

CONSCIOUS AND UNCONSCIOUS INFORMATION PROCESSING IN VISUAL WORKING MEMORY

Filippo Gamarota¹, Roy Luria² and Paola Sessa^{1,3}

@XXX AIP - 28 Settembre 2022



¹Department of Developmental Psychology and Socialization

²Tel Aviv University

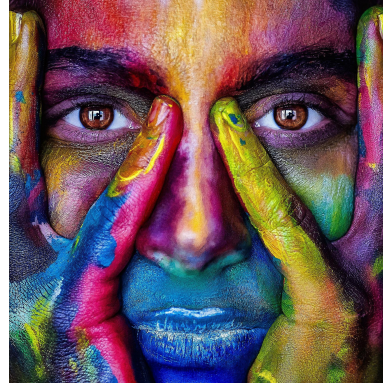
³Padova Neuroscience Center

Working Memory and Consciousness

VWM in everyday life..



Information processing
and manipulation

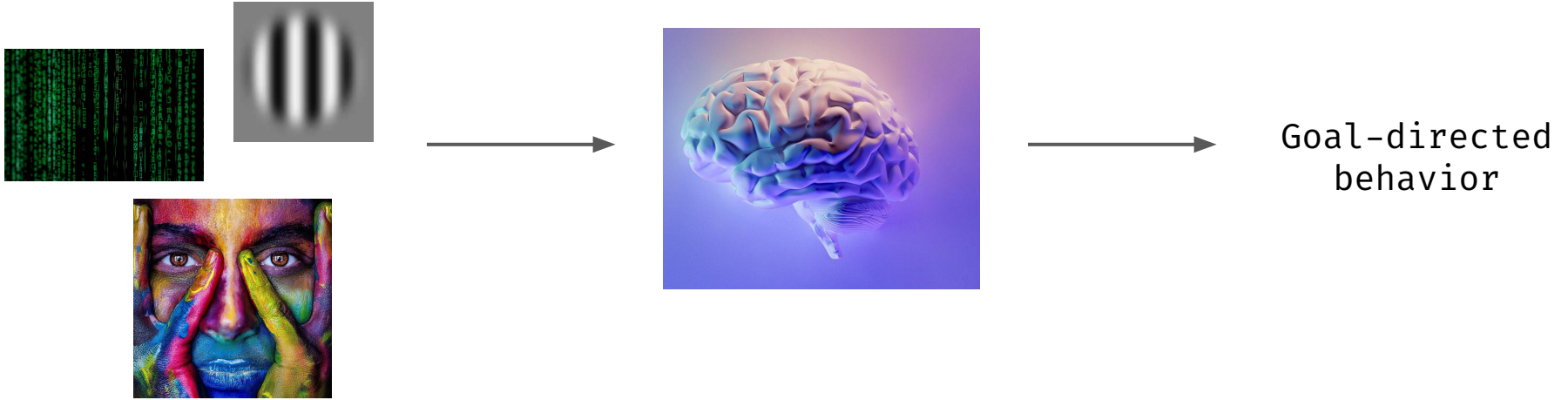


Remembering a face

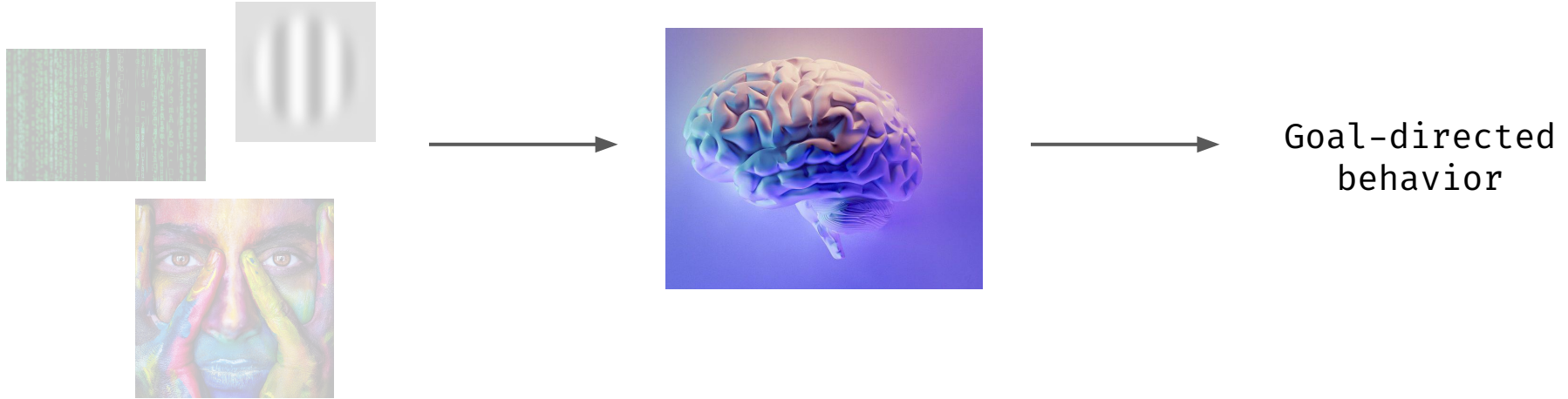


Remembering some digits

VWM in everyday life..

