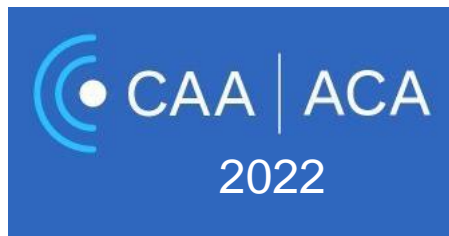


Making listening effort visible in the lab and in the clinic

Matthew Winn

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Funded by R01 DC017114

The University of Minnesota stands on Miní Sóta Makhóche, the homelands of the Dakhóta Oyáte.

Effort is what many people report to be their biggest problem

“... it’s not the deafness that’s a problem, it’s the effort required to get anything from the hearing. It’s all effort.”

—(Participant 012)

Hughes et al., 2018

“It was listening effort rather than the hearing loss that was suggested to negatively impact quality of life.”

Without effort, participant 054 stated “[I] don’t exist, in space.”

People would **disconnect** when they would be “putting a lot of effort in and not getting very much benefit from the effort” (participant 007).

Consequences of elevated listening effort

Increased **need for recovery** time after work

Nachtegaal et al, 2009

More stress-related **sick leave**

Kramer et al, 2006

Increased **unemployment**
among young adults

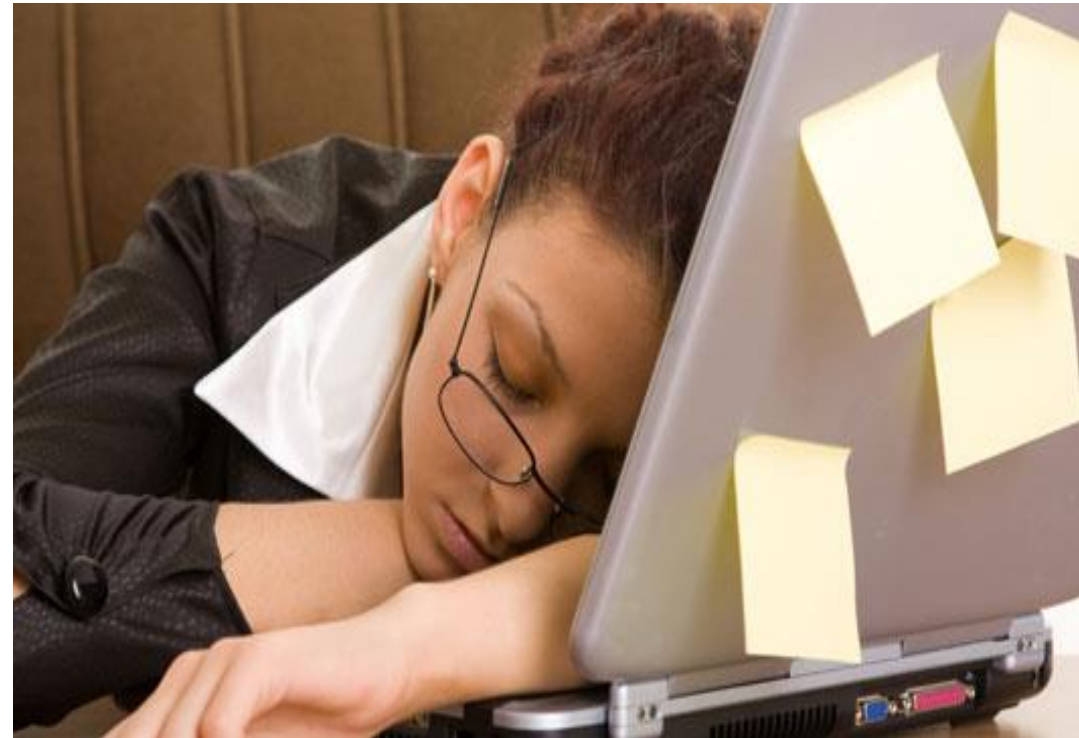
Parving & Christensen 1993,
Järvelin et al, 1997

Early **retirement**

Danermark & Gellerstedt 2004

Social isolation

Demorest & Erdman 1987; Grimby & Ringdahl 2000; Hughes et al. 2018



This is the situation we want to understand:

This chocolate is so delicious!

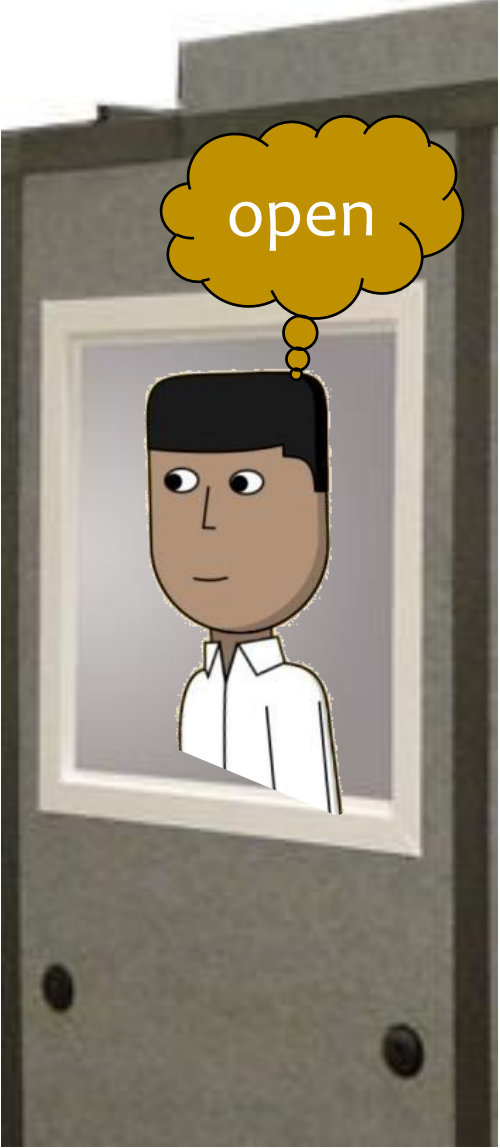
cake



“The salon is not on Mondays”



open



This is the situation we want to understand:



The timing of effort is very important

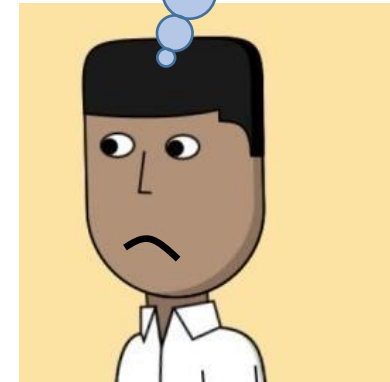
This chocolate
is so delicious!

The cake is the best part

cake

I got it at the
4th

Wait what
was the
best part?



Takeaway points:



“Correct” speech responses can be effortful
if the listener mentally repairs misperceived words

The effort of mental repair can block perception of later words

****** we systematically ignore this in our clinical tests *****

Listeners can't detect effort of mental repair in the voice

Speculations from earlier projects

CI listeners might be using context retroactively
to correct earlier mistakes

For NH listeners, benefit
of context is *immediate*

For CI listeners,
benefit of context is
after the sentence

Winn (2016 Trends in Hearing)

Perception of digit triplets
was poorer following
low-context (higher-effort) sentences

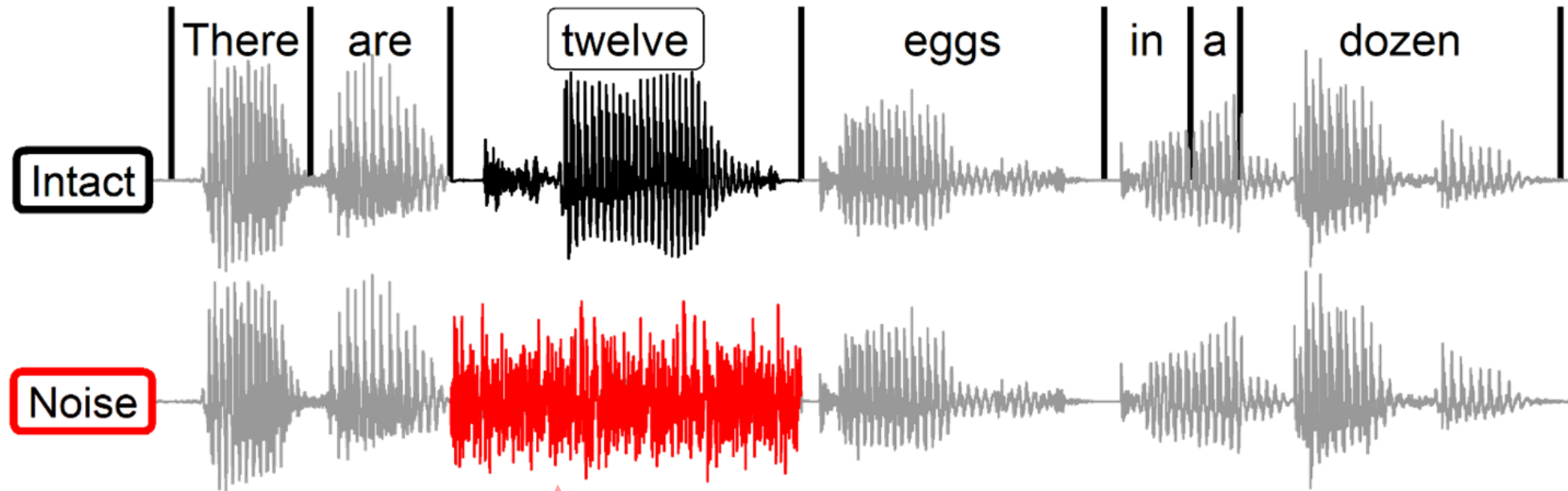
Winn & Moore (2018 Trends in Hearing)

[CI] benefit of slower speaking rate
is observed after the sentence

Winn & Teece (2020 Ear & Hearing)

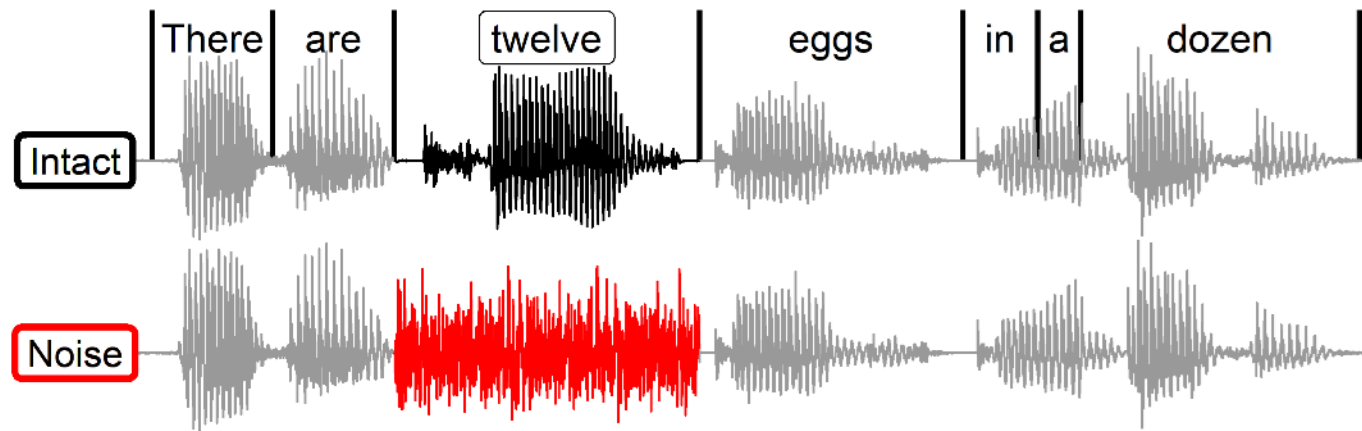
Stimuli

designed to elicit mental repair



The listener would mentally repair “twelve”
and it looks like perfect intelligibility

In some trials, the sentence has a key word **masked by noise**



Key feature: context helps you work BACKWARDS to repair an earlier word in the sentence.

