Human Brain Project

EBRAINS

Integrated effects of multiple Attentional Control signals in the primate brain

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HBP Partnering Projects Meeting: Status quo & outlook

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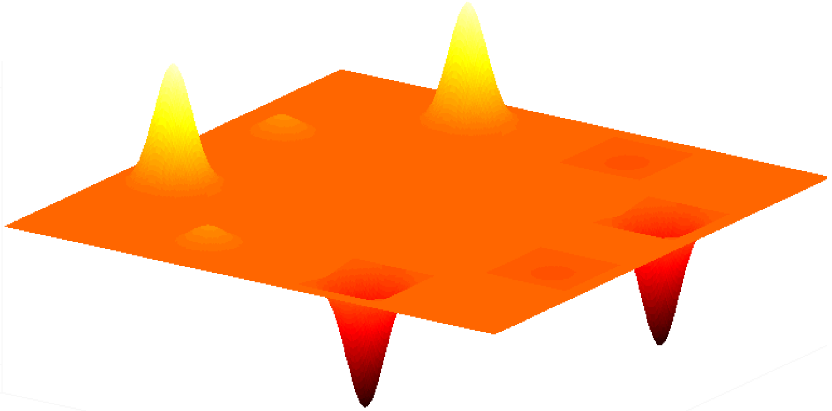
Visual selective attention & Attentional Control signals

Visual selective attention:

- **selection** of relevant information
- **suppression** of distracting information



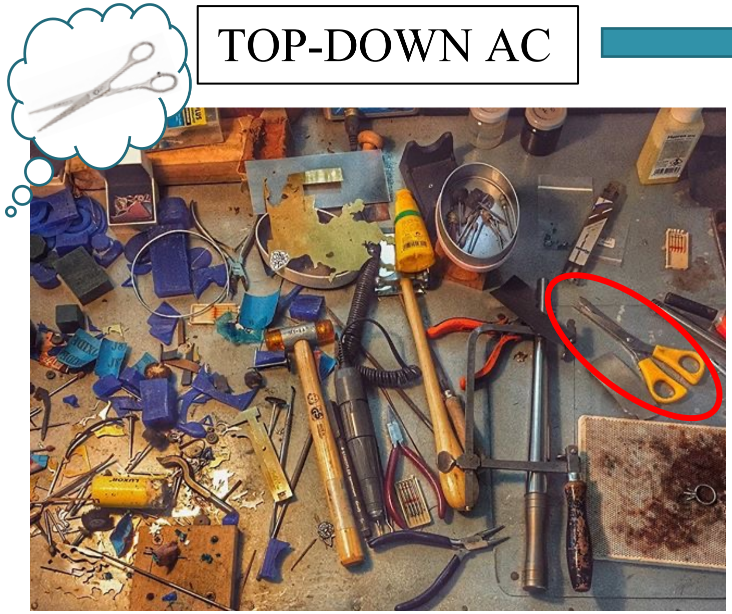
Attentional Control (AC):

- integrates signals form multiple cognitive domains to assign **priorities** to specific sensory inputs, as encoded in **spatial priority maps**

TOP-DOWN AC → SPATIAL PRIORITY MAPS ← BOTTOM-UP AC

↑

EXPERIENCE-DEPENDENT AC



https://instaview.fun/tag/orafa

https://www.gliaudacidellamemoria.com/memoria-a-lungo-termine-e-mnemotecniche/

https://www.stile.it/2018/09/03/bucce-mela-lelisir-non-ti-aspetti-id-195079/

Overarching goal of the research project

- Uncovering the functional architecture of attention in the primate brain to unveil the degree of independence vs. synergy between different **priority signals**:

  - *different priority signals might act as fully **independent** sources of AC*

  or

  - *different priority signals might have **interacting** effects*

- Investigating the neurocognitive implementation of AC in relation to both **target selection** and **distractor filtering** mechanisms.

