NATIONAL RESEARCH UNIVERSITY

Center for Language and Brain

The effects of aging and visual noise on ‘good-enough’ sentence processing

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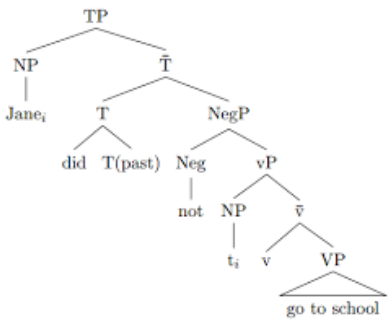
Sentence comprehension

Algorithmic computation:

- Precise
- Complete
- Compositional
- Structure-based



'Good-enough' representations:

- Fast
- Fuzzy
- Based on semantic heuristics

Ferreira et al., 2002;
Ferreira & Patson, 2007;
~ Clahsen & Felser, 2006, shallow structure hypothesis

Sentence comprehension

Algorithmic computation

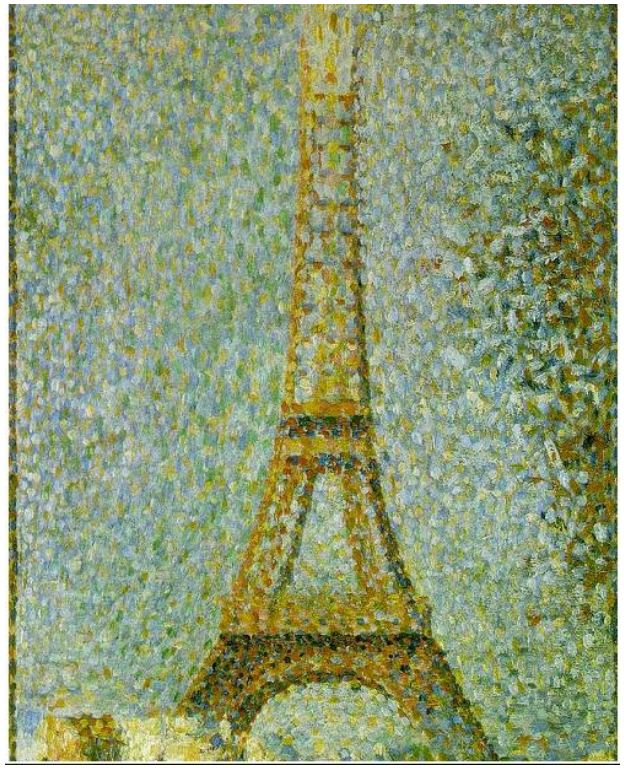
'Good-enough' representations:

Claude Monet. San Giorgio Maggiore at Dusk
(Photo: Anna Teplitskaya, https://lady.mail.ru/article/494134-17-realnyh-mest-s-kartin-velikih-hudozhnikov)

Sentence comprehension

Algorithmic computation

'Good-enough' representations:



Georges Seurat. The Eiffel Tower.
(Photo: Anna Teplitskaya, https://lady.mail.ru/article/494134-17-realnyh-mest-s-kartin-velikih-hudozhnikov)

‘Good-enough’ processing

Ferreira & Stacey, 2000:

(a) The man bit the dog.

(b) The man was bitten by the dog.

(c) The dog bit the man.

(d) The dog was bitten by the man.

Rated as plausible 25% of the time

‘Good-enough’ processing

Malyutina & Den Ouden, 2015:

While the Granny dressed the baby rubbed its face.

Correct
77% in older
66% in younger

Incorrect

‘Blended’:
16% in younger
21% in older

‘Initial’:
7% in younger
13% in older

Linguistic structure?

Communication purpose?

Algorithmic computation

'Good-enough' processing

Processing conditions?

Speaker characteristics?

Comprehender characteristics?

Linguistic structure?

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Processing conditions?

Speaker characteristics?

Comprehender characteristics?

Our bigger project on ‘good-enough’ processing

- Age:

Teenagers, young adults, older adults

- Stimulus modality:

Written / auditory

- Processing conditions:

Normal conditions versus auditory ‘noise’ versus visual ‘noise’

Aging & sentence comprehension

Quantitative changes:

- Slower processing (Salthouse et al., 1991, 1996; Brébion, 2001; Caplan et al., 2011)
- Less accurate comprehension, at least in complex sentence types or challenging processing conditions (Caplan et al., 2011; Caplan & Waters, 2005; Stine-Morrow et al., 2000; Wingfield, Peelle, & Grossman, 2003; although see Tyler et al., 2010)

Qualitative changes?