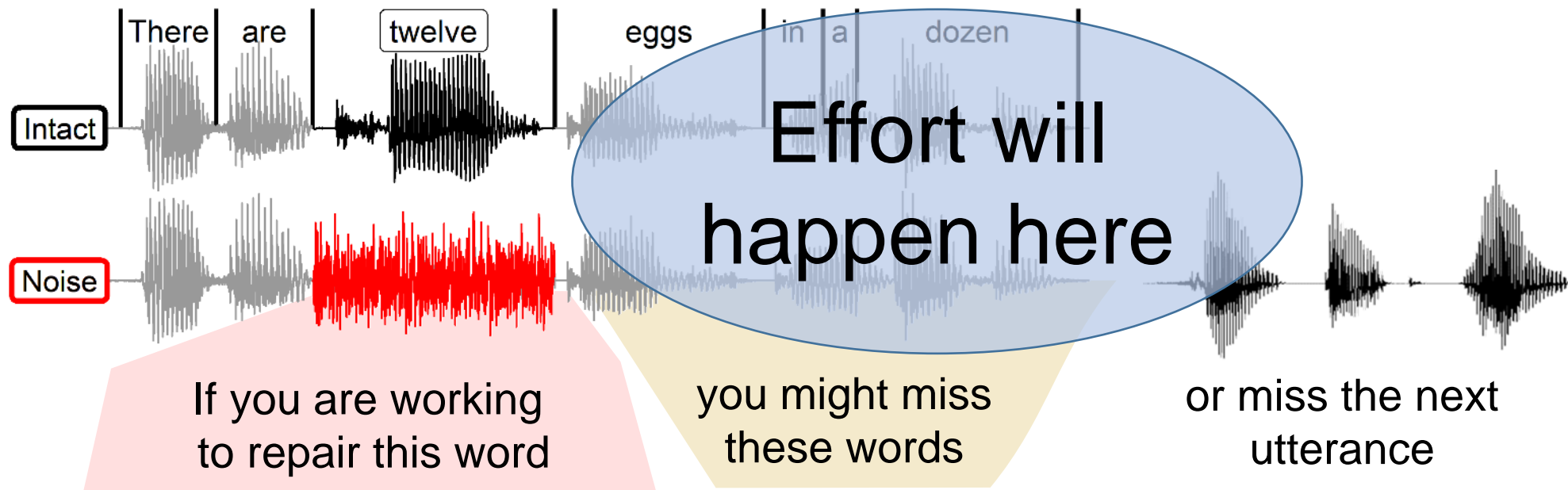
The woman **XXXXX** her candle with a match

The man was **XXXXX** so he opened his map

It was **XXXXX** outside so she needed her umbrella

They say a **XXXXX** is worth a thousand words

*Position controlled, context controlled,
time-locked to measurement of effort*



Intact

There

are

twelve

eggs

in

a

dozen

Effort will
happen here

Noise

If you are working
to repair this word

you might miss
these words

or miss the next
utterance

Measurement of effort using pupil dilation

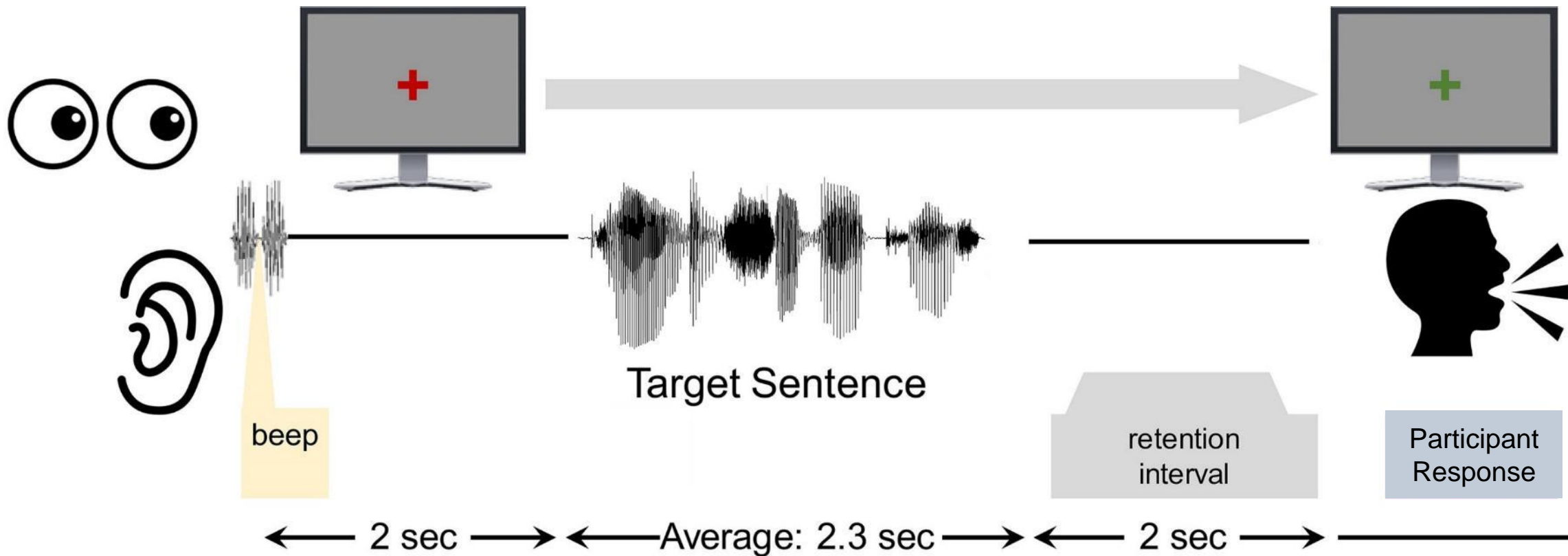
Proportional change in pupil size

0

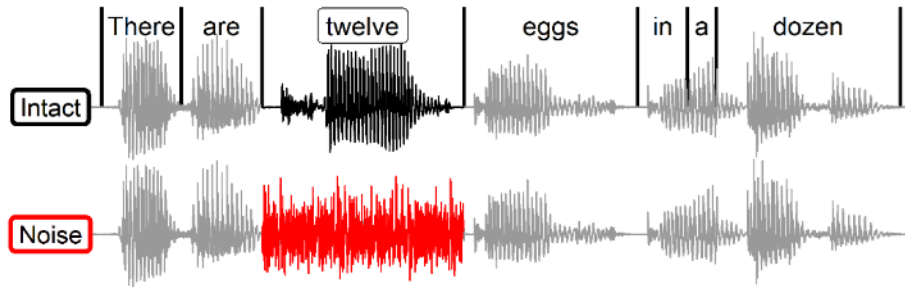
Stimulus

Wait

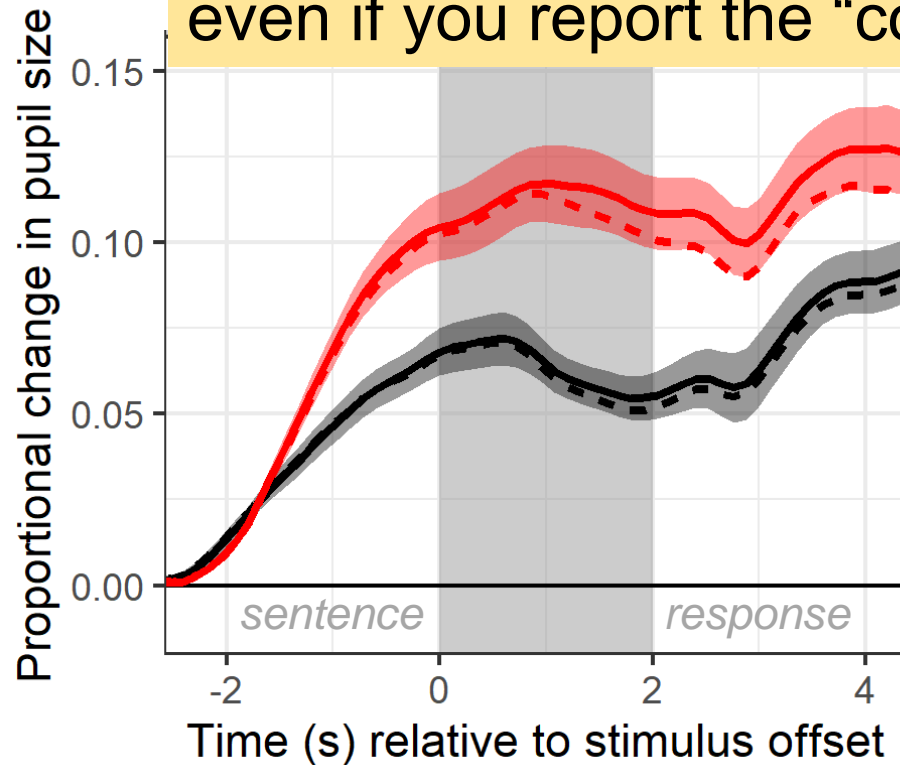
Response



Data from 17 adults with CIs



Mentally repairing misperceived words is effortful, even if you report the “correct” answer

