Aix Marseille université cnrs

Laboratoire de Psychologie Cognitive

New light on the mind's eye

The pupillary light response as a measure of external and internal attention

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http://www.cogsci.nl/smathot

November 25th, 2015, 10-year anniversary Féderation 3c, Marseille

The research leading to these results has received funding from the People Programme (Marie Curie Actions) of the European Union's Seventh Framework Programme (FP7/2007-2013) under REA grant agreement n° 622738.

The pupillary light response

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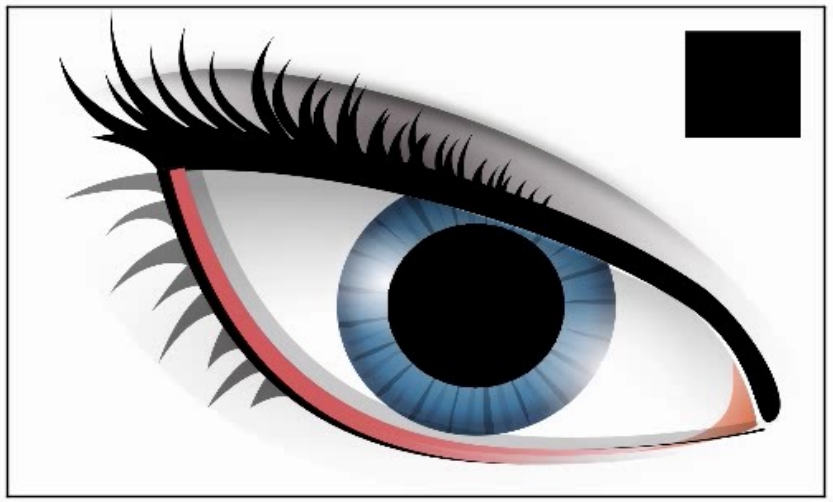

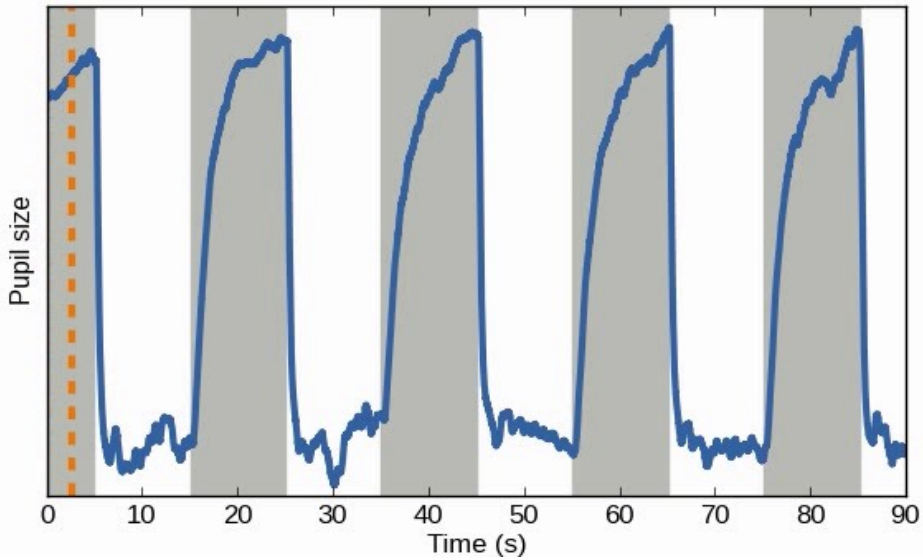

The pupillary light response

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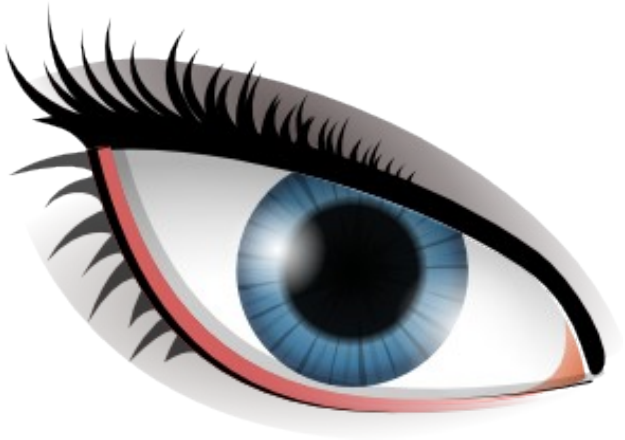
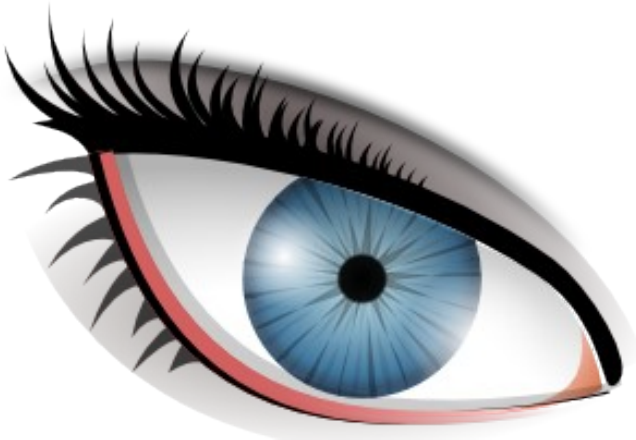