- Greater effects of lexical predictability and context in aging (Dubno et al., 2000, Pichora-Fuller, et al., 1995; Wingfield et al., 2011)
- Difficulties in syntactic processing (Kemper et al., 2001; Kemtes & Kemper, 1997; Waters & Caplan, 2001; Wingfield et al., 2003)
- Direct evidence of 'good-enough' processing: not so many studies (Kemper et al., 2004; Christianson et al., 2006, 2010; Malyutina and Den Ouden, 2016; Amichetti et al., 2016)

Noise & sentence comprehension

- Vast evidence of **quantitative** impact:
  - Although mostly in the <u>auditory</u> domain
  - Evans and Lepore, 1993; Evans and Maxwell, 1997; Schoof and Rosen, 2014; Tun and Wingfield, 1999; Pichora-Fuller, Schneider, and Daneman, 1995…

- **Qualititative** changes are more debatable:
- E.g., Gao et al., 2012:

  Visual noise -> *"more attention to the surface form and less attention to semantic processing"*

???

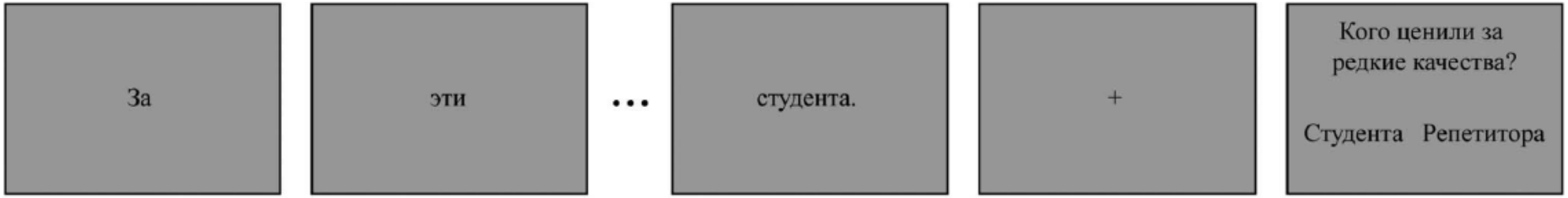
Method

Participants

- Neurologically healthy native speakers of Russian
- 61 younger participants
  - Mean age 24.2, SD 4.7, range 18-38 years
  - 47 female, 16 male
- 36 older participants
  - Mean age 65.0, SD 7,8, range 55-91 years
  - 25 female, 11 male
- Data collection in progress
  - Target (pre-registered) sample size: 80 younger, 40 older

Task

- Self-paced word-by-word reading
- Each sentence followed by two-alternative comprehension question

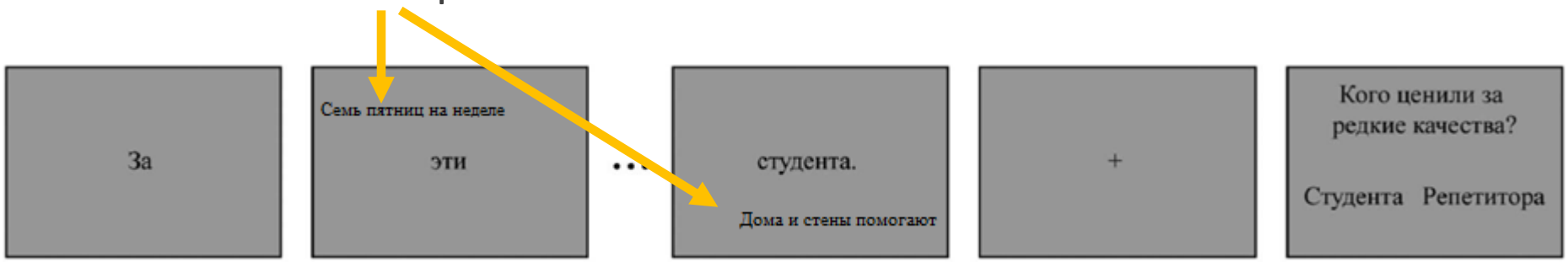


Design

- Normal processing conditions

versus

- Visual ‘noise’ (distraction):
  - Short idioms (length: 3-5 content words)
  - Appearing simultaneously with 4-5 random words in a sentence
  - In random parts of the screen



