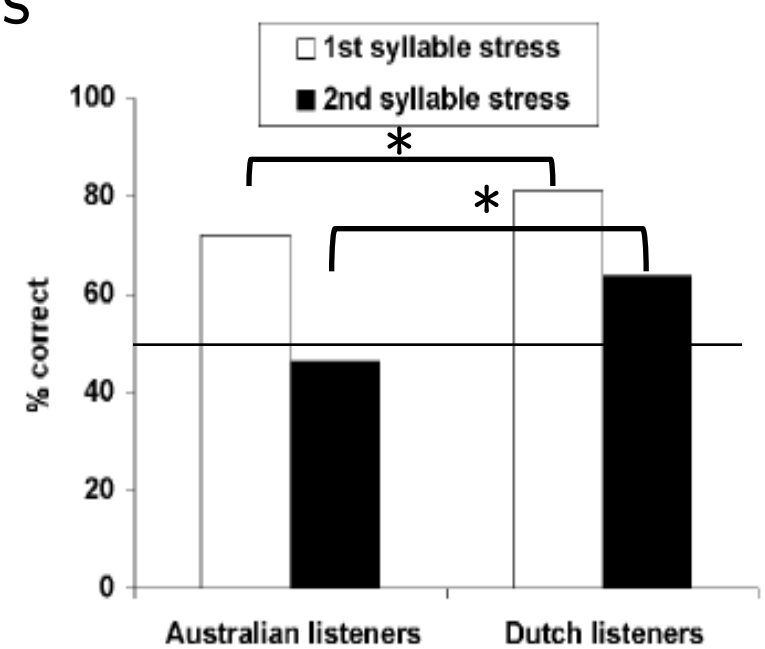


Cooper, Cutler, & Wales (2002)

- Forced-choice word-identification task (Exp. 3)

Stimulus	Response	
MYS-	*MYStic* or *misTAKE*?	(1st syllable stress)
mis-	*MYStic* or *misTAKE*?	(2nd syllable stress)

- Results



In this task, Dutch listeners showed **more** sensitivity to the suprasegmental cues to stress than English listeners!

Theory of L2 Word Recognition

- *Functional Load Hypothesis*
  - The **functional load of suprasegmental cues** to stress (i.e., their informativeness and usefulness **for signaling lexical identity**) predicts L2 learners' ability to use the same cues in L2 word recognition **(Tremblay, Broersma, & Coughlin, under review)**
  - This should be true even if the cues are used differently in the L1 and L2 (within and across prosodic domains)

Theory of L2 Word Recognition

Prediction of the *Functional Load Hypothesis* for the use of stress in L2/new word recognition

French, Korean $<$ English $<$ Chinese

in sensitivity to <u>suprasegmental</u> cues to English stress

Tremblay (2008)

- Can French Canadian L2 learners of English use suprasegmental cues to English stress in lexical access?
- Participants
  - Native English listeners
  - French Canadian "late" L2 learners of English (age of acquisition: 9) at low-intermediate, high-intermediate, and advanced proficiency levels

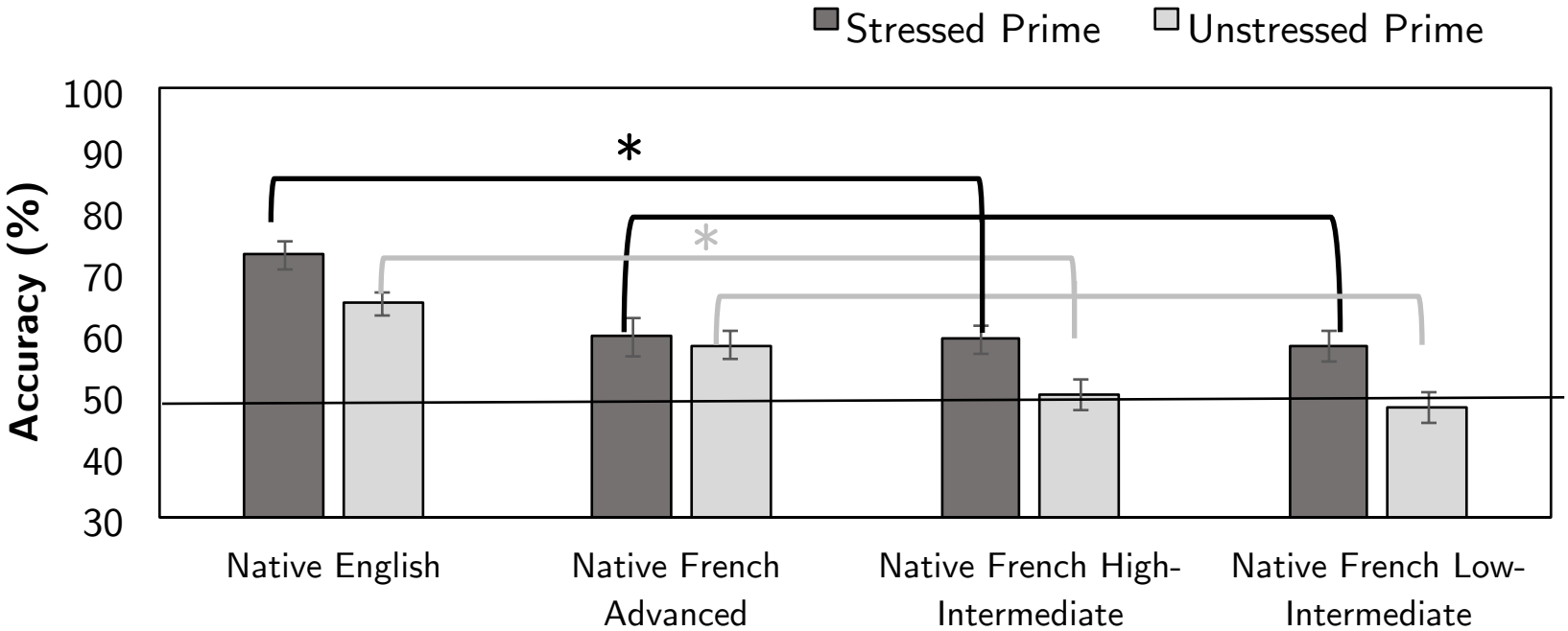
Tremblay (2008)

- Forced-choice word-identification task adapted from **Cooper et al. (2002)**
  - Experimental condition (**stress**)

Stimulus	Response	
...MYS-	*MYStic* or *misTAKE*?	(1st syllable stress)
...mis-	*MYStic* or *misTAKE*?	(2nd syllable stress)

Tremblay (2008)

- Forced-choice word-identification task adapted from **Cooper et al. (2002)**
  - Results: Experimental condition (**stress**)



Functional Load Hypothesis

- Predictions corroborated for French listeners,
  (though **Peperkamp & Dupoux**'s (2002) Model makes the same prediction)
- What about Korean and Chinese listeners?

Functional Load Hypothesis

- (Seoul) Korean
  - Like French, Korean does not have lexical stress (i.e., "stress" is "fixed")
  - Prominence is instead phrasal, with words at the end of the phrase receiving a pitch accent (e.g., **Jun**, 1998, 2000)
  - Hence, the functional load of suprasegmental cues in Korean (i.e., their informativeness and usefulness for signaling lexical identity) is rather weak
- Prediction
  - Korean listeners should have difficulty using suprasegmental cues to English stress
    (but also predicted by **Peperkamp & Dupoux**'s (2002) Model)

Functional Load Hypothesis

- (Mandarin) Chinese
  - Mandarin has 4 lexical tones (main cue: F0)
  - (Standard) Mandarin has a contrast between full-full and full-reduced words (main cue: duration)
    (Chao, 1968; Duanmu, 2007)
    - *DONGXI* 'east and west' vs. *DONGxi* 'stuff'
  - The functional load of suprasegmental cues, especially F0, is much higher in Mandarin than it is in English
- Prediction
  - Chinese listeners should have little difficulty in using suprasegmental cues, especially F0, to English stress
    - **Not predicted by Peperkamp & Dupoux's (2002) Model**

Lin, Wang, Idsardi, & Xu (2013)

- Do Korean and Chinese L2 learners of English encode English stress similarly to native English listeners?
- Participants
  - Native English listeners
  - Korean "late" L2 learners of English (age of acquisition: 12)
  - Mandarin "late" L2 learners of English (age of acquisition: 10)
    - Matched to Korean listeners in English proficiency

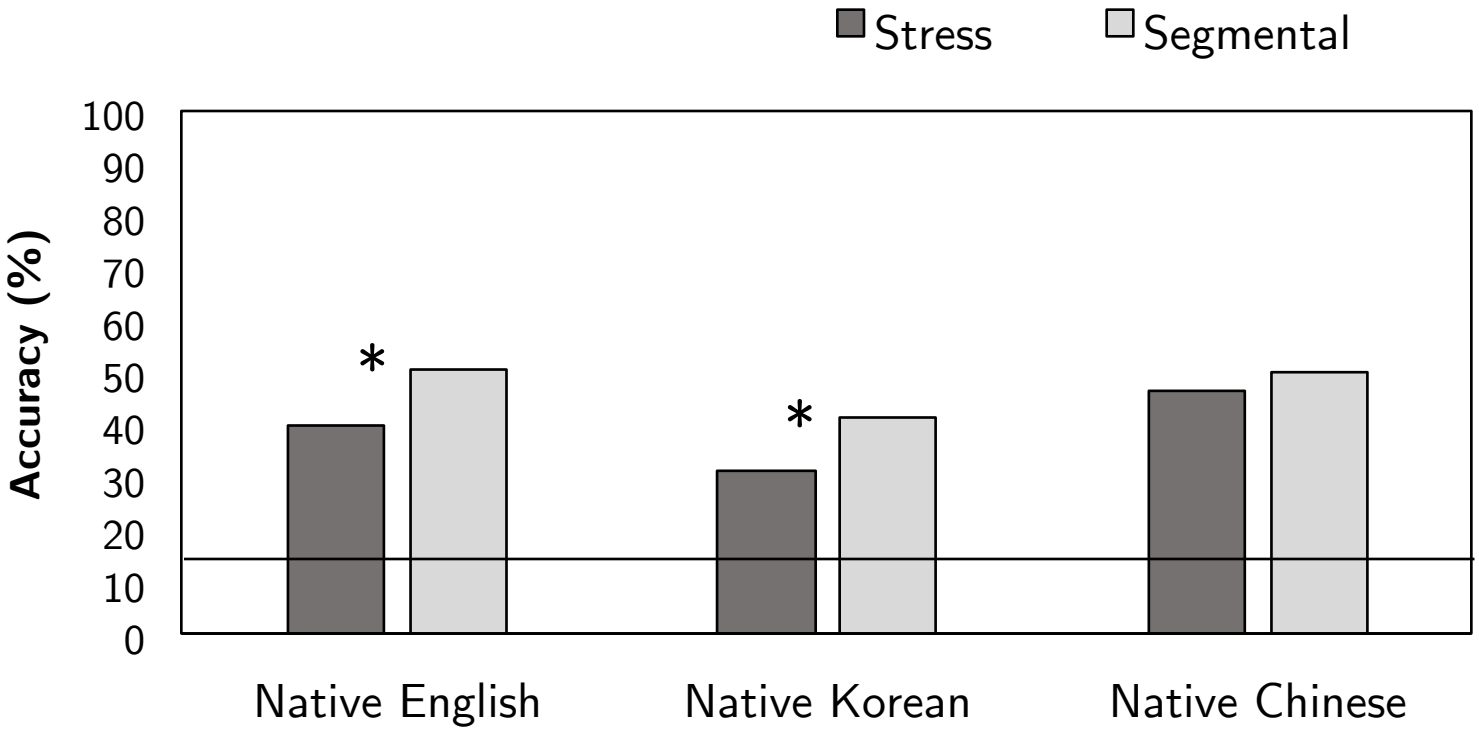
Lin, Wang, Idsardi, & Xu (2013)