Captures lots of light

Has lots of optical distortions



Captures less light

Has less optical distortions

The pupillary light response

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- The pupillary light response is traditionally considered a reflex
- Recent studies show cognitive influences[1]
- Today: the light response as a measure of
  - External attention: selecting from visual input
    - Attending to a face in a crowd
  - Internal attention: sensory representations without visual input
    - Remembering a face

[1] Reviewed in Mathôt & Van der Stigchel (2015)

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The pupillary light response and external attention

Mathôt, Dalmaijer, Grainger, & Van der Stigchel (2014) doi:10.1167/14.14.7

External attention

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- If you attend to something, you see it more clearly
- Sudden visual events capture attention[1]
  - A light that is switched on
  - A sudden movement
- … regardless of goals
  - It's reflexive
- … and this can occur without eye movements
  - Covert visual attention

[1] Yantis & Jonides (1984)

External attention

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- Reflexive shifts of attention are brief
- … and followed by inhibition (of return) [1]
- This prevents us from attending to the same things over and over again [2]
  - A been-there-done-that mechanism
- Does the light response reflect:
  - Reflexive attention?
  - Inhibition of return?

[1] Posner and Cohen (1984) [2] Klein (2000)

Methods

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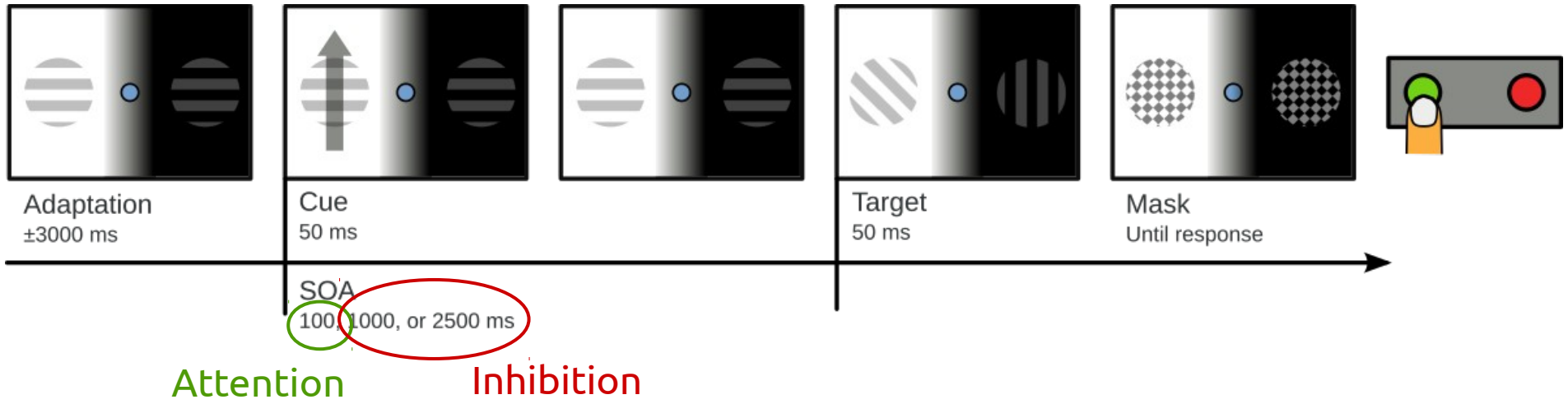

Results

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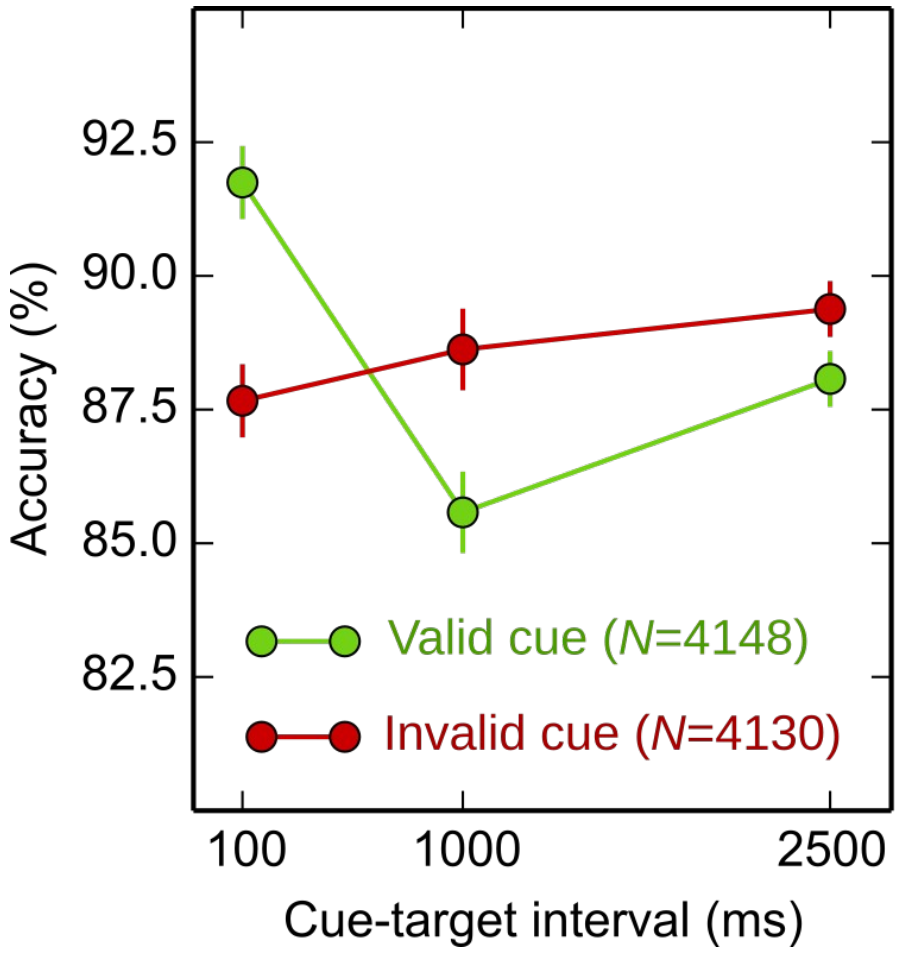

