Listeners interpret rising and falling intonation prior to the final boundary

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ProPro 2017

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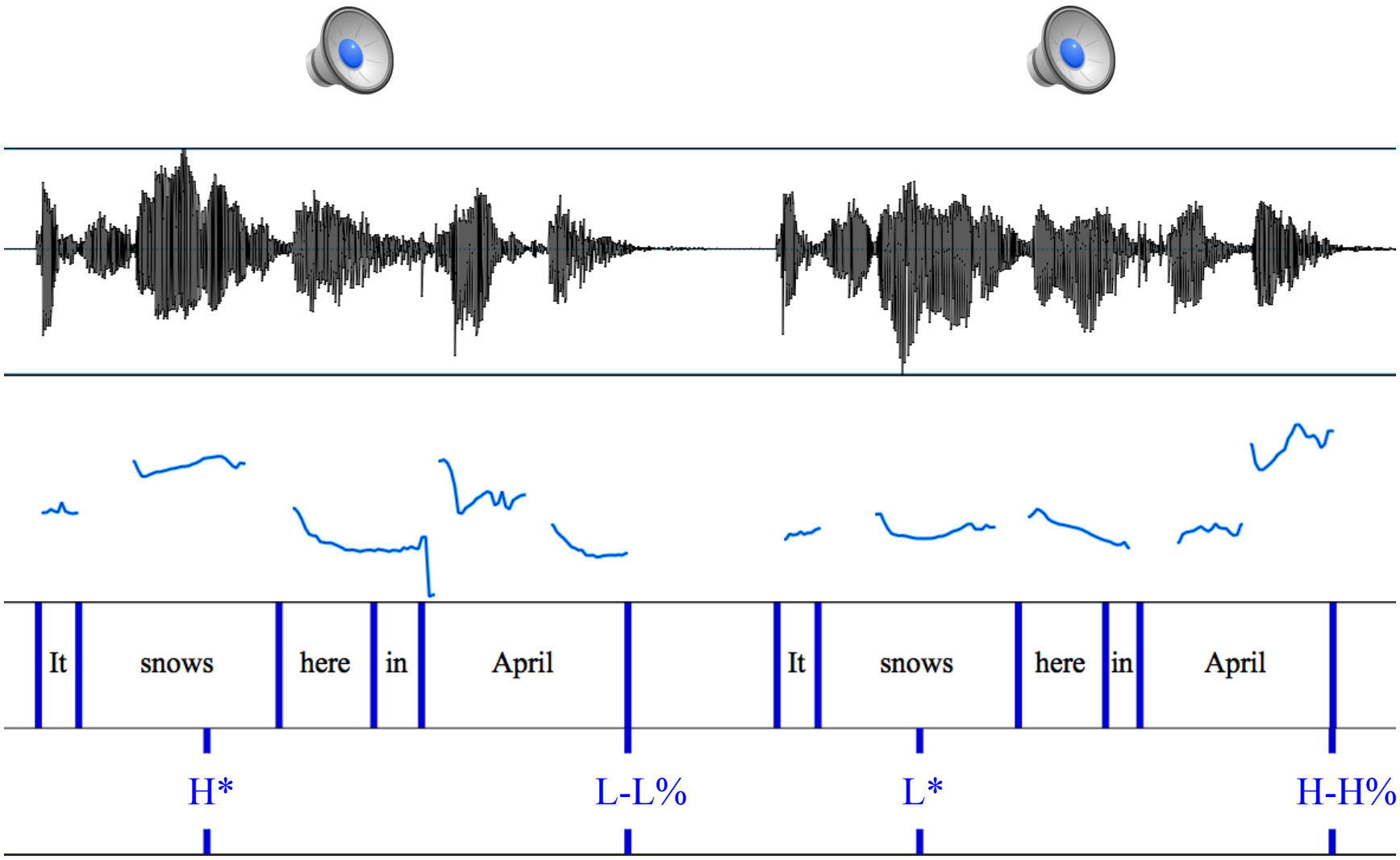
Processing of intonation

- How do we determine the information conveyed to the listener at each point in an intonational contour?


It
snows
here
in
April
It
snows
here
in
April
H*
L-L%
L*
H-H%

Incremental processing

- Listeners don't need to wait for the end of the sentence to make predictions about upcoming speech

The boy will fly a….

Incremental processing

- Listeners don't need to wait for the end of the sentence to make predictions about upcoming speech

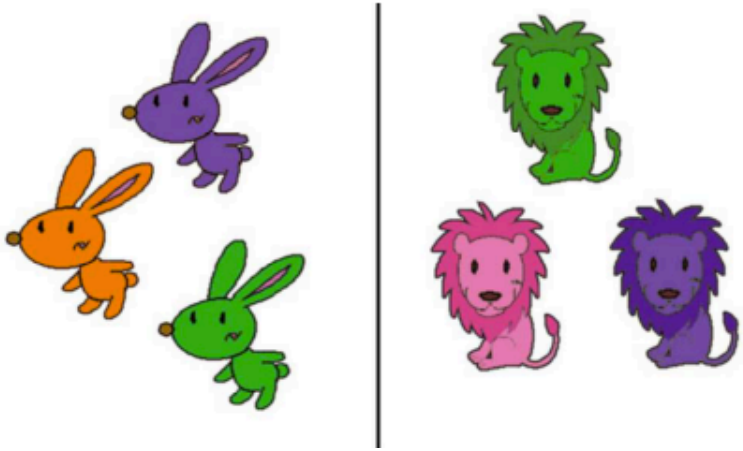
The boy will fly a pl…

Incremental processing of intonation?

- Data in support
  - Dahan et al. 2002, Weber et al. 2006, Ito & Speer 2008, Ito et al. 2014

Where's the pink lion?

Now, where's the GREEN lion.

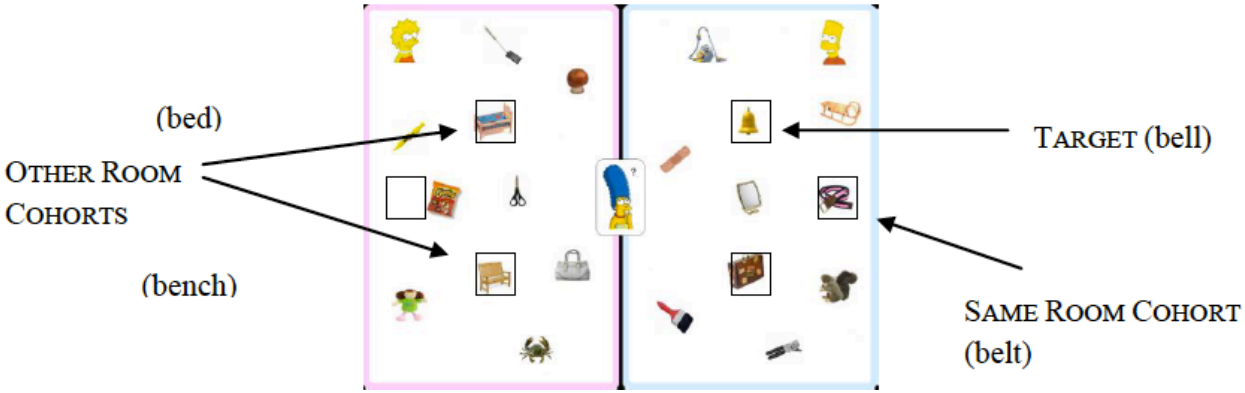


Incremental processing of intonation?

- Data against
  - Dennison & Schafer 2010

Lisa had the BELL.

Lisa HAD the bell…

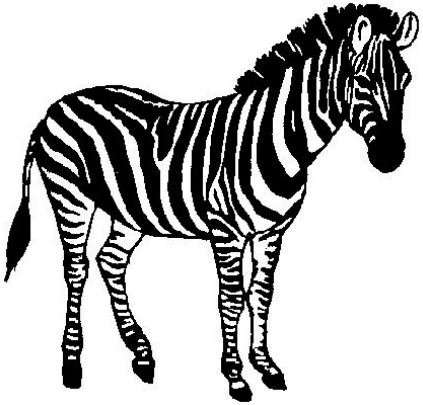


Incremental processing of intonation?

- Yes incremental, but the context matters
  - Kurumada et al. 2014, Kurumada et al. in revision

It looks like a ZEbra.

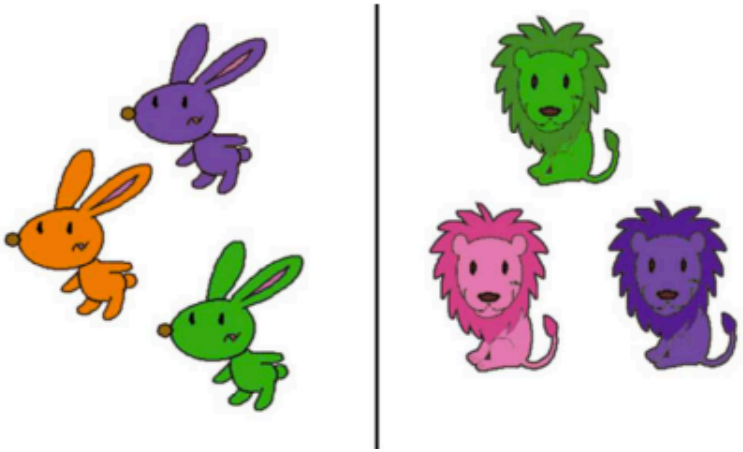
It LOOKS like a zebra…



Previous work

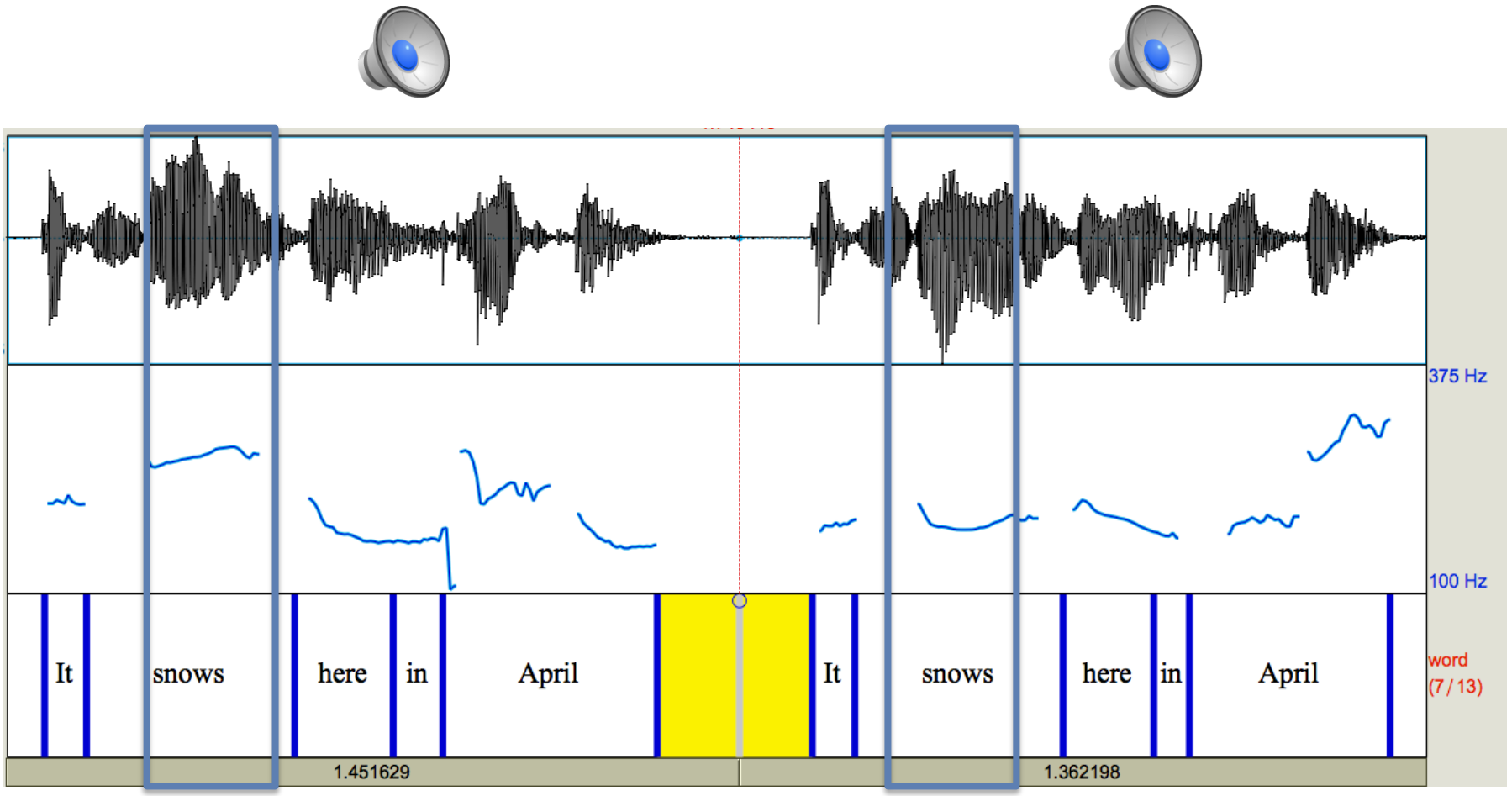
- Focus primarily on (contrastive) pitch accents