- Sequence recall task à la Dupoux (Dupoux et al., 2001)
  - Experimental condition: **Stress** (e.g., *MIpa, miPA*...)
  - Control condition: **Segmental** (e.g., *kupi*, *kuti*...)
- Lexical decision task
  - *deMISE* vs. **DEmise* (no vowel reduction cue)
  - *SCANdal vs. *scanDAL* (vowel reduction cue)

Lin, Wang, Idsardi, & Xu (2013)

- Results

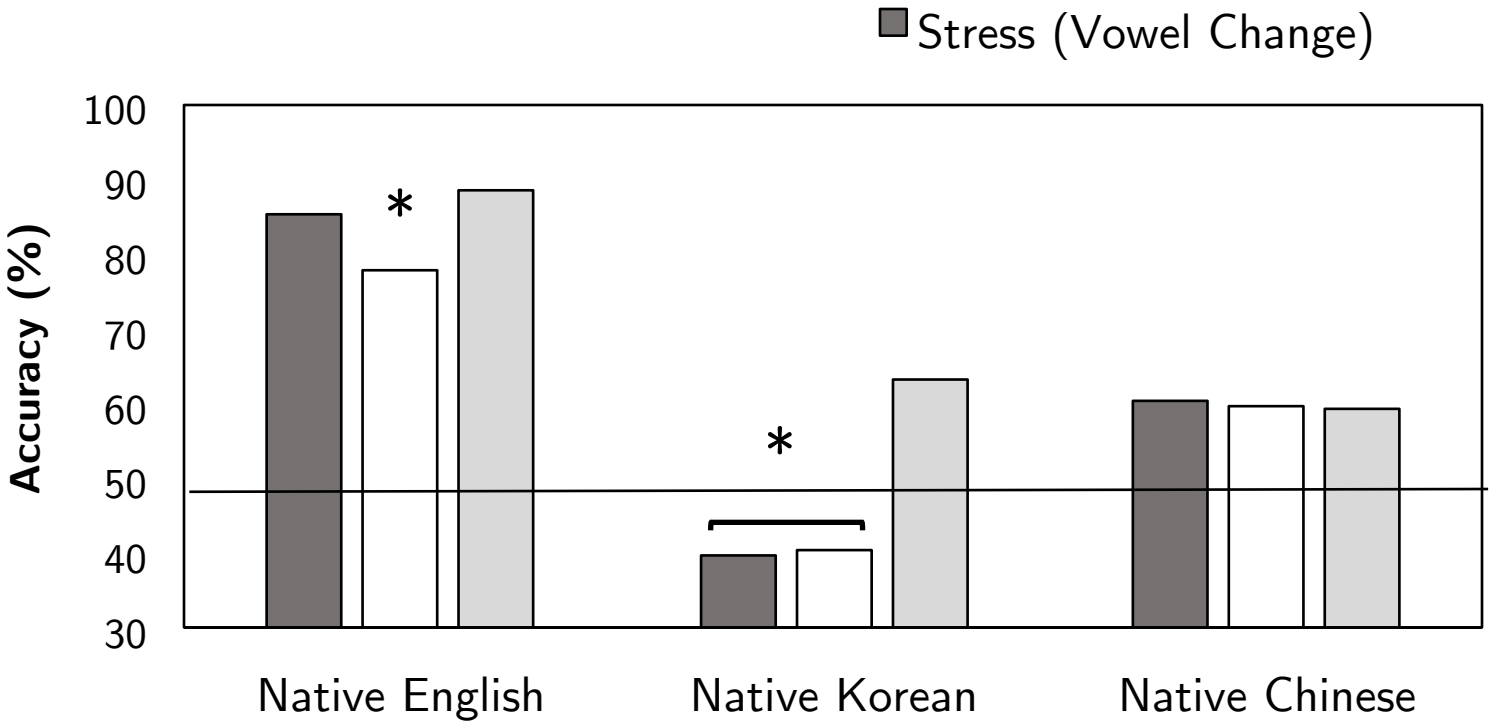
  Sequence recall task



Lin, Wang, Idsardi, & Xu (2013)

- Results

  Lexical decision task: Performance on non-words



Lin, Wang, Idsardi, & Xu (2013)

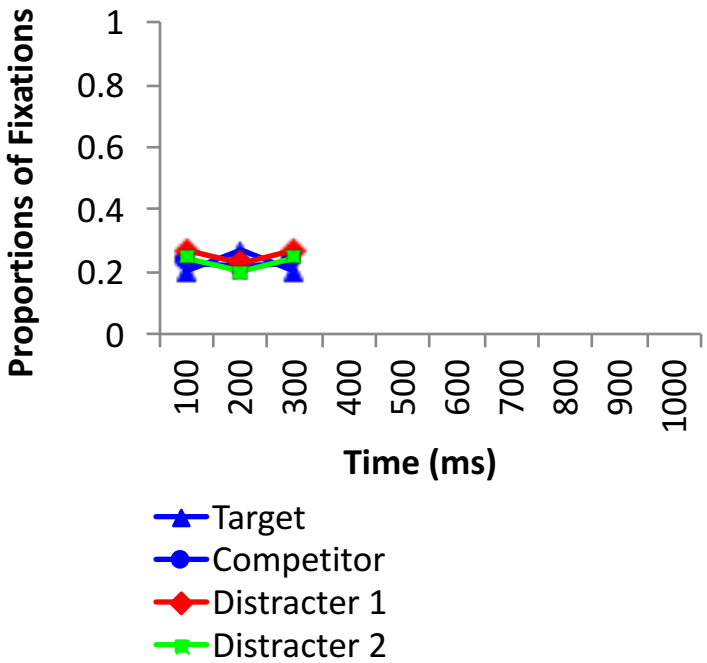
- Only English listeners showed sensitivity to vowel reduction
- Only Mandarin listeners showed similar sensitivity to suprasegmental and segmental information
- Results very much in line with our *Functional Load Hypothesis*
  - Processing appears to depend more on L1 cues than on whether the L1 has lexical stress

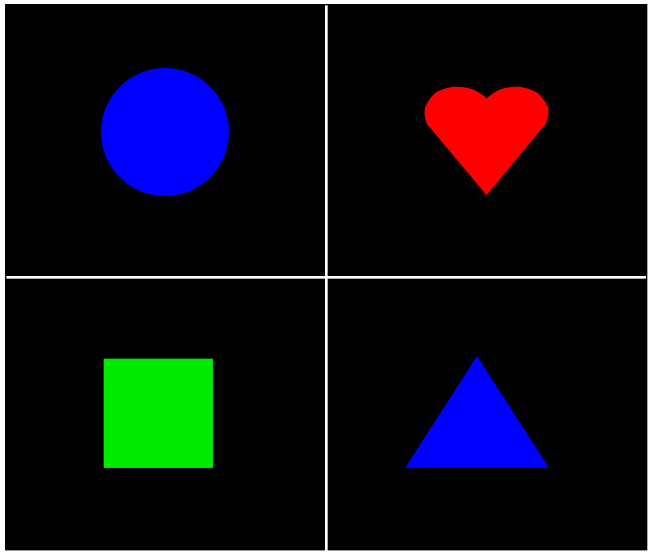
Connell, Hüls, Martínez-García, Qin, Shin, Yan, & Tremblay (in prep.)

- Follow-up to Lin et al. (2013) but using **visual-world eye tracking** (a more sensitive measure of L2 word recognition)

Visual-World Eye Tracking

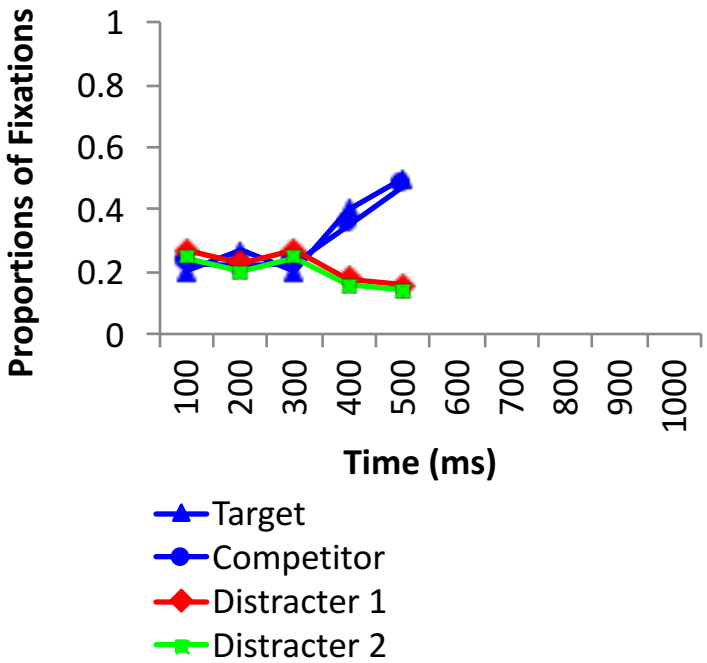
Click on the...

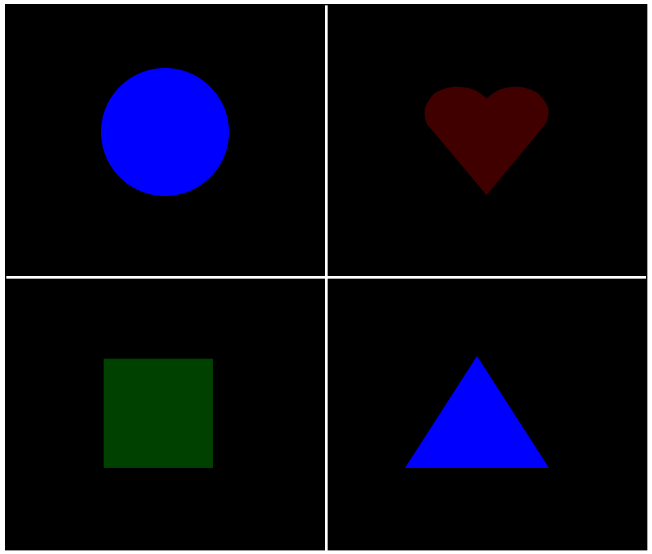




Visual-World Eye Tracking

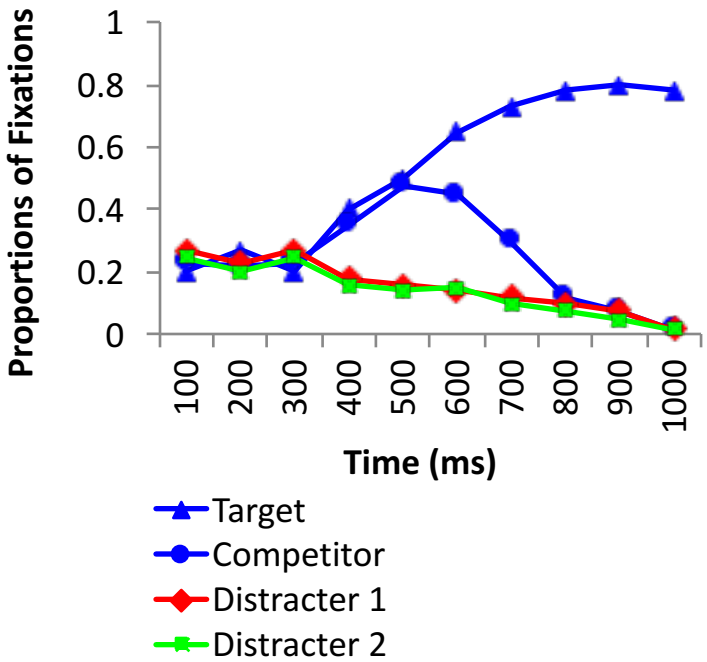
Click on the blue...