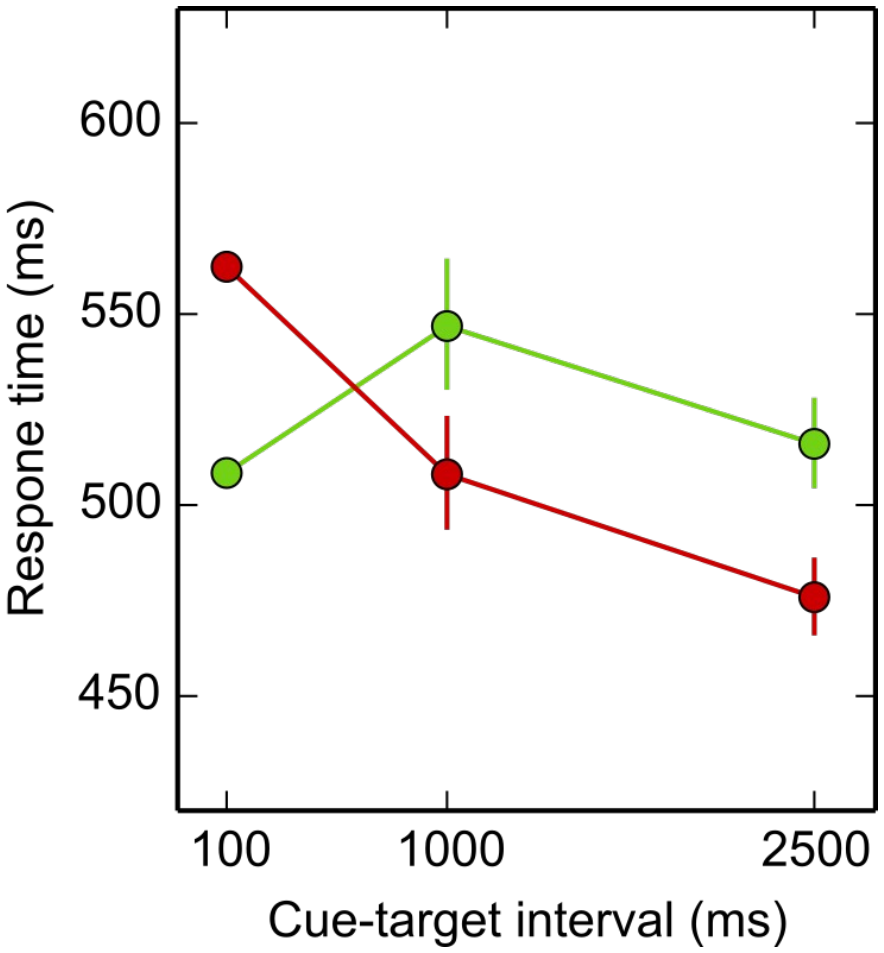

Prediction

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