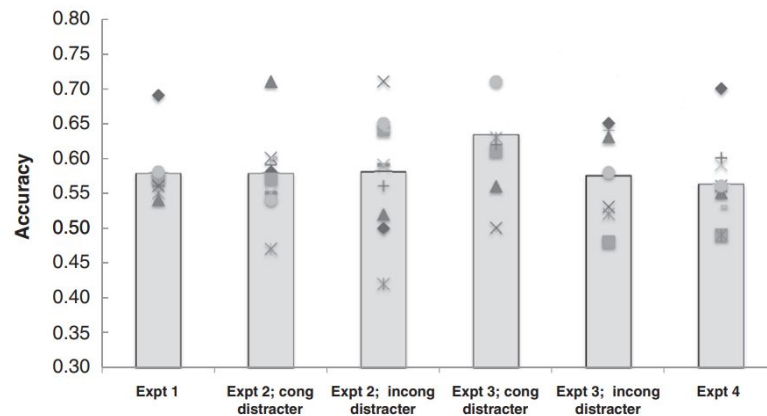
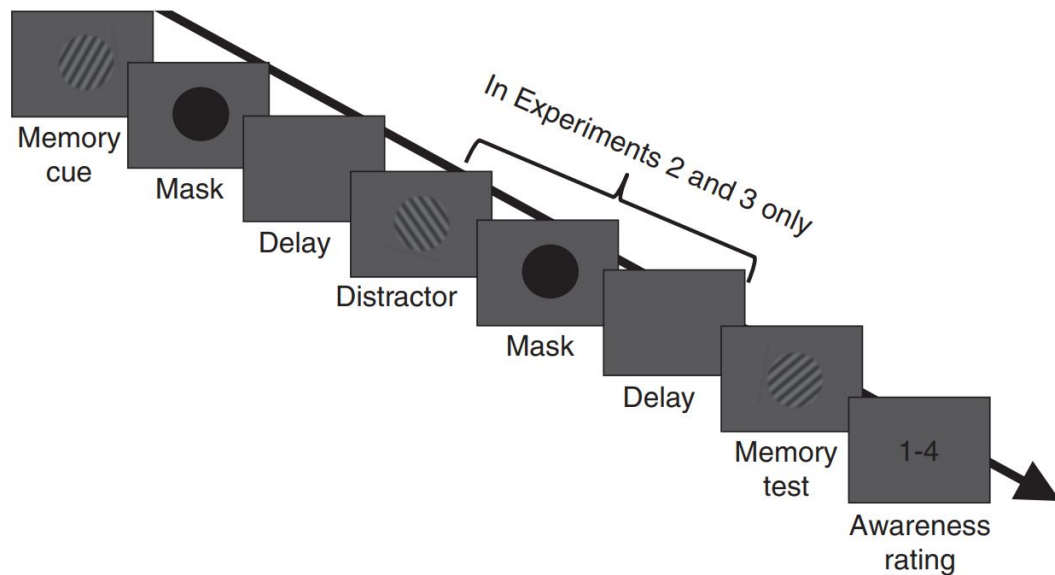


What happen when the information is subliminal?



Testing the dissociation between WM and Consciousness

The first attempt...



Probing the limits of activity-silent non-conscious working memory

Darinka Trübtschek^{a,b,c,1}, Sébastien Marti^{c,2}, Henrik Ueberschär^d, and Stanislas Dehaene^{c,e,1}

^aCognitive Neuroimaging Unit, Commissariat à l'Energie Atomique DSV/IZBM, INSERM, NeuroSpin Center, Université Paris-Sud, Université Paris-Saclay, 91191 Gif/Yvette, France; ^bEcole des Neurosciences de Paris Ile-de-France, 75006 Paris, France; ^cEcole Doctorale Cerveau-Cognition-Comportement, Sorbonne Université, 75005 Paris, France; ^dInstitut de Mathématiques de Jussieu, Sorbonne Université, 75005 Paris, France; and ^eCollège de France, 75005 Paris, France

Contributed by Stanislas Dehaene, May 21, 2019 (sent for review December 7, 2018; reviewed by Floris P. de Lange, Lucia Melloni, and David Soto)

OPEN Temporal-order information can be maintained in non-conscious working memory

Darinka Trübtschek^{1,2,3}, Sébastien Marti³ & Stanislas Dehaene^{3,4}

ORIGINAL ARTICLE

Neural Evidence for Non-conscious Working Memory

Fredrik Bergström^{1,2,3} and Johan Eriksson^{1,2}

frontiers in
HUMAN NEUROSCIENCE

ORIGINAL RESEARCH ARTICLE

published: 21 November 2014
doi: 10.3389/fnhum.2014.00938



Maintenance of non-consciously presented information engages the prefrontal cortex

Fredrik Bergström^{1,2*} and Johan Eriksson^{1,2}

We decided to do a meta-analysis














Neuroscience & Biobehavioral Reviews

Volume 136, May 2022, 104618



Unconscious Visual Working Memory: A critical review and Bayesian meta-analysis

Filippo Garbarota ^{a, b}  , Naotsugu Tsuchiya ^{c, d, e}  , Massimiliano Pastore ^a  , Nicola Di Polito ^f  
, Paola Sessa ^{a, b}  

- **Medium effect ~0.5**
- **High heterogeneity**
- Evidence for **publication bias**

Few open questions...

- Is the **WM effect genuine or emerged only in specific conditions?**
- How **VWM information is retained?**
- Does VWM is sensitive to different **levels of consciousness?**

Experiment

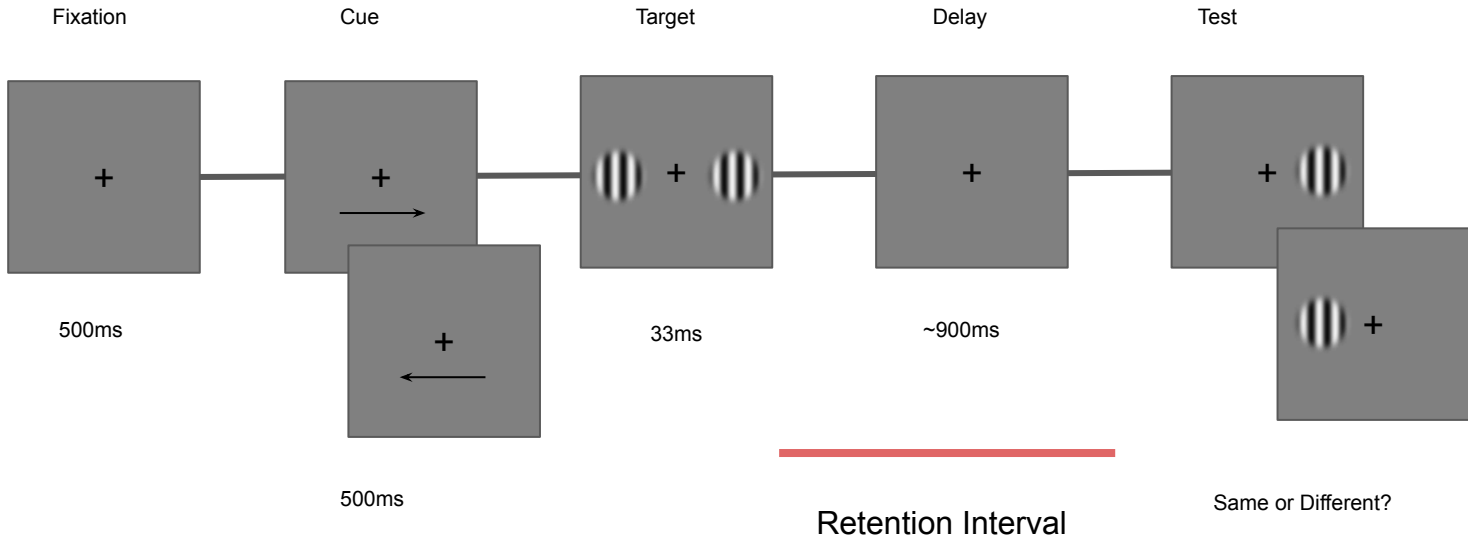
What do we need to test the unconscious WM?