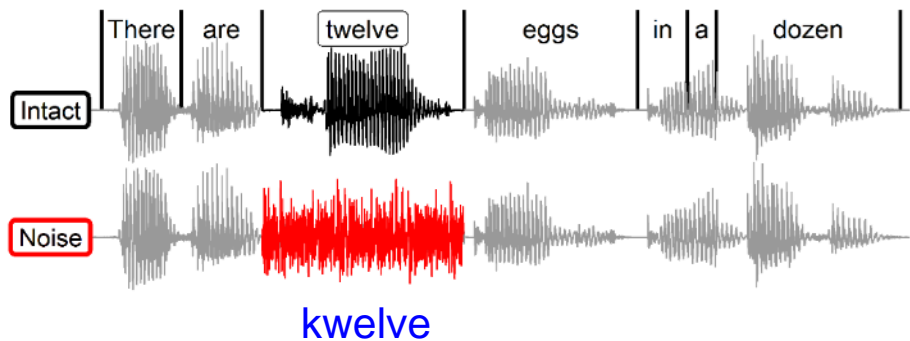


There are  eggs in a dozen
Mentally repaired

Intact sentences

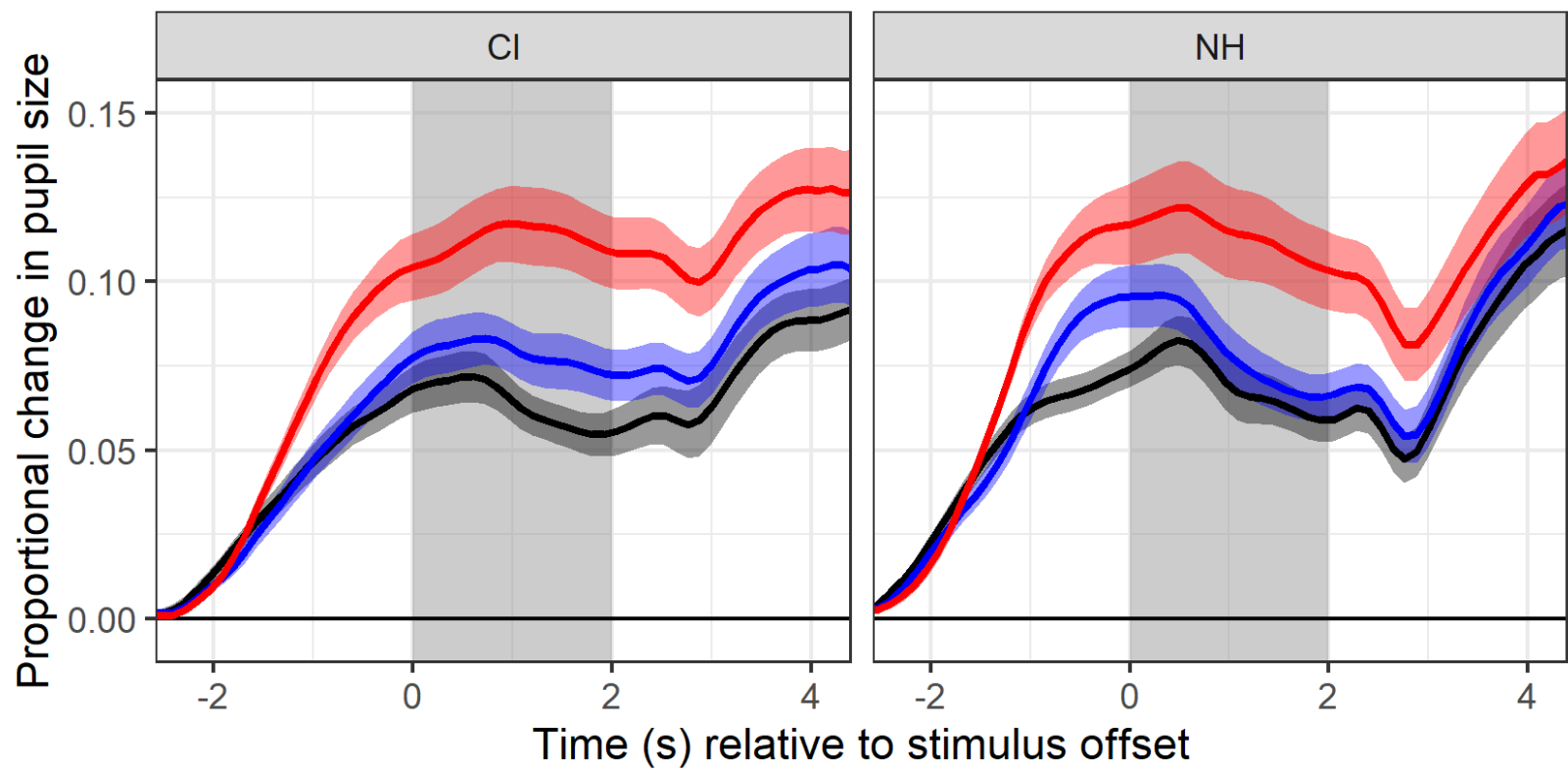
There are twelve eggs in a dozen

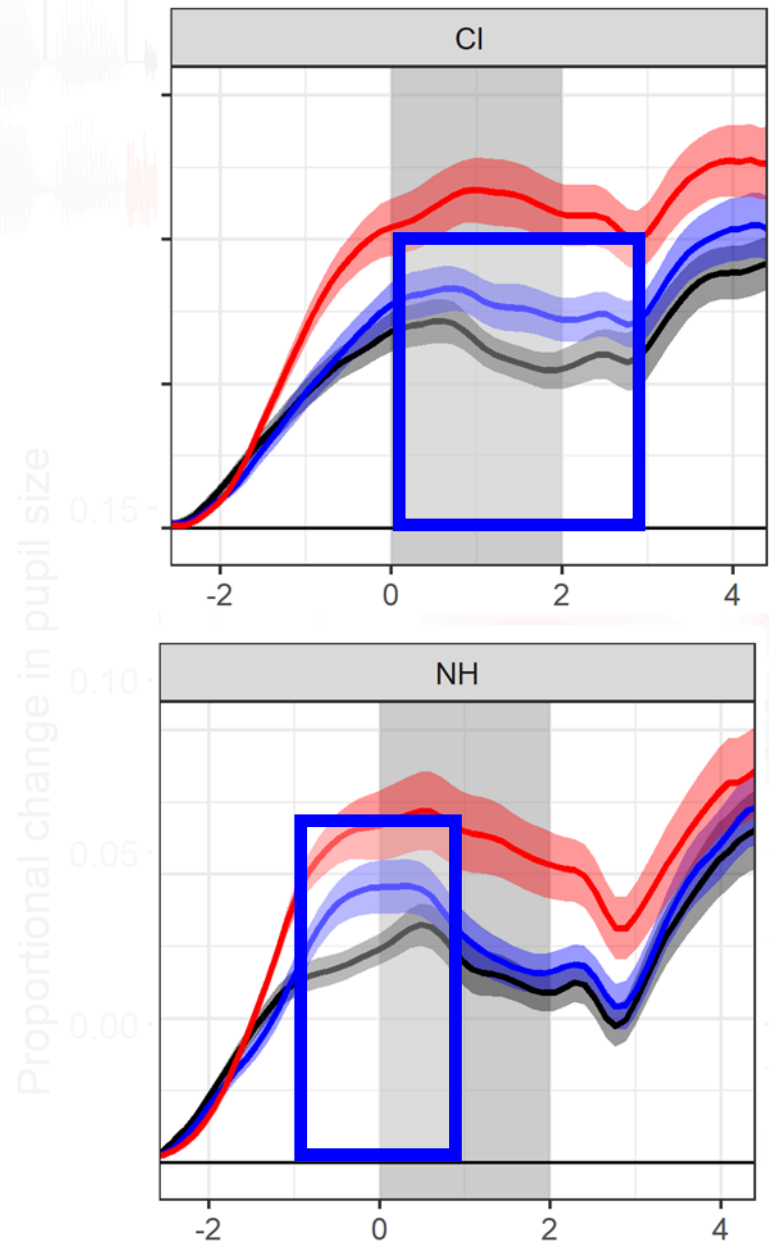
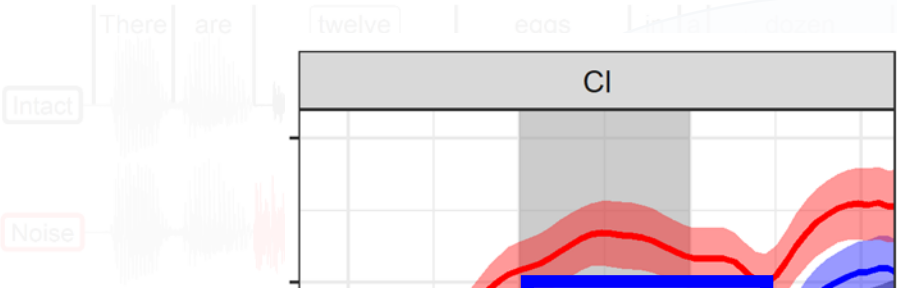
--- Only correct trials