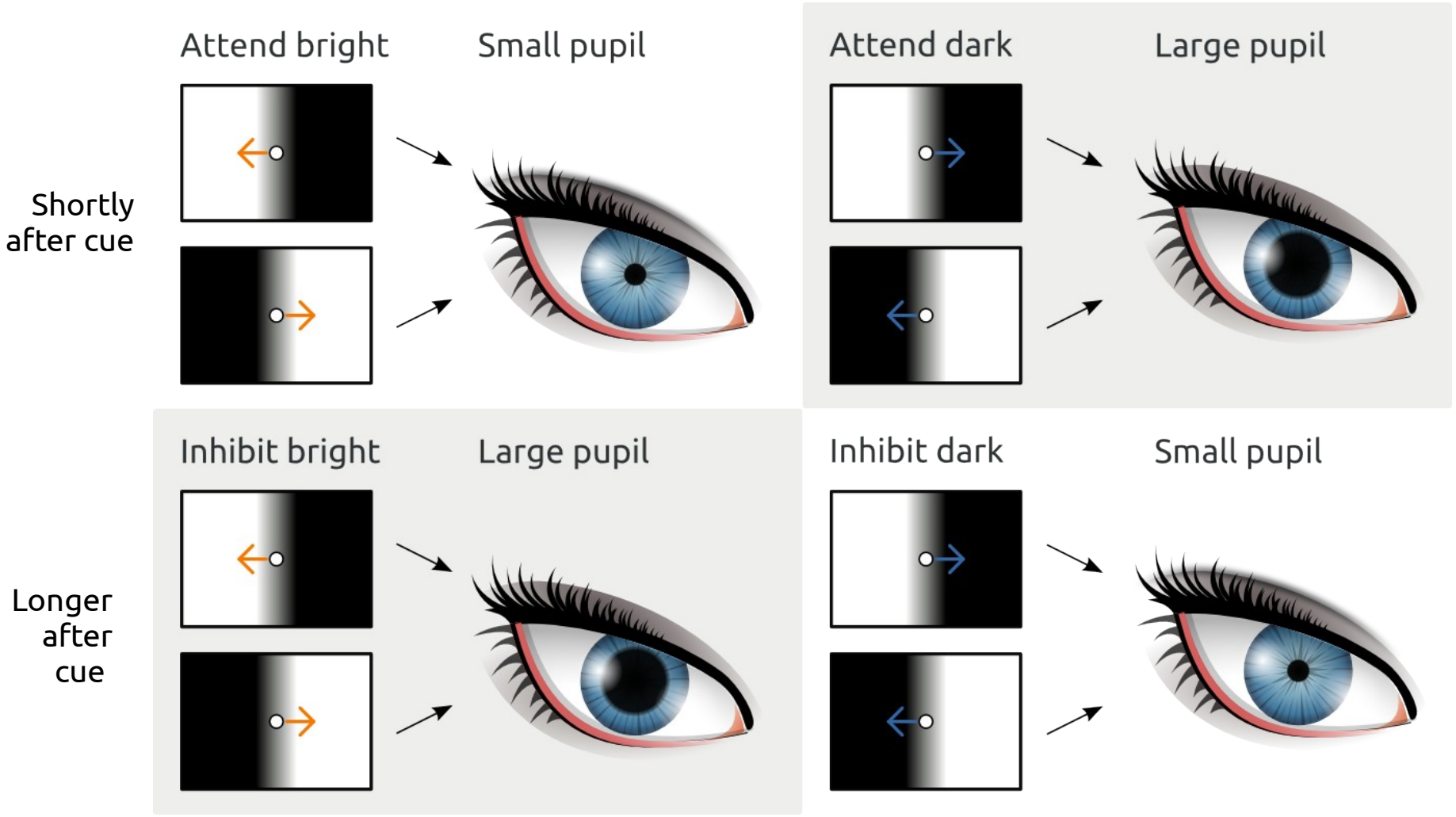

Results

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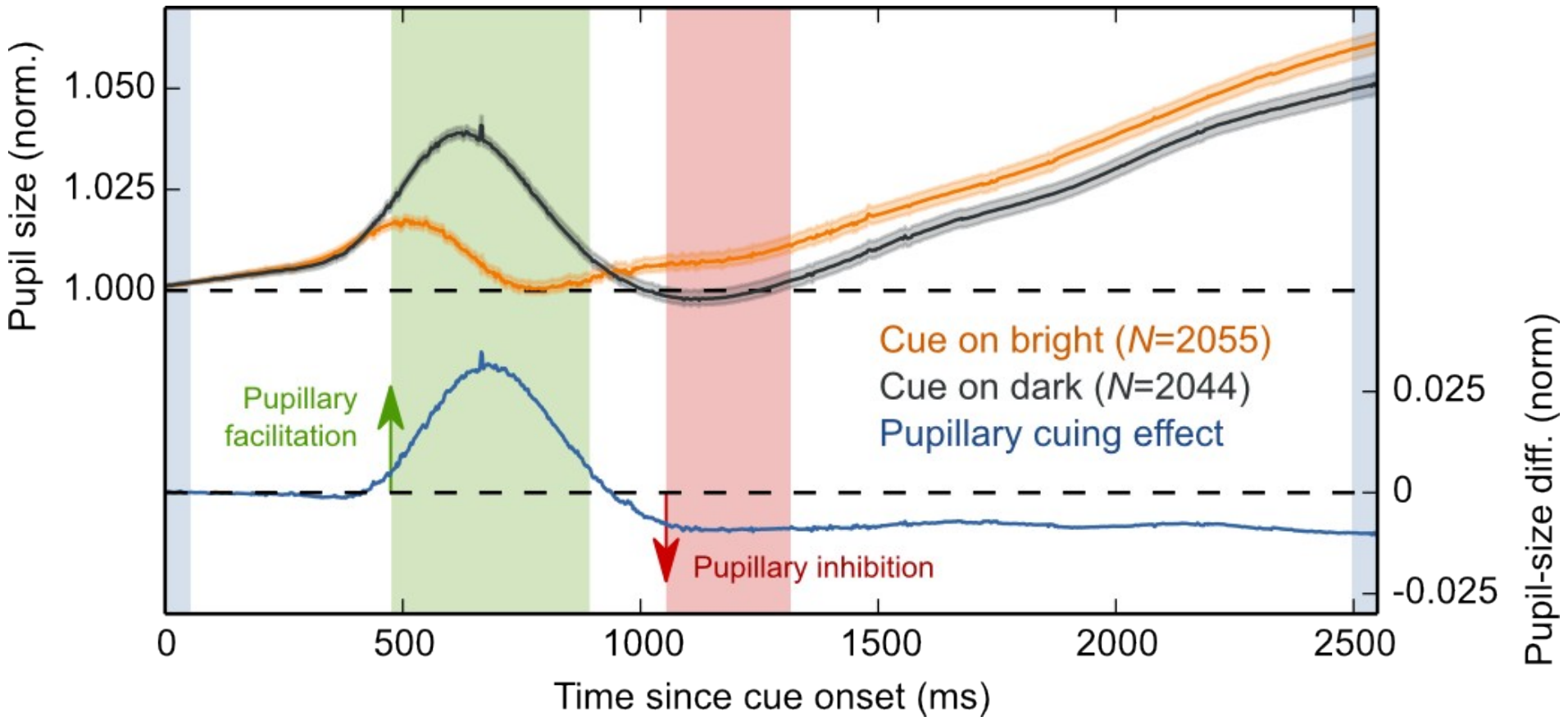