Psychophysical method
to **manipulate the
conscious experience**

Paradigm that elicit the
**behavioral above-chance
effect**

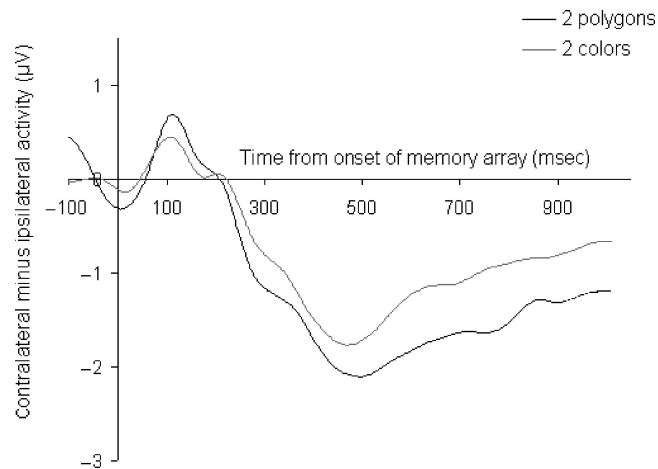
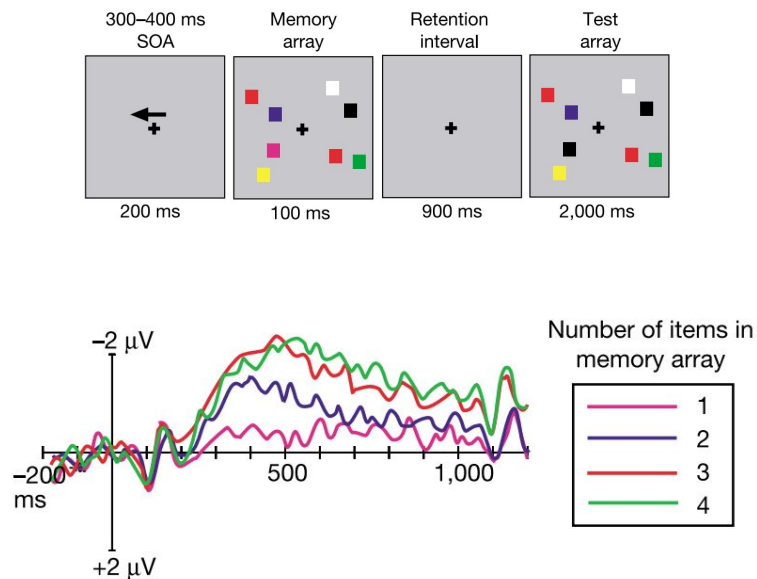
**VWM specific
neural correlate**