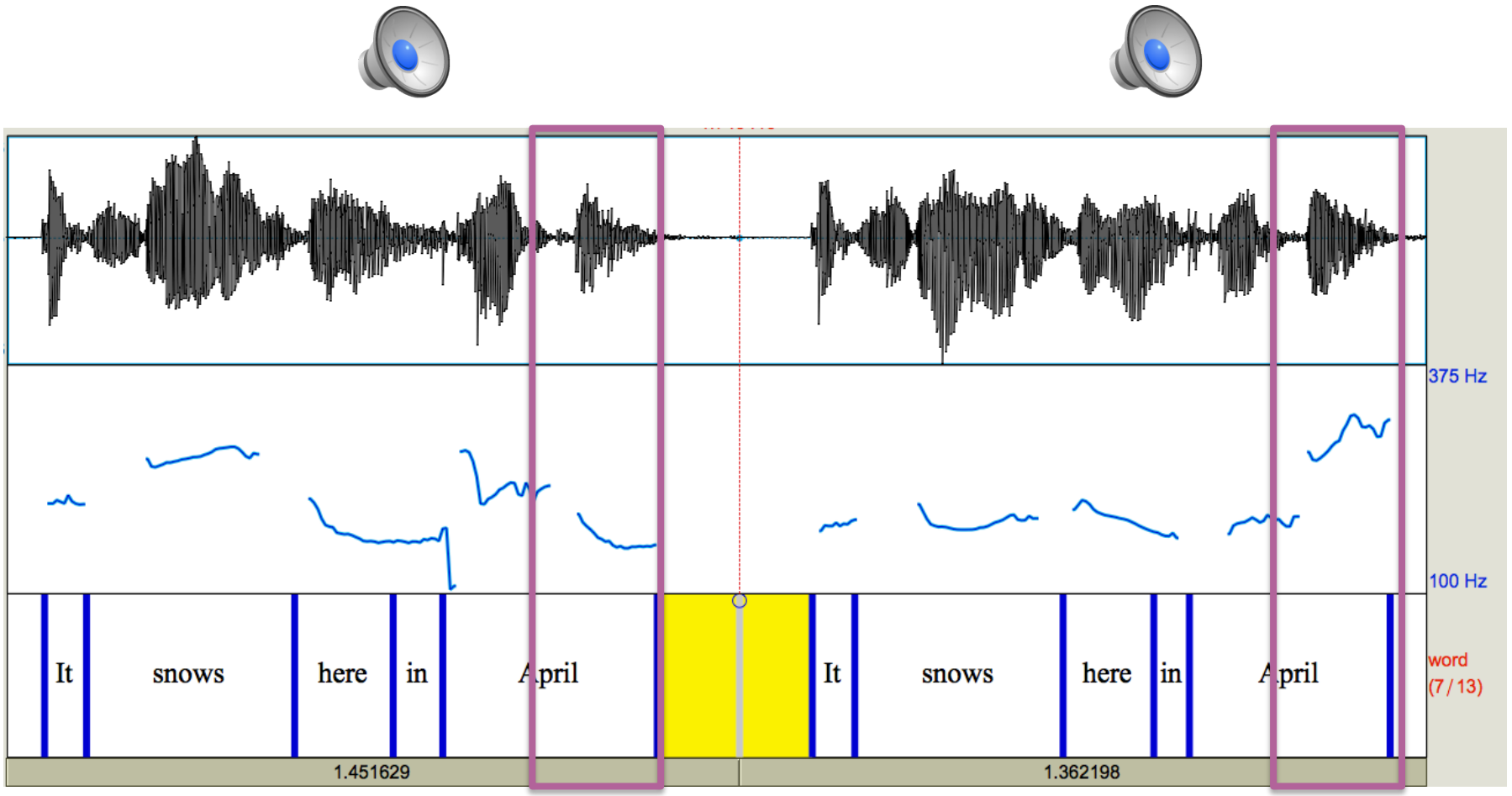
"Where's the pink lion? Now, where's the GREEN…"



Let's look a different comparison

- Falling vs. rising intonation
  - "statements" vs. "questions"


375 Hz
100 Hz
It
snows
here
in
April
It
snows
here
in
April
word
(7 / 13)
1.451629
1.362198


375 Hz
100 Hz
word
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It
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It
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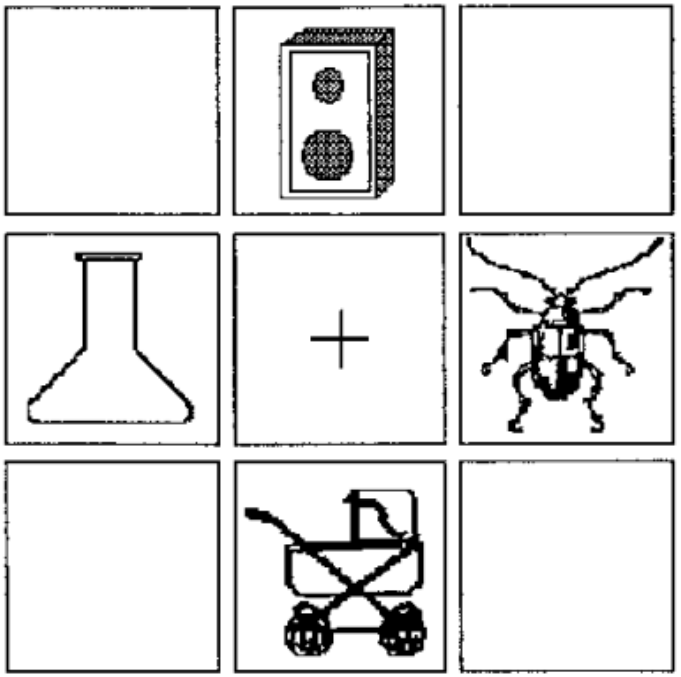
in
April
1.451629
1.362198

Incremental processing of intonation?

- Is the processing of “rising” and “falling” contours in questions and statements incremental?

- We need a fine-grain measure to answer this kind of question
  - Eyetracking in the Visual World paradigm

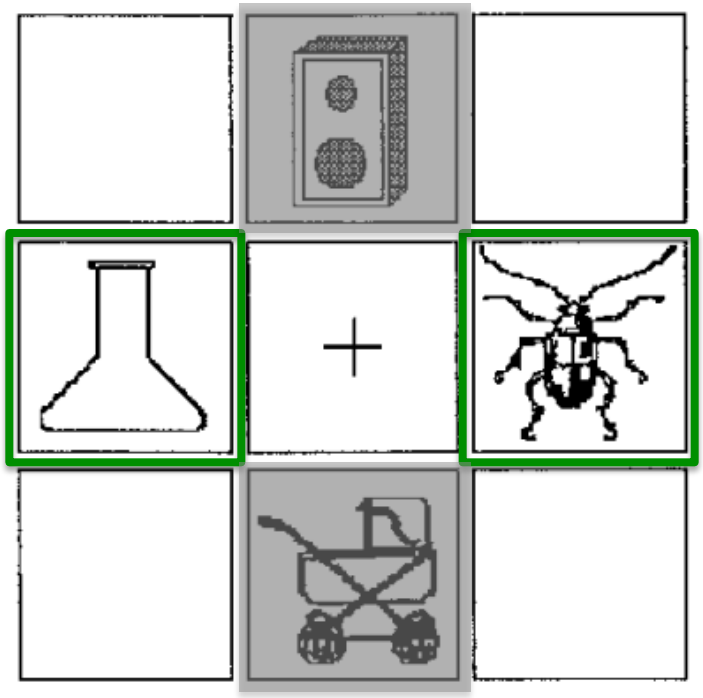
Visual World paradigm



"Click on the beaker"

Allopenna et al. 1998

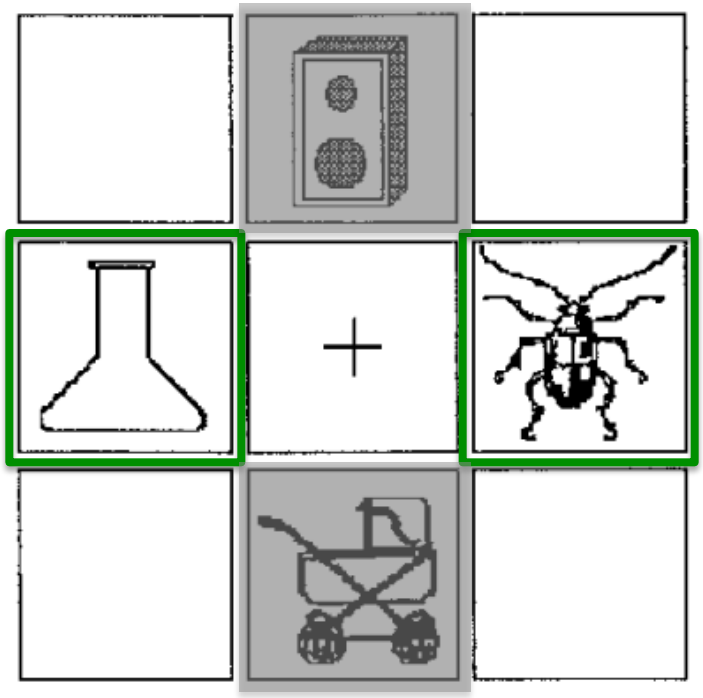
Visual World paradigm

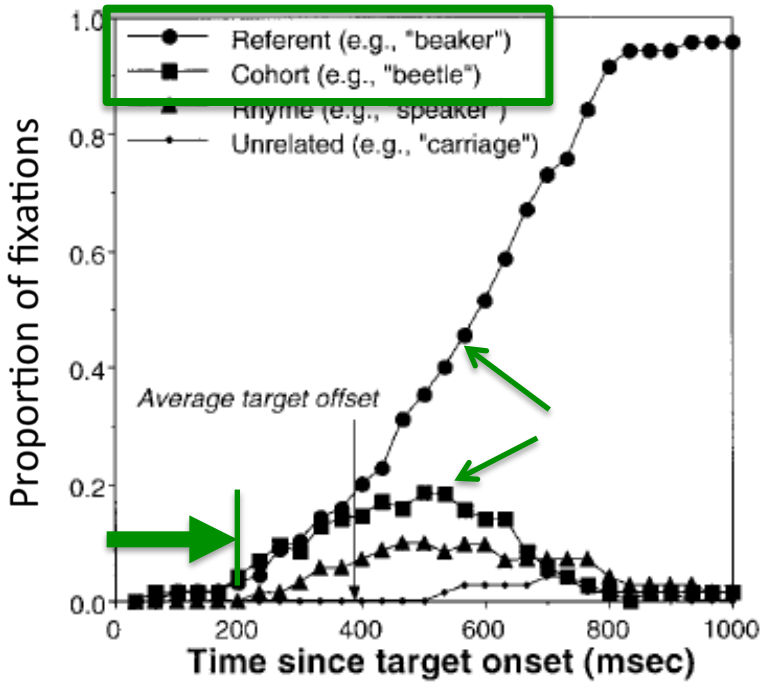


"Click on the beaker"

Allopenna et al. 1998

Visual World paradigm





Allopenna et al. 1998

Eyetracking and boundary tones

- Challenges
  - Meanings are not referential (“question” vs. “statement”)
  - Co-occur with other cues to the speaker’s intention (e.g. syntactic cues)

“Got a” Game

- Participants play against a computer
- Computer has only two moves
  - Make a statement (announce a match)
  - Ask a question (ask for a match)

Heeren et al. 2015

The “Got a” construction

- “Got a candy!” vs. “Got a candy?”

statement

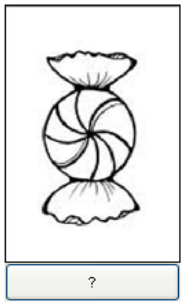
question

- The intonation distinguishes the pragmatic interpretations

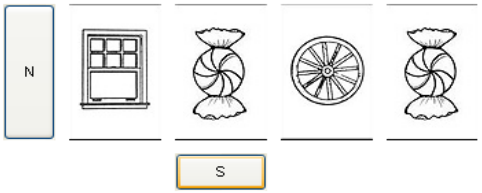
Heeren et al. 2015

“Got a” Game

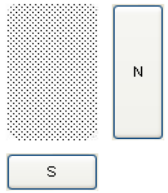
match card



playing cards



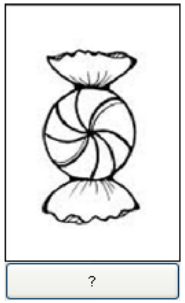
block card



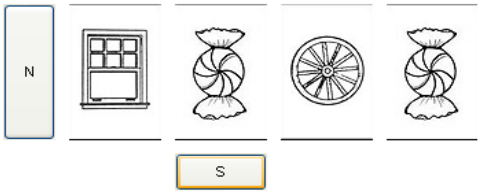
Heeren et al. 2015

Computer makes a statement

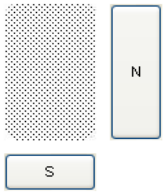
match card



playing cards

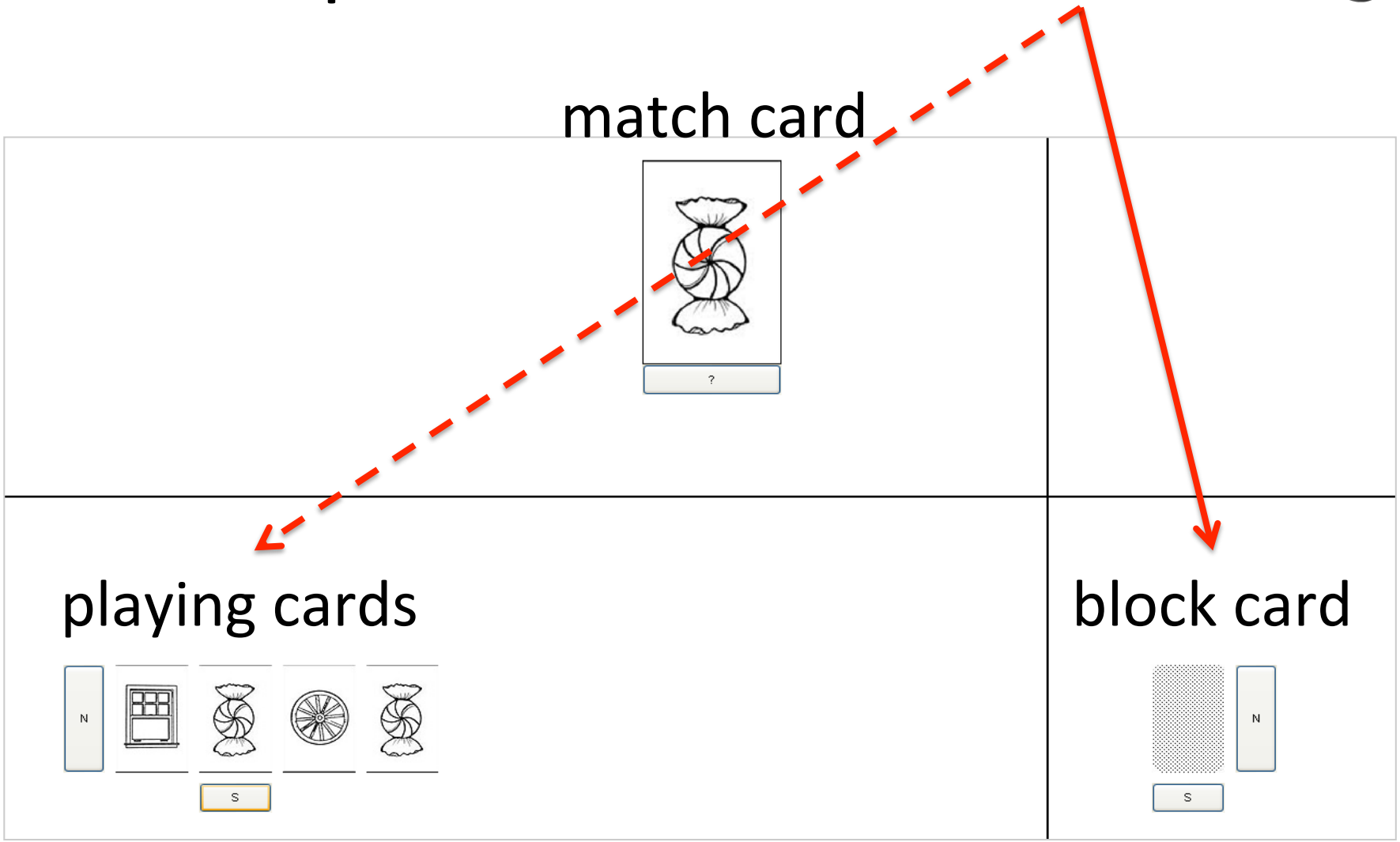


block card



Heeren et al. 2015

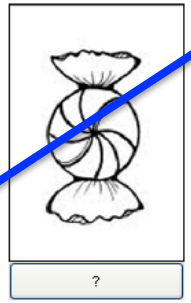
Computer makes a statement



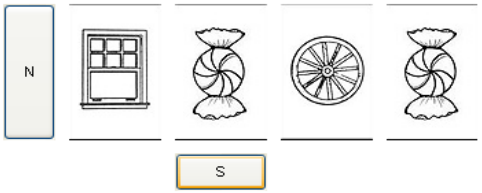
Heeren et al. 2015

Computer asks a question

match card



playing cards



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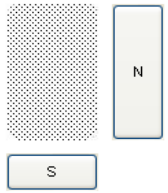
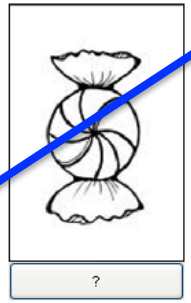