Interim discussion

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- Pupil size reflects reflexive attention
- … and subsequent inhibition of return
- Can we link this to behavior?
  - Strong behavioral effect → Strong pupillary effect

Results

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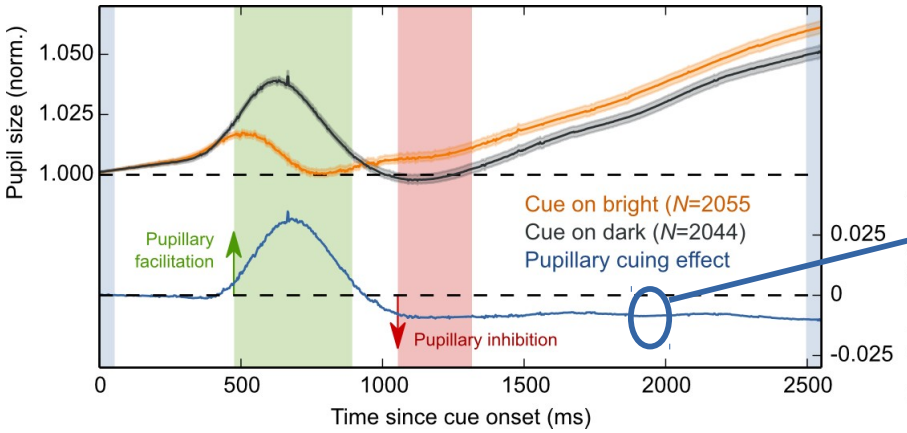