Change-Detection Task

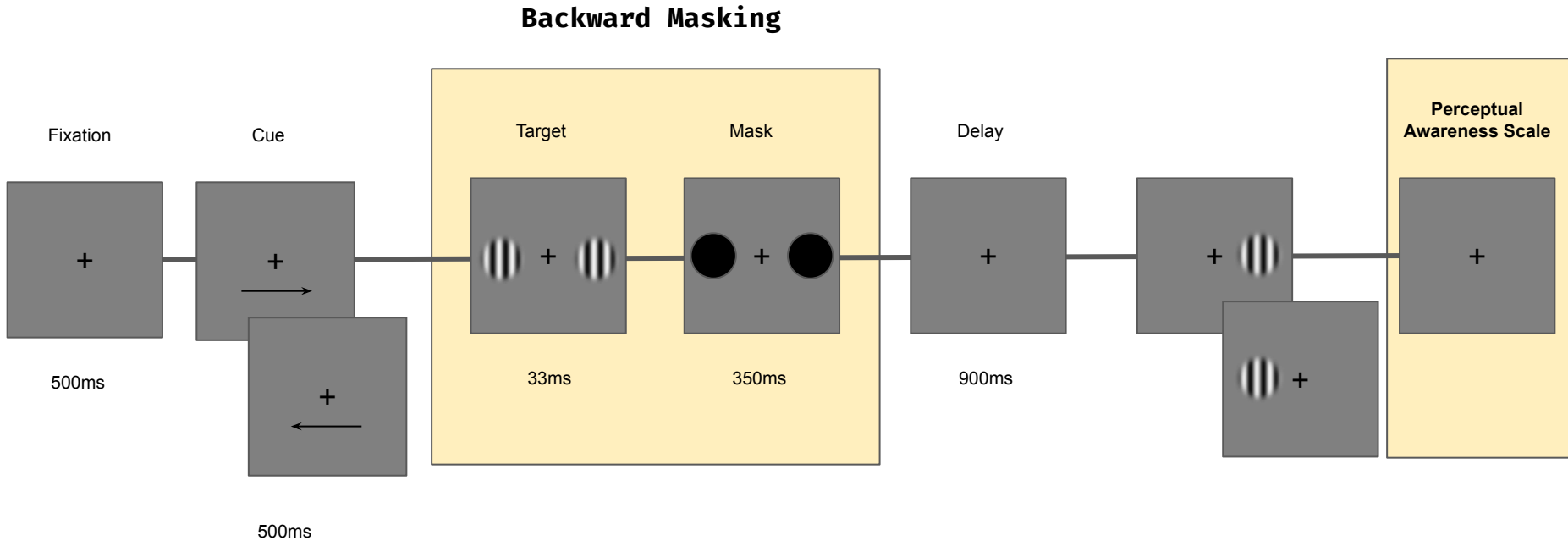


The Contralateral Delay Activity

The **CDA** amplitude increase as the amount of visual information increase



Consciousness Manipulation

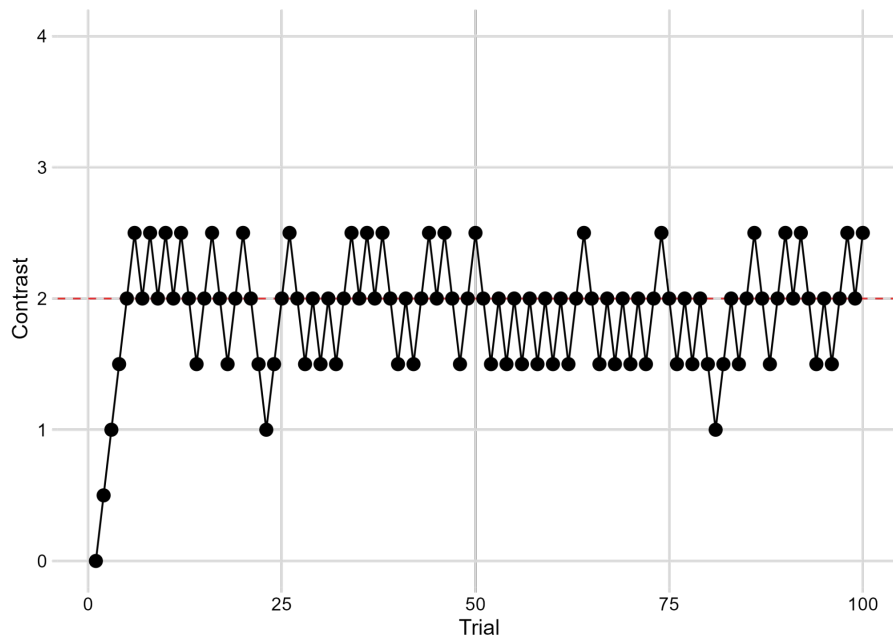
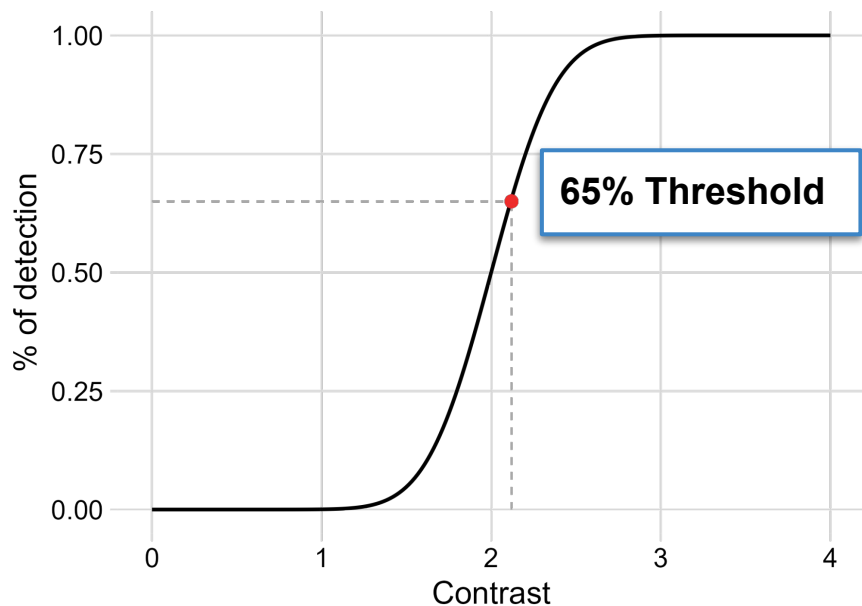


Consciousness assessment

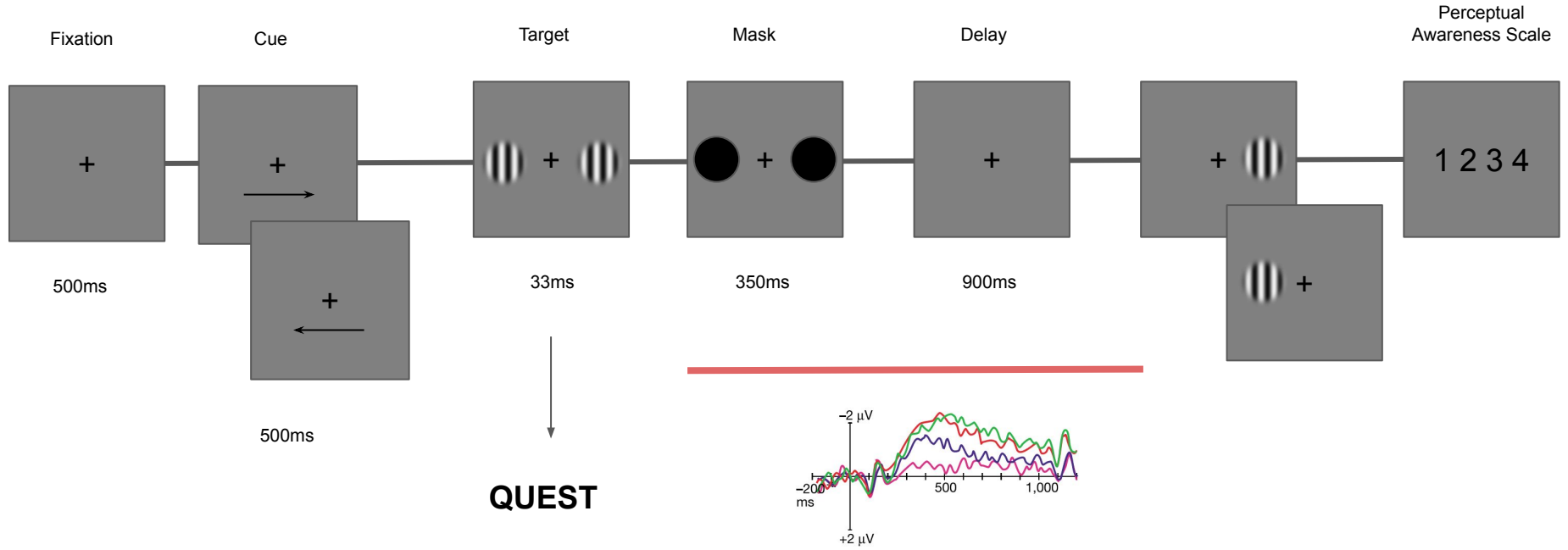
Perceptual Awareness Scale

Category	Description	
No experience	No impression of the stimulus. All answers are seen as mere guesses.	Unconscious
Brief glimpse	A feeling that something has been shown. Not characterized by any content and this cannot be specified any further.	
Almost clear experience	Ambiguous experience of the stimulus. Some stimulus aspects are experienced more vividly than others. A feeling of almost being certain about one's answer.	Conscious
Clear experience	Non-ambiguous experience of the stimulus. No doubt in one's answer.	