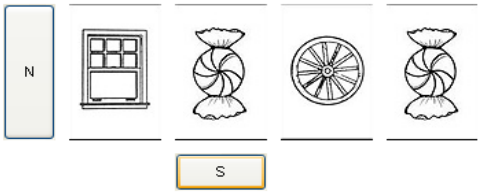
Heeren et al. 2015

Computer asks a question

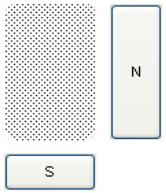
match card



playing cards



block card



Heeren et al. 2015

“Got a” Game

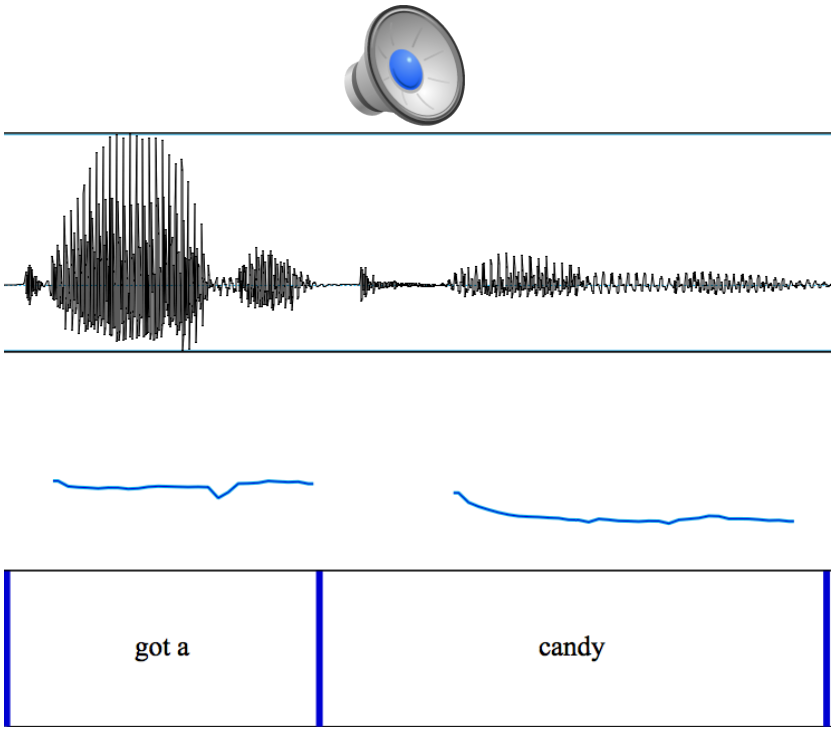
- Critical utterances are elliptical
  - “Got a candy”
- Filler utterances have syntactic cues
  - “Do you have a candy”
  - “I’ve got a candy”

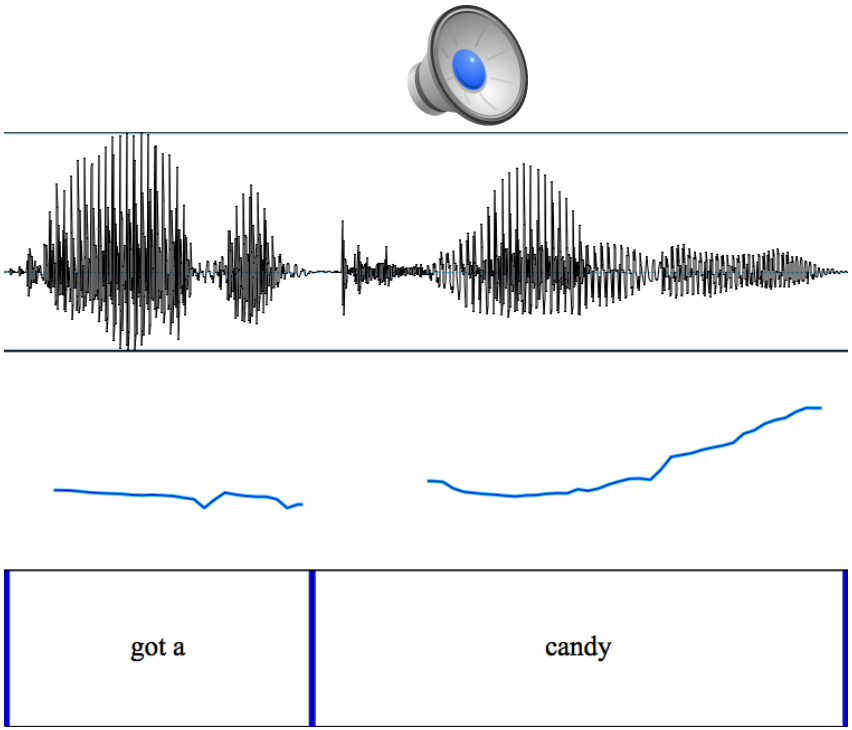
Heeren et al. 2015

Experiments

- Exp 1: test the paradigm
- Exp 2: test the relative importance of pitch accent vs. boundary tone for processing
- Exp 3: test the importance of cues prior to the pitch accent for processing

Experiment 1: stimuli





Heeren et al. 2015

Experiment 1: methods

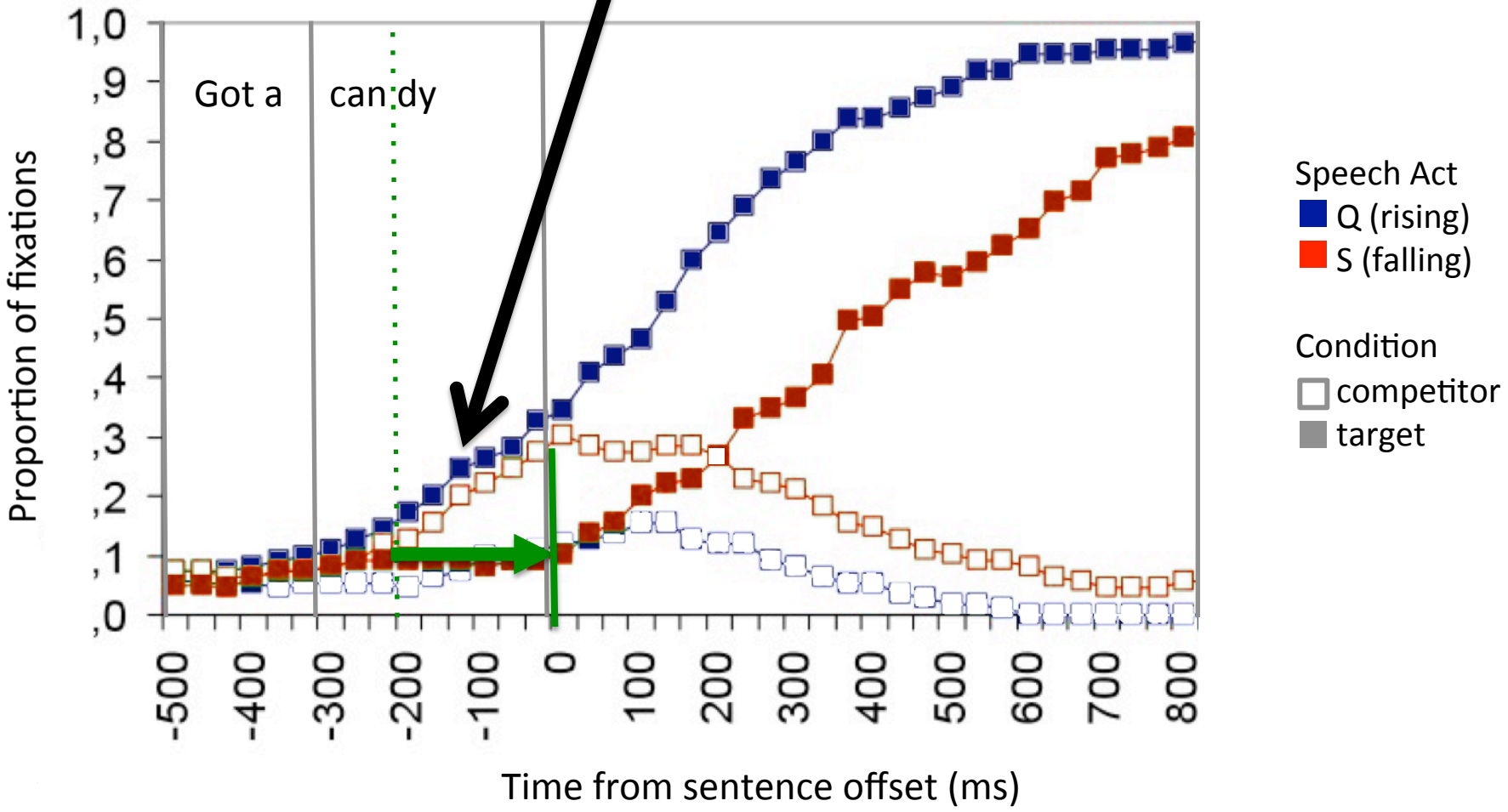
- Target nouns
  - candy, shoe, wheel, window