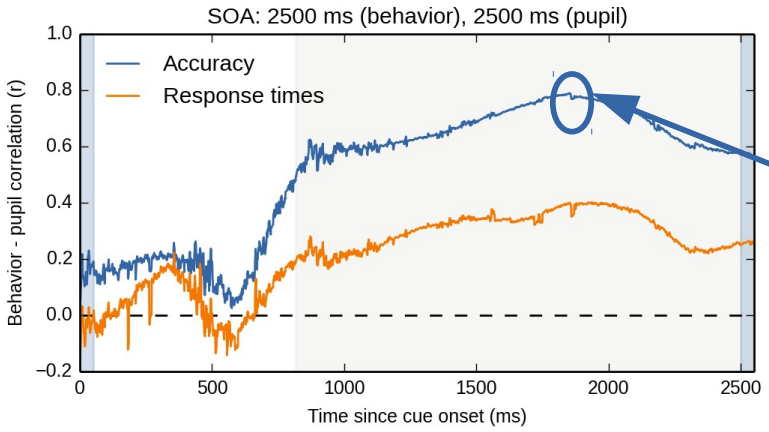

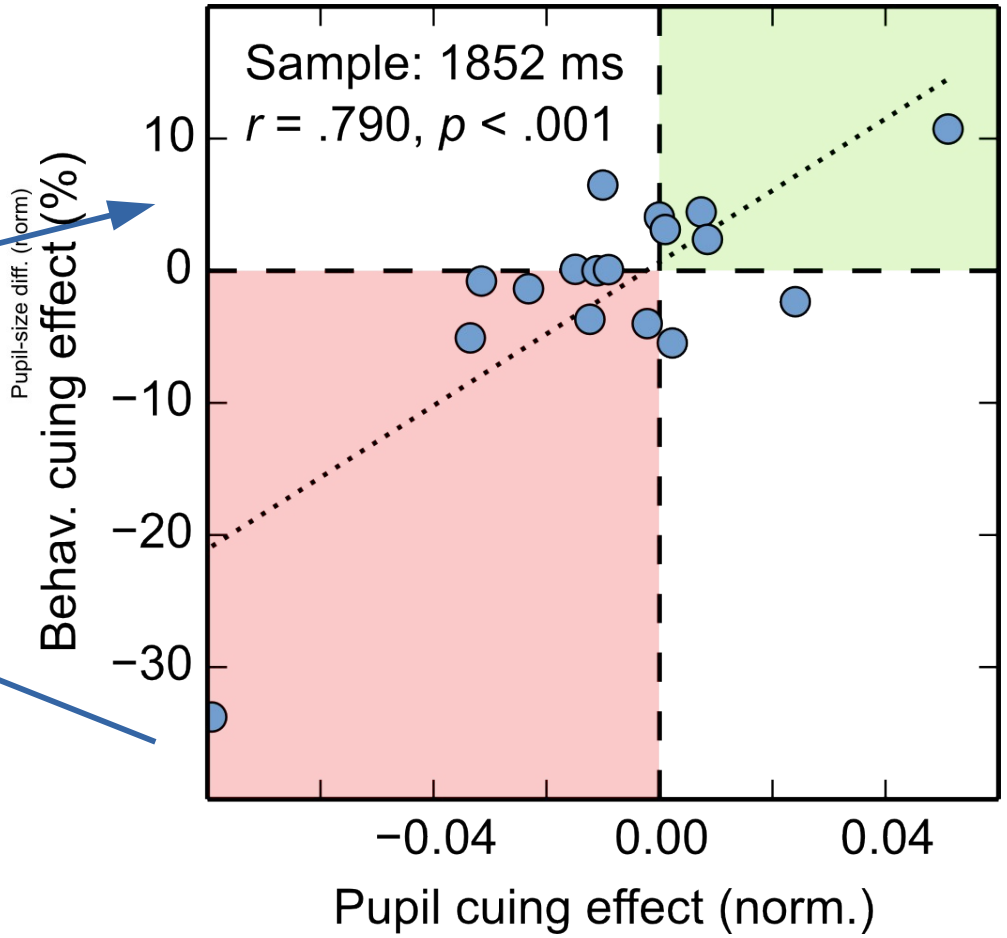

Results

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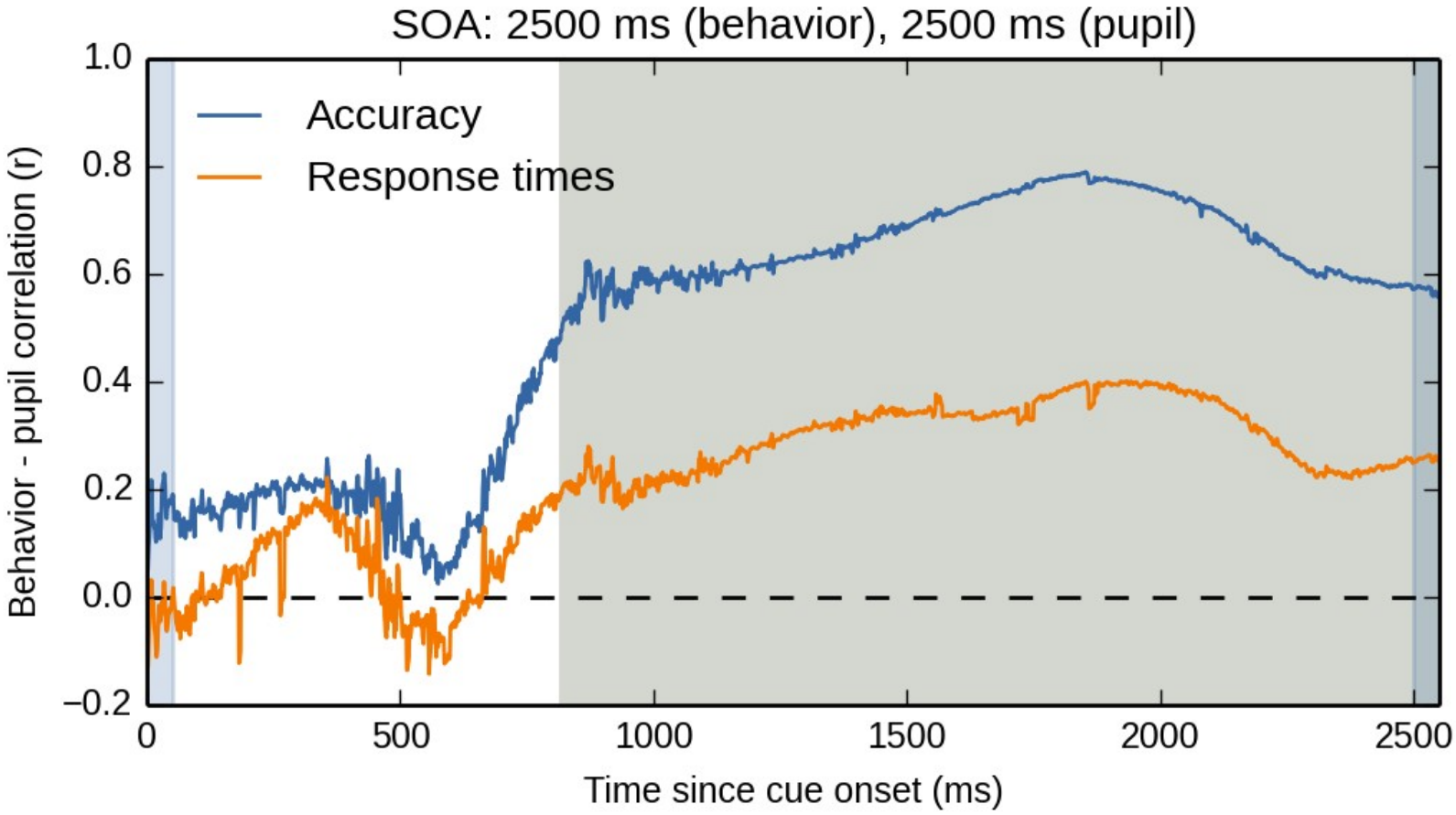