QUEST Adaptive procedure



Backward Masking



Hypotheses

1. **Subliminal visual information is retained in VWM and can be actively used** (i.e., above-chance behavioral accuracy on subliminal trials [PAS=1])

2. **The CDA reflects the maintenance of subliminal visual information** (i.e., CDA for subliminal [PAS=1] info different than zero/baseline)

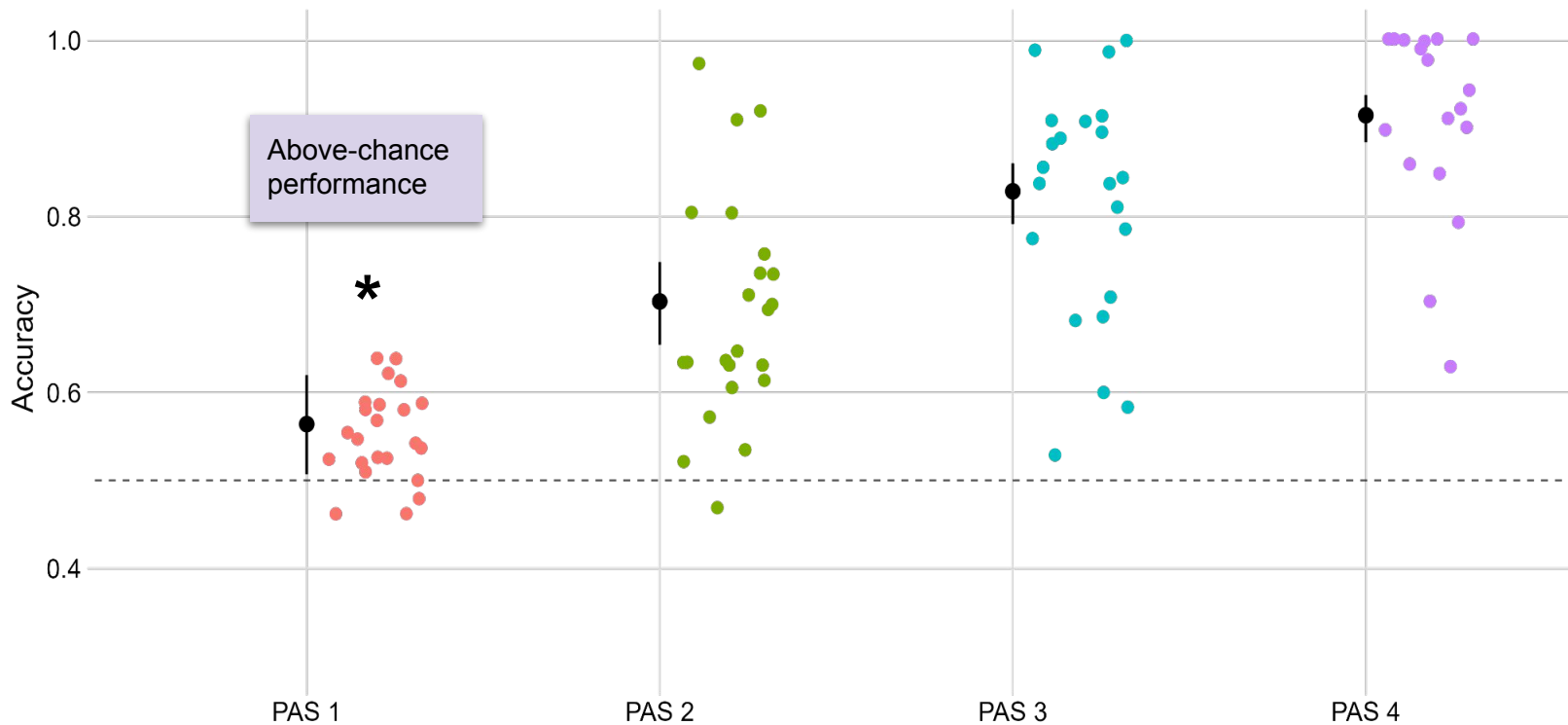
3. **The CDA tracks the clarity of the visual experience** (i.e., higher CDA amplitude for supraliminal [PAS>1] trials vs. subliminal trials [PAS=1])

Experimental Setup

- **23 subjects** (21 females, 2 males)
- **522 total trials** (174 catch trials with no stimulus)
- **~ 1 hour** for the full experiment
- **64 channels EEG** recording