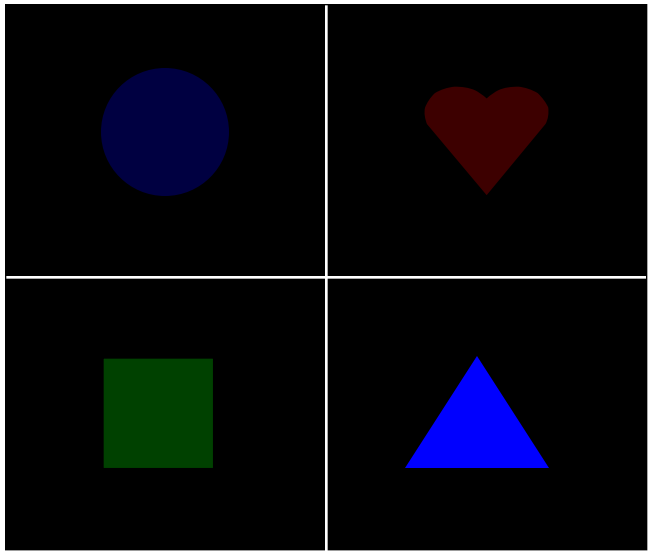




Visual-World Eye Tracking

Click on the blue triangle





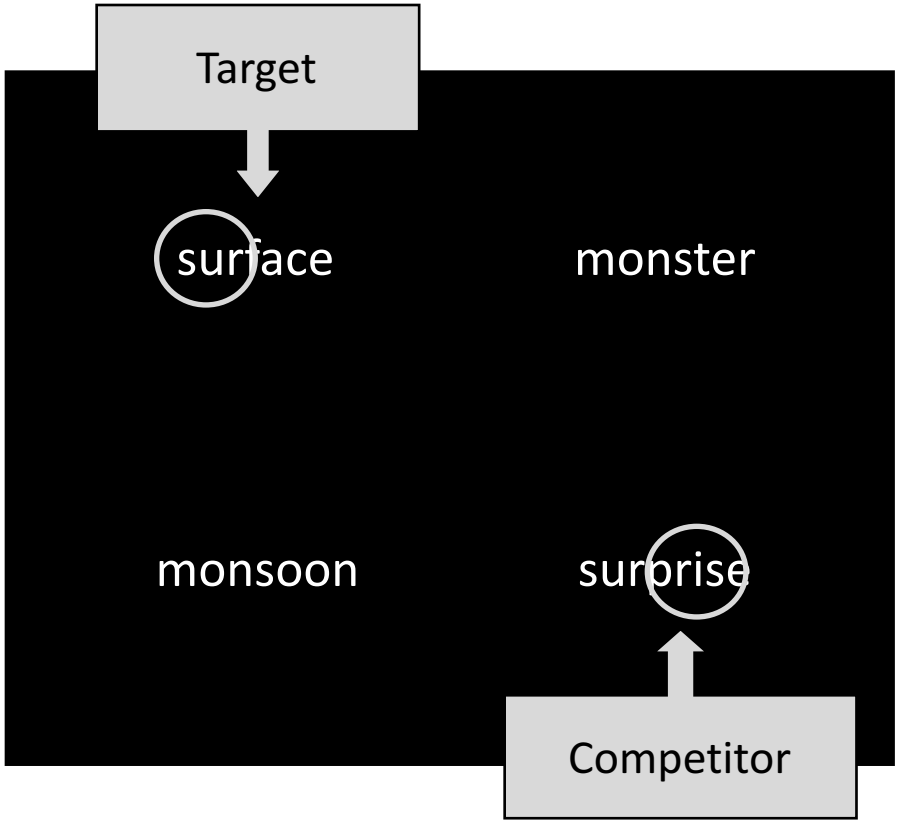
Connell, Hüls, Martínez-García, Qin, Shin, Yan, & Tremblay (in prep.)

- Participants
  - Native English listeners
  - Chinese "late" L2 learners of English (age of acquisition: 10)
  - Korean "late" L2 learners of English (age of acquisition: 11)
    - More proficient than our Chinese L2 learners of English!

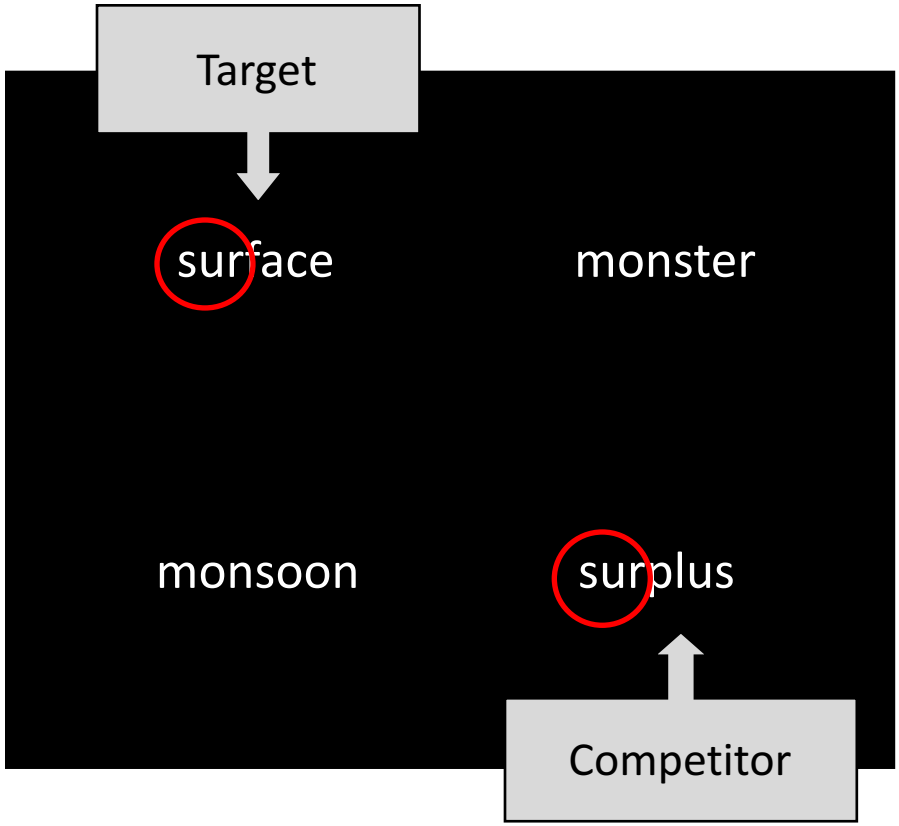
Connell, Hüls, Martínez-García, Qin, Shin, Yan, & Tremblay (in prep.)

No Vowel Reduction Conditions

Stress Mismatch



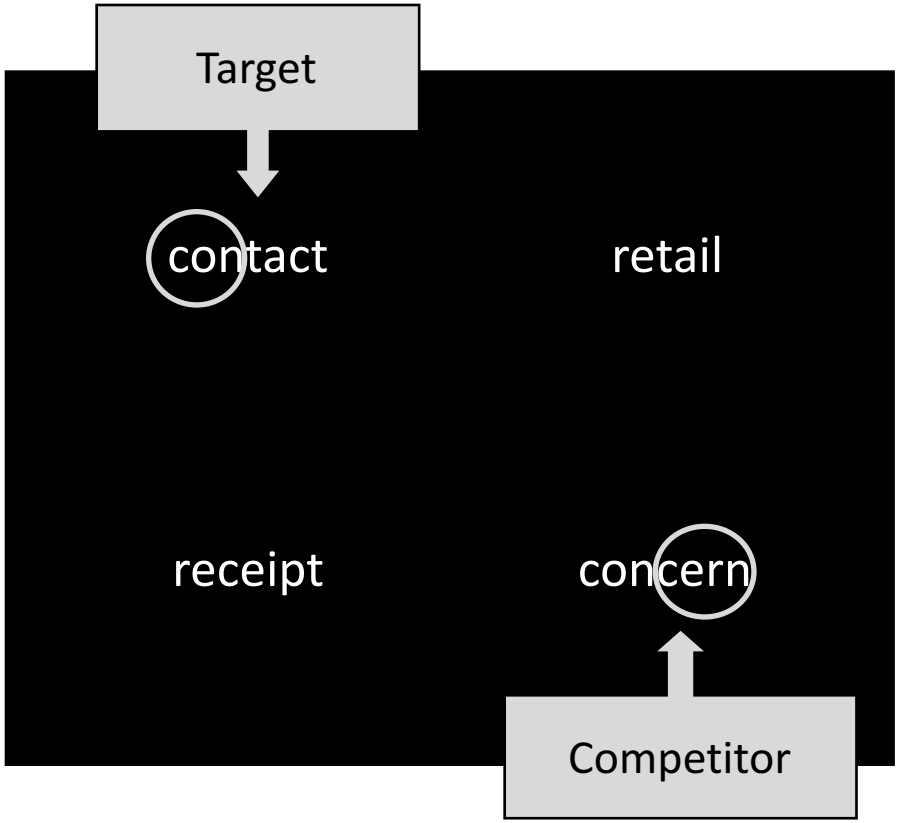
Stress Match



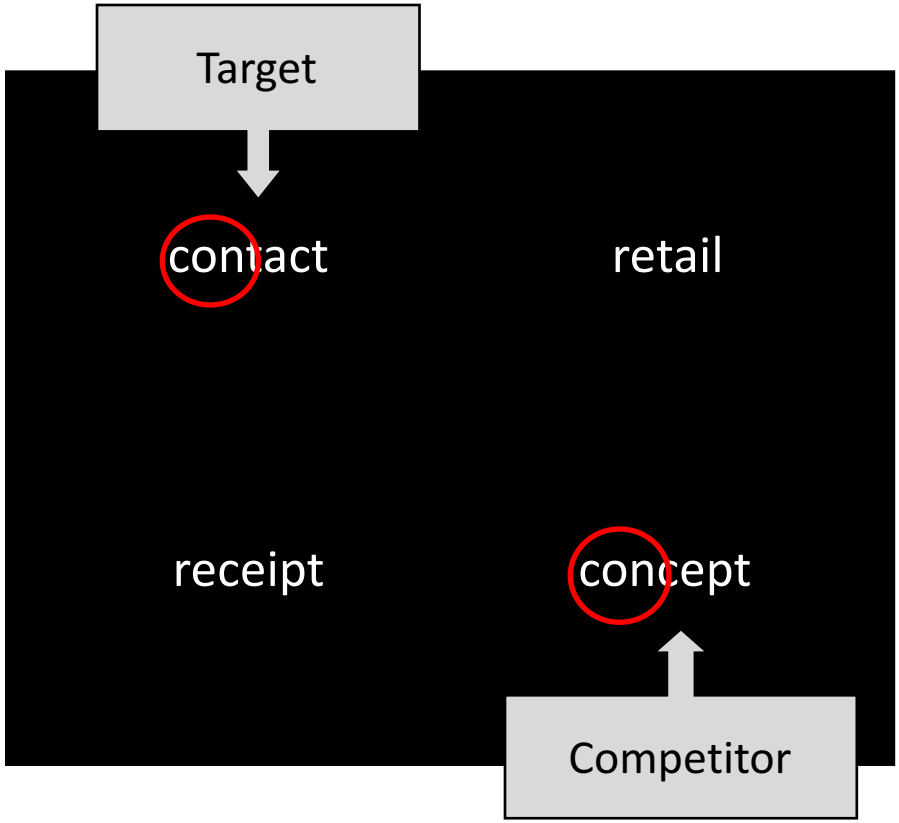
Connell, Hüls, Martínez-García, Qin, Shin, Yan, & Tremblay (in prep.)