- Participants = 16

Heeren et al. 2015

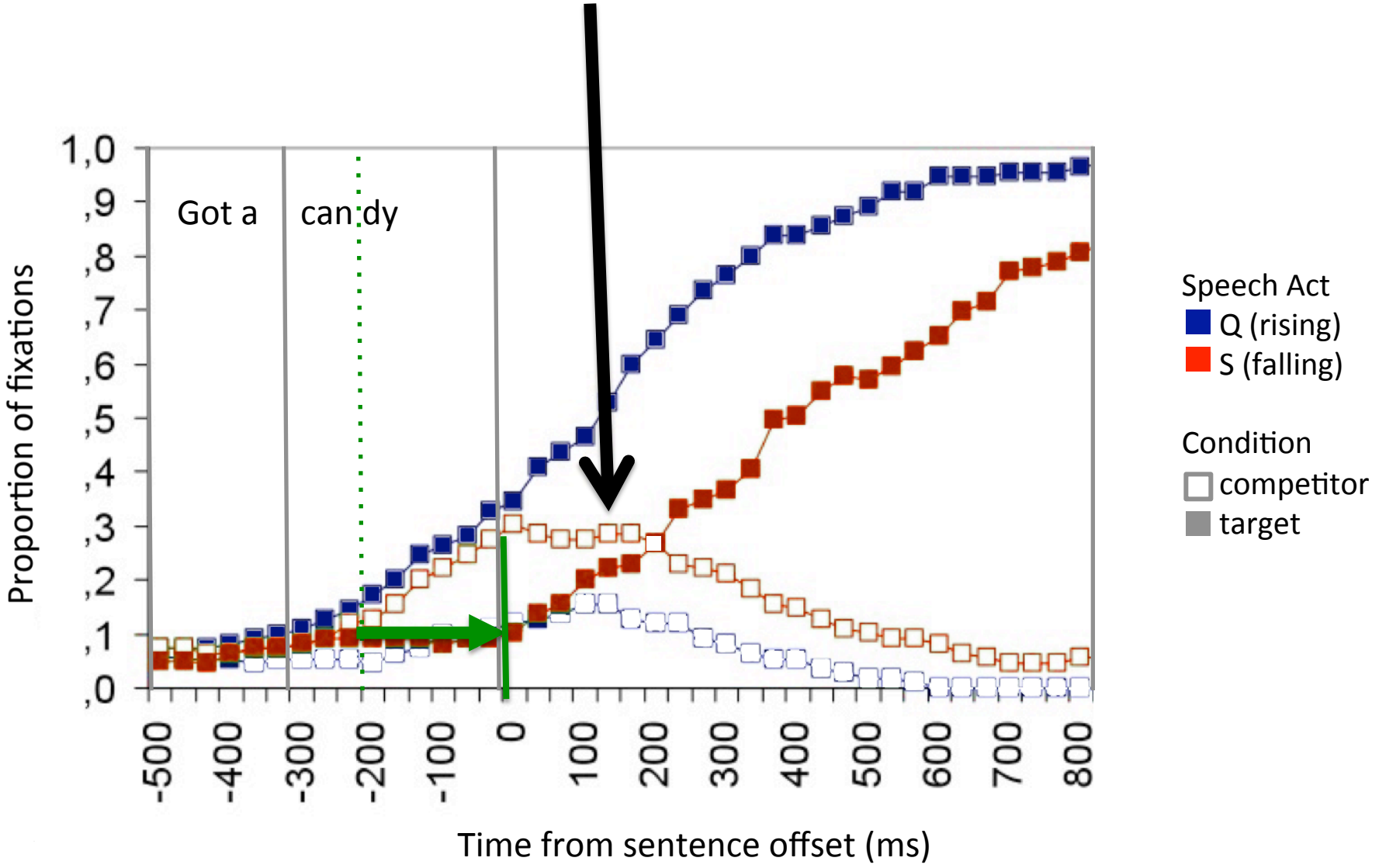
Early bias to fixate the playing cards

- Target for Q, competitor for S



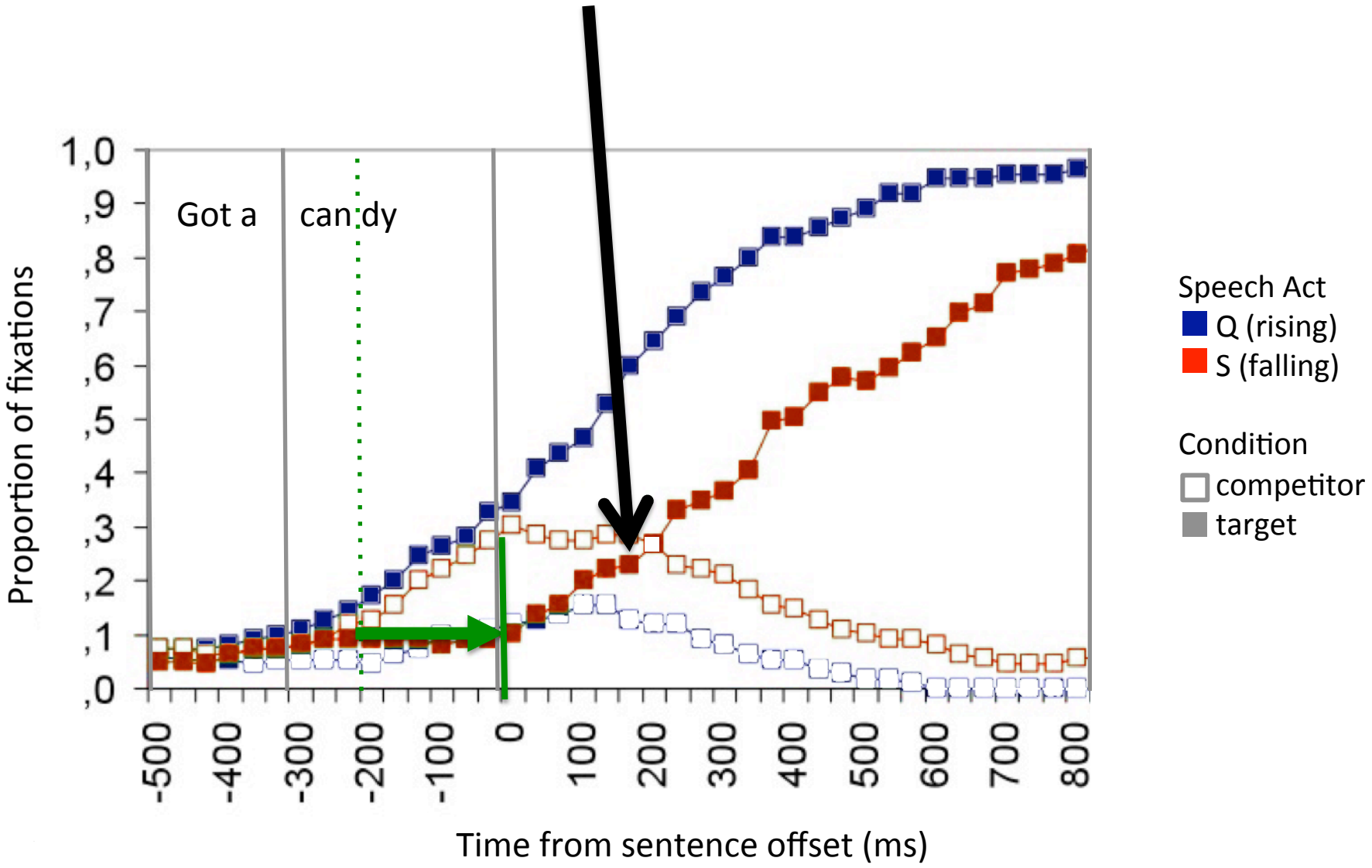
Heeren et al. 2015

Fixations to competitor in S condition drop



Heeren et al. 2015

Fixations to target in S condition rise



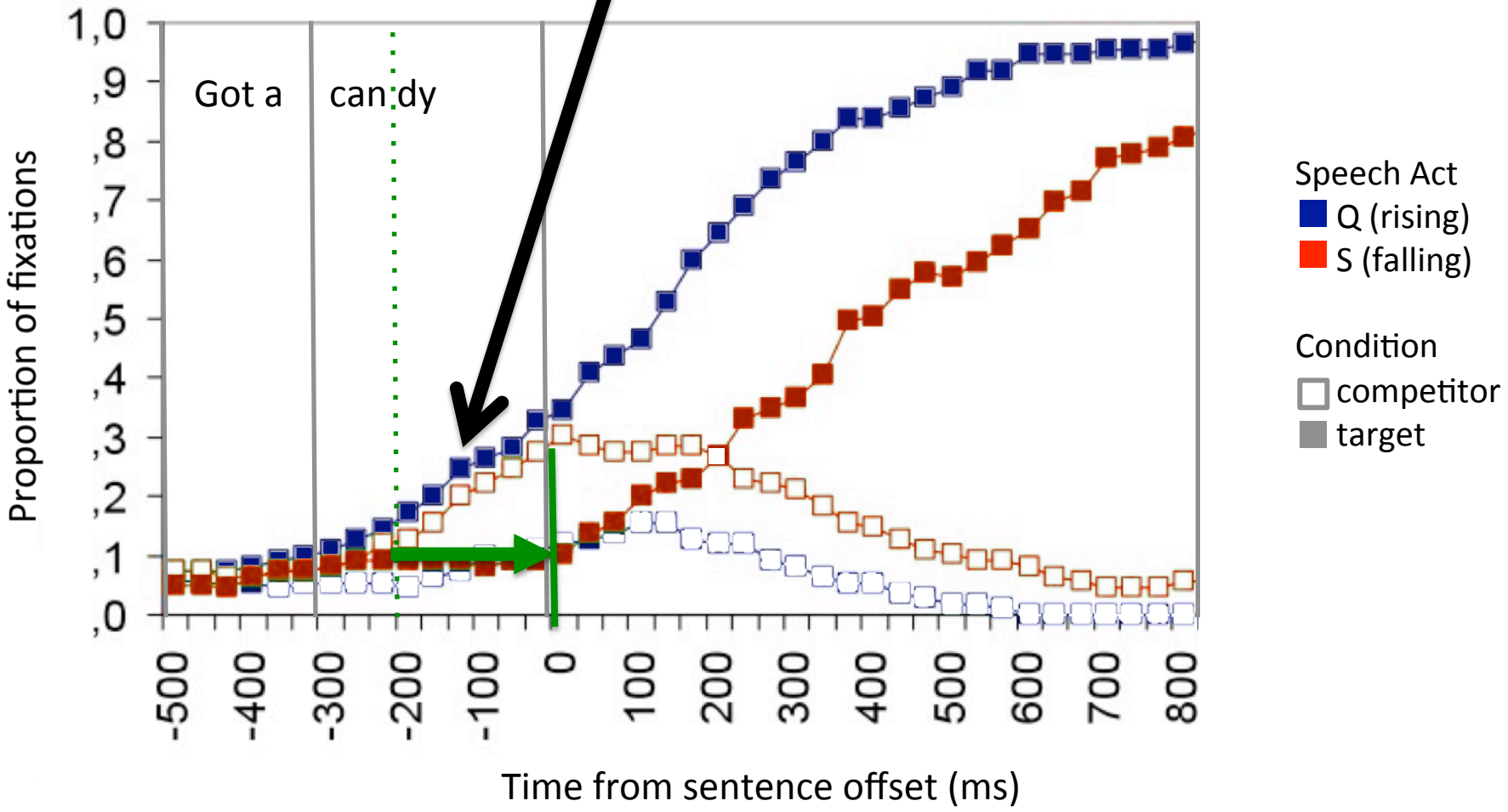
Heeren et al. 2015

Experiment 1: summary

- Listeners interpret contours during the boundary tone.
- Is this evidence for non-incremental processing of intonational contours?

Early bias to fixate the playing cards

- Target for Q, competitor for S



Question

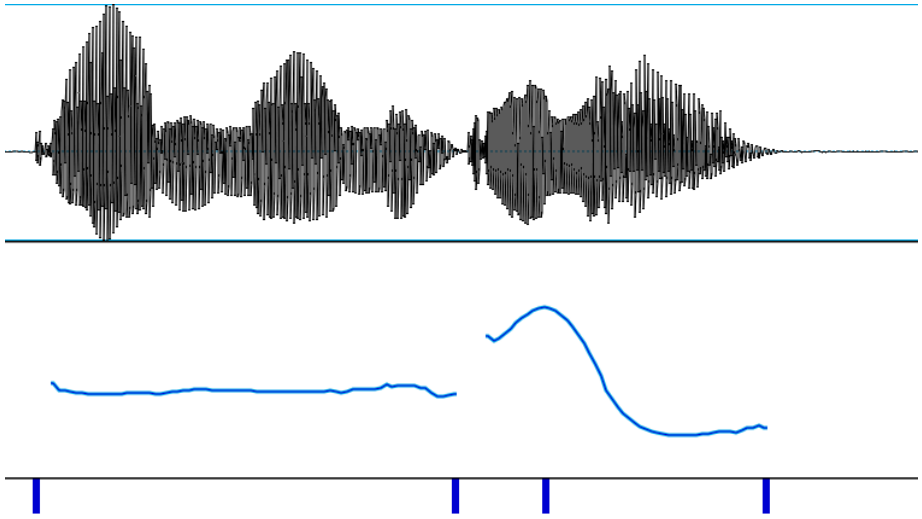
- Can listeners make use of cues earlier in the contour than the boundary tone?

Experiment 2

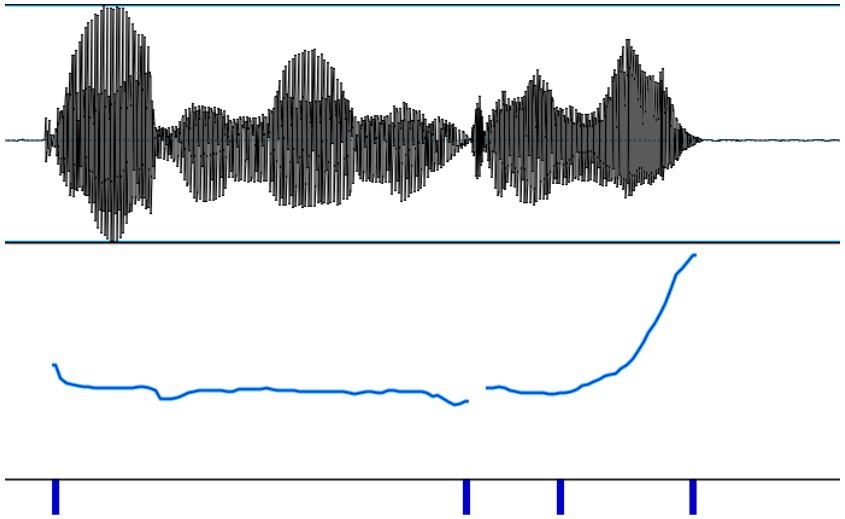
- Substitute new stimuli where we can isolate a point between the pitch accent and the boundary tone

Experiment 2: stimuli

Got an armadillo.

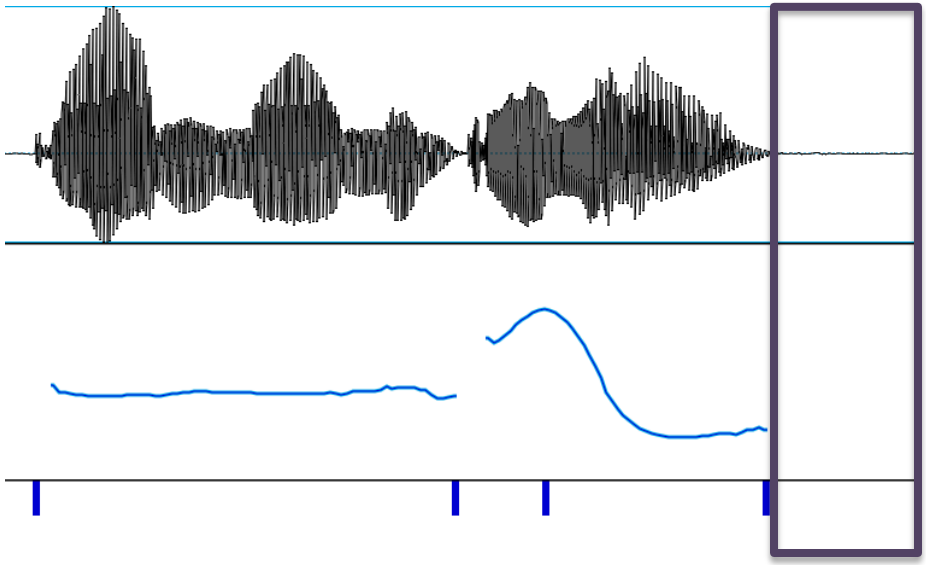


Got an armadillo?

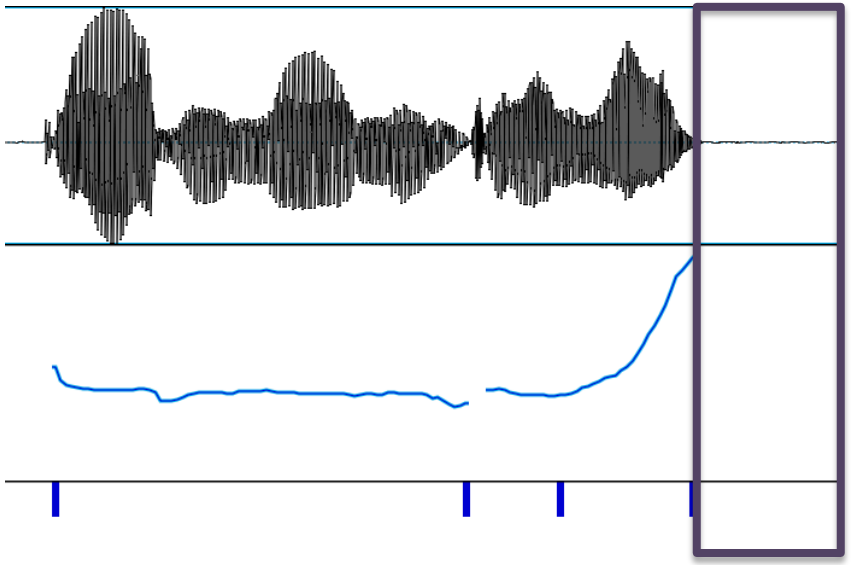


1. Listeners need the full contour

Got an armadillo.