Behavioral Results

Accuracy ~ PAS

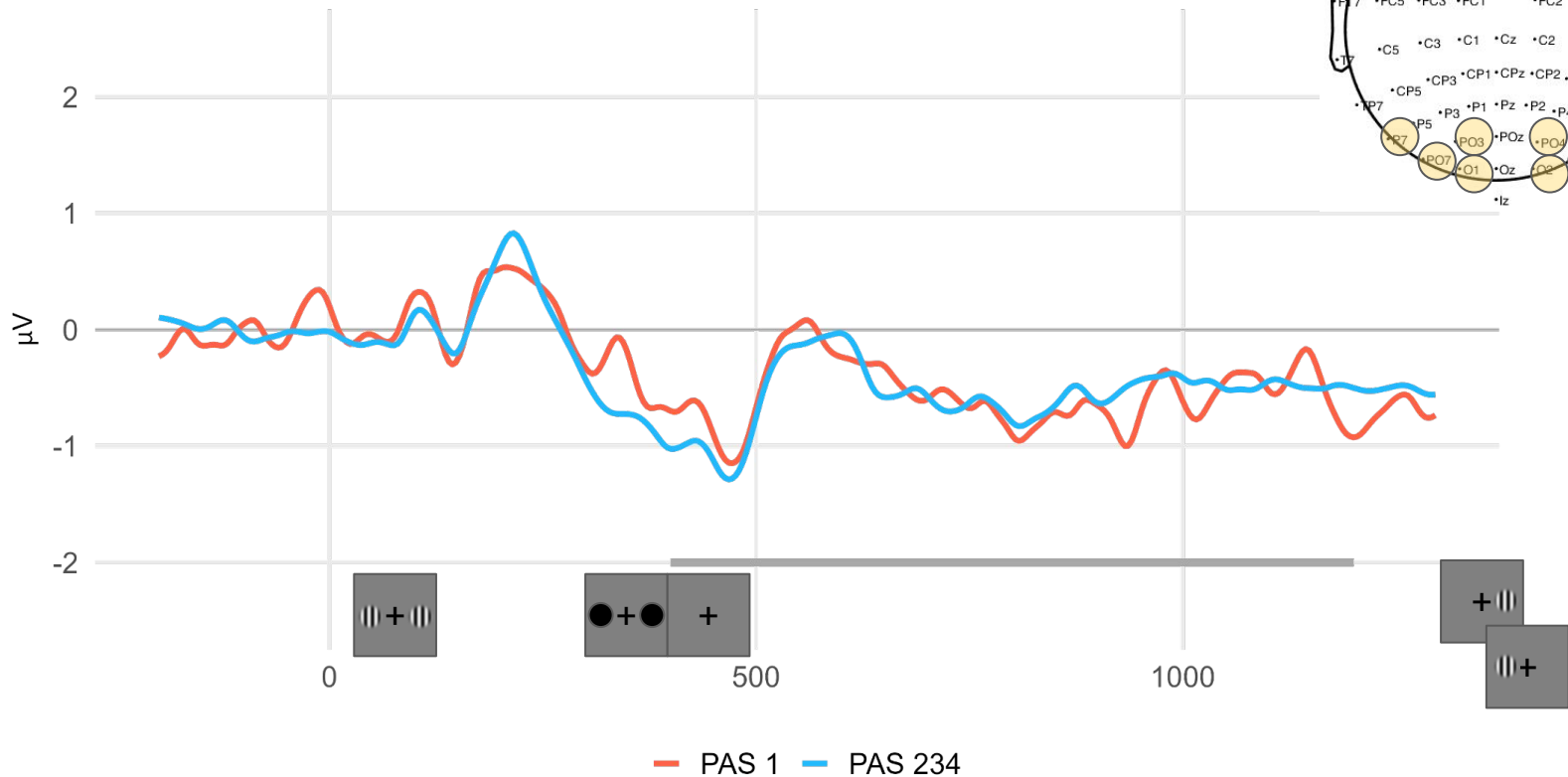


Multilevel logistic regression - PAS 1 vs 50% (OR = 1.29, 95% CI = [1.03, 1.63], $z = 2.19$ $p = 0.0284$)

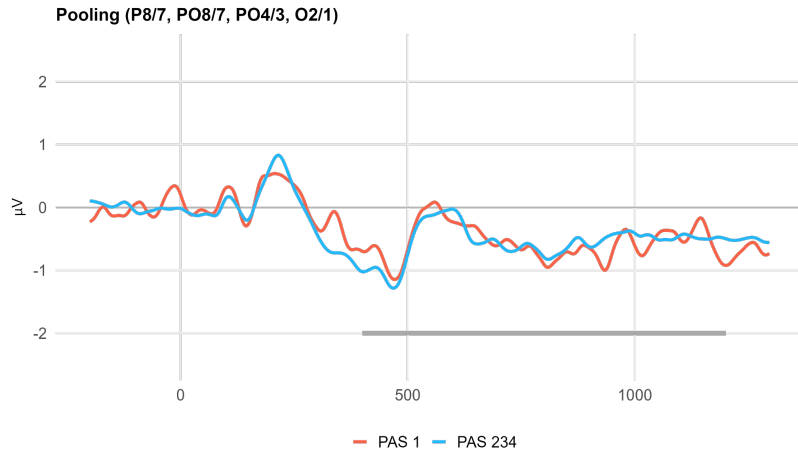
ERP Results

CDA results

Pooling (P8/7, PO8/7, PO4/3, O2/1)



CDA results



PAS 1 vs 0

$M = -0.487$, $SE = 0.224$, $t_{23} = -2.168$, $p = 0.021$, $d = 0.452$

PAS 1 vs 234

$M = 0.034$, $SE = 0.207$, $t_{23} = 0.165$, $p = 0.565$, $d = 0.034$, $BF_{01} = 4.517$

We analyzed the time window 400 - 1200 ms (the retention interval)

Main Conclusions

Conclusions

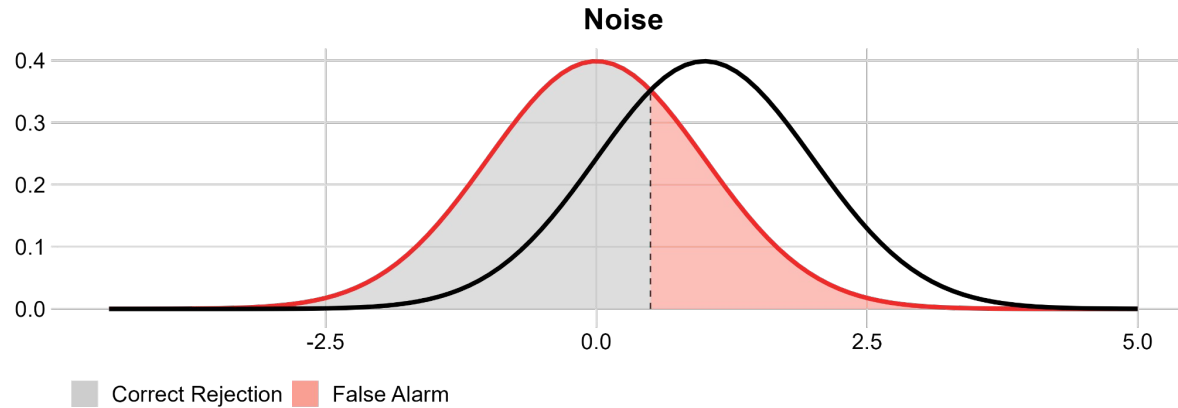
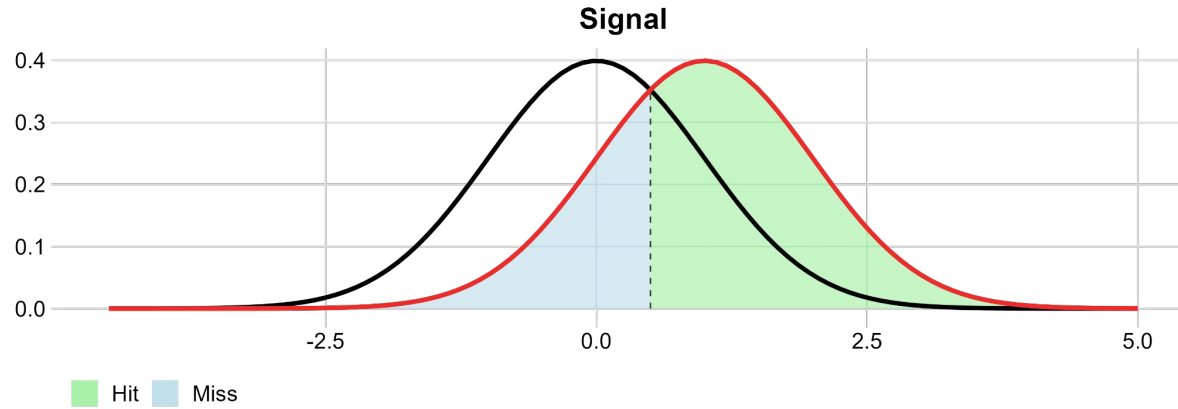
CDA PAS 1 > 0: Subliminal information is retained in VWM