Stimuli

Russian grammatically complex (unambiguous) sentences:

Semantically plausible (syntax = semantics):

(1) *Rimma dressed* ***the child***$_{\textbf{Acc,fem}}$ *of the writer*$_{Gen,fem}$ ***who was babbling***$_{\textbf{Acc,fem}}$ *incomprehensible words. Who was babbling?*

(2) *Rimma dressed the child*$_{\text{Acc,fem}}$ *of* ***the writer***$_{\textbf{Gen,fem}}$ ***who published***$_{\textbf{Gen,fem}}$ *an interesting novel. Who published a novel?*

vs.

Semantically implausible (syntax ≠ semantics):

(3) *Rimma dressed* ***the child***$_{\textbf{Acc,fem}}$ *of the writer*$_{Gen,fem}$ ***who published***$_{\textbf{Acc,fem}}$ *an interesting novel. Who published a novel?*

(4) *Rimma dressed the child*$_{\text{Acc,fem}}$ *of* ***the writer***$_{\textbf{Gen,fem}}$ ***who was babbling***$_{\textbf{Gen,fem}}$ *incomprehensible words. Who was babbling?*

Balanced by **syntactic structure**: 'high attachment' (1, 3) vs. 'low attachment' (2,4)

Stimuli

- Lower accuracy in implausible than plausible
  -> reliance on good-enough processing
  (lexico-semantic heuristics rather than syntax)

- Two experimental lists, alternated between no-noise and visual-noise condition
- Each list contains:
  - 28 stimuli
  - 56 fillers
    - Same structure but different comprehension questions (n=18)
    - Diverse simpler grammatical structures (n=38)