The effort of mental repair is very similar for CI and NH listeners

More repair → More effort





CI listeners:
late and sustained effort
 on mispronounced word

NH listeners: quick
 detection and resolution
 of mispronounced word

The effort of
 mental repair
 is very similar for
 CI and NH listeners

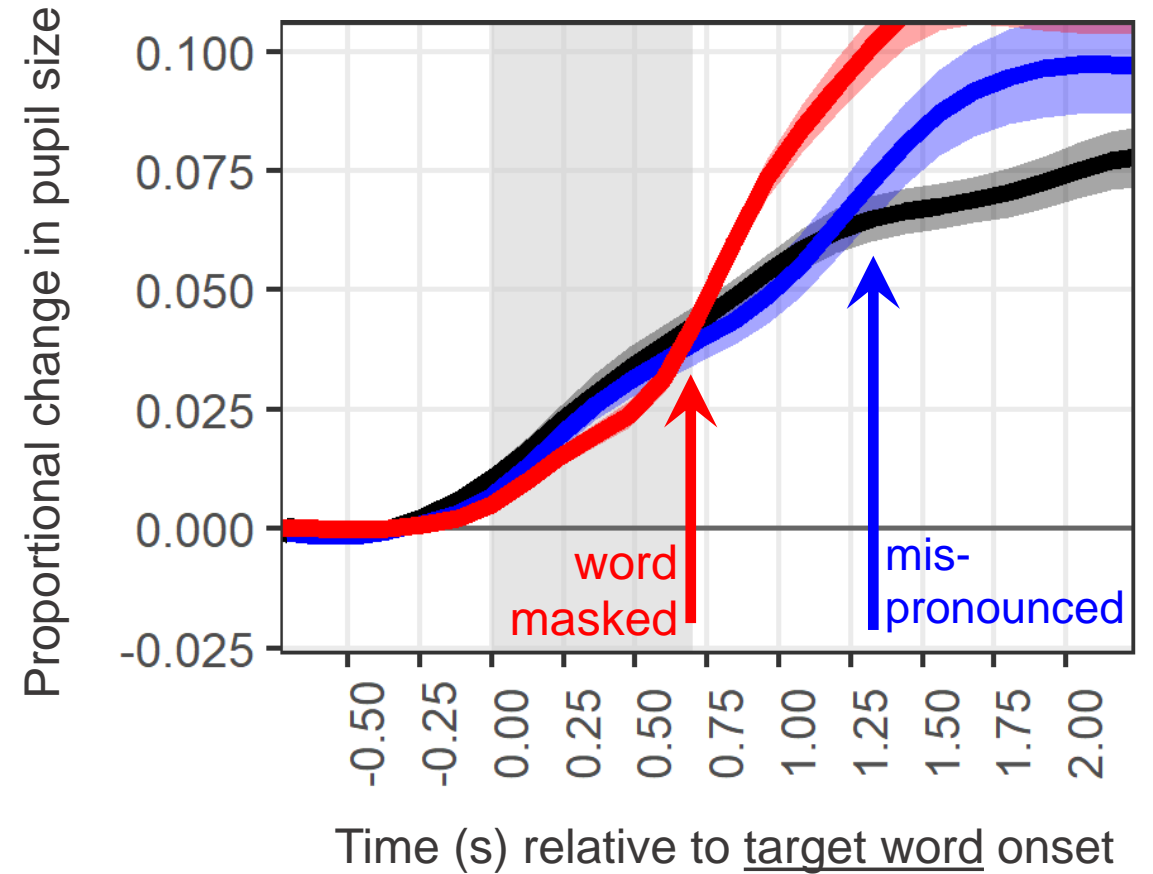
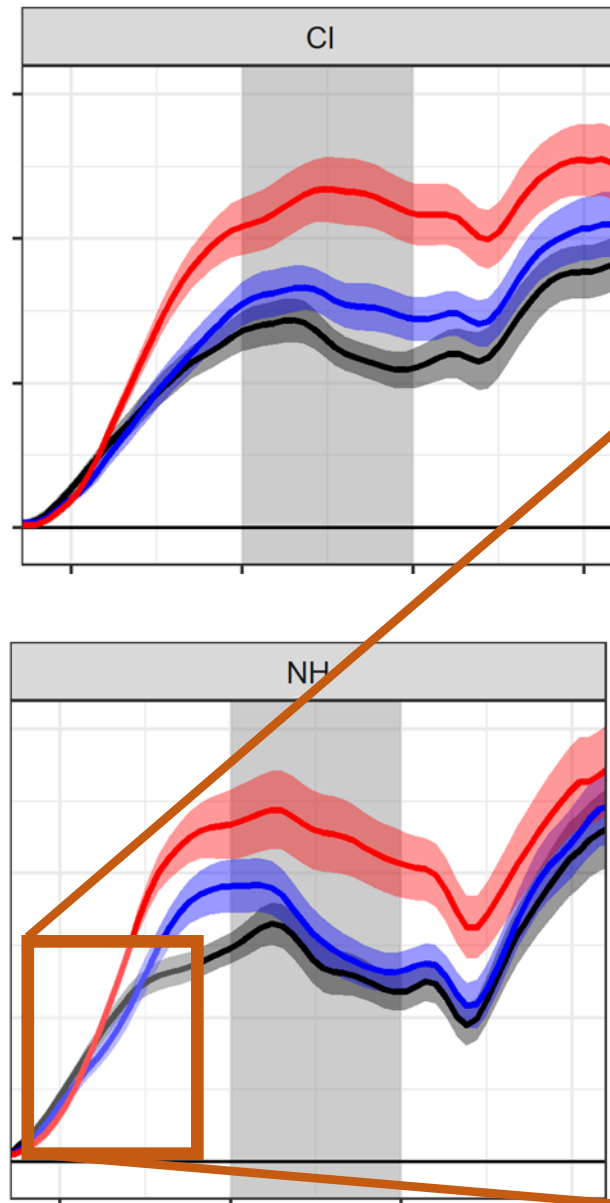
More repair →
 More effort

Stimulus Type
 (target word status)

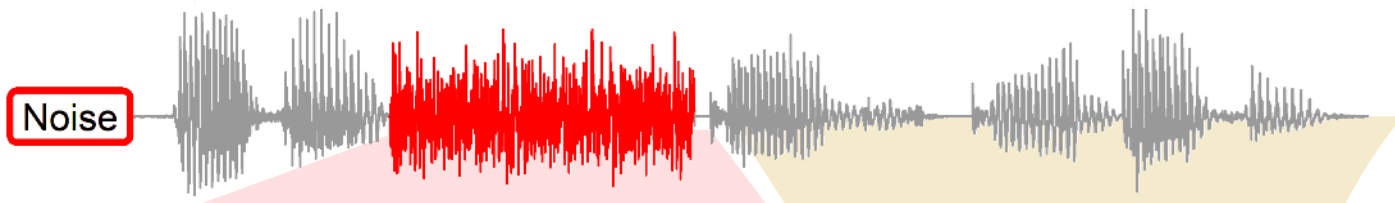
- Noise-masked
- Mispronounced
- Intact

Pupils dilated 0.7 seconds after **acoustic distortion**,
and dilated 1.3s after **phonetic distortion**

CI listeners were slower to detect linguistic distortion

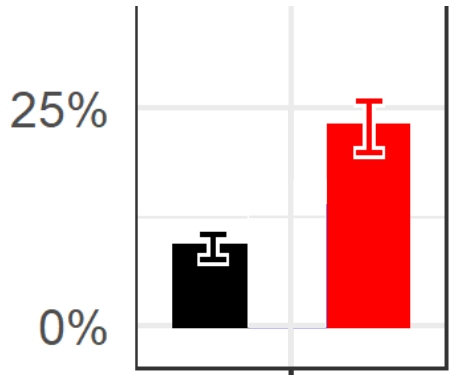


There are twelve eggs in a dozen
[Intro] They ate **pizza** with cheese and **pepperoni**



If you are working to repair this word

you might miss these words



Sentences with Errors other than target word

They ate **pizza** with cheese and ...
I don't know, something else.

They ate **pizza** with pepperoni
and peppers.