Discussion

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- Pupil inhibition is related to behavioral inhibition of return
- … which suggests that both reflect the same mechanism
- The pupillary light response is a sensitive measure of external attention and inhibition

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The pupillary light response and internal attention

Work in progress with Jonathan Grainger and Kristof Strijkers

Internal attention

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- You don't need visual input for sensory representations
- You can:
  - Keep something in working memory
  - Retrieve something from long-term memory
  - Read
- Umbrella term: internal attention[1]

[1] Chun, Golomb, & Turk-Browne (2011)

Methods

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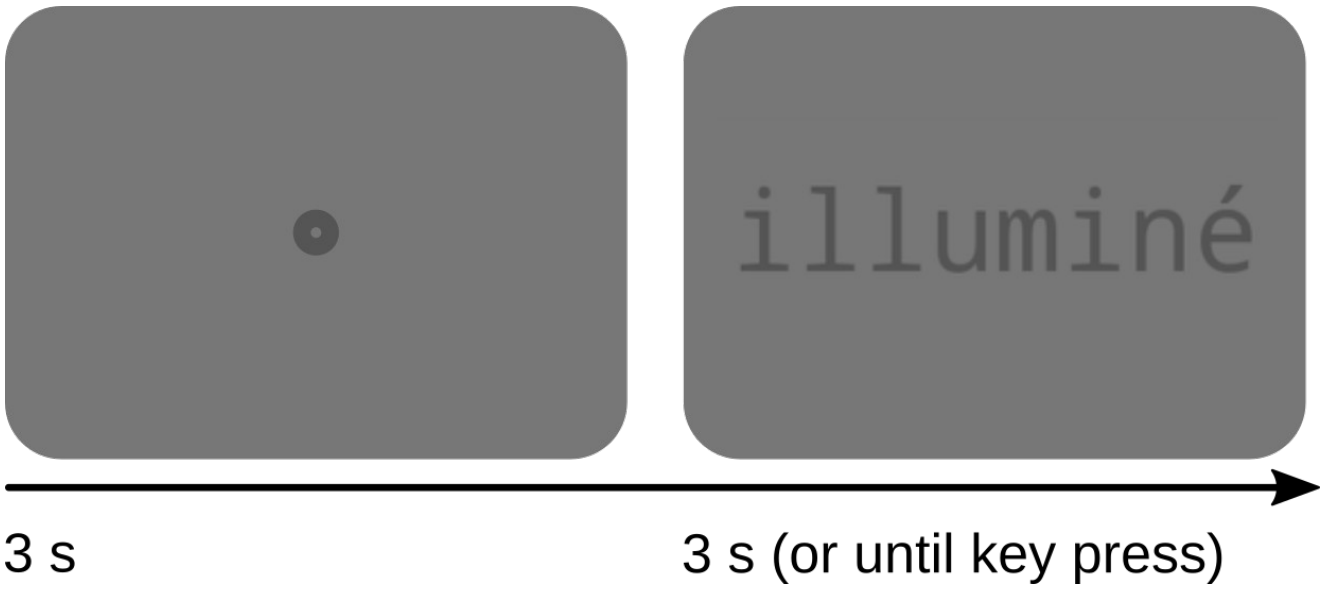
- Single word shown for 3 s
  - Brightness-conveying, darkness-conveying, neutral, and animal names
  - Matched on visual and lexical properties
- Press key for animal names



Predictions

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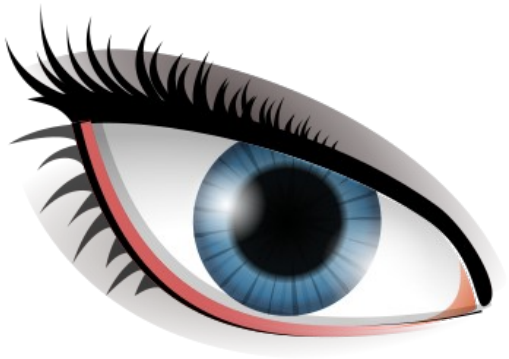
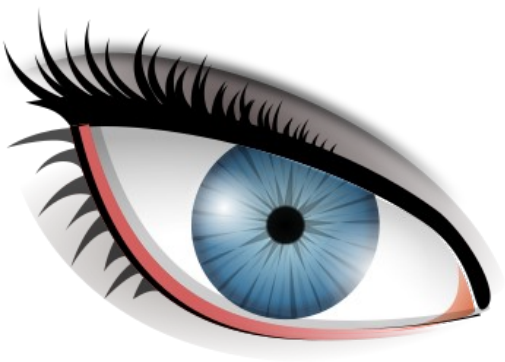
Darkness-conveying words