Vowel Reduction Conditions

Stress Mismatch

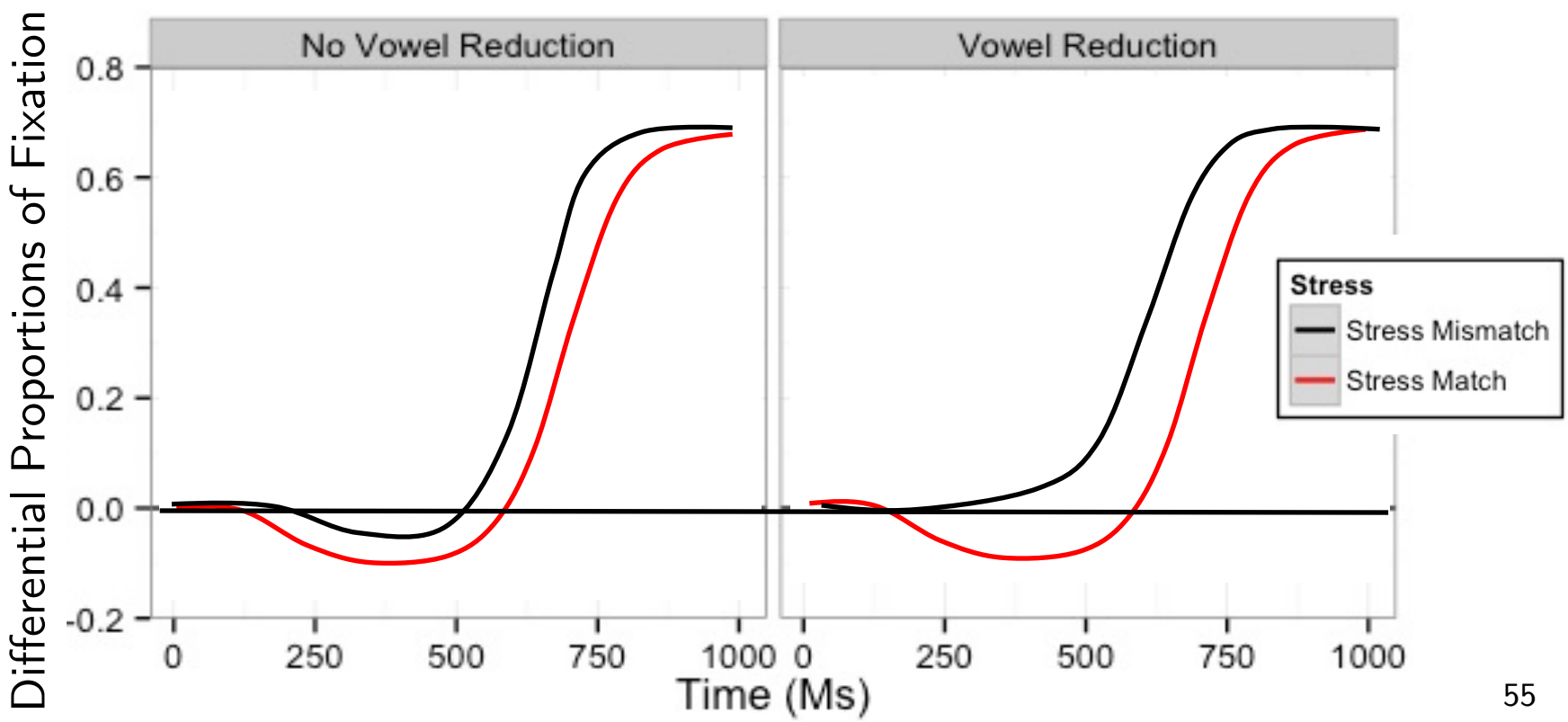


Stress Match

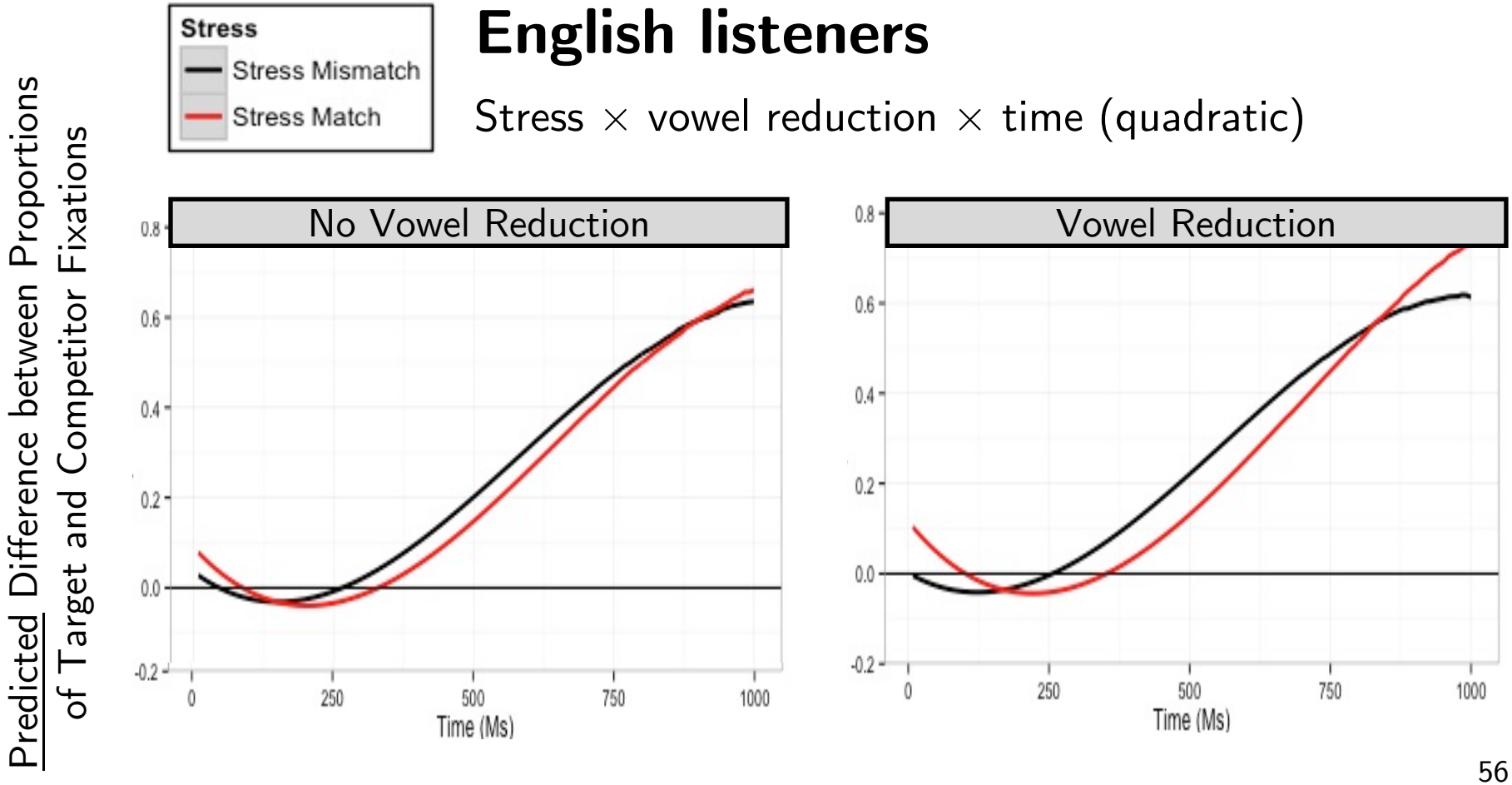


Connell, Hüls, Martínez-García, Qin, Shin, Yan, & Tremblay (in prep.)

- Predictions
  - If stress constrains lexical access in English and if the strength of this effect depends on vowel reduction...



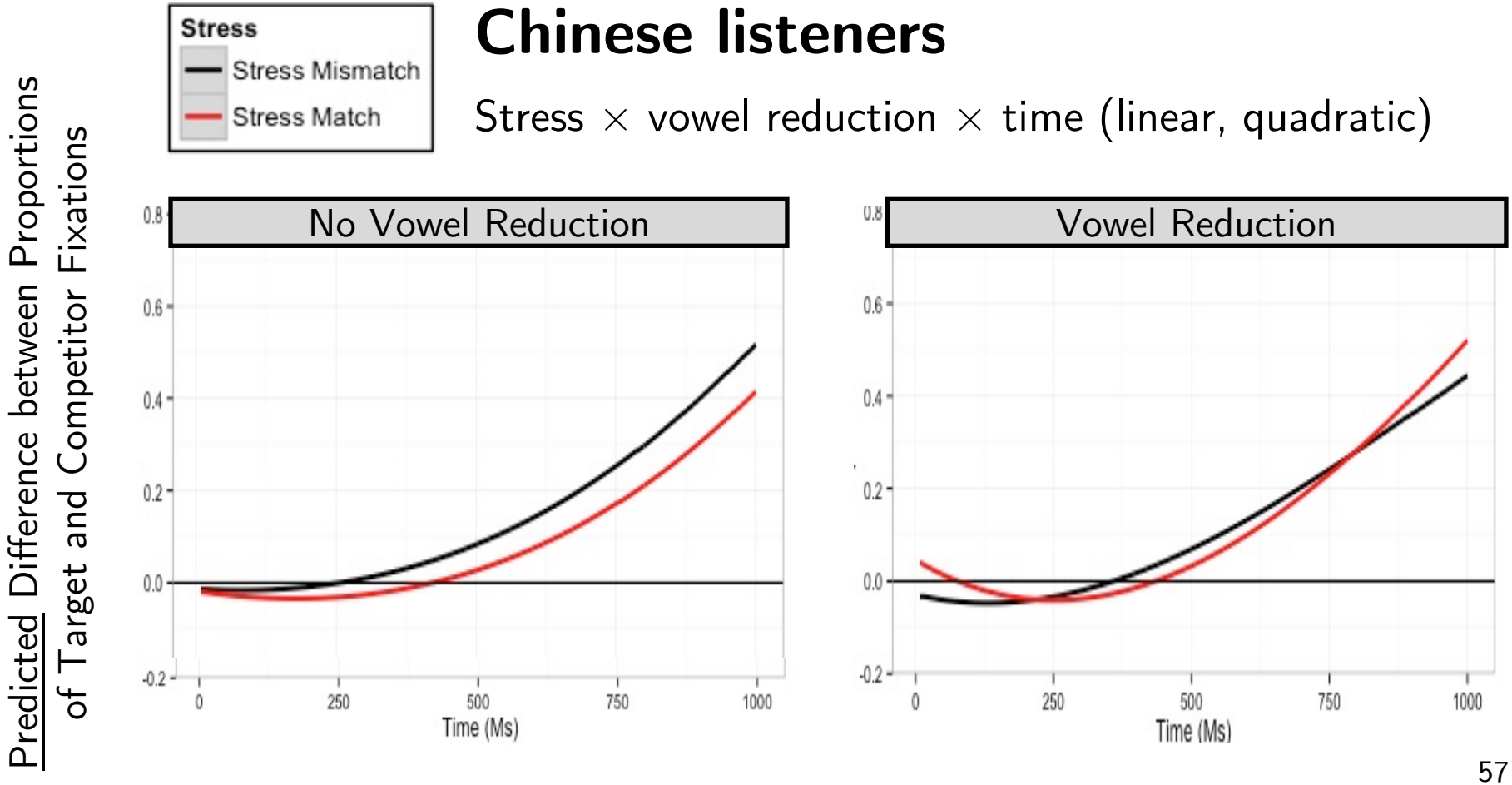
Connell, Hüls, Martínez-García, Qin, Shin, Yan, & Tremblay (in prep.)