Accuracy PAS 1 > 50%: Subliminal information is used for the CDT

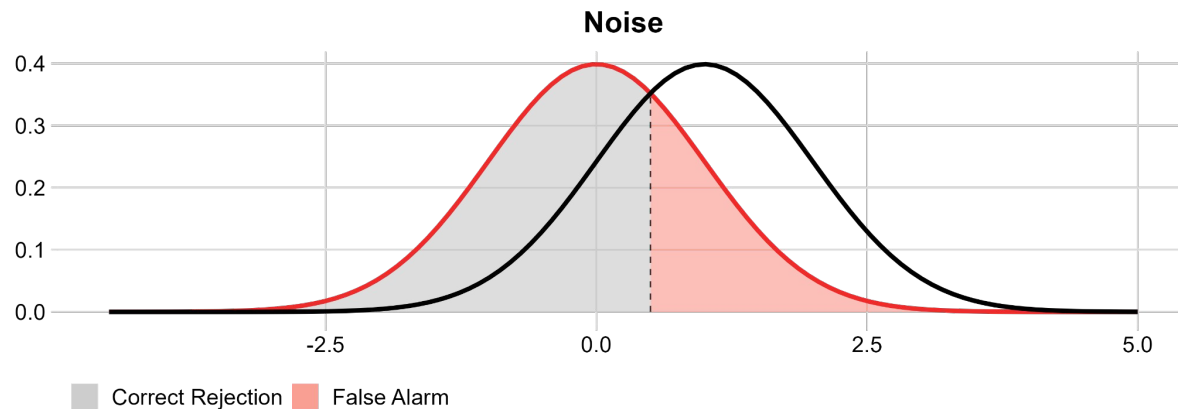
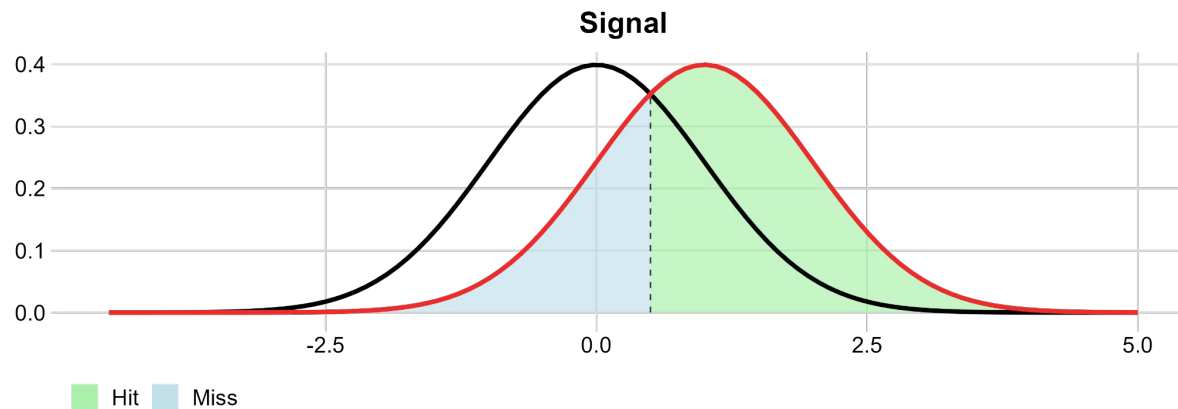
CDA PAS 1 = CDA PAS 2-4: CDA is not tracking the conscious
experience

Extra: Response Criterion

Signal Detection Theory

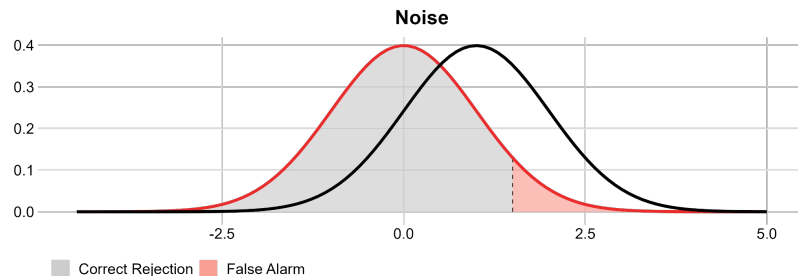
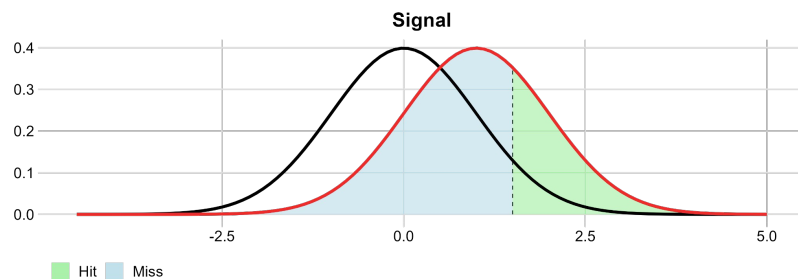


Unbiased Participant

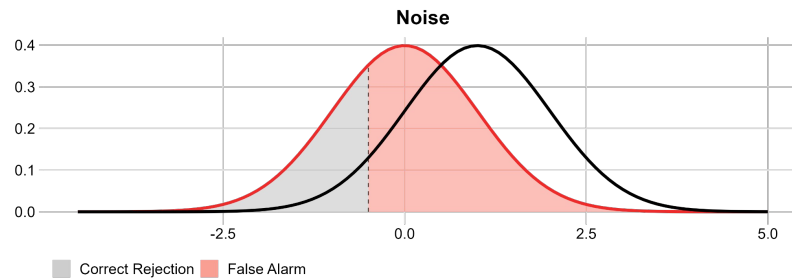
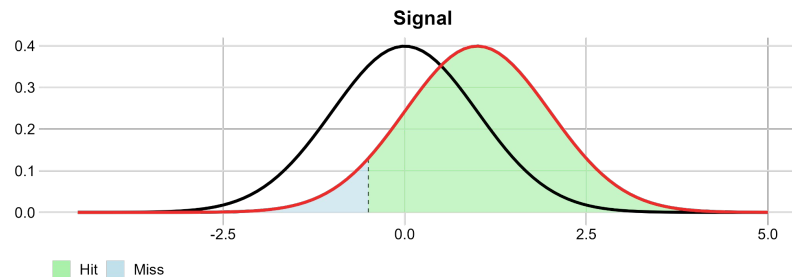