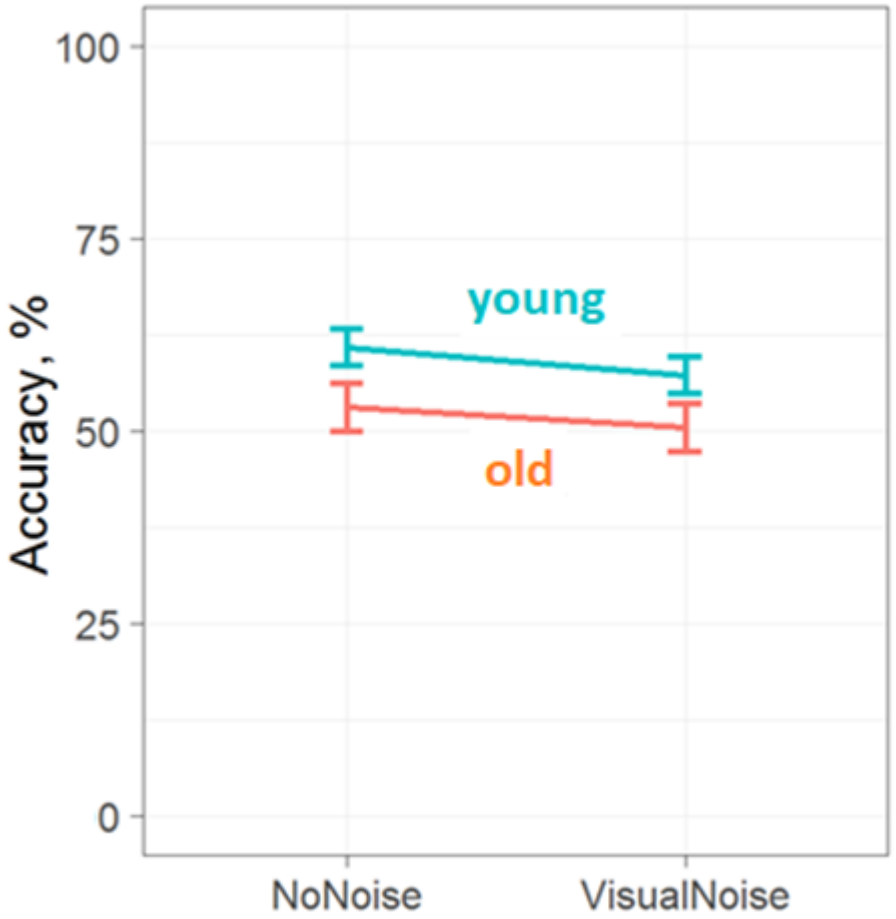
Data analysis

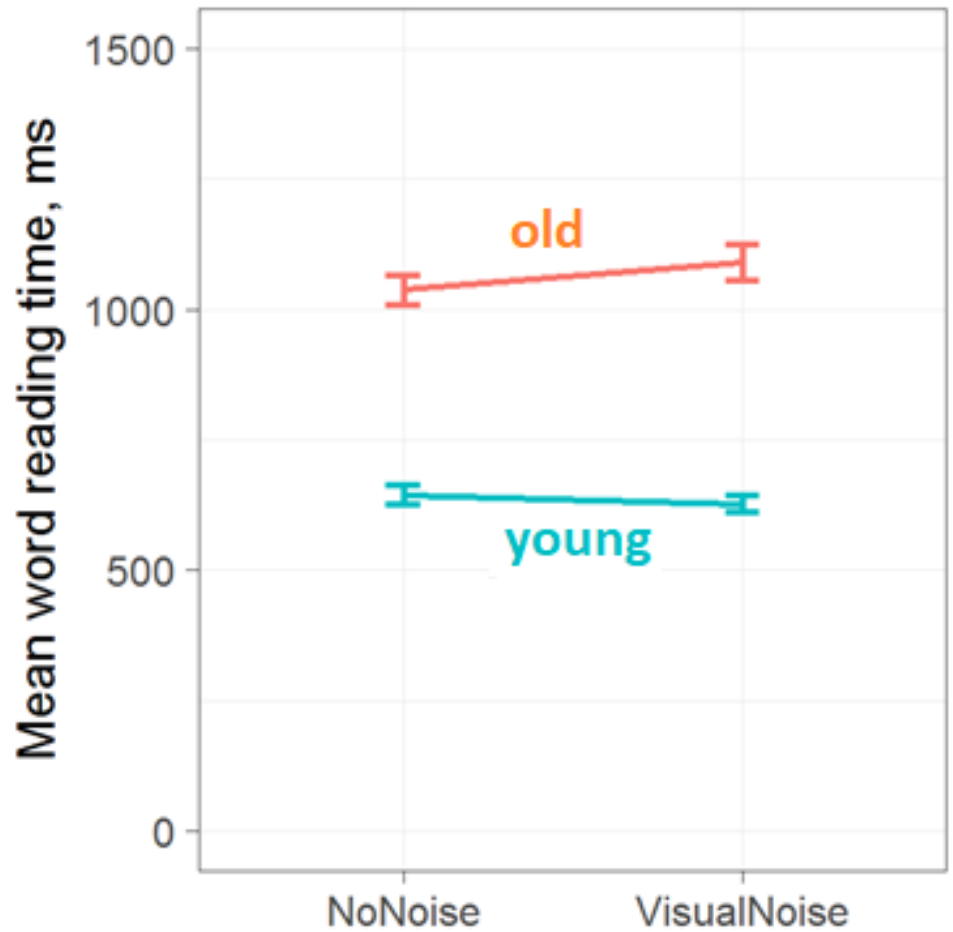
- Linear mixed-effects models (*lme4* package in R)
- Dependent variables:
  - Question response accuracy
  - Mean word reading time
- Tested factors and interactions:

Plausibility	Do we rely on good-enough processing?
Age	Is there a general decline in performance with age?
Noise	Is there a general decline in performance in noise?
Age x Noise	Are older adults more affected by noise?
Plausibility x Age	**Do <u>older</u> people rely on good-enough processing more?**
Plausibility x Noise	**Do we rely on good-enough processing more <u>in noise</u>?**
Plausibility x Age x Noise	Do older people rely on good-enough processing more specifically in noise? [Did not converge]

Results & Discussion

	Accuracy	Reading time
Age	$p = .18$	$\boldsymbol{p < .001}$
Noise	$\boldsymbol{p = .005}$	$p = .99$
Age x Noise	$p = .91$	$\boldsymbol{p = .03}$