Brightness-conveying words



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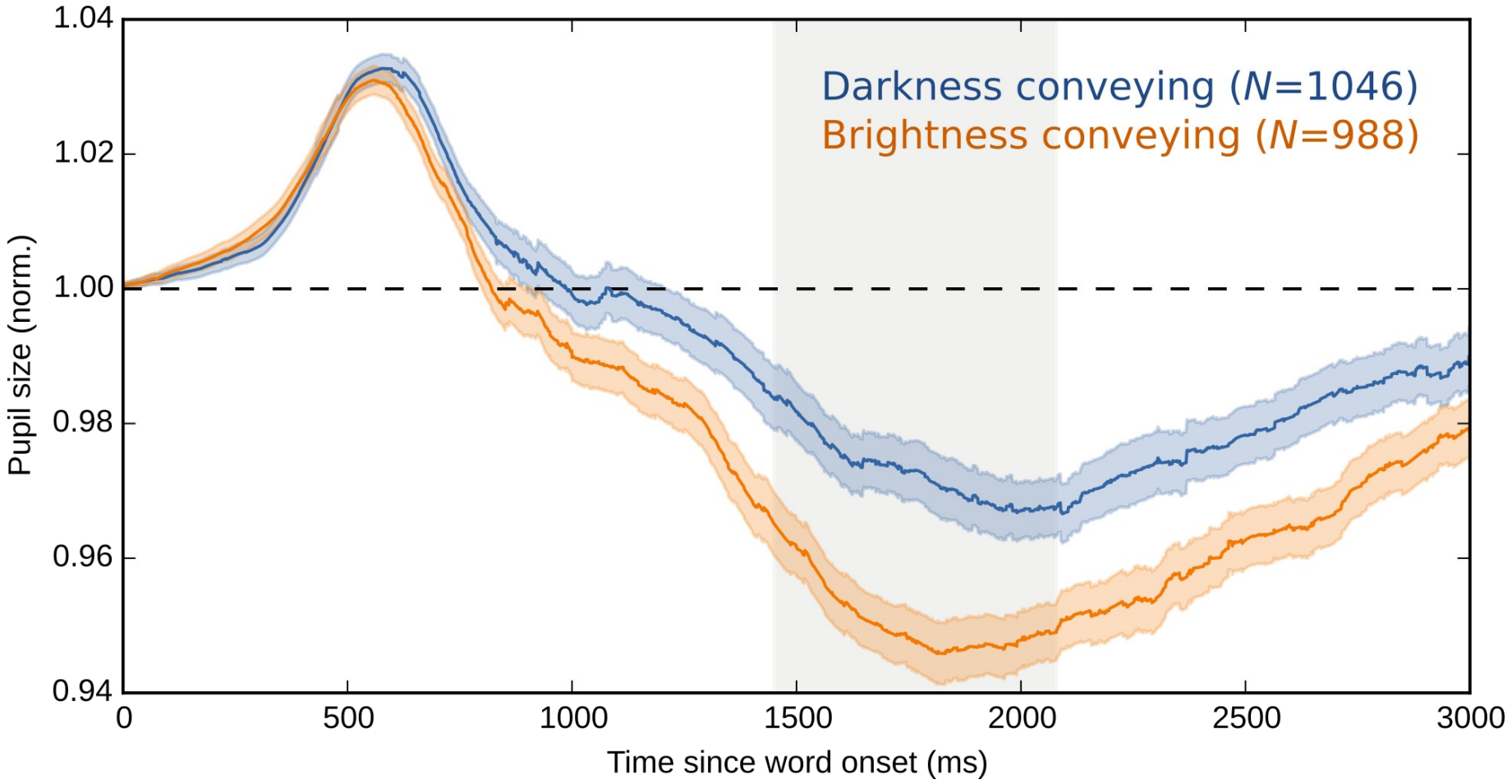

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But …

“Afraid of the dark”

- What about emotional intensity?
  - “Afraid of the dark” → Large pupils
- Normative ratings:
  - Subjective brightness
  - Valence
  - Emotional intensity:
    - Intensity = |3-valence|

Results

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- Valence:
  - Bright words more positive than dark
  - Both positive and negative emotions trigger dilation → not a problem
- Emotional intensity:
  - Bright slightly more intense than dark
  - Intense emotions trigger dilation → acts in the opposite direction
- … and subjective brightness best predictor

Discussion

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- Pupil size reflects semantic brightness
  - Read “sun” → small pupil
  - Read “night” → large pupil
- Word comprehension activates sensory representations (at least sometimes):
  - And these affect pupil size
  - Embodiment
  - Internal attention

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Conclusion

Conclusion

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- Pupillary responses are not passive reflexes
- … but are types of eye movements that reflect high-level visual processing
- External attention
  - Directing your attention to something out there
- Internal attention
  - Sensory representations without visual input

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Thank you for your attention

Sebastiaan Mathôt

Mathôt & Van der Stigchel (2015). New light on the mind's eye: The pupillary light response as active vision. *Curr Dir Psychol Sci* doi:10.1177/0963721415593725

Get papers, slides for this talk, and much more from http://www.cogsci.nl/smathot

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