English listeners

Stress × vowel reduction × time (quadratic)

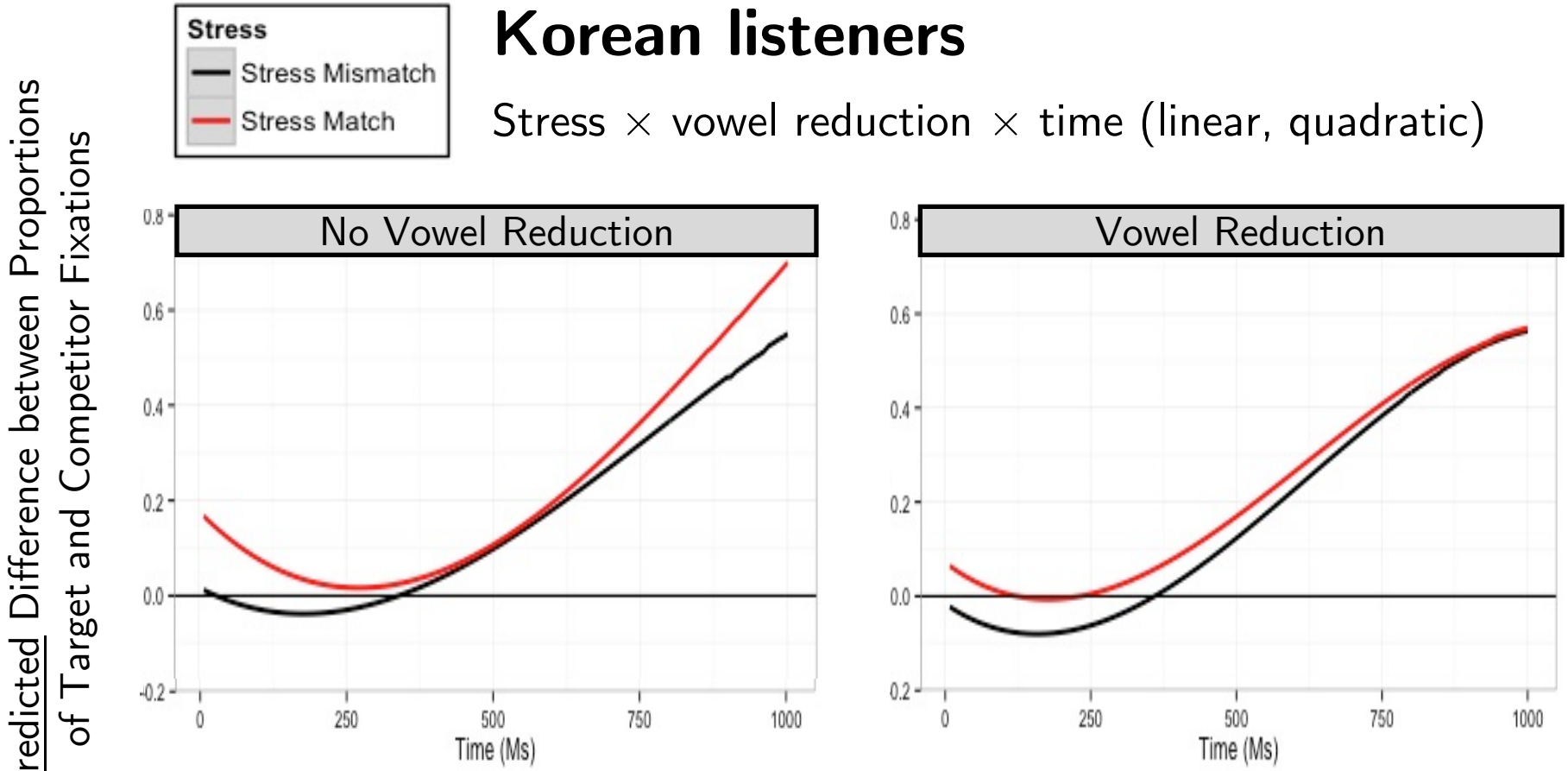
Connell, Hüls, Martínez-García, Qin, Shin, Yan, & Tremblay (in prep.)



Chinese listeners

Stress × vowel reduction × time (linear, quadratic)

Connell, Hüls, Martínez-García, Qin, Shin, Yan, & Tremblay (in prep.)



Korean listeners

Stress × vowel reduction × time (linear, quadratic)

Effect in the wrong direction!

Connell, Hüls, Martínez-García, Qin, Shin, Yan, & Tremblay (in prep.)

- English and Chinese listeners, but not Korean listeners, use stress to recognize L2 words, but only English listeners' word recognition benefits from vowel reduction, in line with the *Functional Load Hypothesis*
- Can we find stronger evidence for the *Functional Load Hypothesis* by isolating the prosodic cues to English stress?

Qin, Chien, & Tremblay (to appear)

- Do native English listeners and Chinese L2 learners of English differ in their sensitivity to the prosodic correlates of English stress?
- Participants
  - Native English listeners
  - Chinese "late" L2 learners of English (age of acquisition: 11) from two L1 dialects
    - Standard-Mandarin dialect
    - Taiwan-Mandarin dialect

Qin, Chien, & Tremblay (to appear)

- Standard Mandarin
  - Lexical tones cued primarily by F0 cues
  - Stress distinction cued primarily by duration cues **(Chao, 1968; Duanmu, 2007)**
    - *DONGXI* 'east and west' vs. *DONGxi* 'stuff'
- Taiwan Mandarin
  - Lexical tones cued primarily by F0 cues
  - No stress distinction **(Kubler, 1985; Swihart, 2003)**
    - *DONGXI* 'east and west' vs. *DONGXI* 'stuff'

Qin, Chien, & Tremblay (to appear)

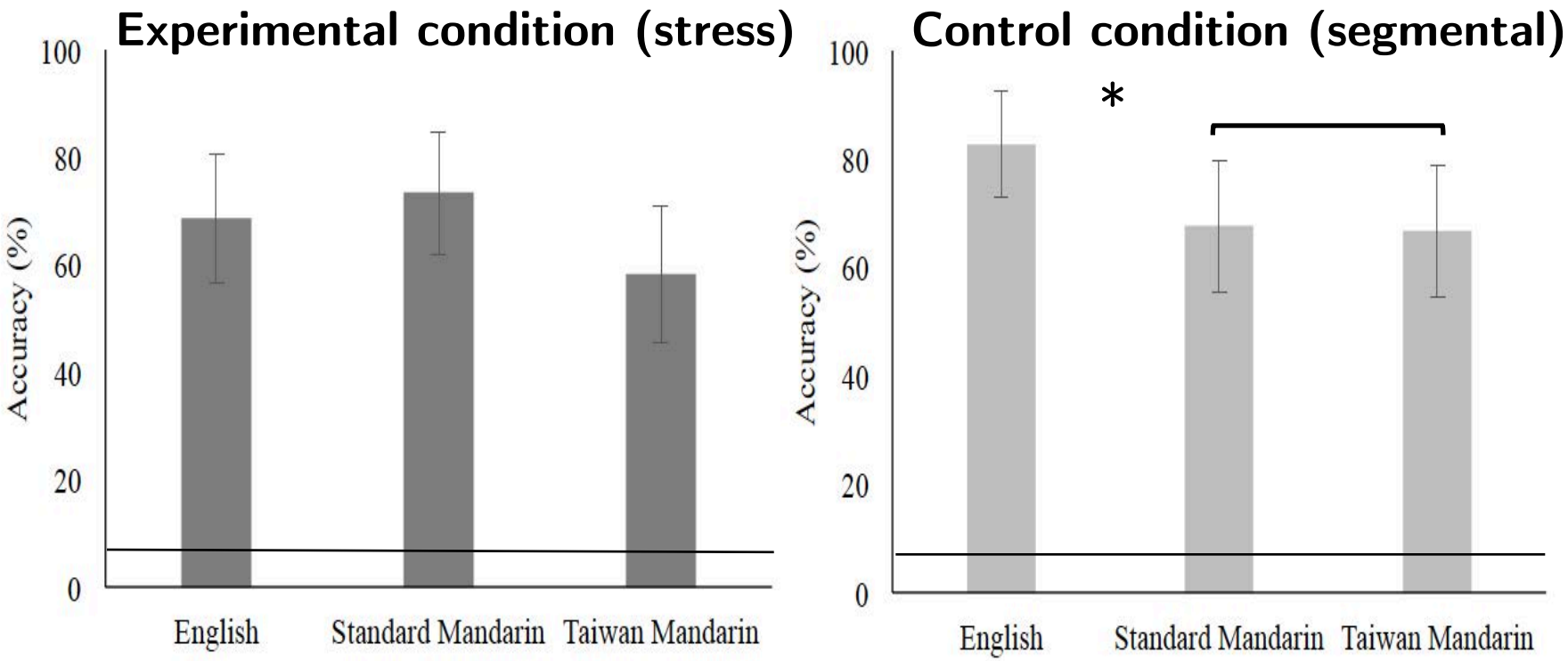
- Predictions
  - Standard-Mandarin listeners and native English listeners should be able to use both F0 and duration cues to English stress
  - Taiwan-Mandarin listeners may be able to use only F0 cues to English stress
  - Both groups of Mandarin listeners should rely more on F0 than native English listeners when F0 and duration are pitted against each other

Qin, Chien, & Tremblay (to appear)

- Sequence recall task à la Dupoux, but with English-like stimuli and with a single talker
  - Experimental condition: **Stress** (e.g., /ˈfʌði/, /fʌˈði/...)
  - Control condition: **Segmental** (e.g., /tɪbi/, /kɪbi/...)
- Experiment 1: Natural stimuli
- Experiment 2: Resynthesized
  - Converging F0 and duration cues
  - Only F0 cues
  - Only duration cues
  - Conflicting F0 and duration cues