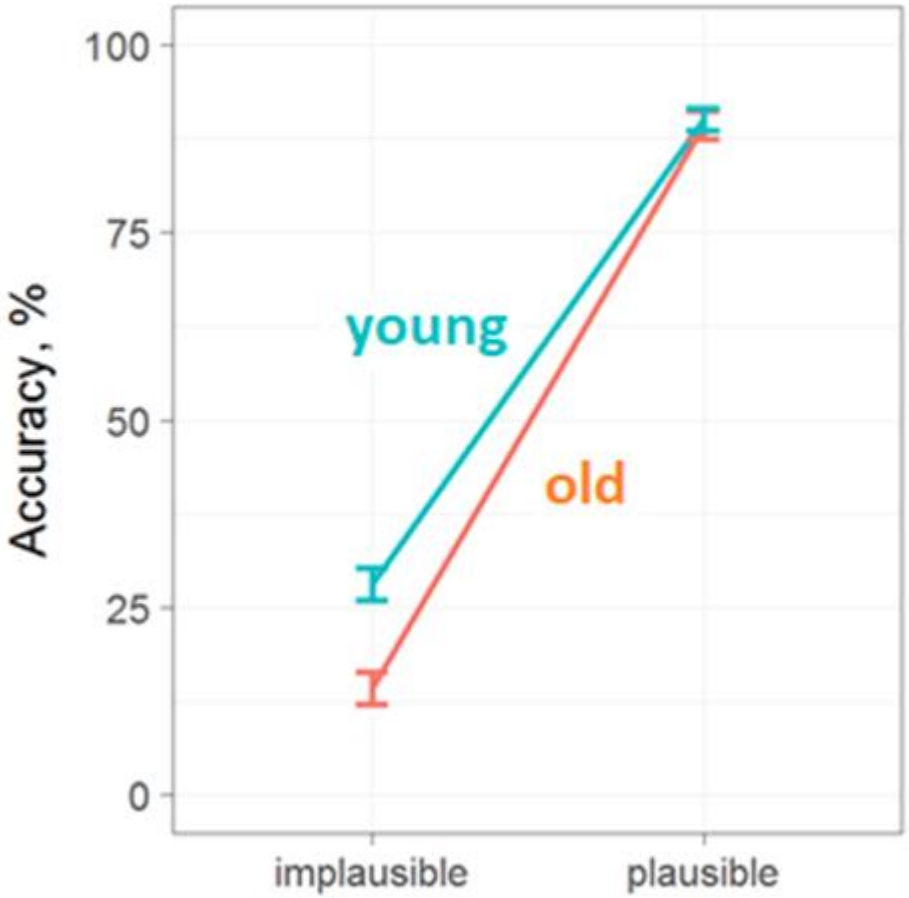


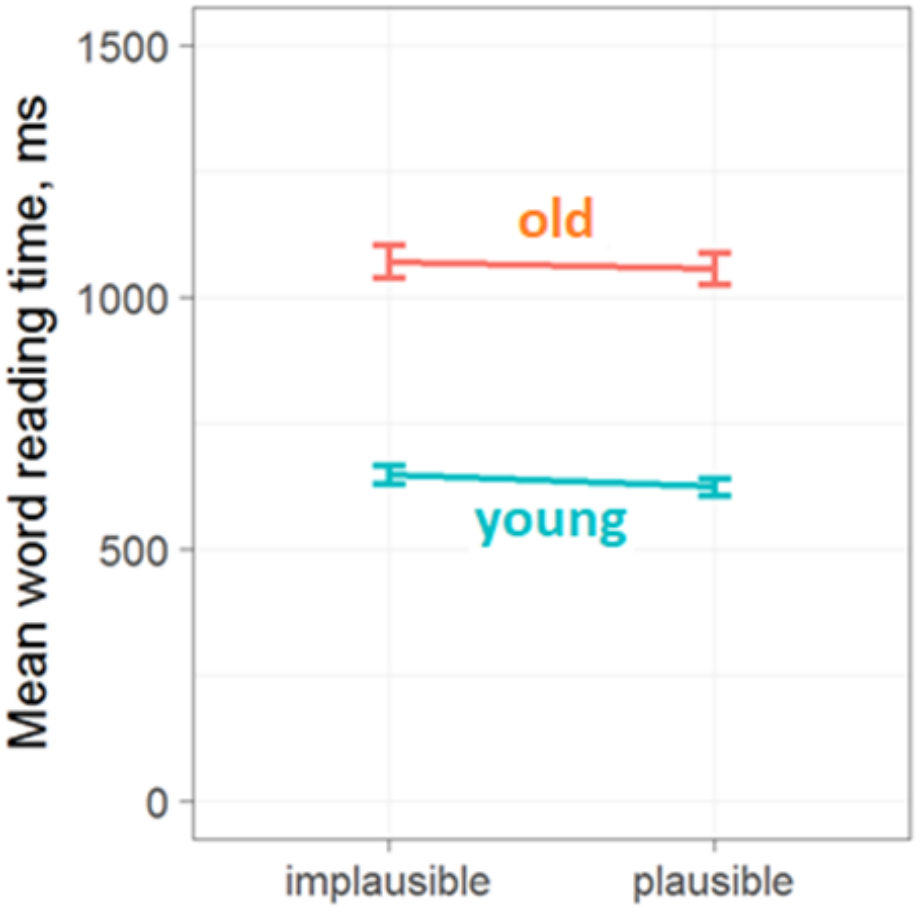


	Accuracy	Reading time
Age	$p = .18$	$\boldsymbol{p < .001}$
Noise	$\boldsymbol{p = .005}$	$p = .99$
Age x Noise	$p = .91$	$\boldsymbol{p = .03}$

- Generally, older adults read slower
- Generally, comprehension is less accurate in noise
- Older and younger adults behave differently in noise:
  - Older adults slow down, younger do not

	Accuracy	Reading time
Plausibility	***p* < .001**	*p* = .09
Age x Plausibility	***p* = .003**	*p* = .20