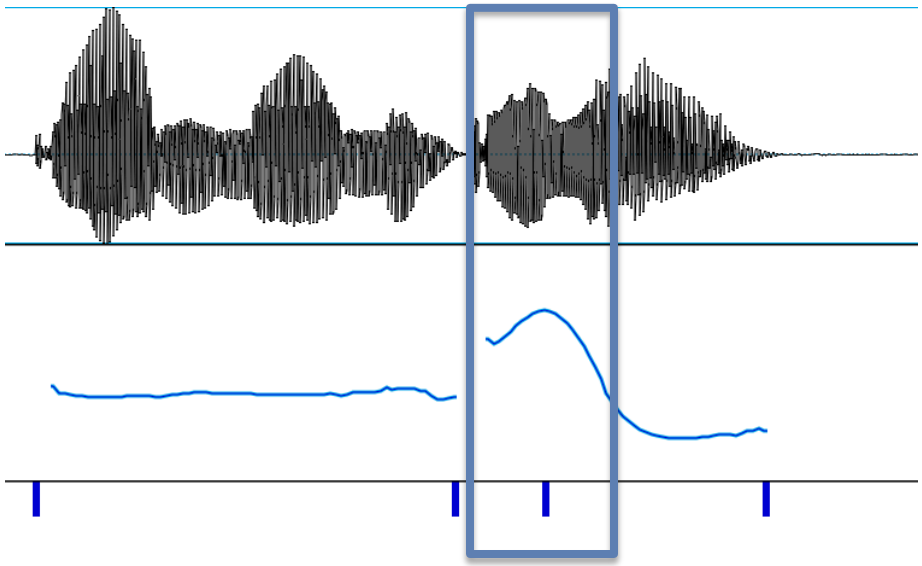


Got an armadillo?

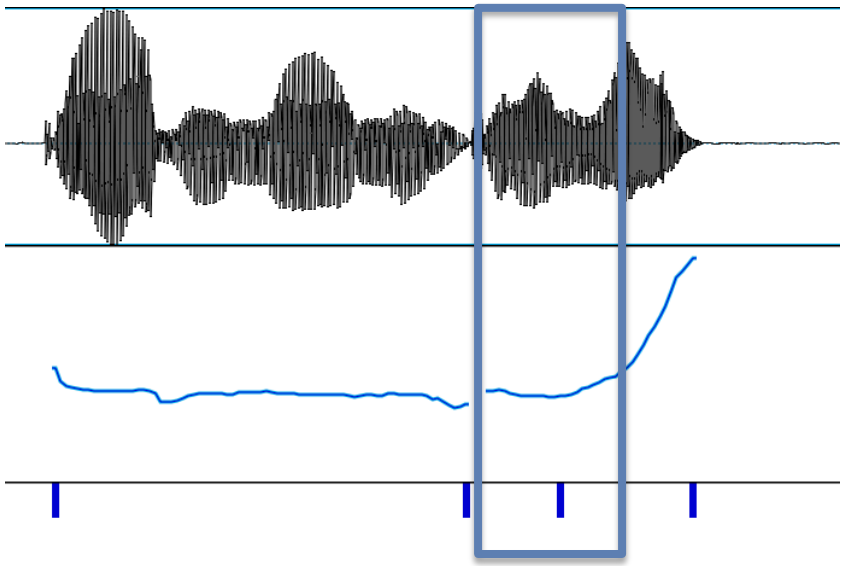


2. Listeners can use the pitch accent

Got an armadillo.



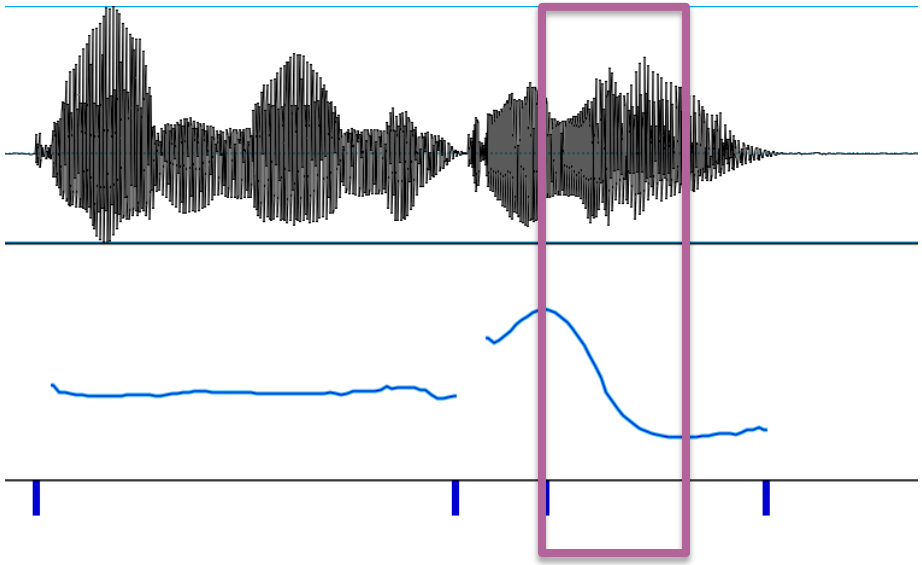
Got an armadillo?



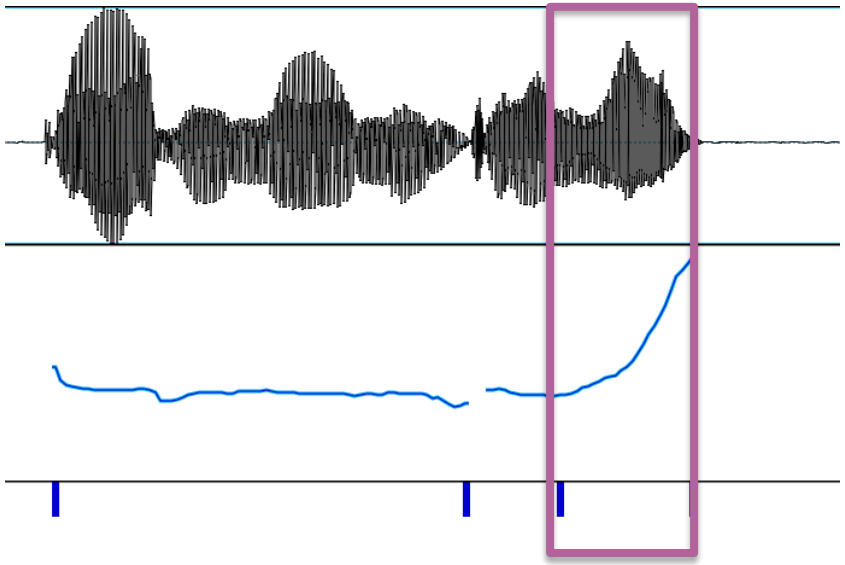
3. Listeners can use the boundary tone onset

(post “turning point”)

Got an armadillo.



Got an armadillo?



Experiment 2: hypotheses

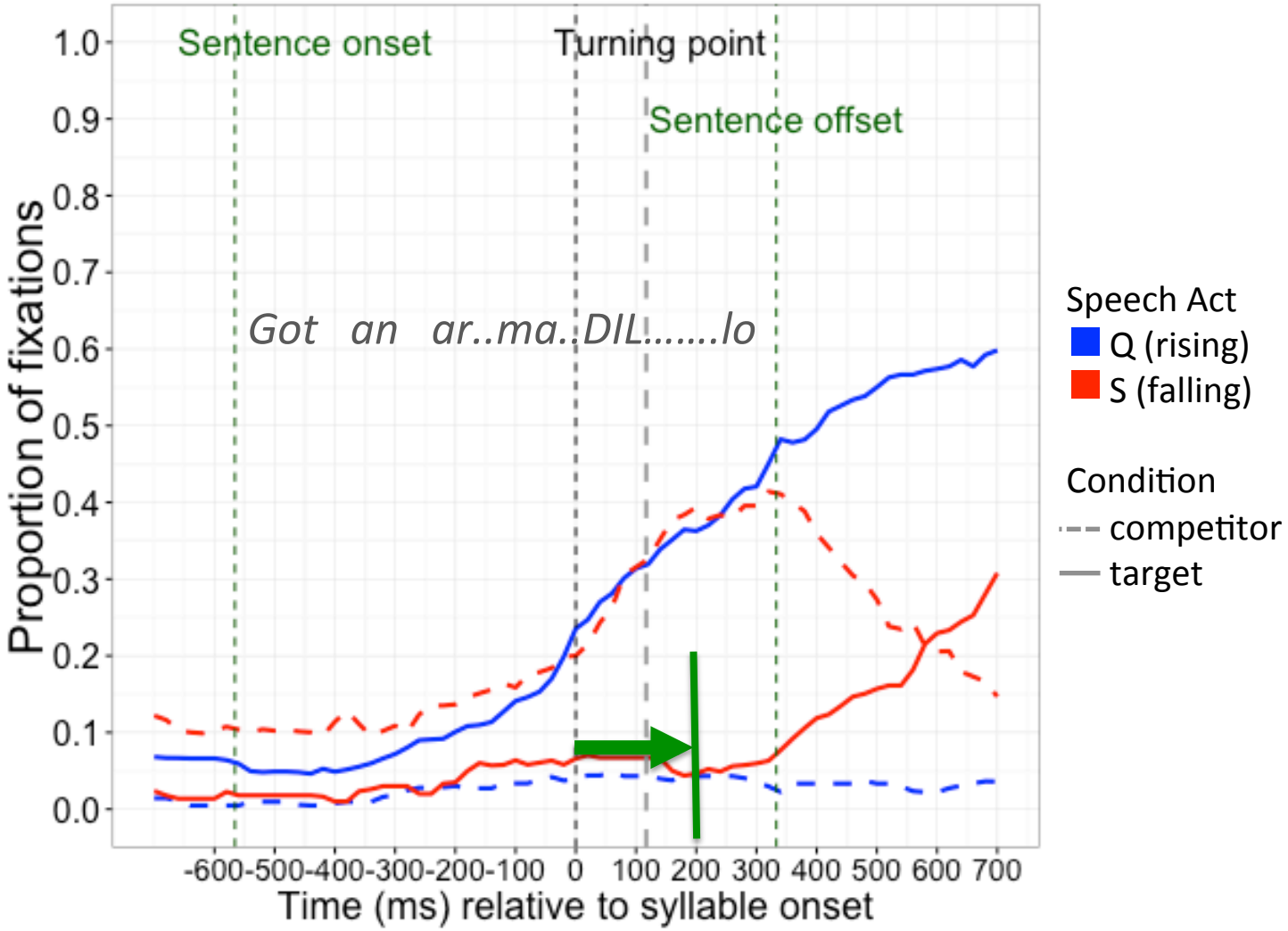
1. Listeners need to wait until they hear the entire contour (the end of the utterance)
2. Listeners can distinguish the contours based on the pitch accent (syllable onset)
3. Listeners can distinguish the contours based on the boundary tone onset (after the *turning point*)

Experiment 2: methods

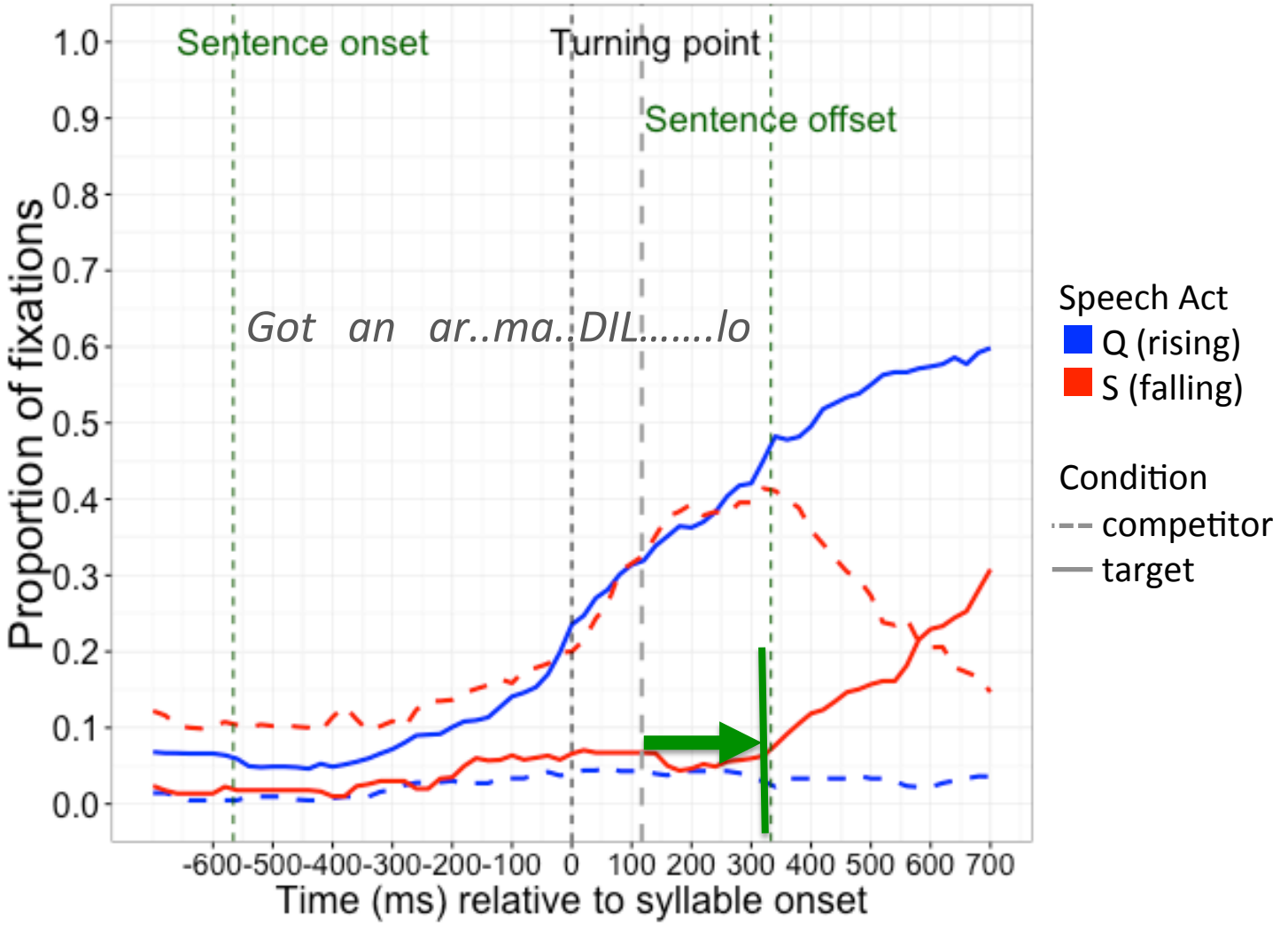
- Target nouns
  - armadillo, ballerina, origami, ravioli