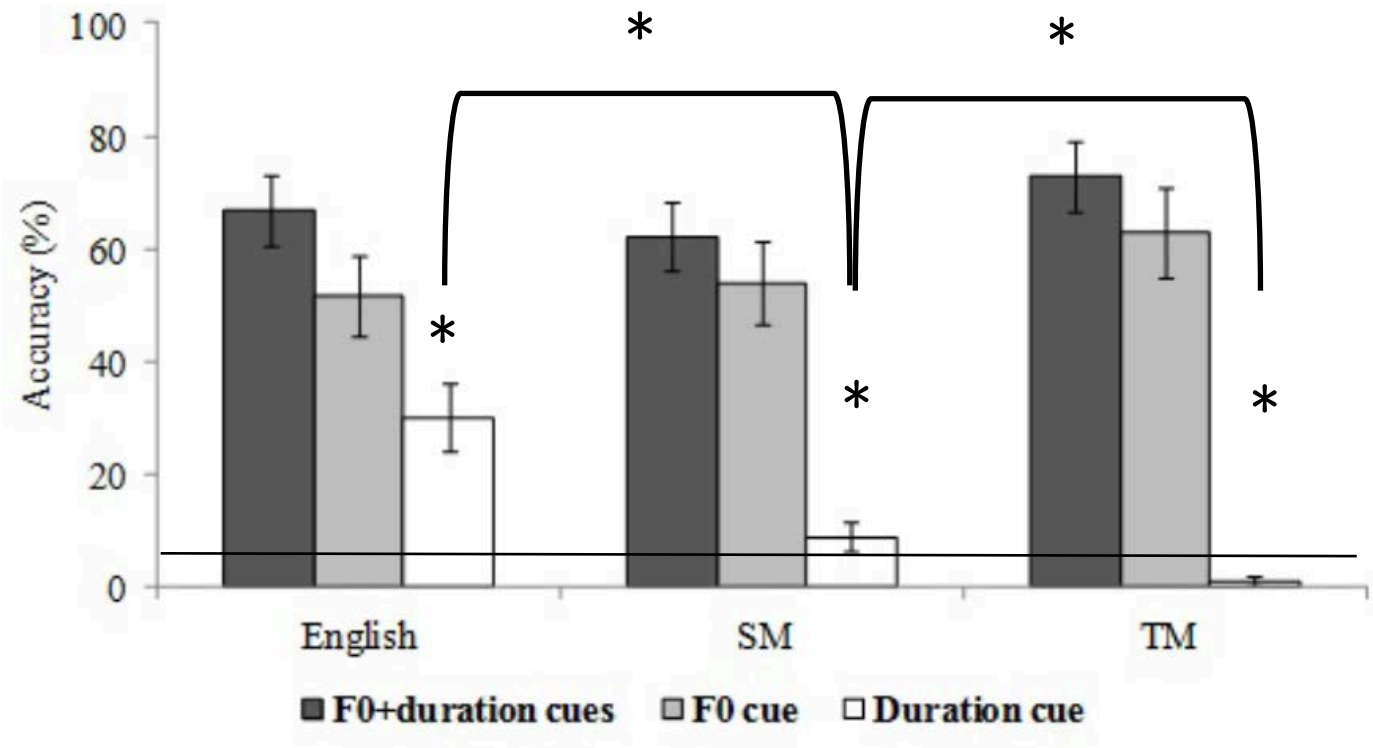
Qin, Chien, & Tremblay (to appear)

- Results: Experiment 1 (natural stimuli)
  - Sequence recall accuracy



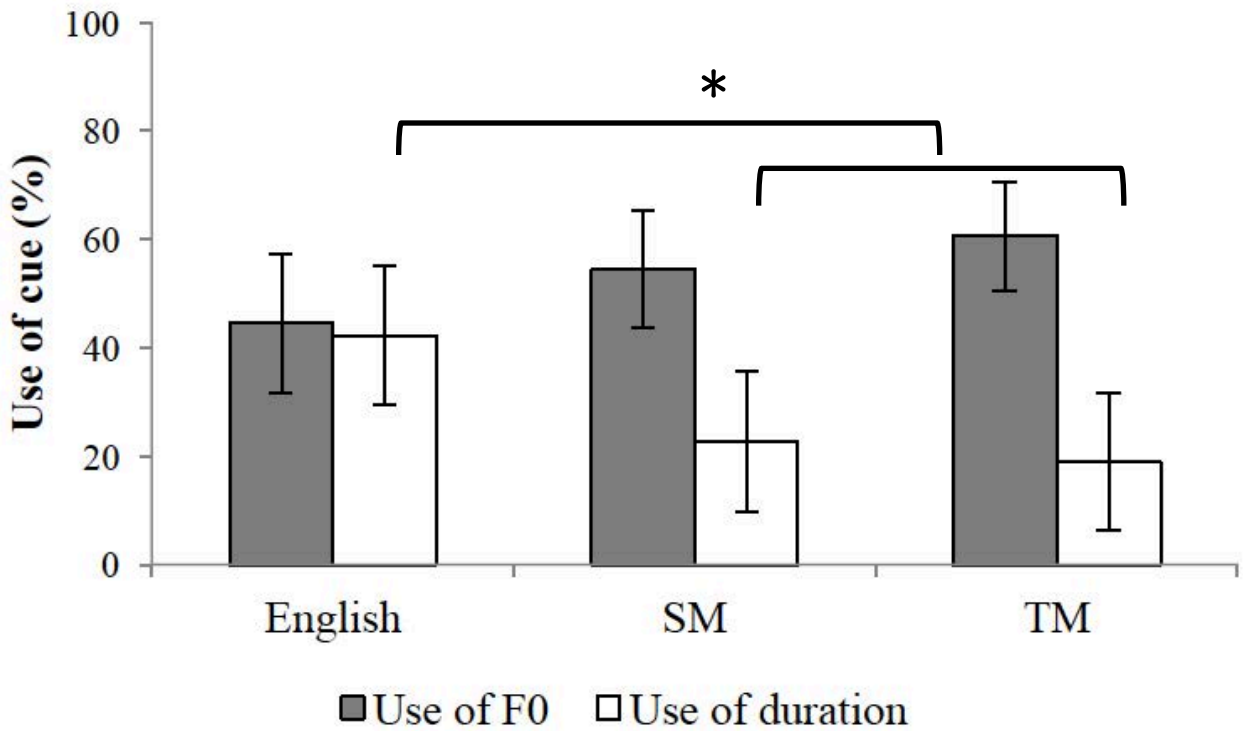
Qin, Chien, & Tremblay (to appear)

- Results: Experiment 2 (resynthesized stimuli)
  - Sequence recall accuracy



Qin, Chien, & Tremblay (to appear)

- Results: Experiment 2 (resynthesized stimuli)
  - % use of cue in condition with conflicting cues



Qin, Chien, & Tremblay (to appear)

- Clear evidence that the functional load of prosodic cues in the L1 determines how listeners process stress in the L2
  - F0 cues: higher functional load in Mandarin than in English → Mandarin listeners rely more on F0 than English listeners to process English stress
  - Duration cues: higher functional load in Standard Mandarin (stress) than in Taiwan Mandarin (no stress) → Standard Mandarin listeners, but not Taiwan listeners, use duration to process English stress

2. Use of Pitch Accents in L2 Speech Segmentation

Theory of L2 Word Recognition

- *Functional Load Hypothesis*
  - The functional load of suprasegmental cues to stress (i.e., their informativeness and usefulness for signaling lexical identity) predicts L2 learners' ability to use the same cues in L2 word recognition
    (Tremblay, Broersma, & Coughlin, under review)
  - **This should be true even if the cues are used differently in the L1 and L2 (within and across prosodic domains)**

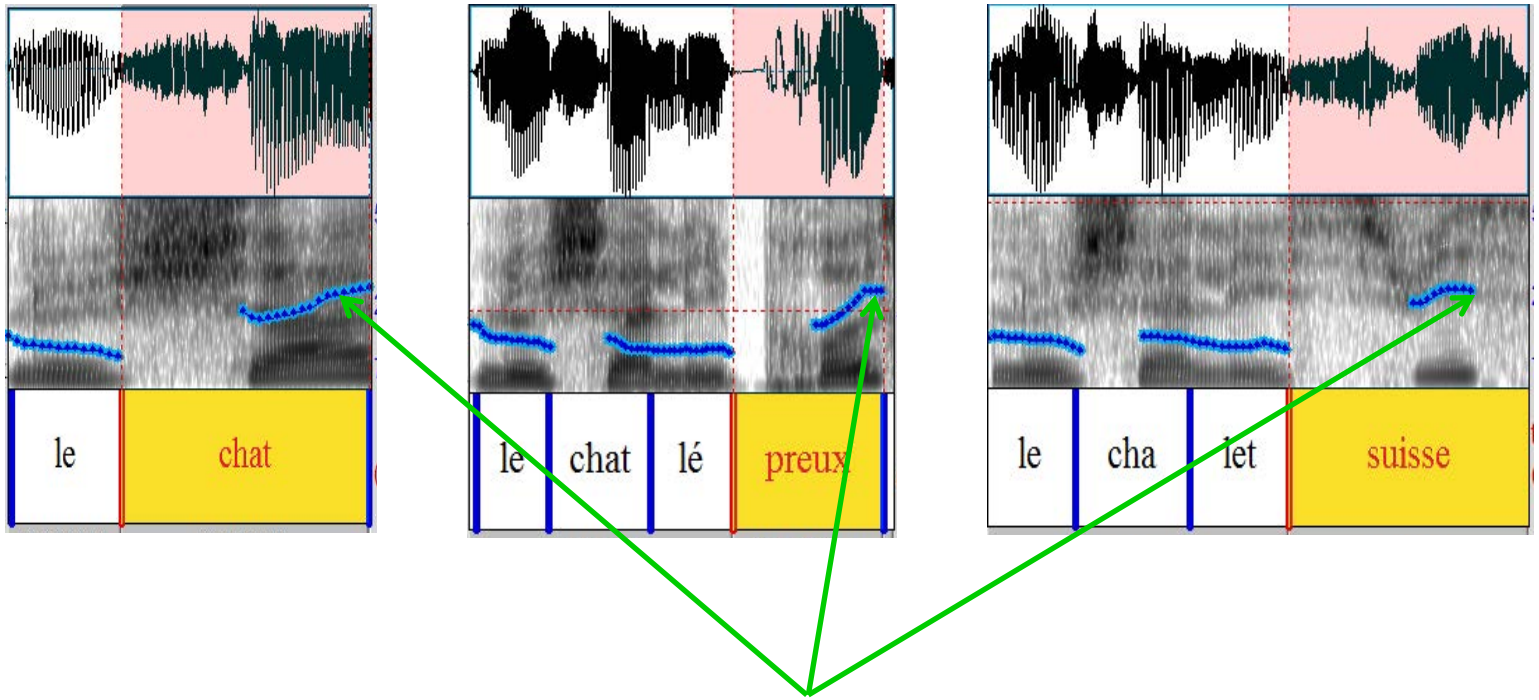
Prosodic Information in French

- Prominence is phrasal: Accentual Phrase (AP)
- Underlying tonal pattern of AP: L(HL)H*

L ... H*	
[le CHAT]$_{AP}$	'the cat'
[le chaLET]$_{AP}$	'the cabin'
[le chat léPREUX]$_{AP}$	'the leprous cat'
[le chalet SUISSE]$_{AP}$	'the Swiss cabin'

(e.g., Jun & Fougeron, 2000, 2002; Vaissière, 1983; Verluyten, 1982; Welby, 2006)

F0 Rise in French



F0 peaks at the end of the last syllable of the Accentual Phrase (AP)

(e.g., Jun & Fougeron, 2000, 2002; Vaissière, 1983; Verluyten, 1982; Welby, 2006)