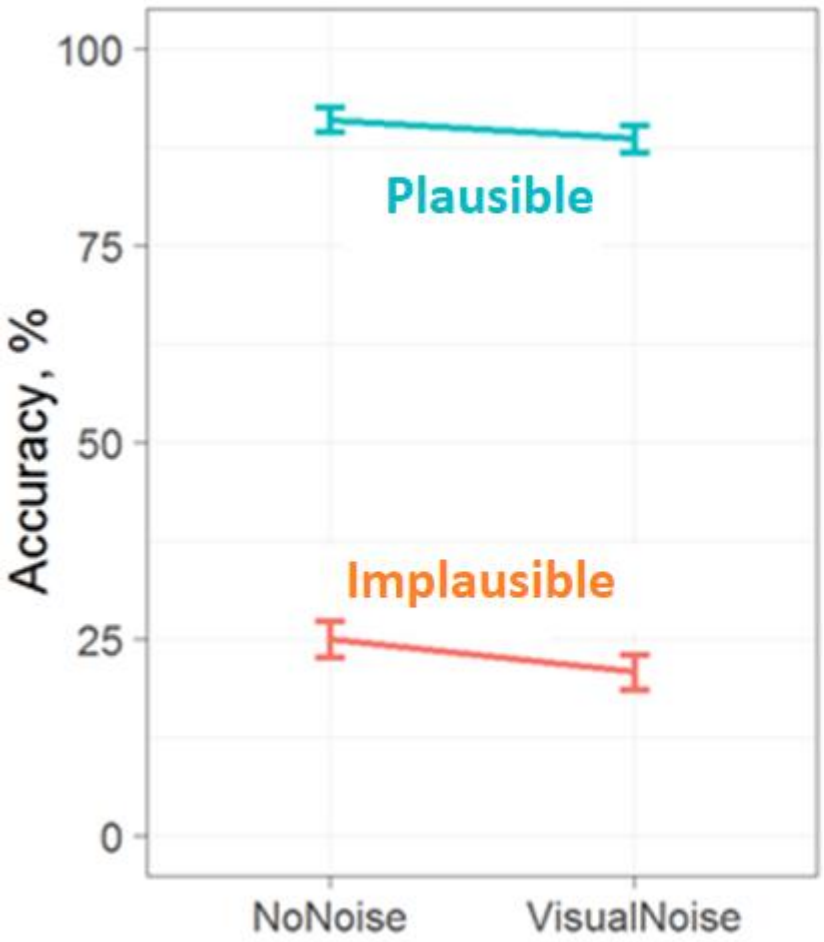


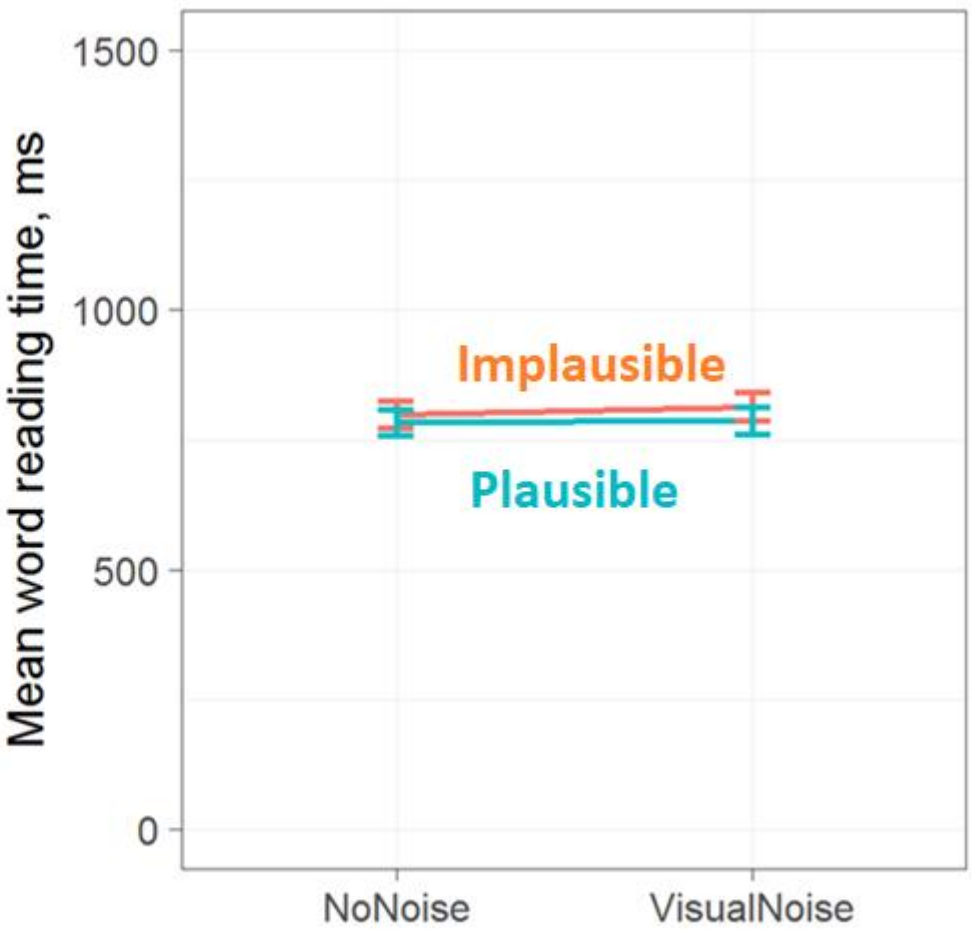


	Accuracy	Reading time
Plausibility	***p* < .001**	*p* = .09
Age x Plausibility	***p* = .003**	*p* = .20

- Both younger and older adults rely on good-enough processing
- Older adults are <u>more</u> subject to good-enough processing