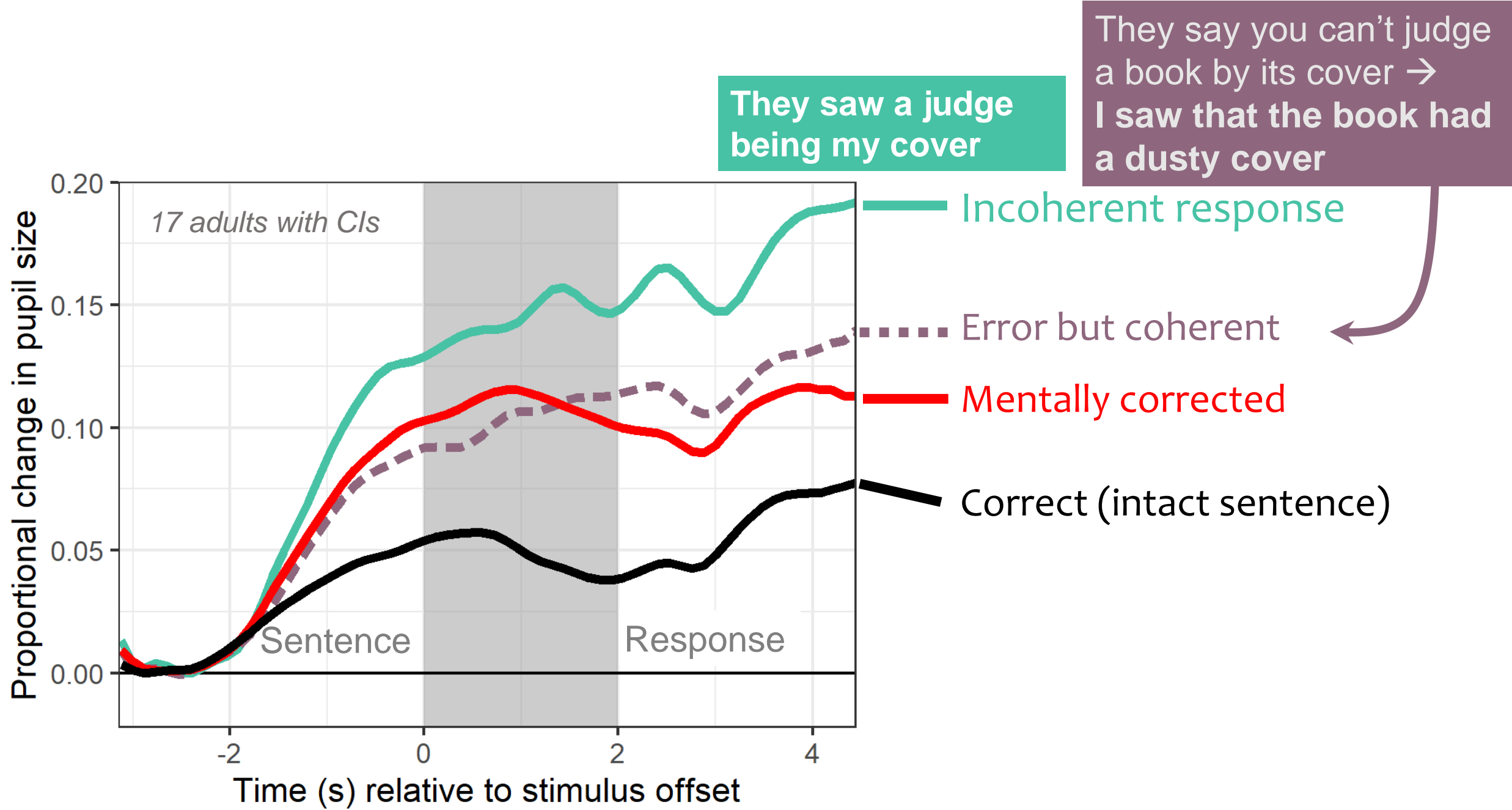


hend amry  @LibyaLiberty · 7h

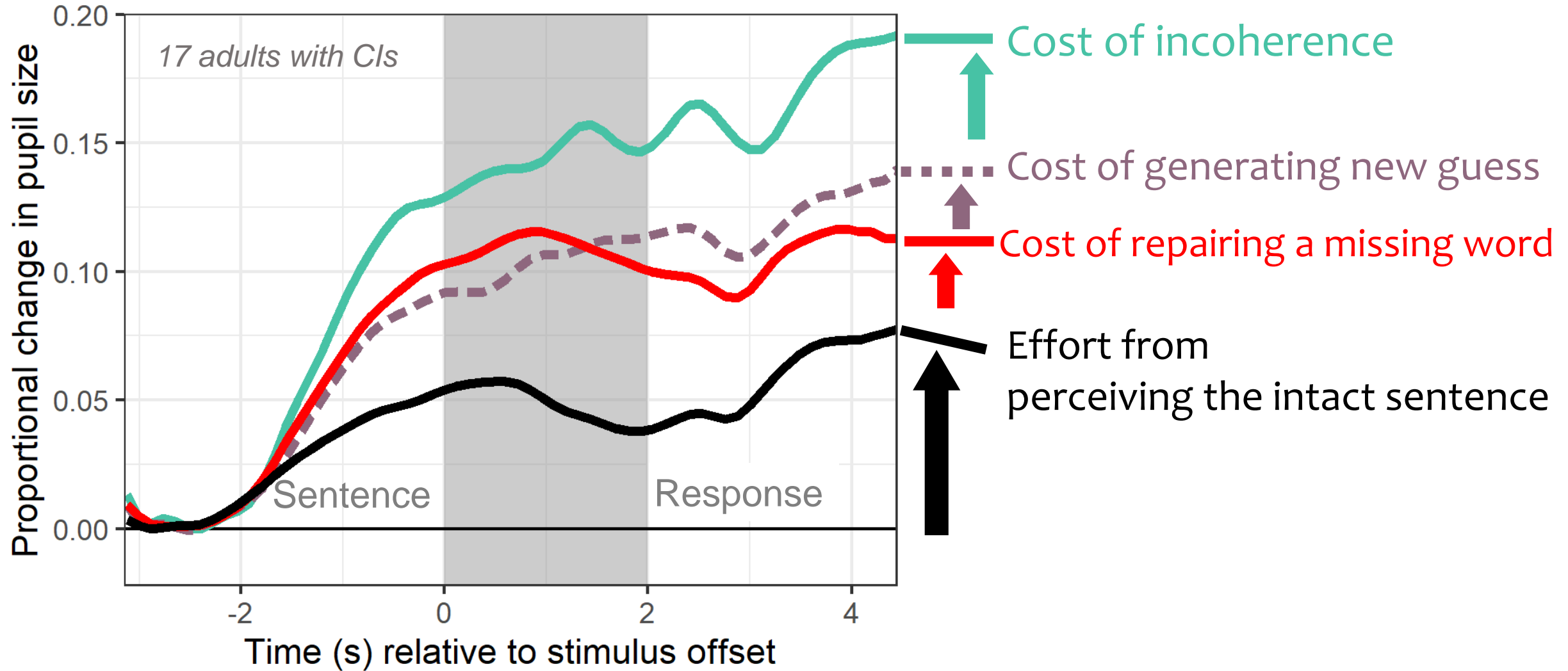
A great translate fail:
the word for “mixed” is mshkala,
the word for “problem” is mushkila

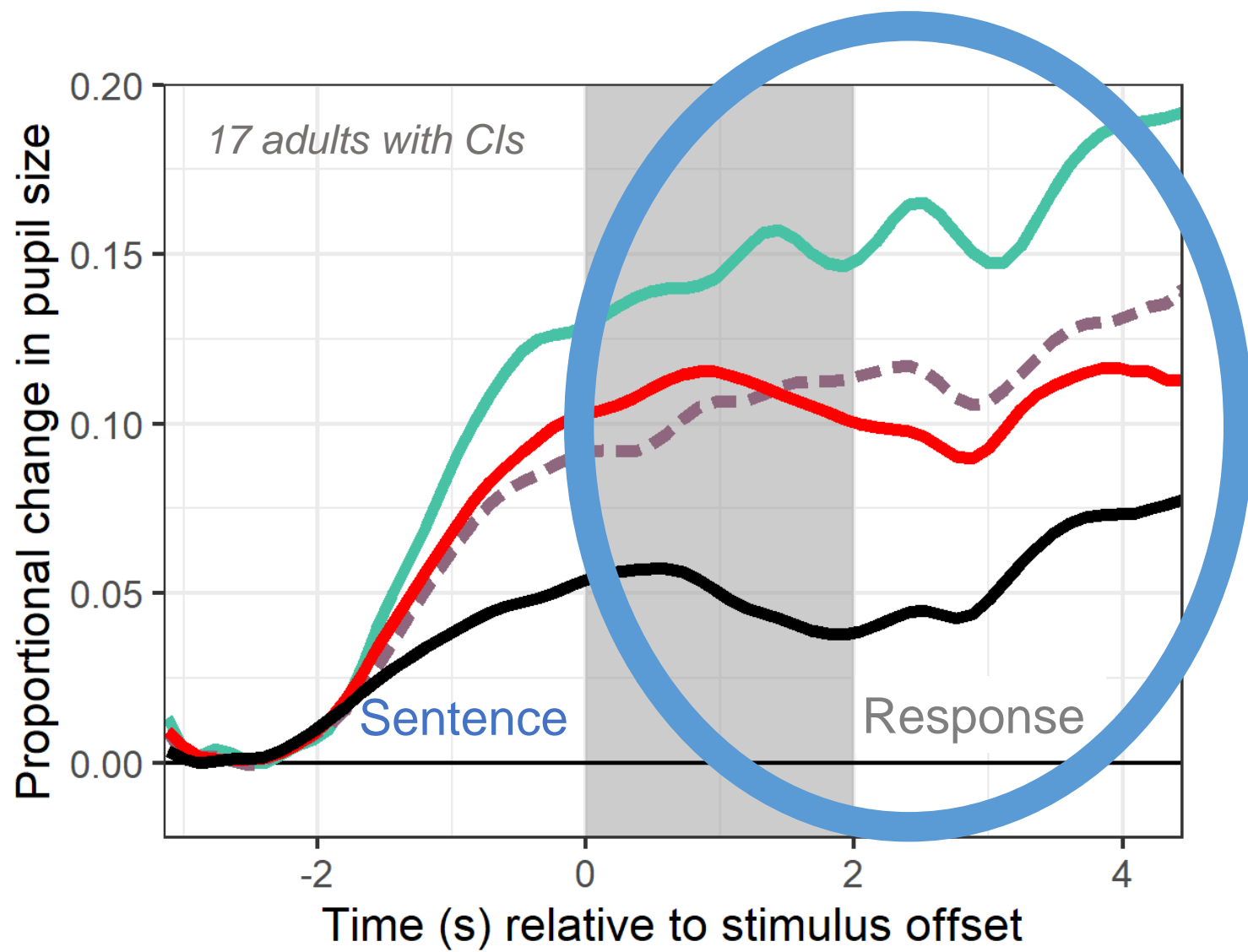
Effort isn't related to phonetic accuracy;
it's related to the accuracy of meaning