Strategic plan

1) To construct and validate a set of simple, highly standardized behavioral protocols for investigating the unique and combined influence of multiple **priority signals**

2) To gather a **multi-scale dataset** associated with the neural implementation of these priority signals, as well as of their interaction

3) To synthetize, interpret and model the collected evidence

MAC-Brain: Developing a **Multiscale** account of **Attentional Control** as the constraining interface between vision and action: A cross-species investigation of relevant neural circuits in the human and macaque Brain

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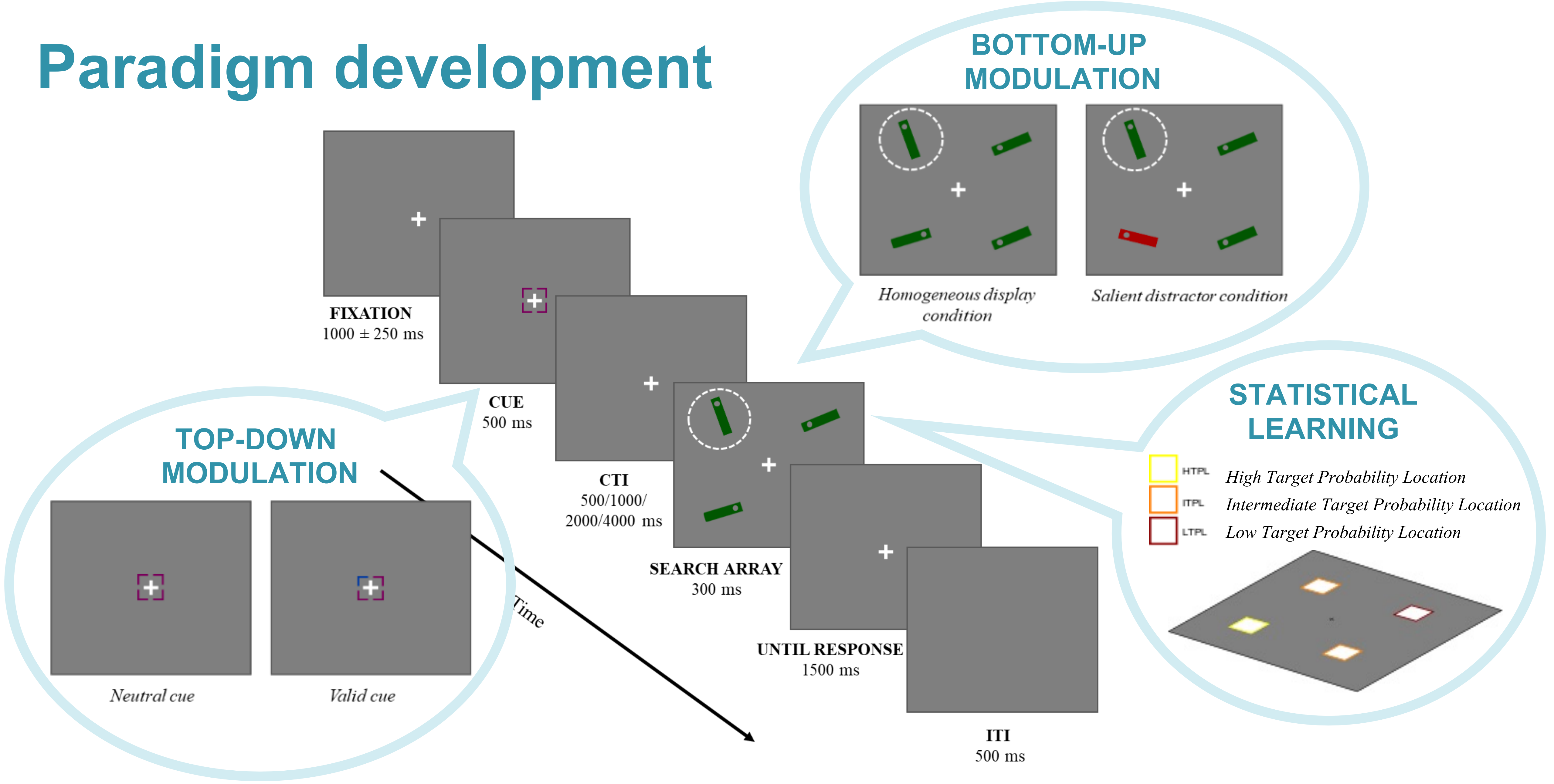
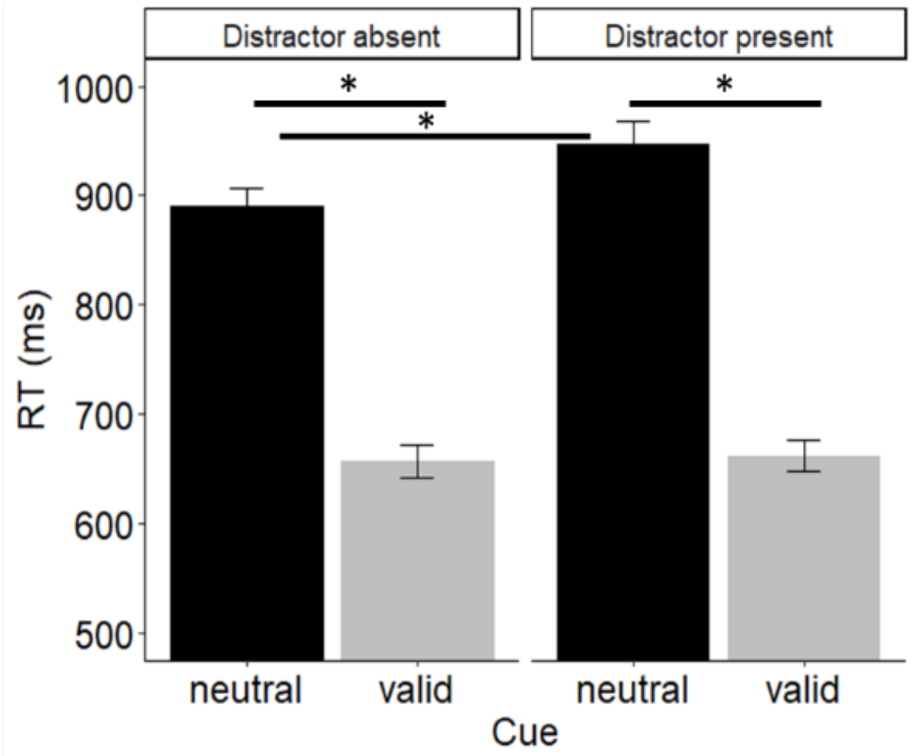
Paradigm development