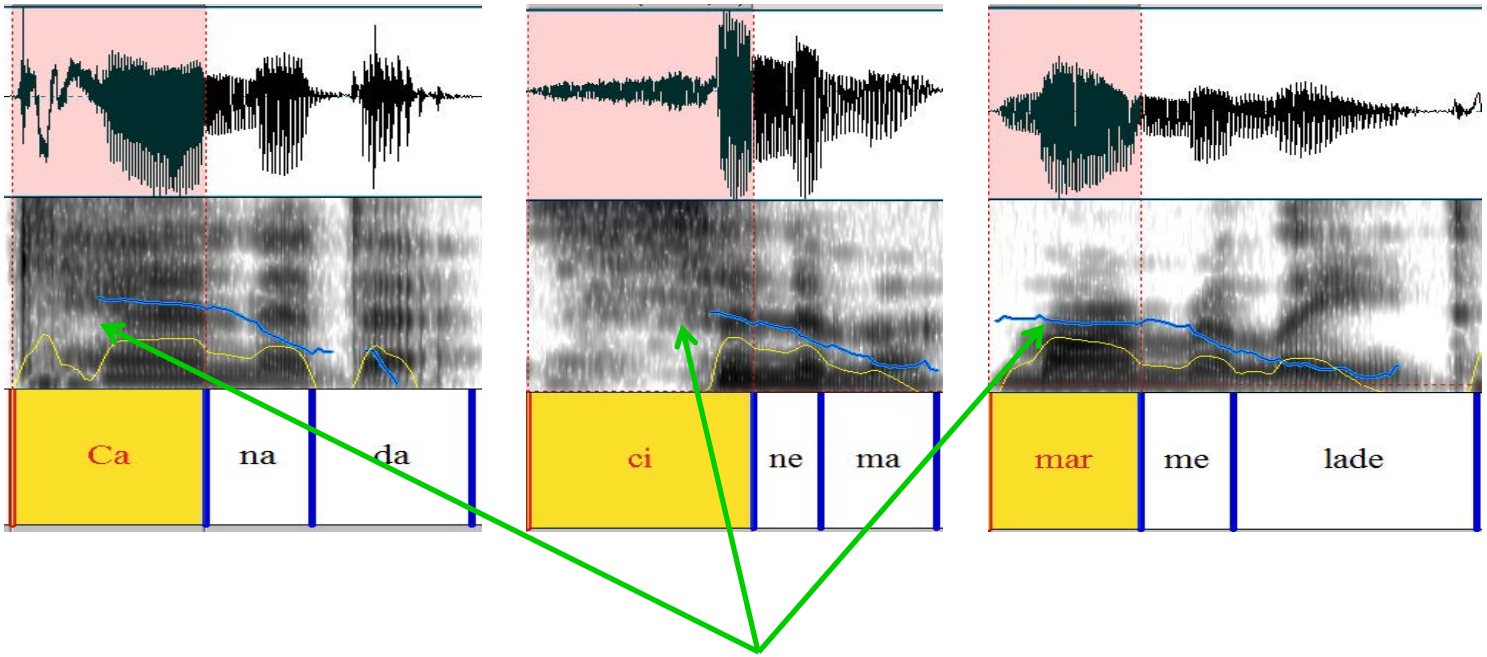
Prosodic Information in English

- Prominence is phrasal (accent) *and* lexical (stress)
- Statistical tendency for words (especially nouns) to be stressed initially
- **Stress strongly correlated with vowel quality**

LESson
NUMber
CAnada
CInema
BALcony
MARmelade

(e.g., Beckman, 1986; Cutler & Carter, 1987; Hayes, 1995)

F0 Rise in English



F0 peaks on the stressed (typically word-initial) syllable in words that receive a neutral pitch accents (H*)

(e.g., Beckman, 1986; Cutler & Carter, 1987; Hayes, 1995)

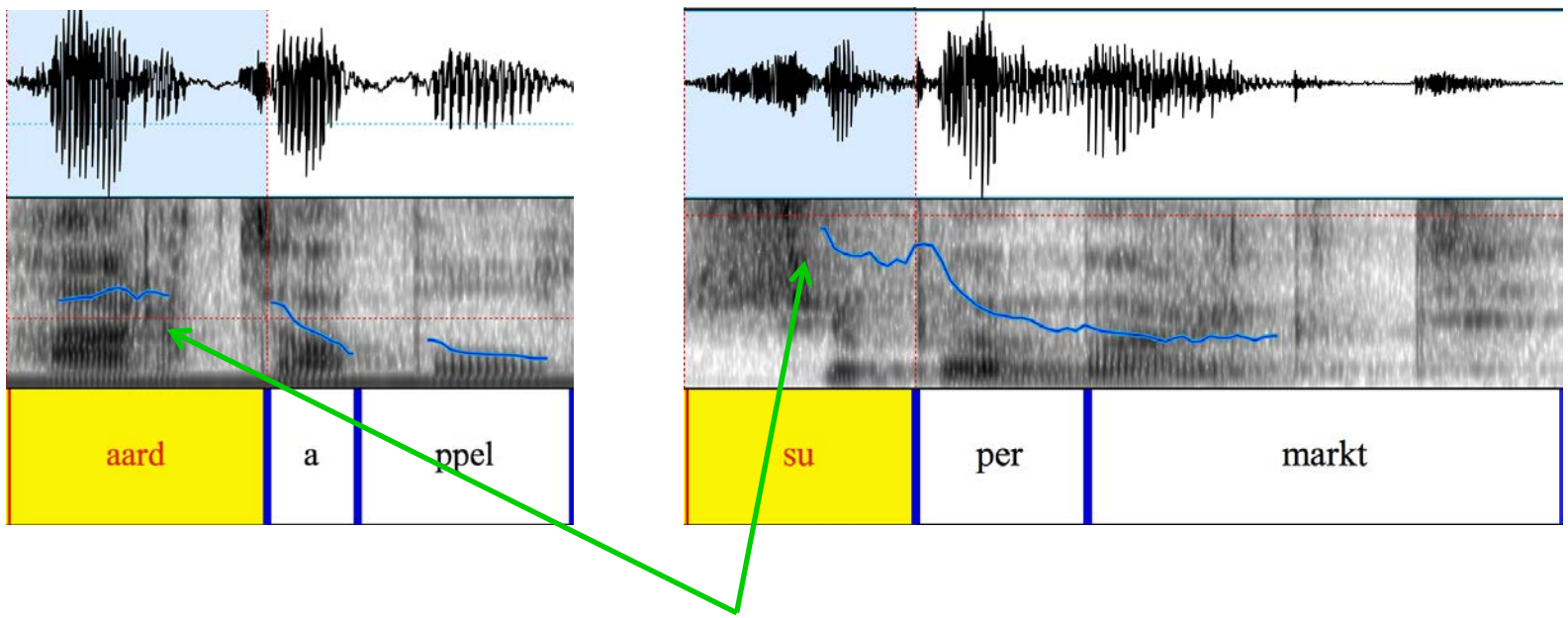
Prosodic Information in Dutch

- Prominence is phrasal (accent) *and* lexical (stress)
- Statistical tendency for words (especially nouns) to be stressed initially
- **Stress weakly correlated with vowel quality (unlike in English)**

AARDappel
BIERtje
VAder
SUpermarkt
PINda
KIEzen
CURsus

(e.g., Schreuder & Baayen, 1994; Vroomen & de Gelder, 1995)

F0 Rise in Dutch



F0 peaks on the stressed (typically word-initial) syllable in words that receive a neutral pitch accent (H*)

(e.g., Gussenhoven, 2004)

F0 Cues: Summary

	F0 Rise
French	AP- (and thus word-) final (later peak)
English	Word-initial (strongly correlated with vowel quality)
Dutch	Word-initial (weakly correlated with vowel quality)

Prediction

- Dutch listeners will make greater use of F0 cues to word-final boundaries in French than English listeners, even if F0 does not signal (word-initial) lexical stress in French

Tremblay, Broersma, & Coughlin (under review)

- Do Dutch and English listeners of French differ in their use of F0 cues to word-final boundaries in French?
- Participants
  - Native French listeners
  - English "late" L2 learners of French (age of acquisition: 14)
  - Dutch "late" L2 learners of French (age of acquisition: 13)

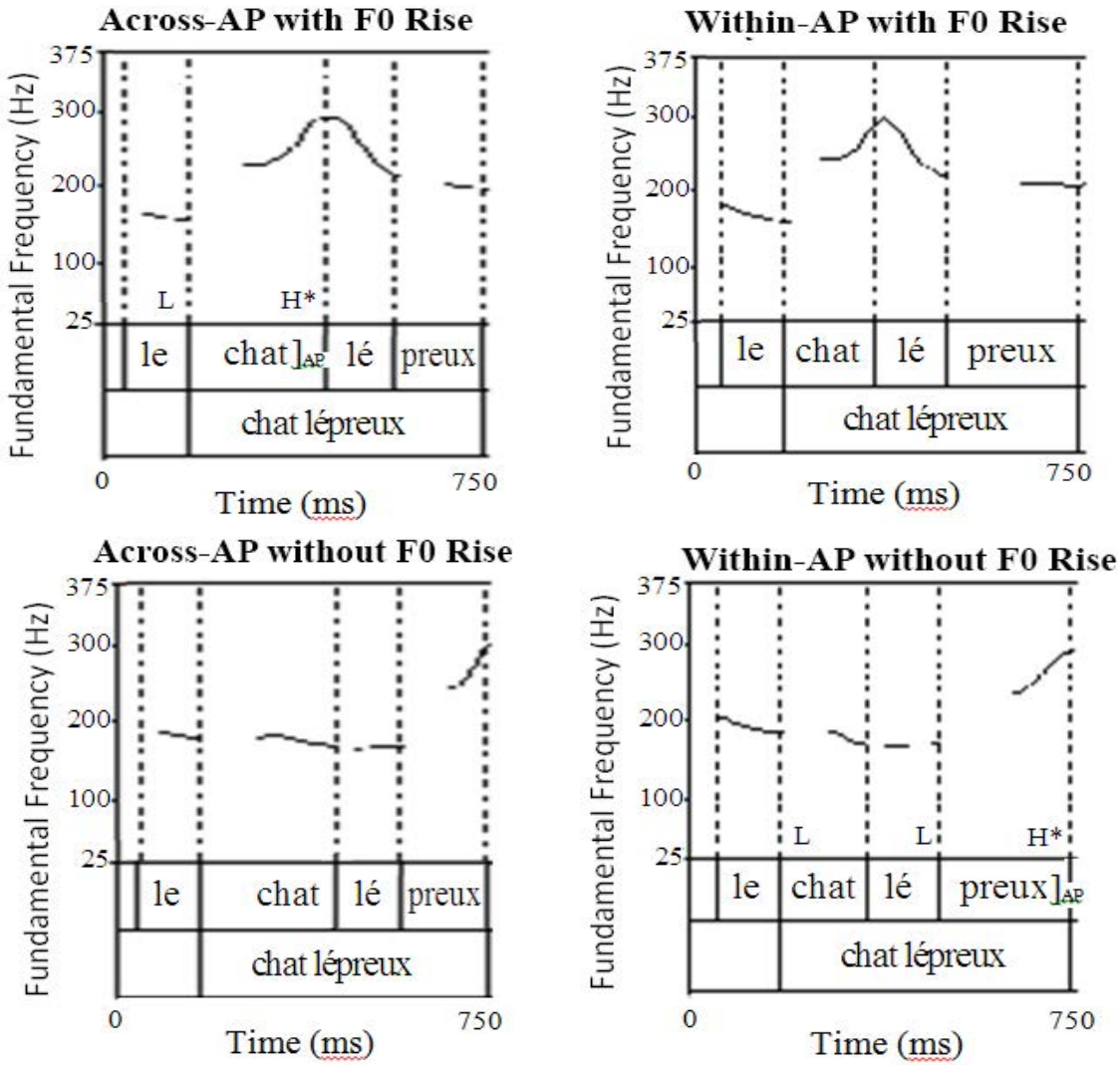
Tremblay, Broersma, & Coughlin (under review)

	Across-AP	**Within-AP**
F0 Rise	H* L [*Le chat*]$_{AP}$ [l*épreux*... (natural)	H L [*Le chat lépreux*]$_{AP}$ ... (resynthesized)
No F0 Rise	L H [*Le chat*]$_{AP}$ [*lépreux*... (resynthesized)	L H* [*Le chat lépreux*]$_{AP}$ ... (natural)
	'the leprous cat'	