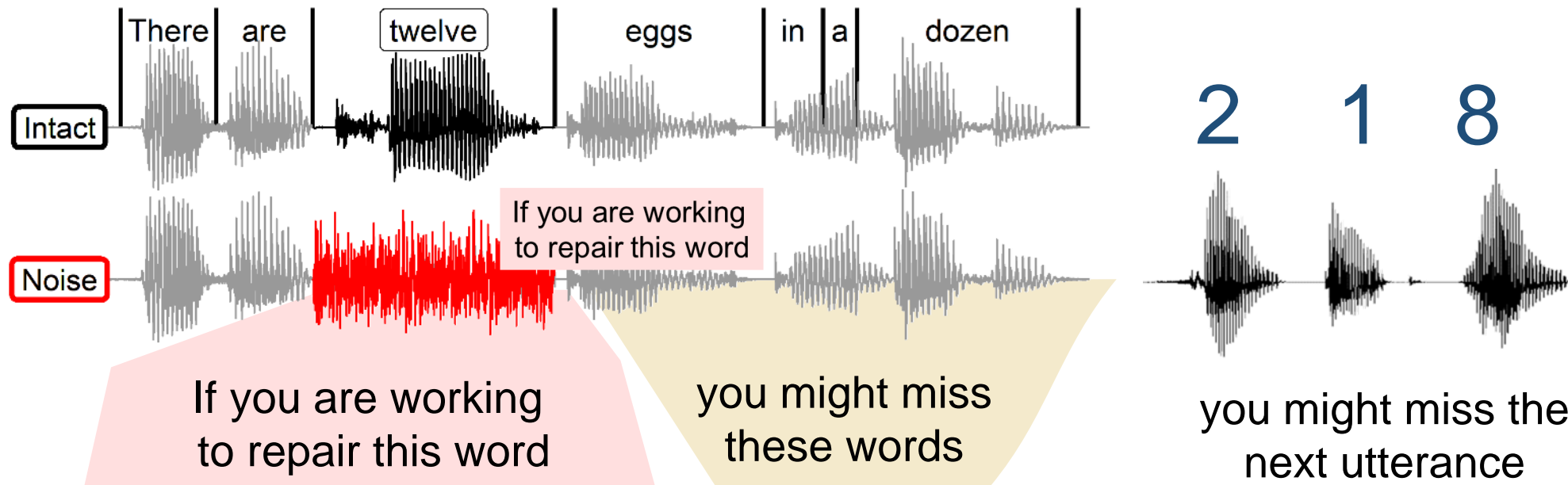


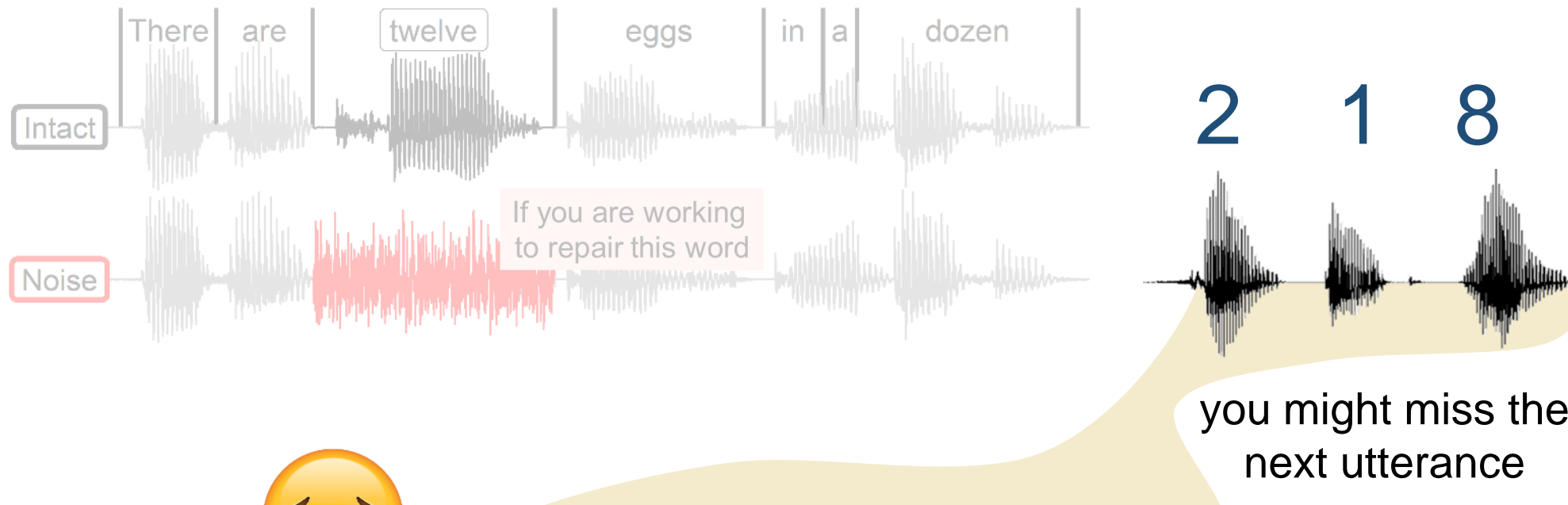


It is effortful to make **sense**
of a perception

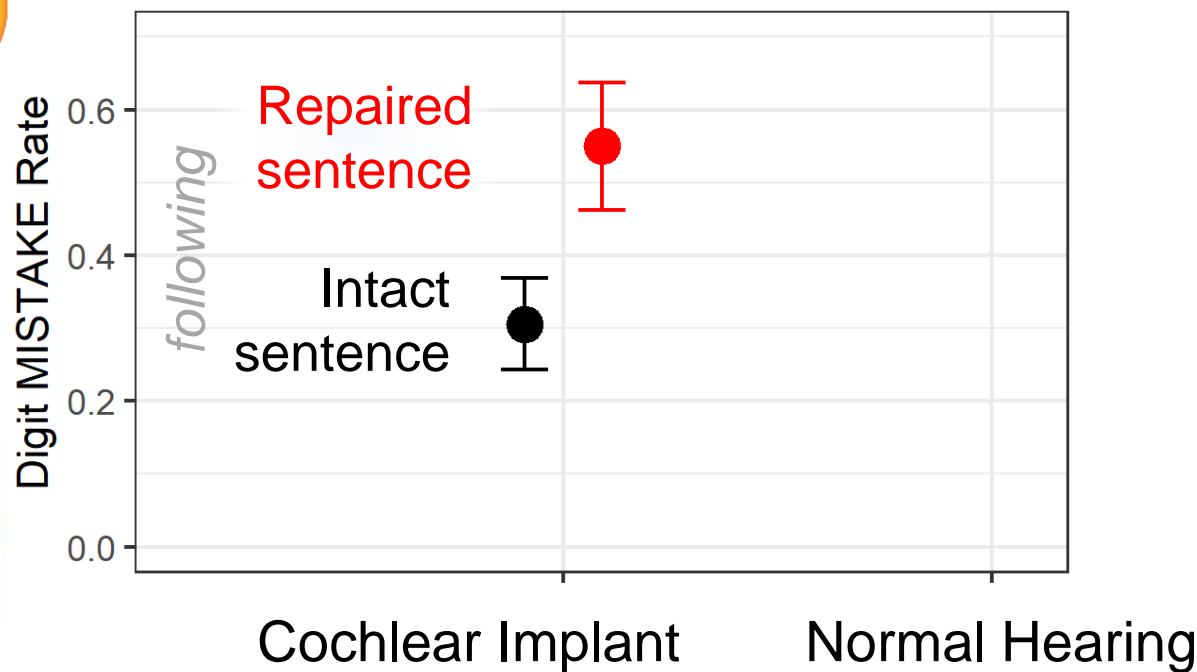








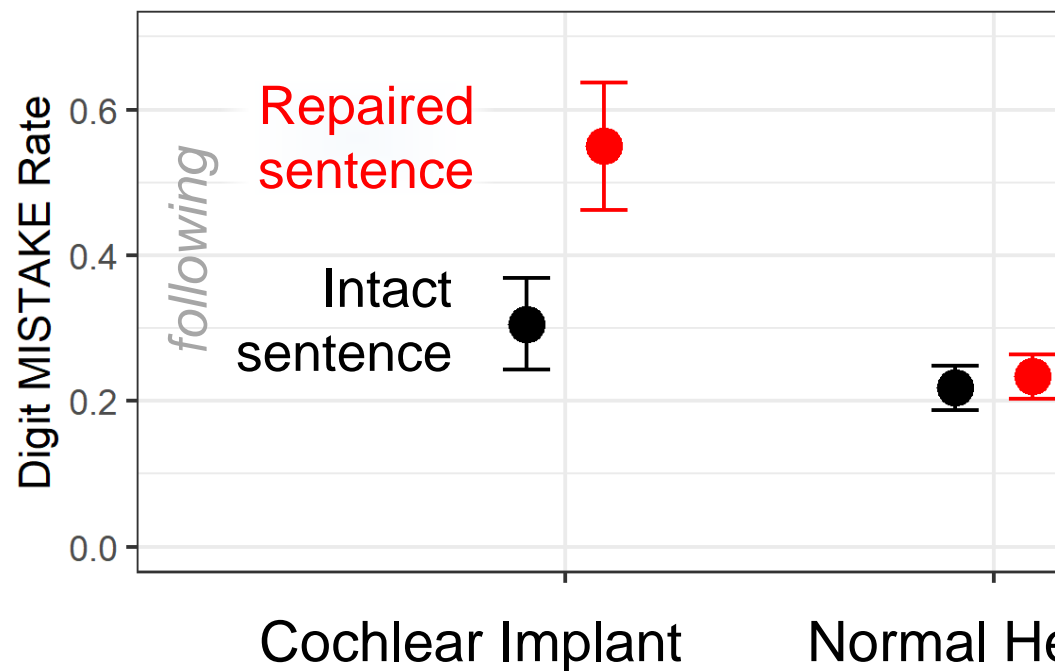
Mental repair during a sentence carries forward to block perception of the next thing





Mental repair during a sentence carries forward to block perception of the next thing

a single mistake might de-rail an entire conversation



NH listeners don't suffer this downstream cost

For CI
listeners:

Mental repair
is effortful

Mental repair
during a sentence
carries forward
to block perception
of the next thing

Effort doesn't come from
making mistakes.

Effort comes from trying to
make sense of an incomplete perception

For CI
listeners:

Mental repair
is effortful

Mental repair
during a sentence
carries forward
to block perception
of the next thing

Can you notice
when they have to do this
mental repair?

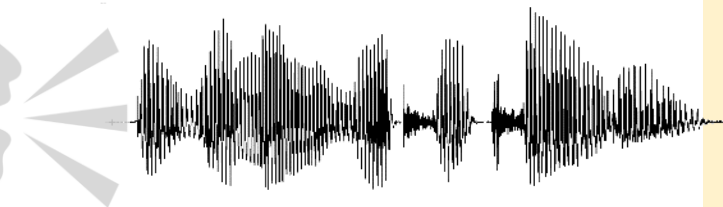
Listening

Sentence with missing word



Full sentence

Response



Interpretation of response

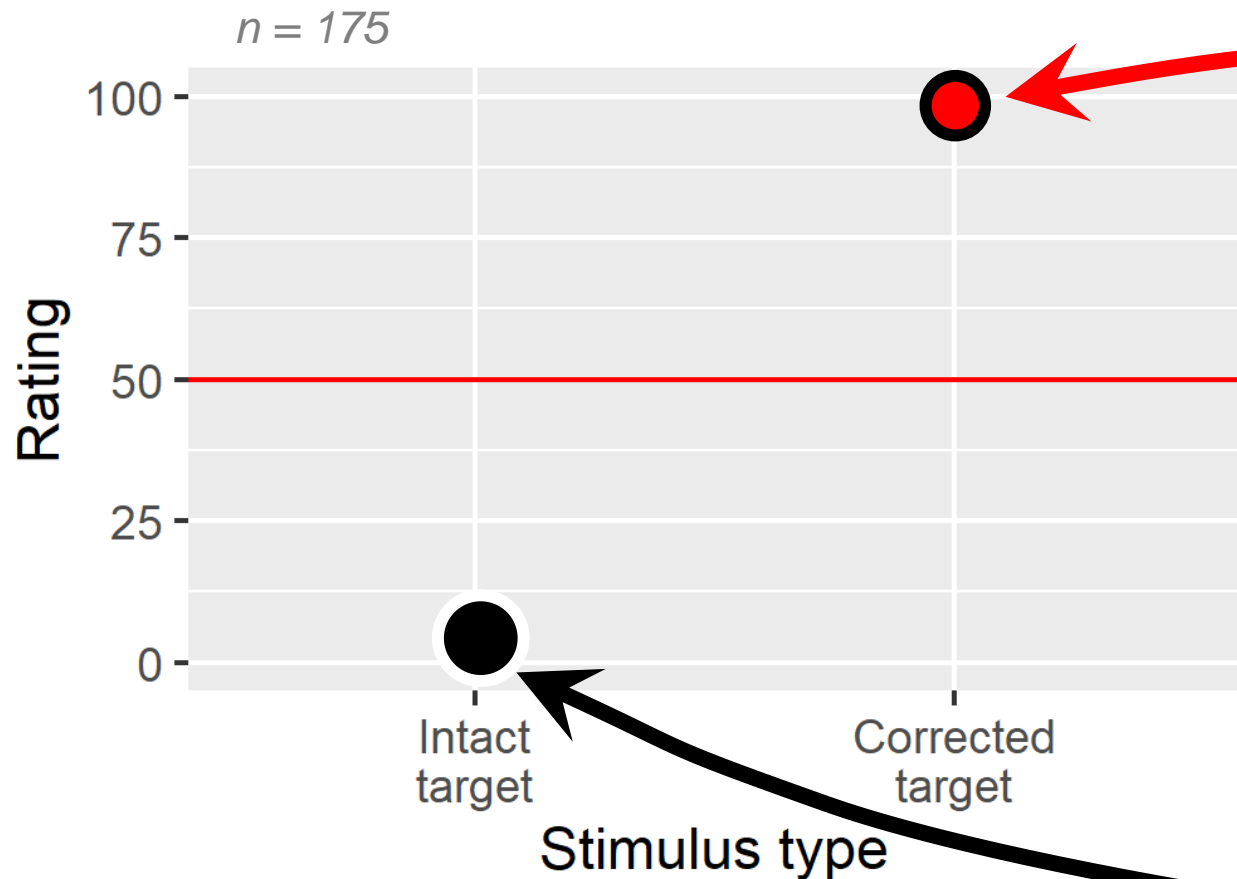
I think they mentally repaired a misperception



I think they heard the full sentence

Can a listener detect the extra effort of repairing a misperception?