	Accuracy	Reading time
Plausibility x Noise	p = .94	p = .50

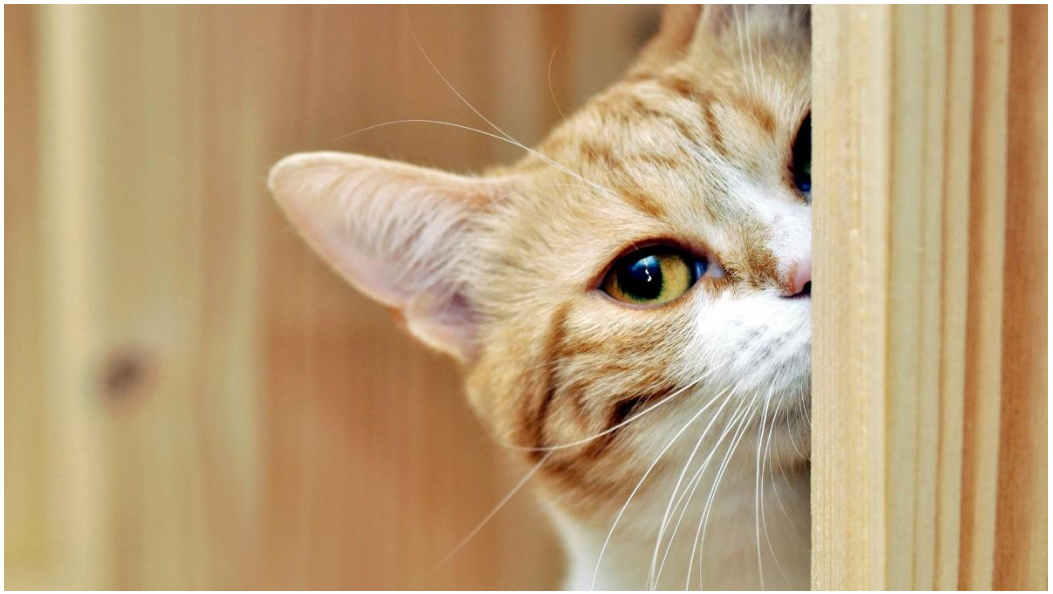




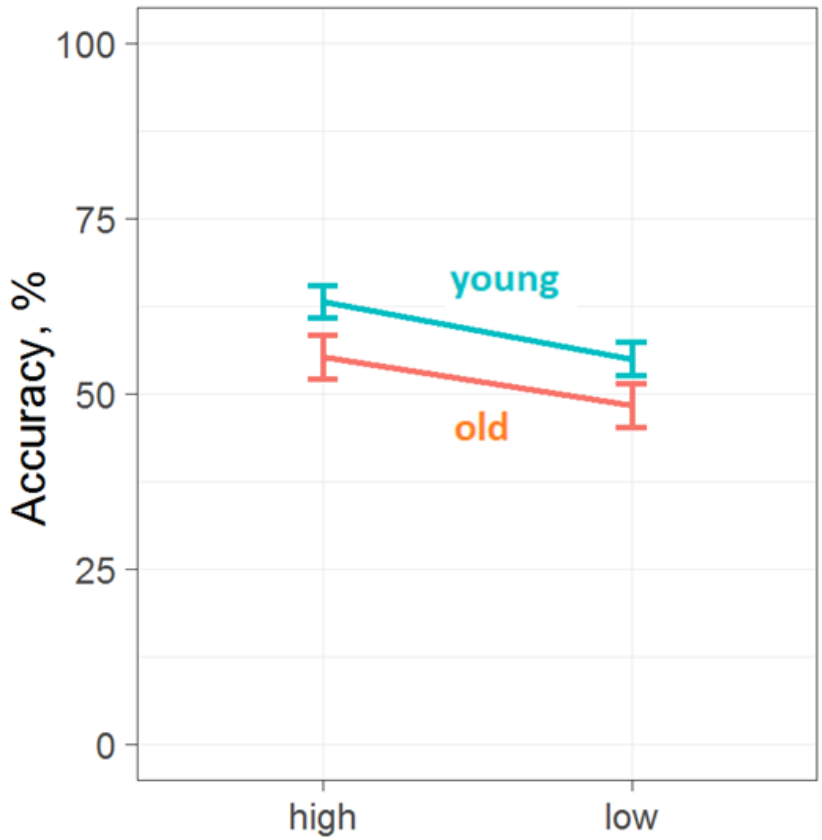
	Accuracy	Reading time
Plausibility x Noise	p = .94	p = .50

- No evidence for greater reliance on good-enough processing in visual noise

+ Exploratory analysis



	Accuracy	Reading time
Attachment	***p* < .001**	n/a
Age x Attachment	*p* = .48	n/a



High attachment:

the child$_{Acc,fem}$
of the writer$_{Gen,fem}$
who was babbling$_{Acc,fem}$

Low attachment:

the child$_{Acc,fem}$
of the writer$_{Gen,fem}$
who published$_{Gen,fem}$

	Accuracy	Reading time
Attachment	***p* < .001**	n/a
Age x Attachment	*p* = .48	n/a

- We do use syntactic heuristics (high attachment preferred)
- No evidence for different use of syntactic heuristics by younger versus older adults

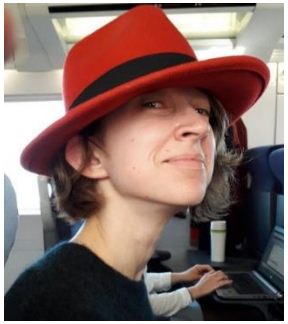
Conclusions

Conclusions

- **Older age** increased reliance on good-enough processing.
  - **Qualitative** age-related changes in sentence comprehensions: **syntactic-to-semantic shift** (Beese et al., 2018). Why?
    - Increased world knowledge and experience?
    - Expectations for common ground?
    - Attempt to spare cognitive resources?
- **Visual distraction** did not increase reliance on good-enough processing.
  - Insufficient distraction?
  - What about stronger distraction or perceptual noise?
  - In progress: auditory distraction (multi-talker babble)

Acknowledgements

- Anna Laurinavichyute



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Thank you!

Questions?

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