Biased Participant

Conservative



Liberal

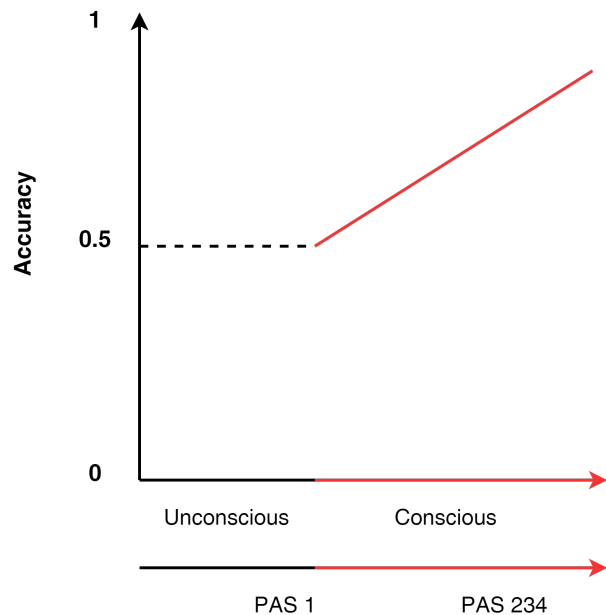


Conservative Criterion Problem

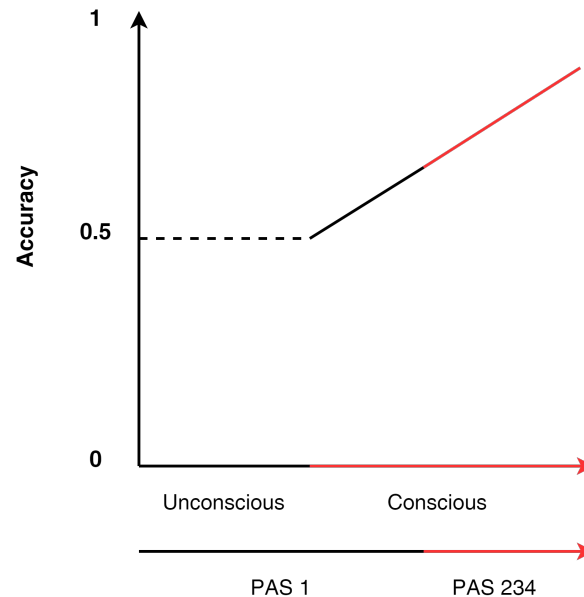
- A **conservative response criterion** (i.e., tendency to say *unconscious*, PAS 1) could **overestimate unconscious processing effects**
- **Previous studies did not report criterion** measures or the **relationship between criterion and accuracy**

Conservative Criterion Problem

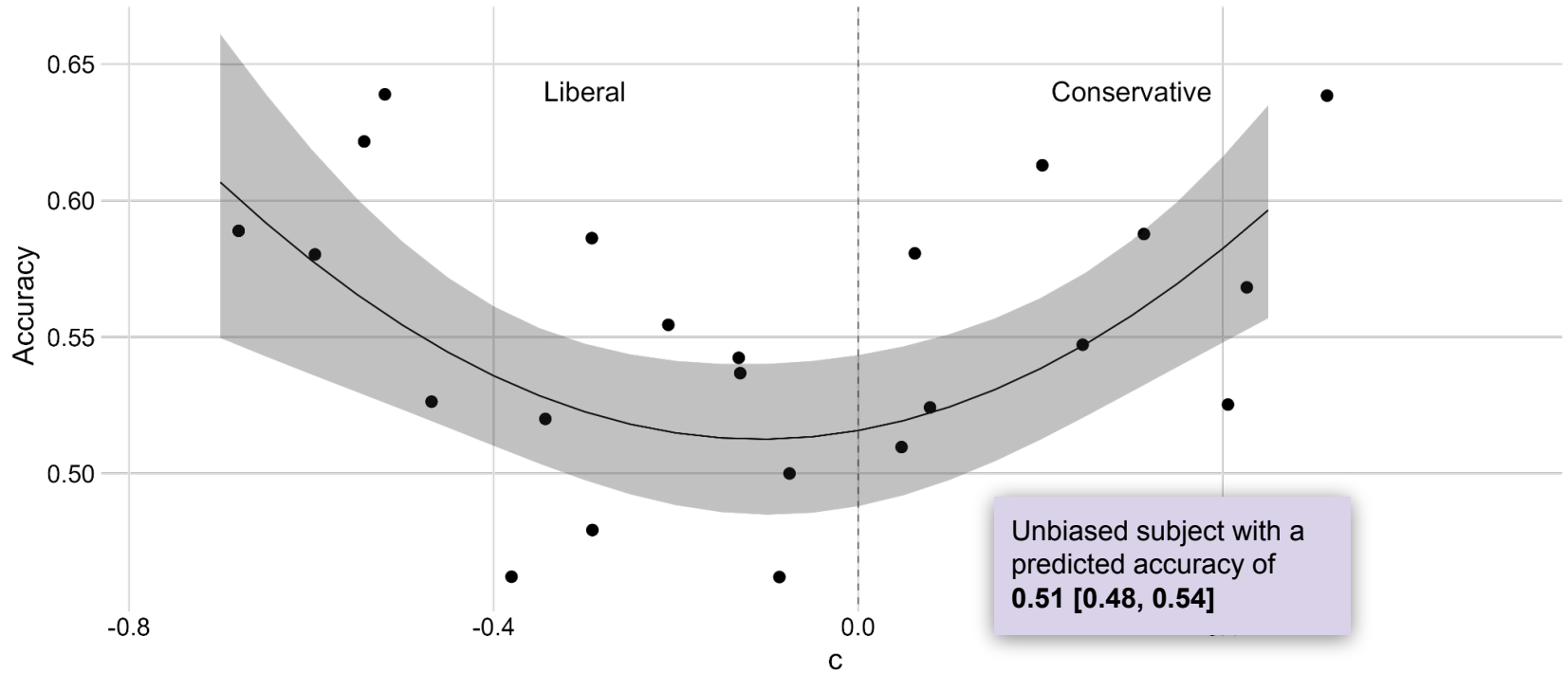
Unbiased



Conservative



Accuracy ~ criterion



Polynomial regression with significant **quadratic component** $\chi^2_1 = 11.674, p < 0.001$

Thanks to my collaborators



Prof. Paola Sessa
University of Padova



Prof. Roy Luria
Tel-Aviv University



filippo.gambarota@phd.unipd.it



filippogambarota



@fgambarota