Interpretation of response



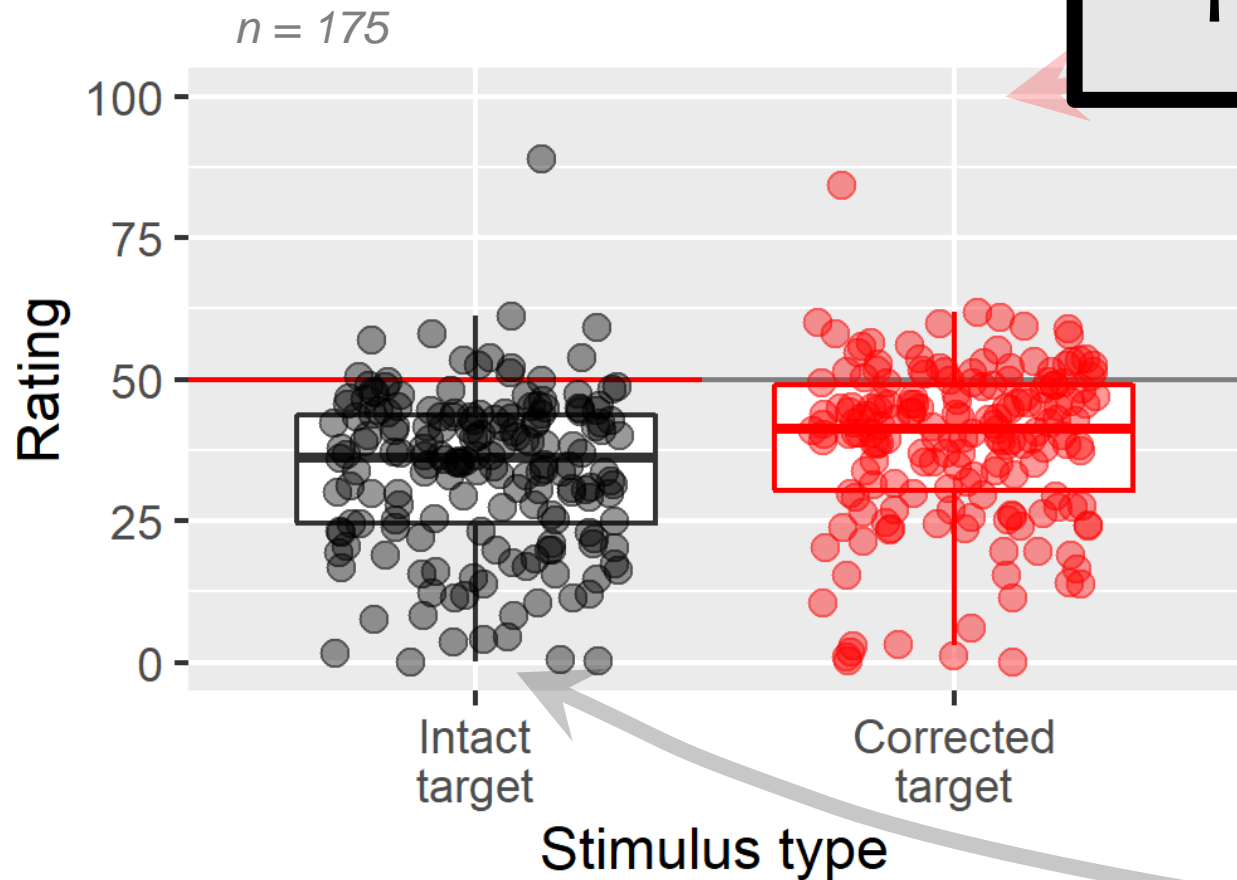
I think they mentally repaired a misperception

I think they heard the full sentence



Can a listener detect the extra effort of repairing a misperception?

No.



Interpretation of response

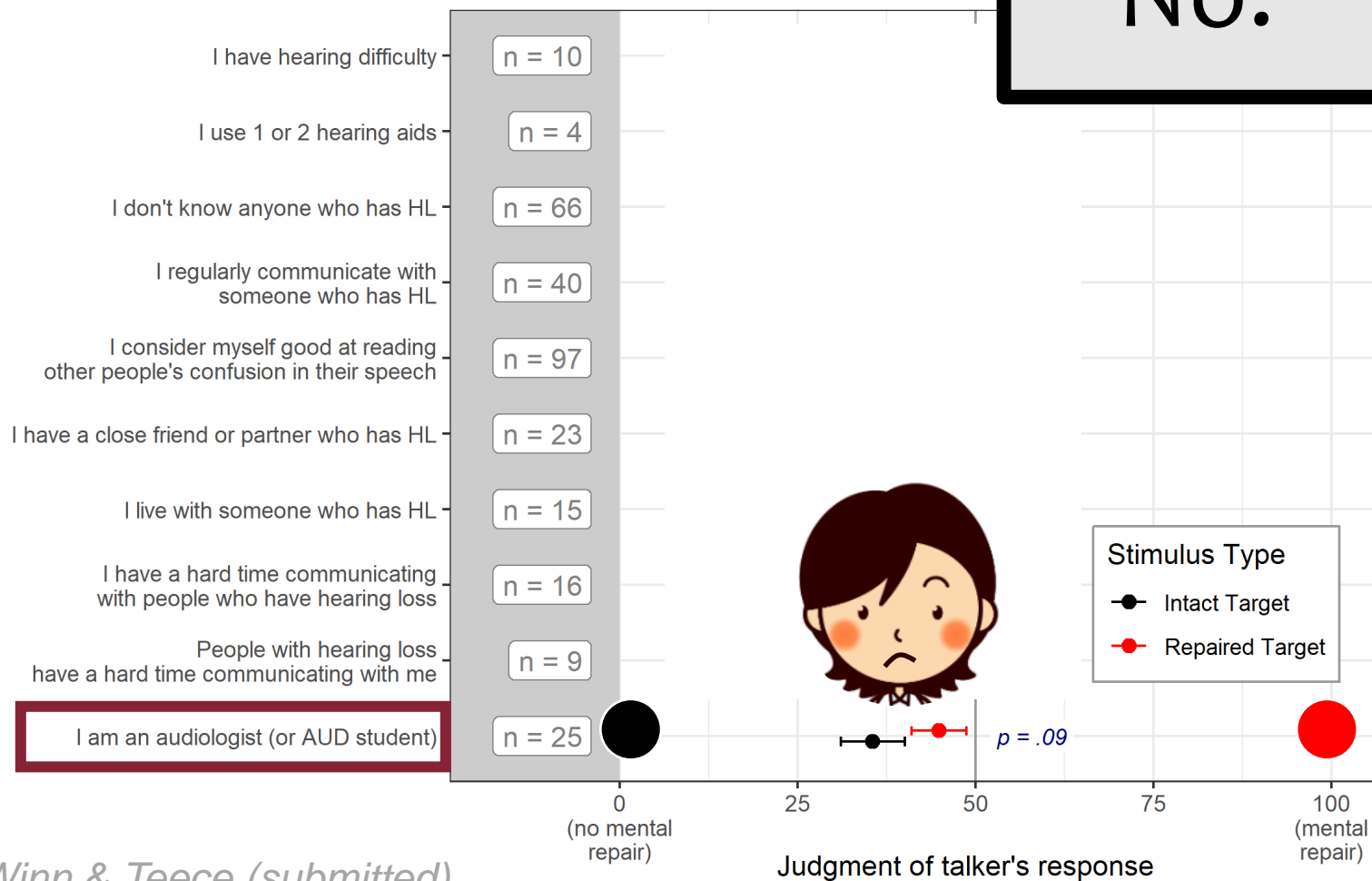
I think they mentally repaired a misperception



I think they heard the full sentence

Can a listener detect the extra effort of repairing a misperception?

No.



Winn & Teece (submitted)