- Participants = 24

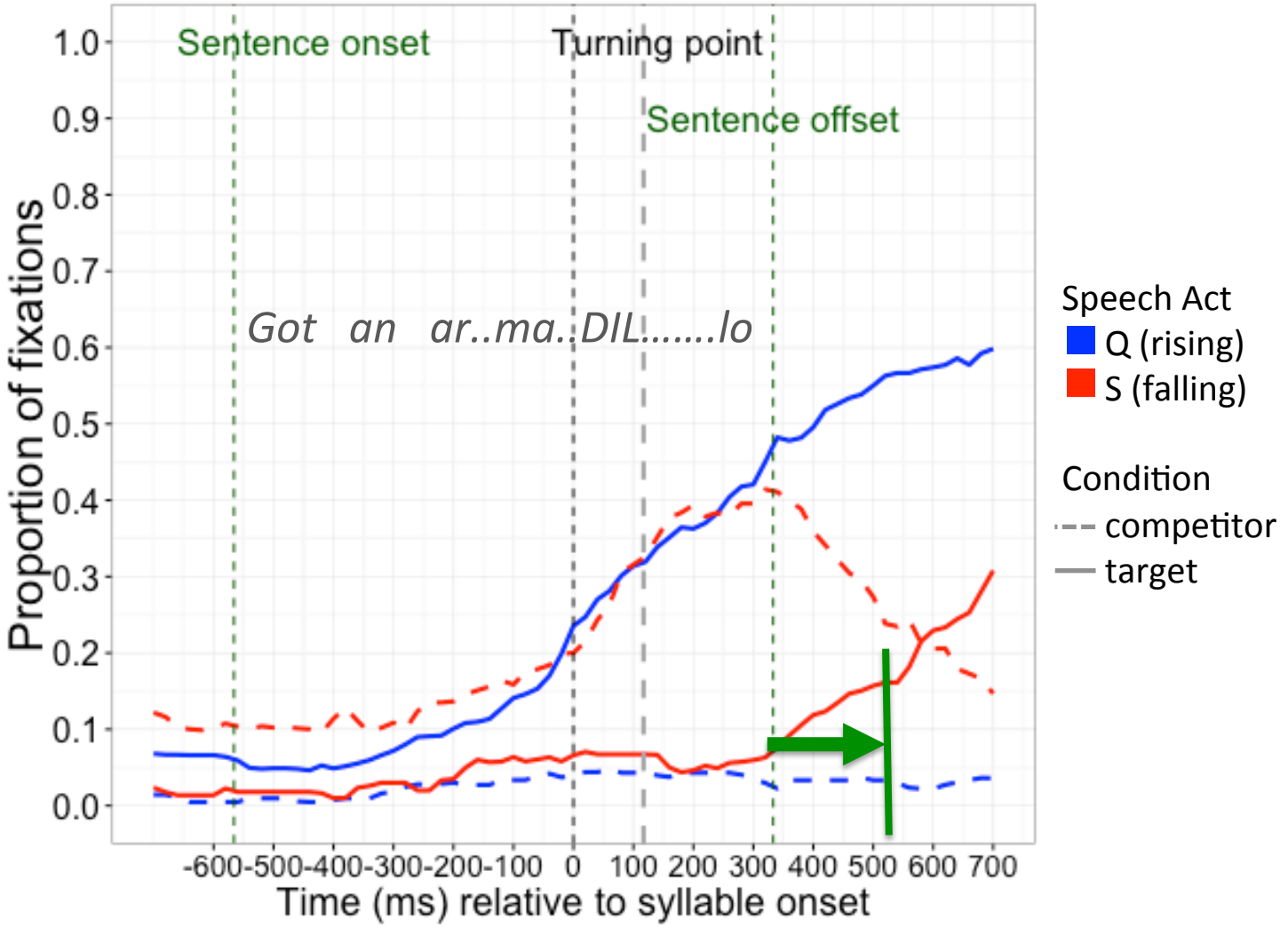
Effects from the pitch accent show up here



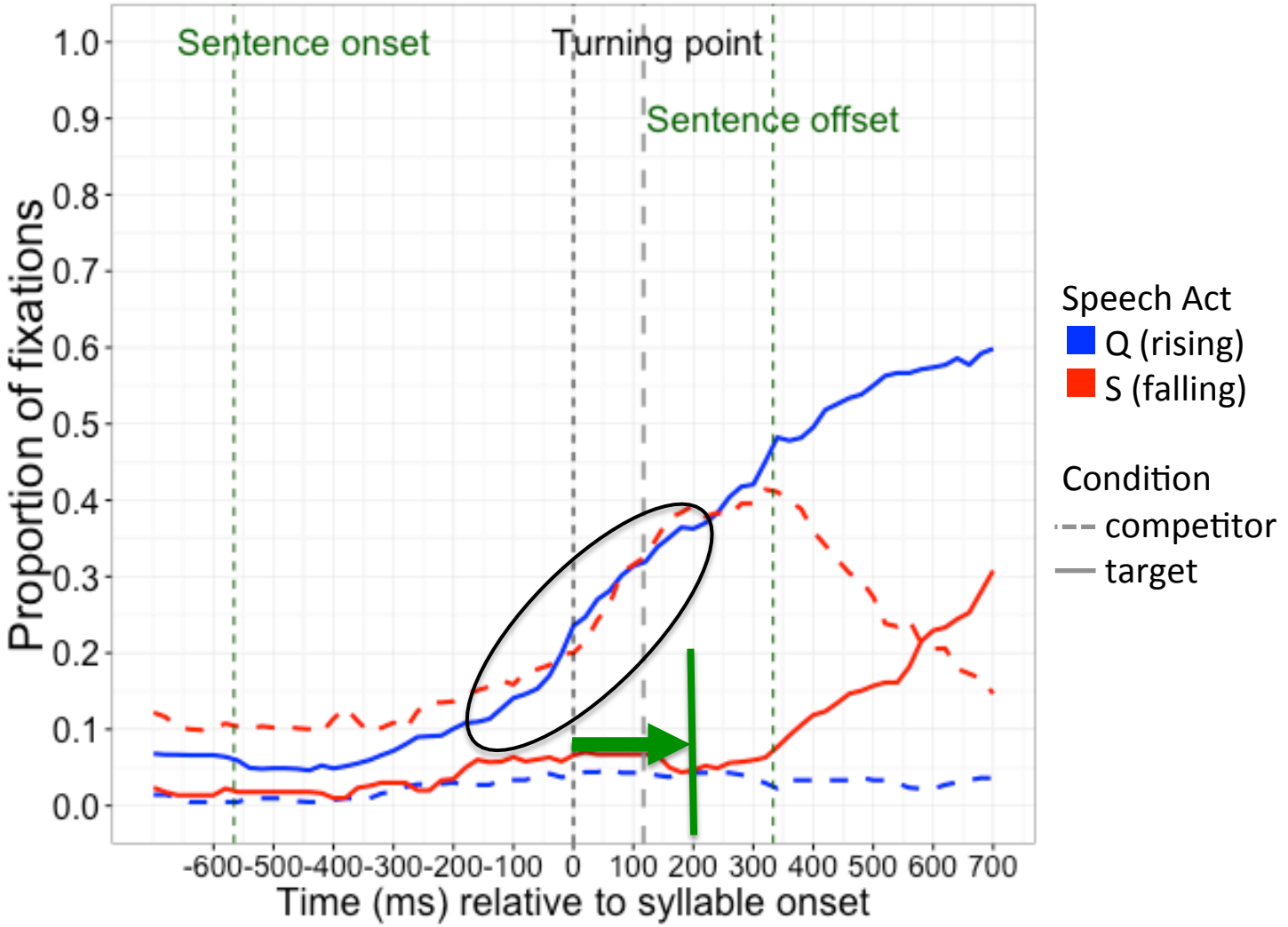
Effects from the boundary tone onset show up here



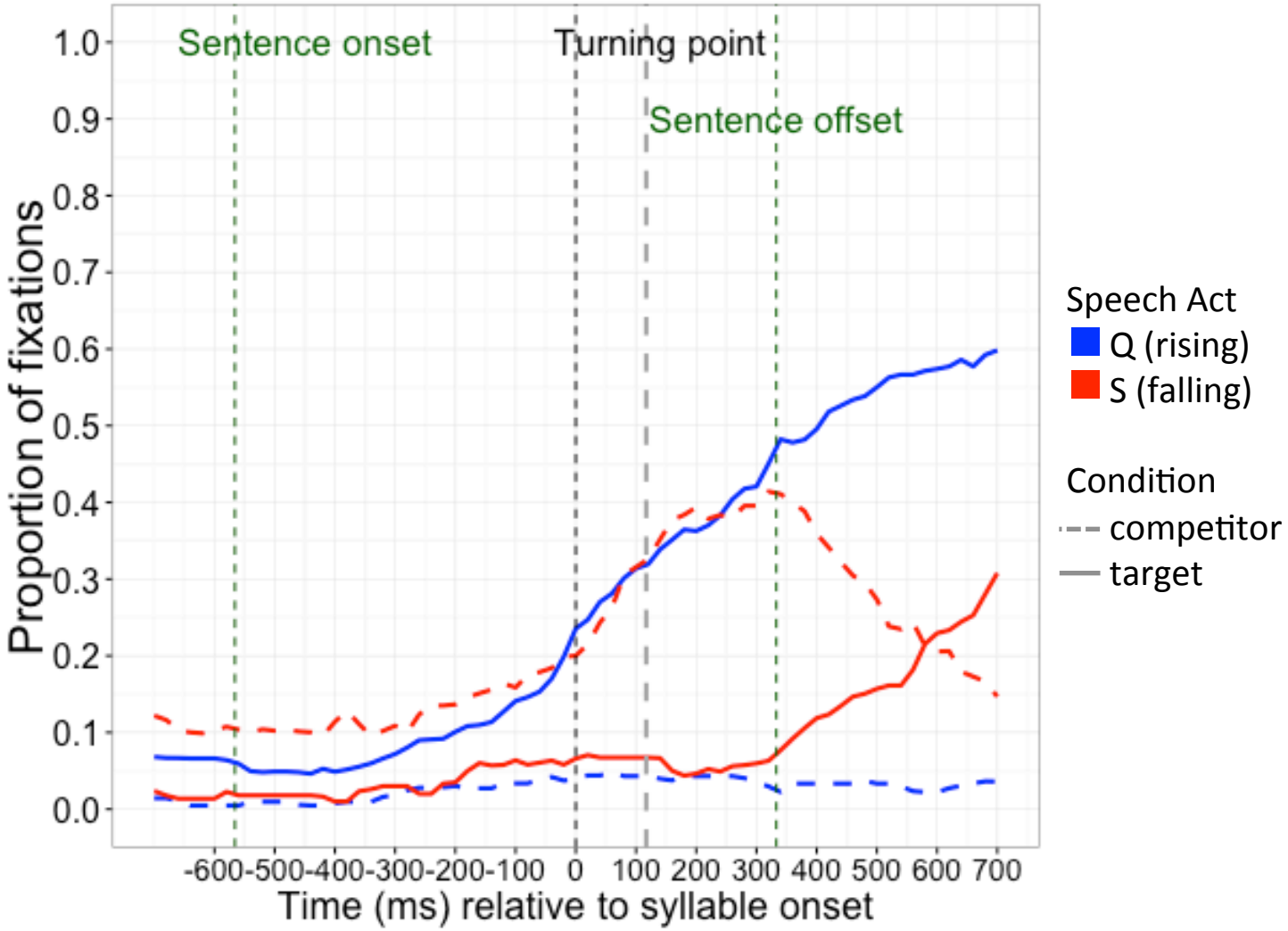
Effects from the full contour show up here