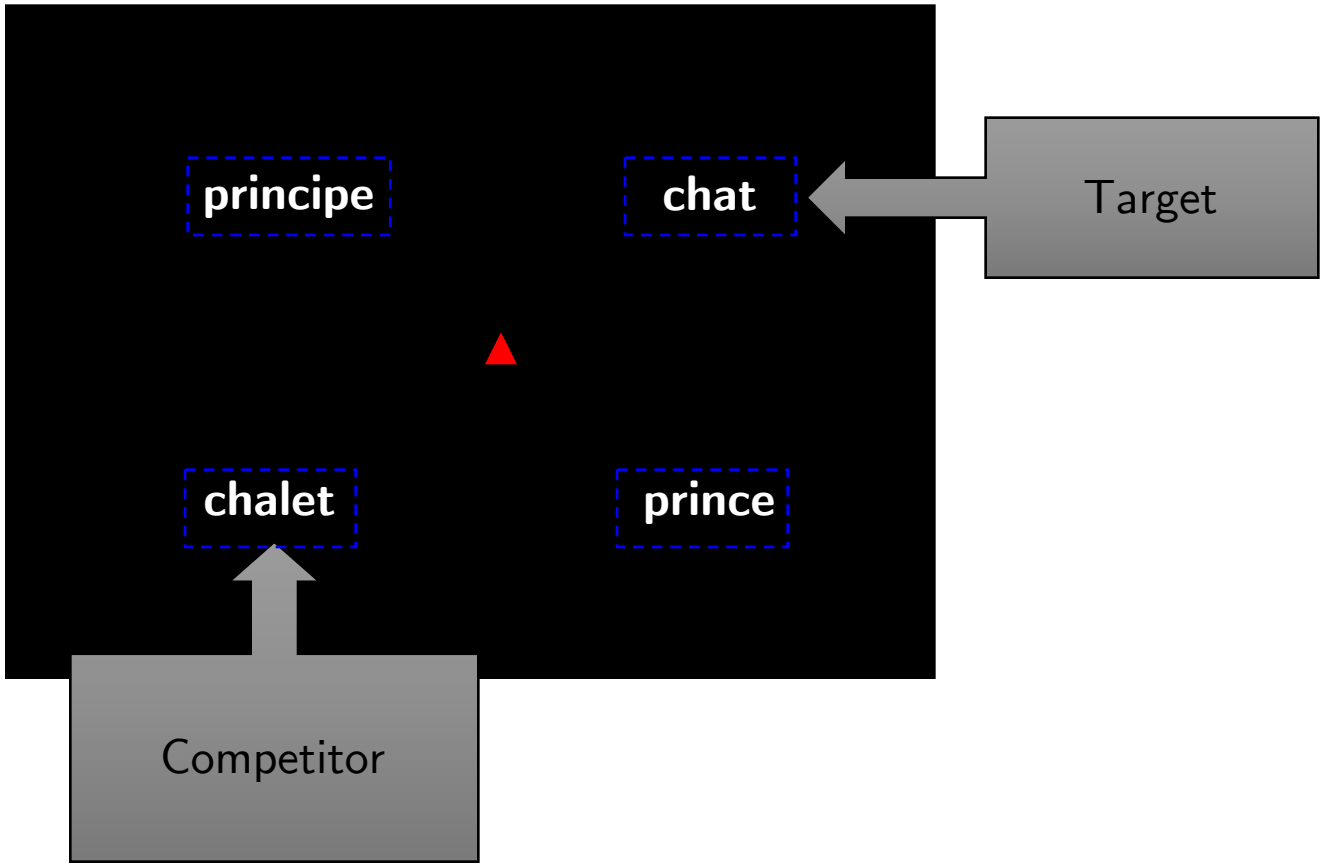
Target: *chat* 'cat'
Competitor: *chalet* 'cabin'

(stimuli from Tremblay, Coughlin, Bahler, & Gaillard, 2012;
eye-tracking experiment from Tremblay, Broersma, Coughlin, & Choi, 2016)

Tremblay, Broersma, & Coughlin (under review)



Tremblay, Broersma, & Coughlin (under review)



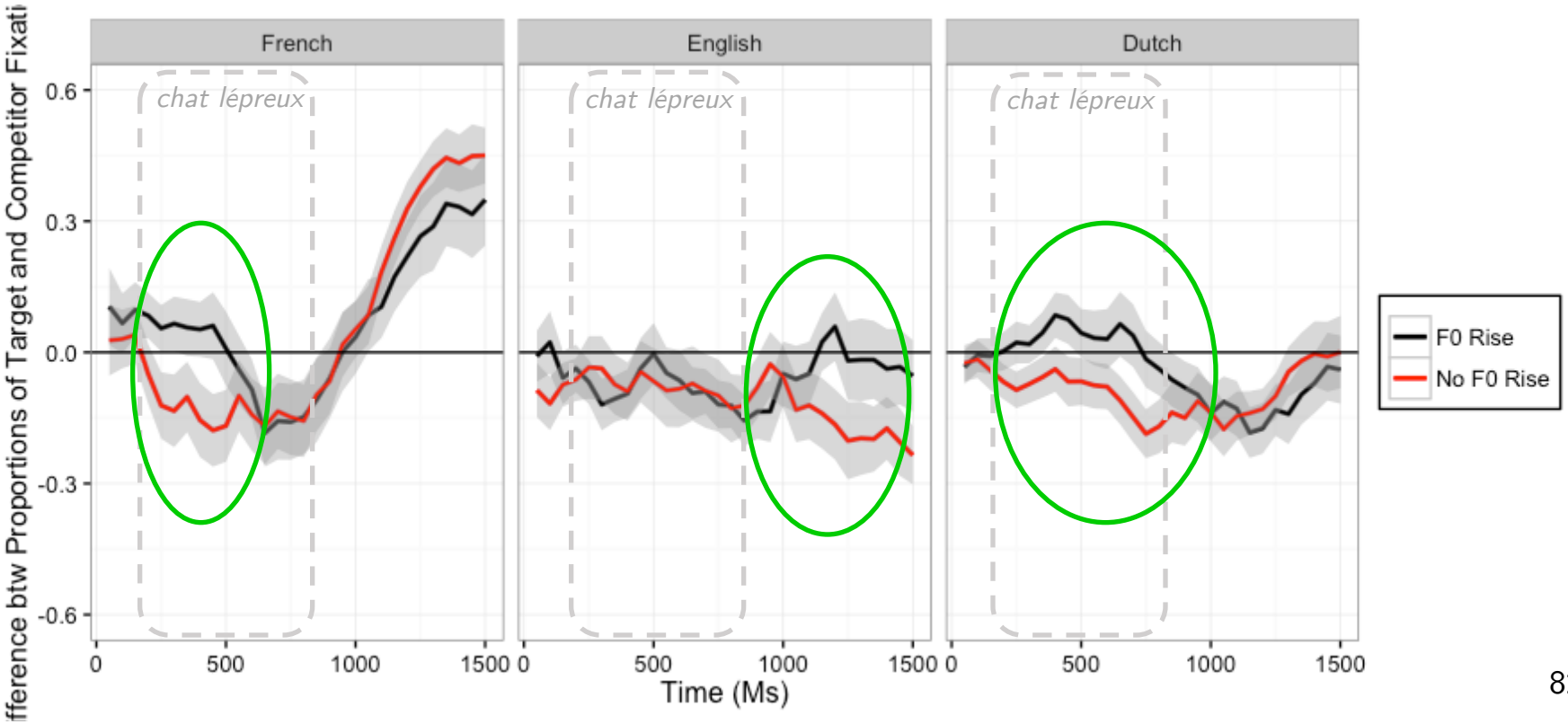
Tremblay, Broersma, & Coughlin (under review)

- Results: Across-AP condition

F0
F0 x Time (linear, cubic)

F0
F0 x Time (linear, quadratic)

F0
F0 x Time (linear, quadratic, cubic)



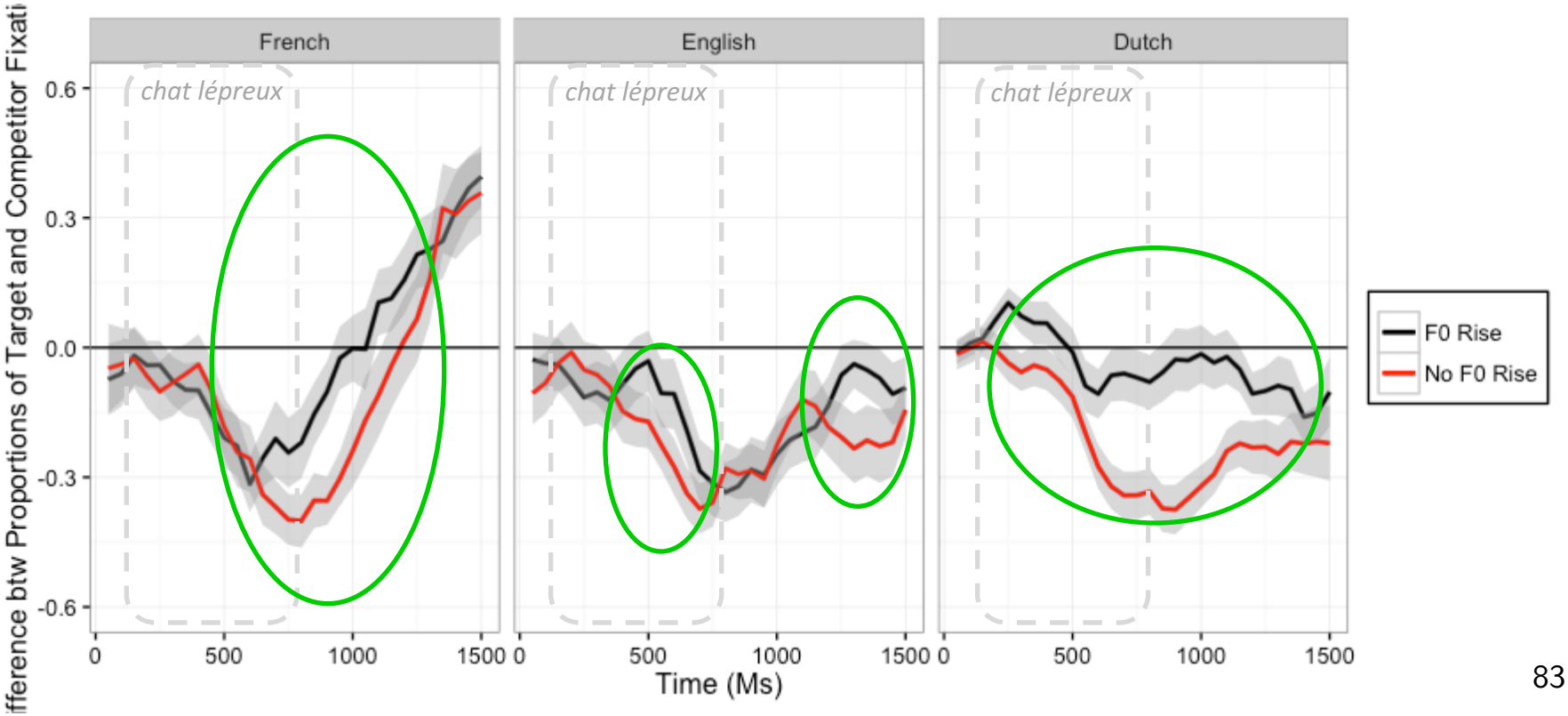
Tremblay, Broersma, & Coughlin (under review)

- Results: Within-AP condition

F0
F0 x Time (linear, quadratic, cubic)

F0
F0 x Time (linear, cubic)

F0
F0 x Time (linear, quadratic, cubic)



Tremblay, Broersma, & Coughlin (under review)

- The greater functional load of suprasegmental cues in Dutch places Dutch listeners at a speech segmentation advantage as compared to English (and even French!) listeners
- If a prosodic cue is important for signaling lexical identity in the L1, it will have a strong influence on L2 speech segmentation *even if this cue is used differently in the L1 and L2*

Theory of L2 Word Recognition

- Success in using prosodic information in L2 word recognition is best predicted by the functional load of this information for identifying words in the L1...
- ... above and beyond similarities and differences between the L1-L2 prosodic systems!

Thank you!

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