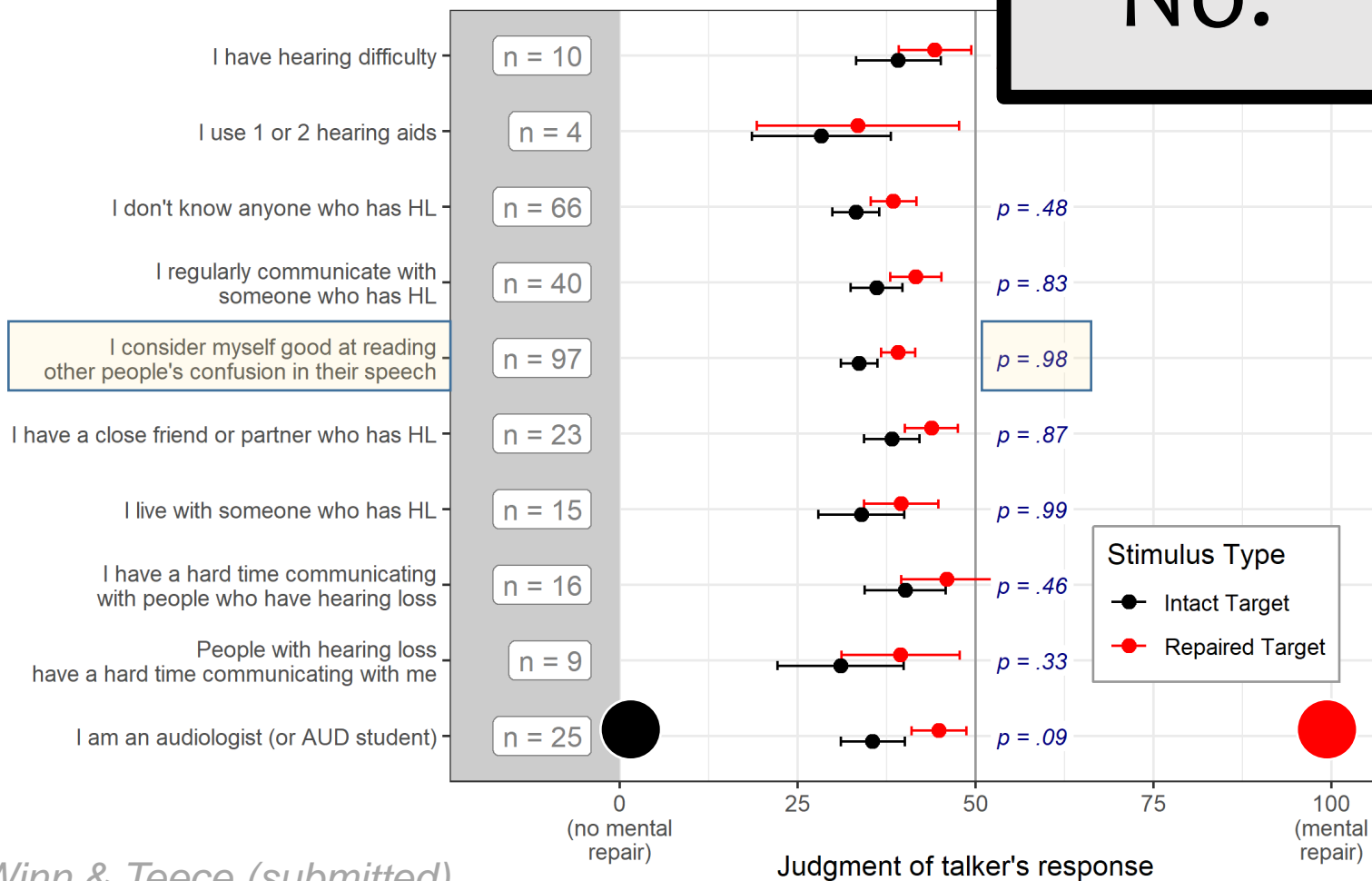
What about audiologists?

No.



Can a listener detect the extra effort of repairing a misperception?

No.



What about audiologists?

No.



Why?

Because people are very good at disguising their effort

What to do with this



**The effort of trying to find meaning
can only be tested with sentence-length materials**

The effort of mental repair is usually invisible

... because we let patients piece together the sentence before responding



Mental
effort

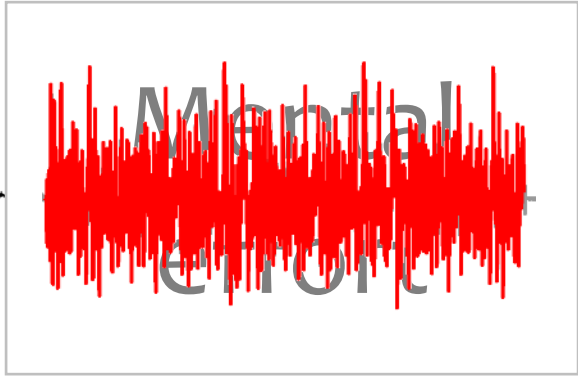
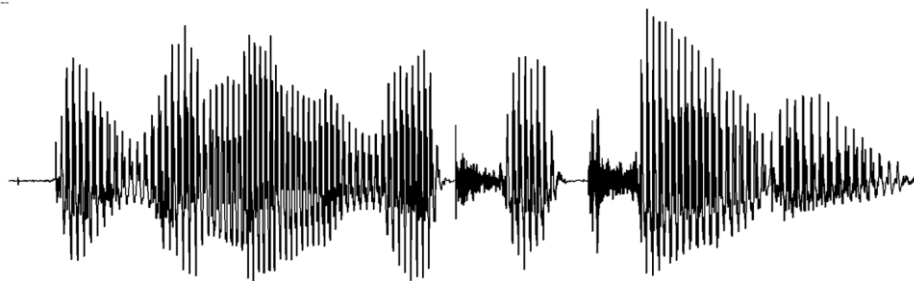
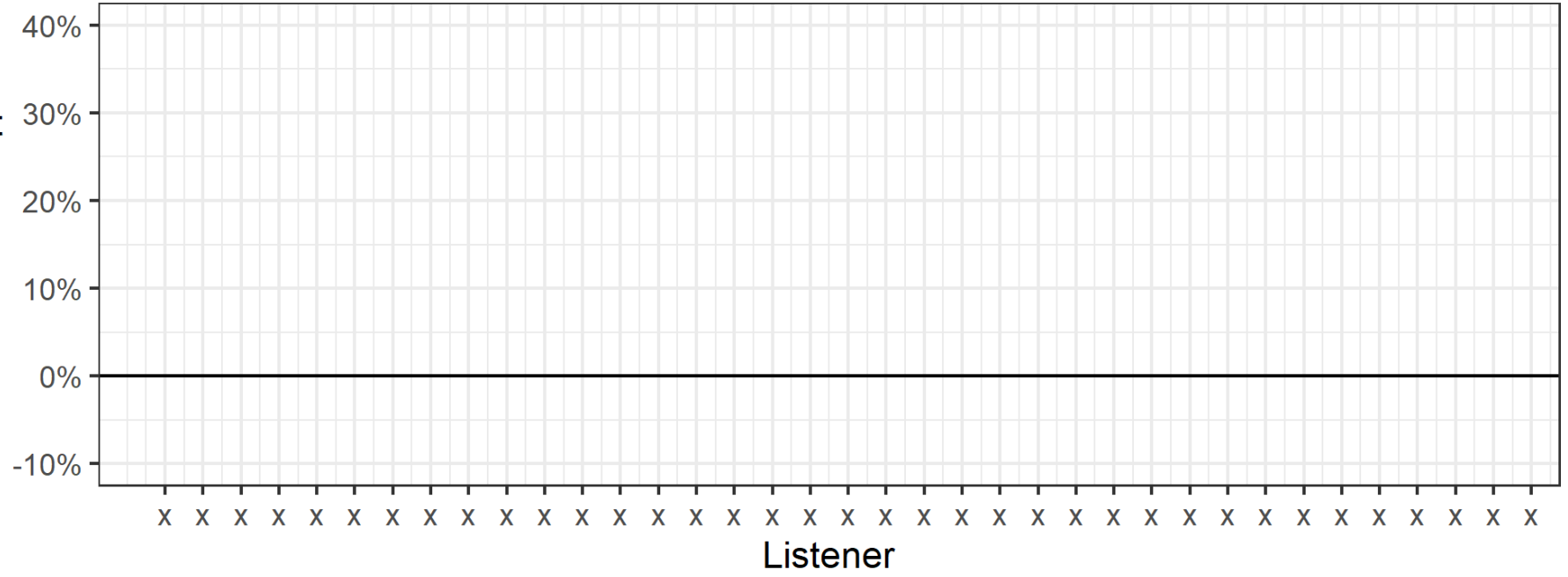
Response

Who benefits from an extra moment?

Benefit from silent moment after sentence



Steven Gianakas



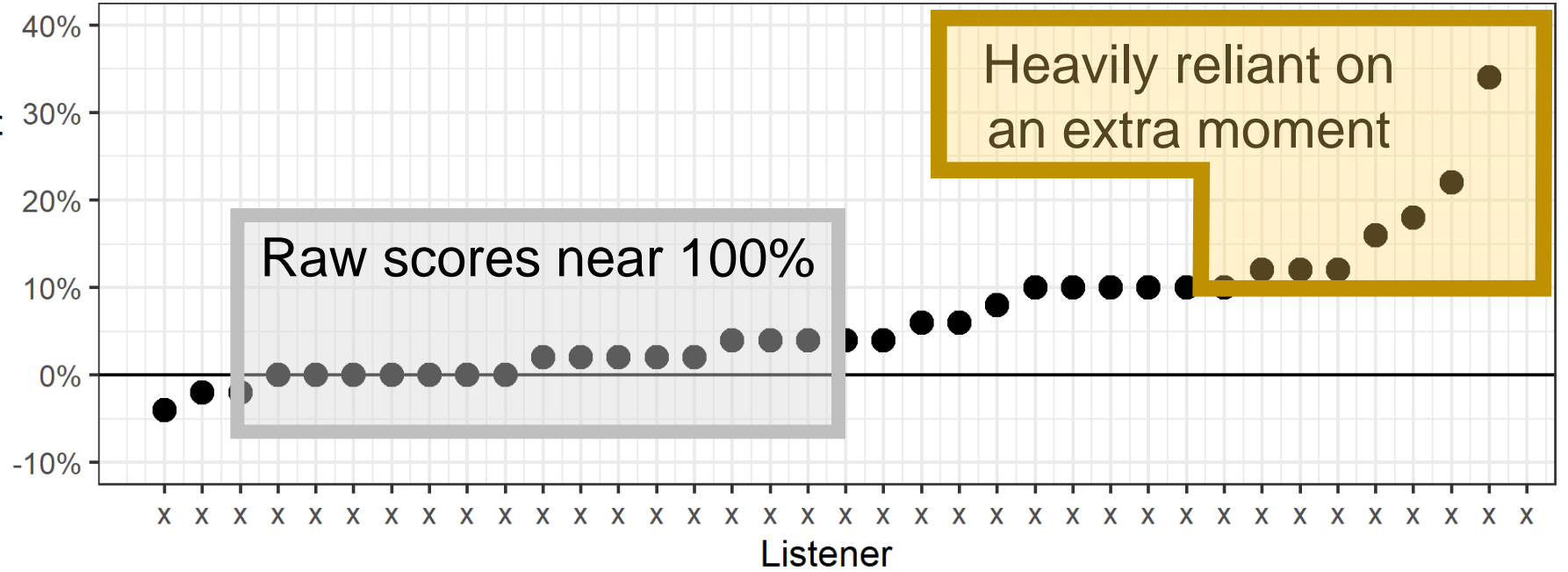
Gianakas et al. JSLHR (in press)

Who benefits from an extra moment?

Benefit from silent moment after sentence



Steven Gianakas



Takeaway points:



“Correct” speech responses can be effortful
if the listener mentally repairs misperceived words

The effort of mental repair can block perception of later words
in the sentence and following the sentence

Listeners can’t detect effort of mental repair in the voice
not even audiologists

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