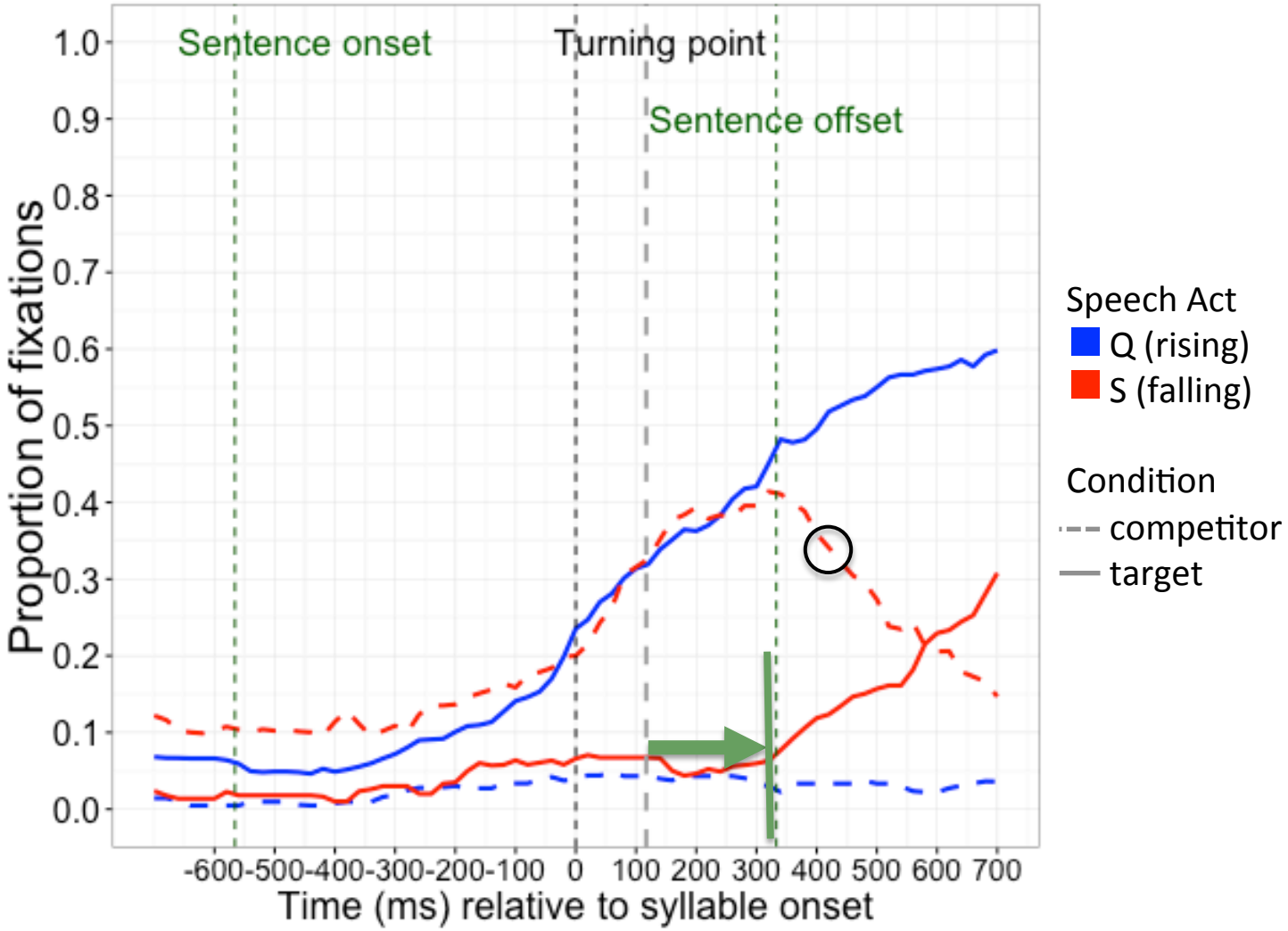
Early bias to fixate the playing cards in both conditions



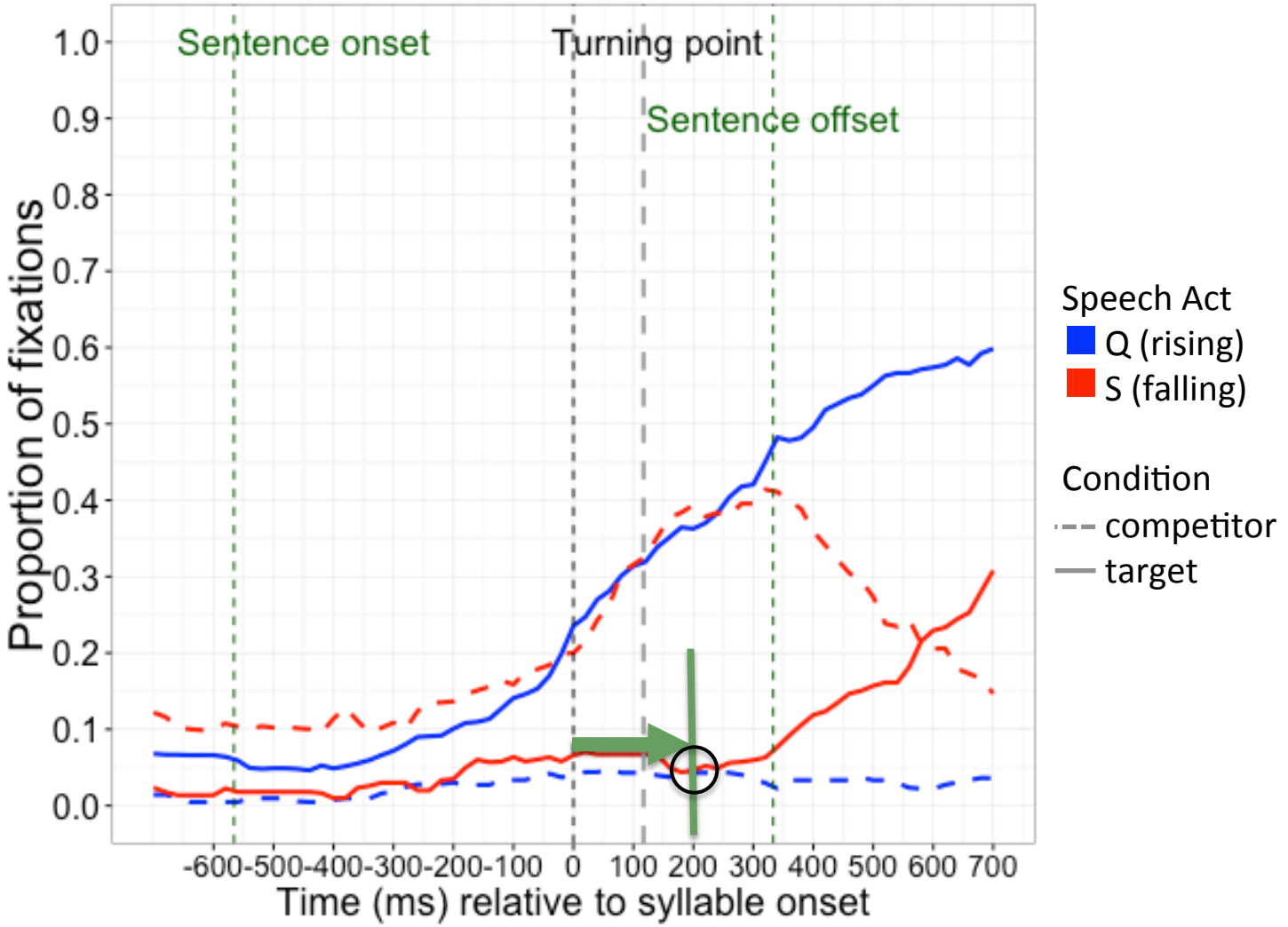
Breakpoint analyses determine where a change in slope occurs for the competitor and target fixations in the S condition



Slope change in fixations to competitor occurs past the turning point



Slope change in fixations to target occurs past the pitch accent



Experiment 2: results

1. Initial bias to fixate the playing cards in both conditions
2. Breakpoint analysis for competitor fixations points to **turning point**
3. Breakpoint analysis for target fixations points to **pitch accent**

Experiment 2: summary

- Some evidence of incremental processing
  - Listeners don't wait until the end of the contour

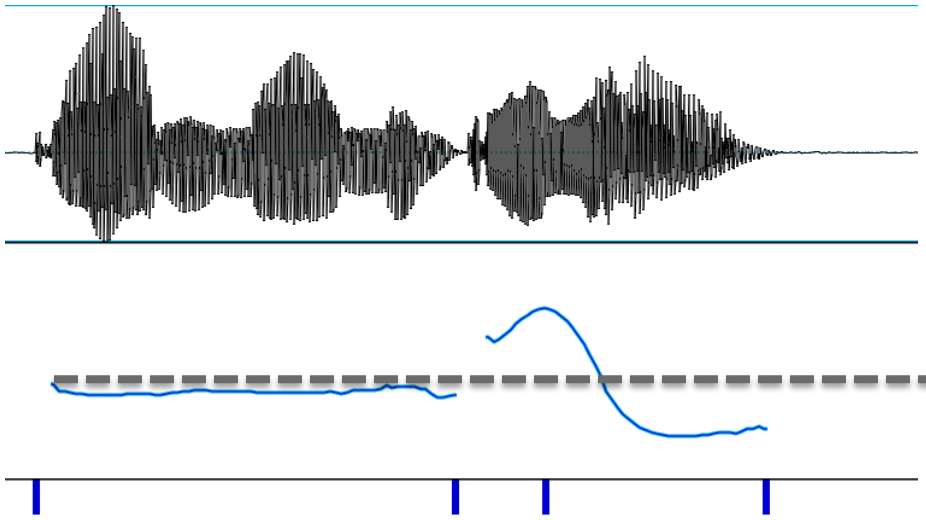
- Not clear what role the pitch accent is playing in processing (if any)

Experiment 3

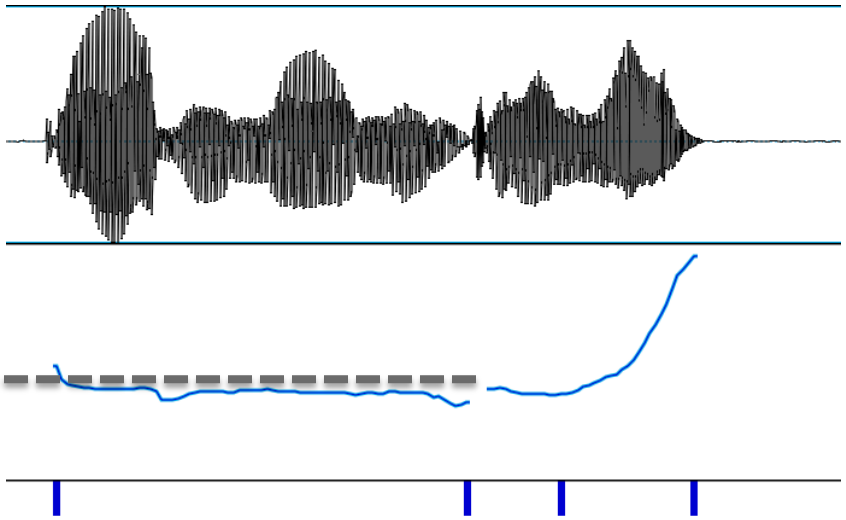
- What happens if the contours are different prior to the pitch accent?
  - Will participants fixate the target even sooner?

Experiment 2: stimuli

Got an armadillo.

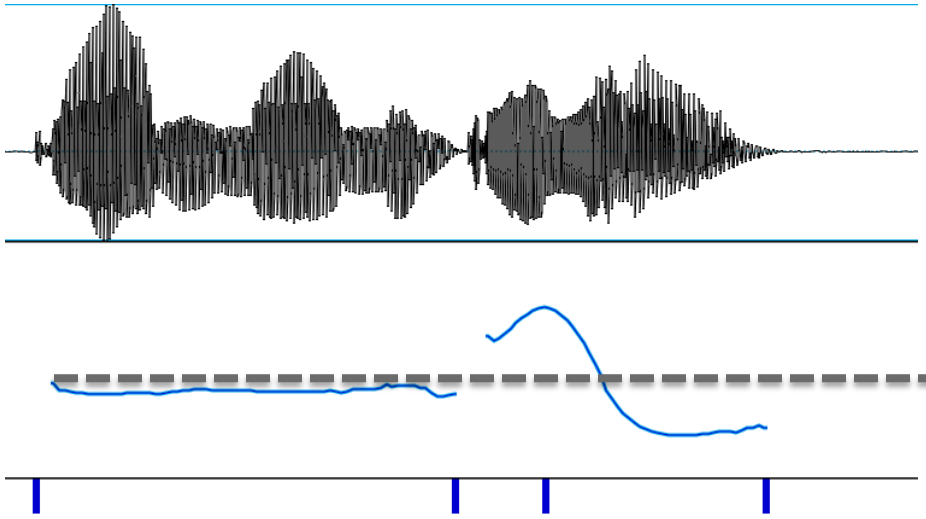


Got an armadillo?

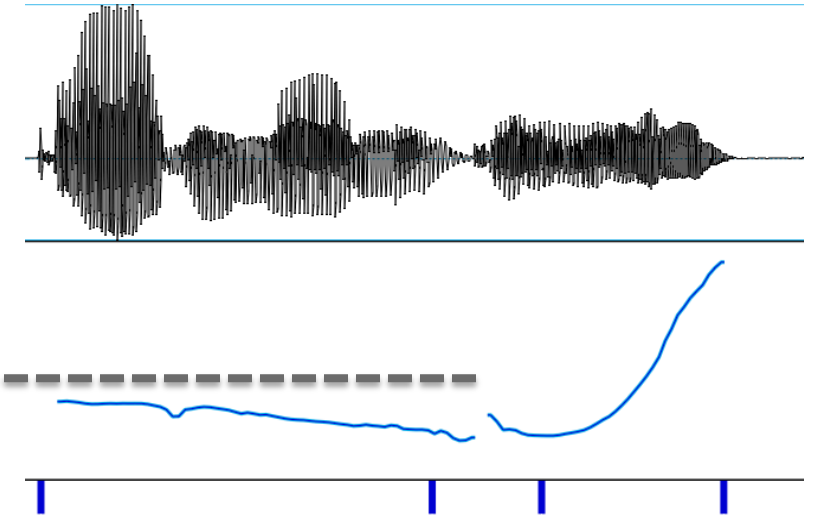


Experiment 3: stimuli

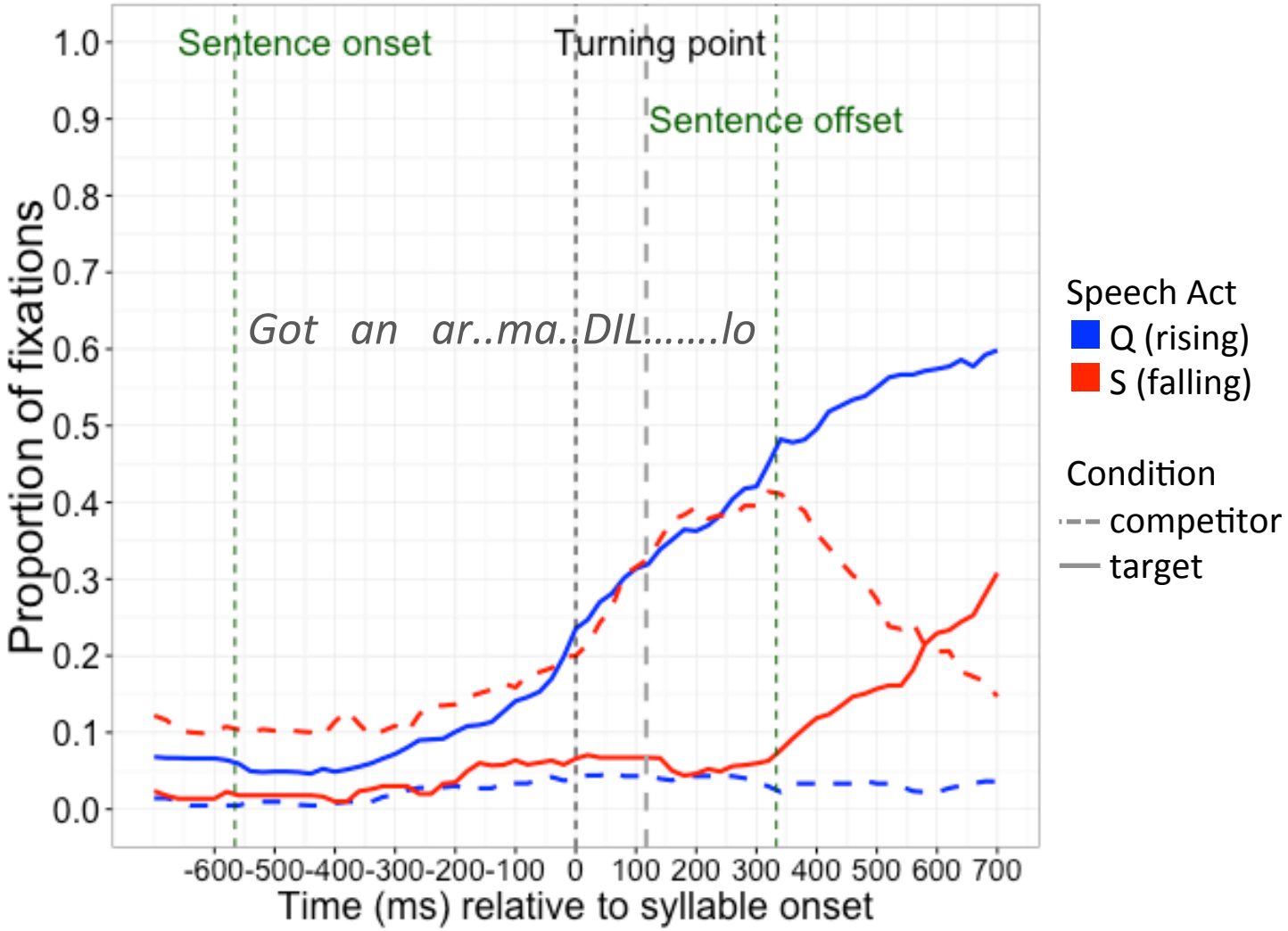
Got an armadillo.



Got an armadillo?

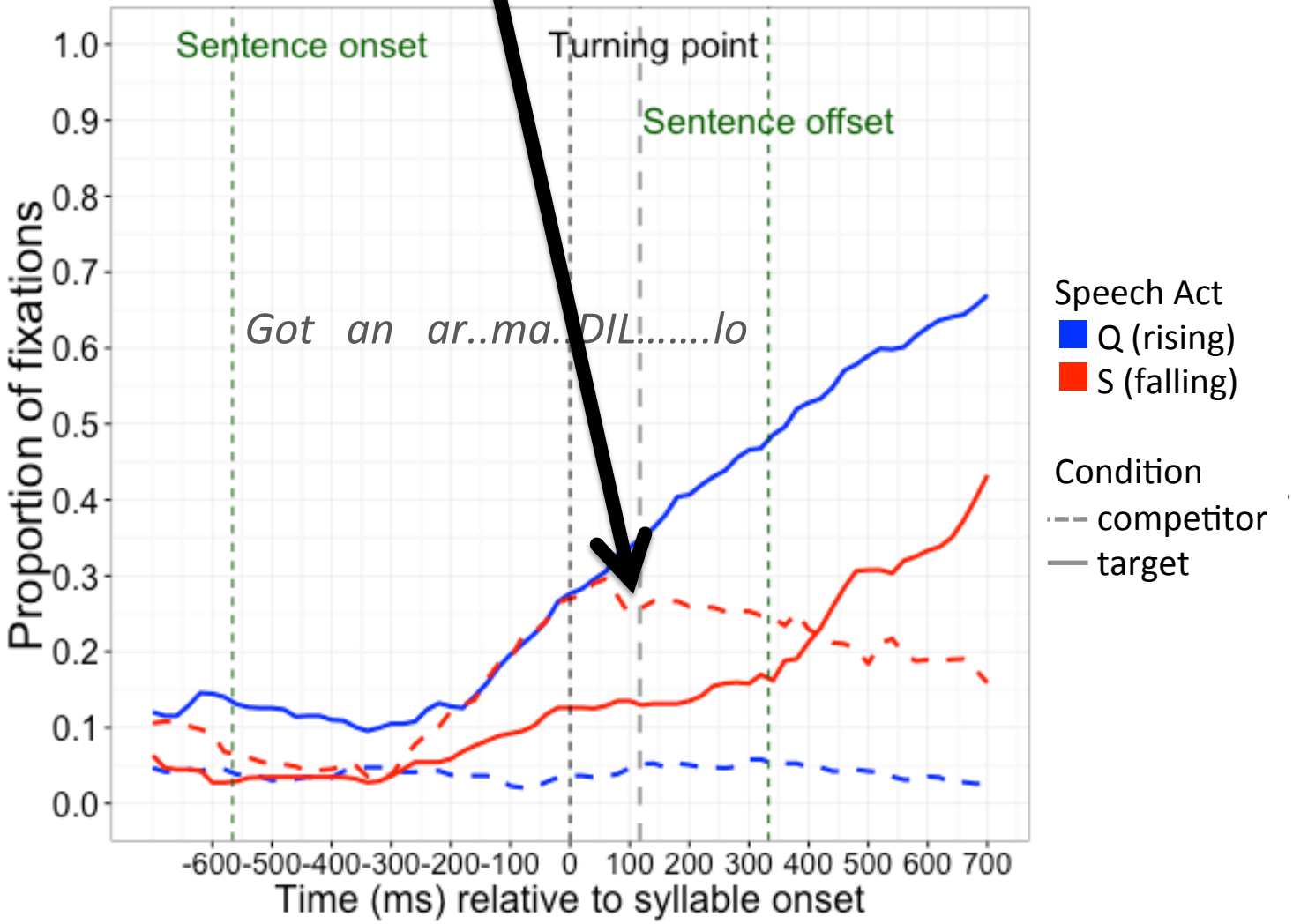


Experiment 2: refresher



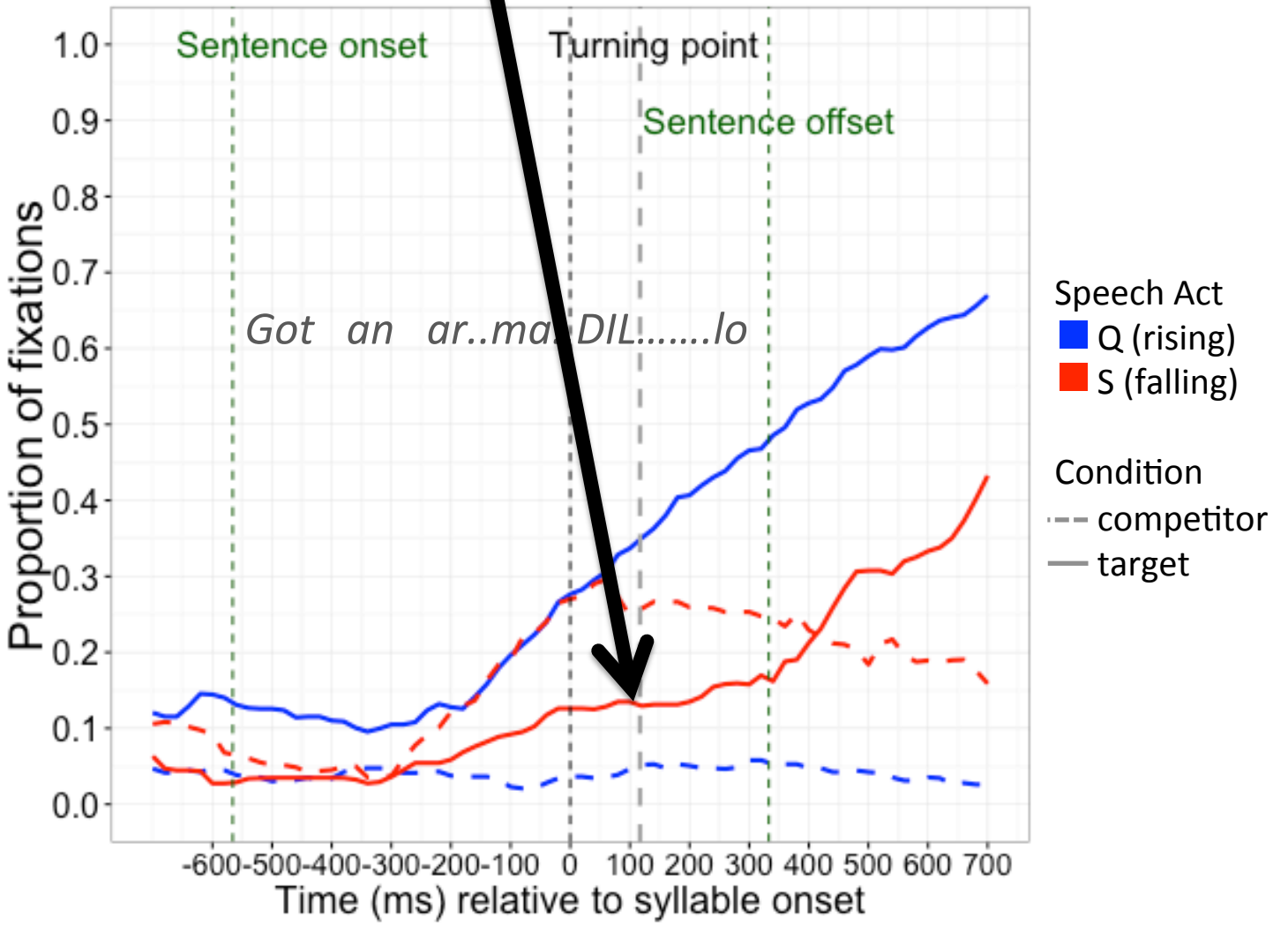
Experiment 3

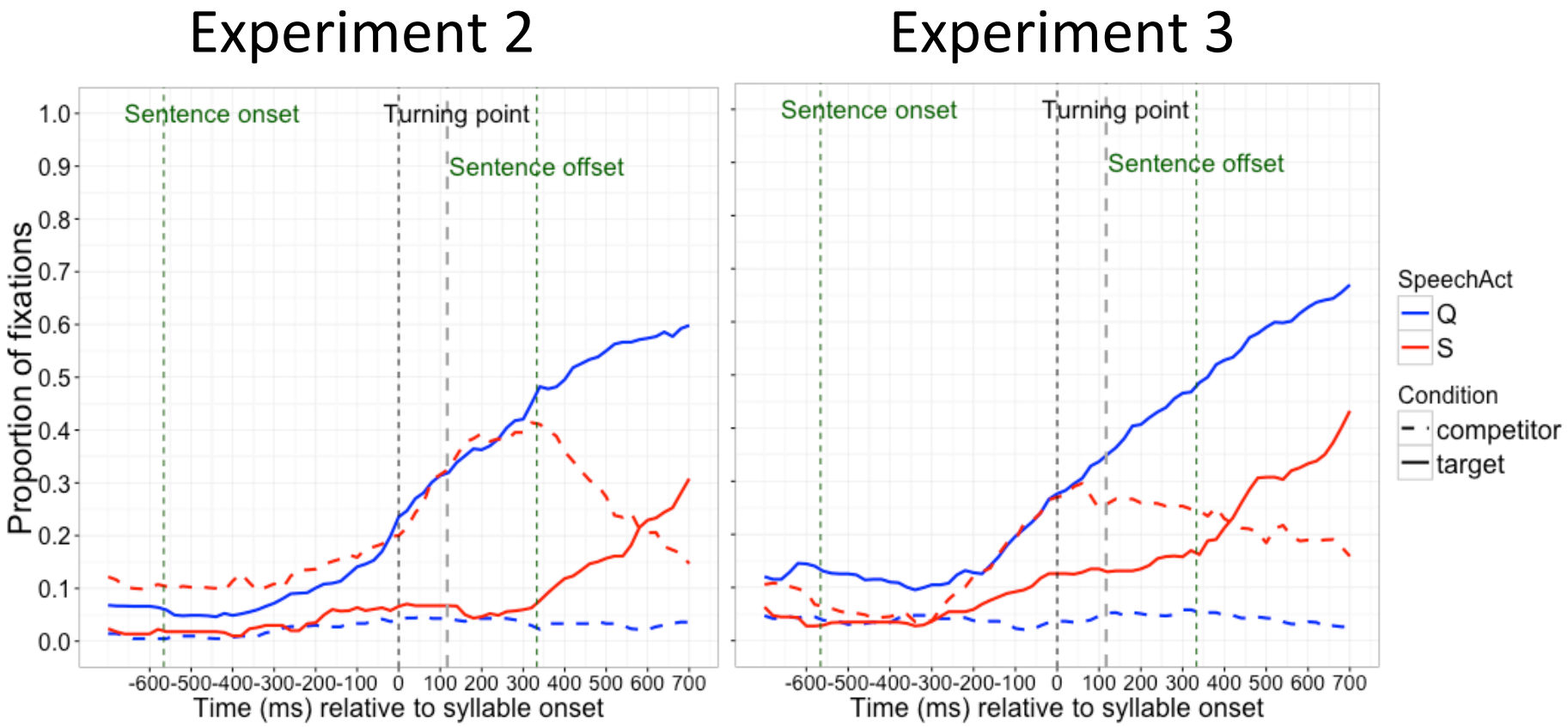
Fixations to competitor in S condition decrease sooner



Experiment 3

Fixations to target in S condition increase sooner




Experiment 2
Experiment 3
Sentence onset
Turning point
Sentence offset
Proportion of fixations
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-600 -500 -400 -300 -200 -100 0 100 200 300 400 500 600 700
Time (ms) relative to syllable onset
SpeechAct
Q
S
Condition
competitor
target

Experiment 3: results

- Listeners look less at the competitor and more at the target in the statements when the contours differ from sentence onset

- Evidence of incremental processing

Takeaway

- Listeners integrate both lexical and intonational cues when interpreting questions vs. statements (intonation wins)
- Listeners can use cues in the contours prior to the boundary offset
- Processing is incremental

Big question

- How do we determine the information conveyed to the listener at each point in an intonational contour?

Future work

- Given that processing incremental, what factors determine how informative each portion of the contour is for listeners?
  - Acoustic, lexical, syntactic, discourse…

Thank you!