Behavioral results

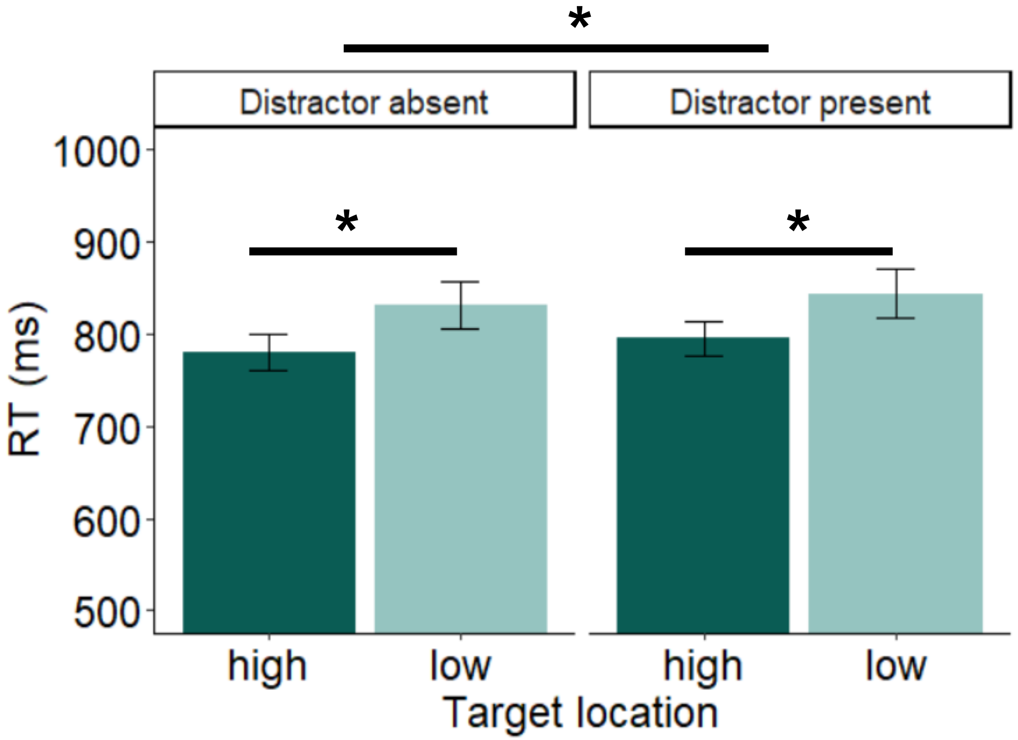
Exp 1 – *Endogenous cueing* (EC)

- Full predictability of target location helps optimize attentional deployment and target selection. Top-down AC exerts a gating effect on bottom-up signals.



Exp 2 – *Statistical Learning* (SL)

- Implicit attentional biases are developed following exposure to imbalances in target frequency across spatial locations.



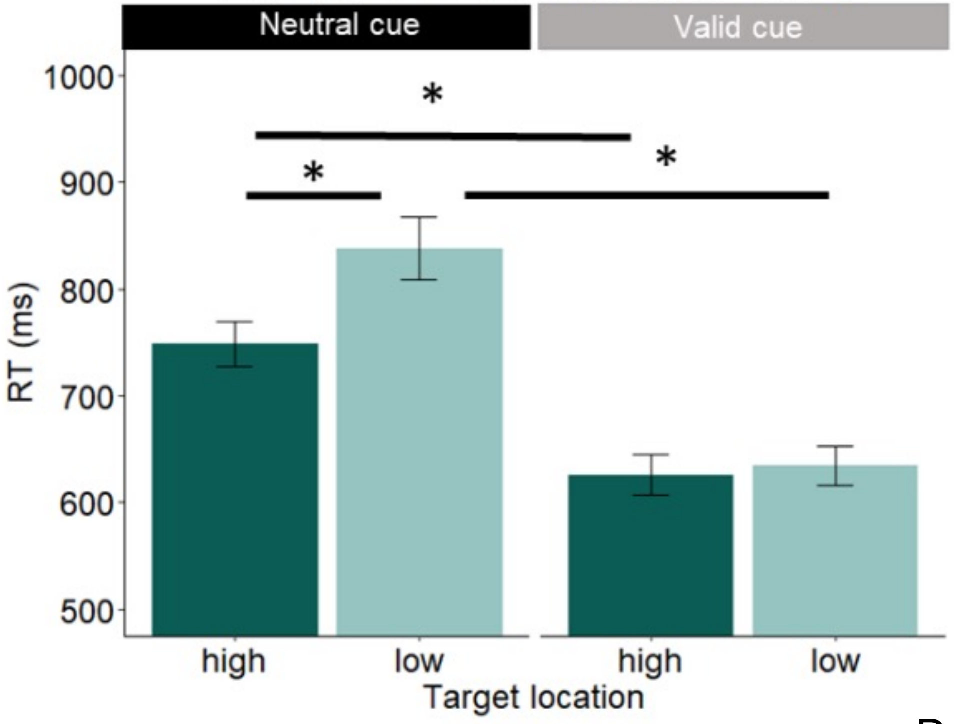
Dolci et al., *in preparation*

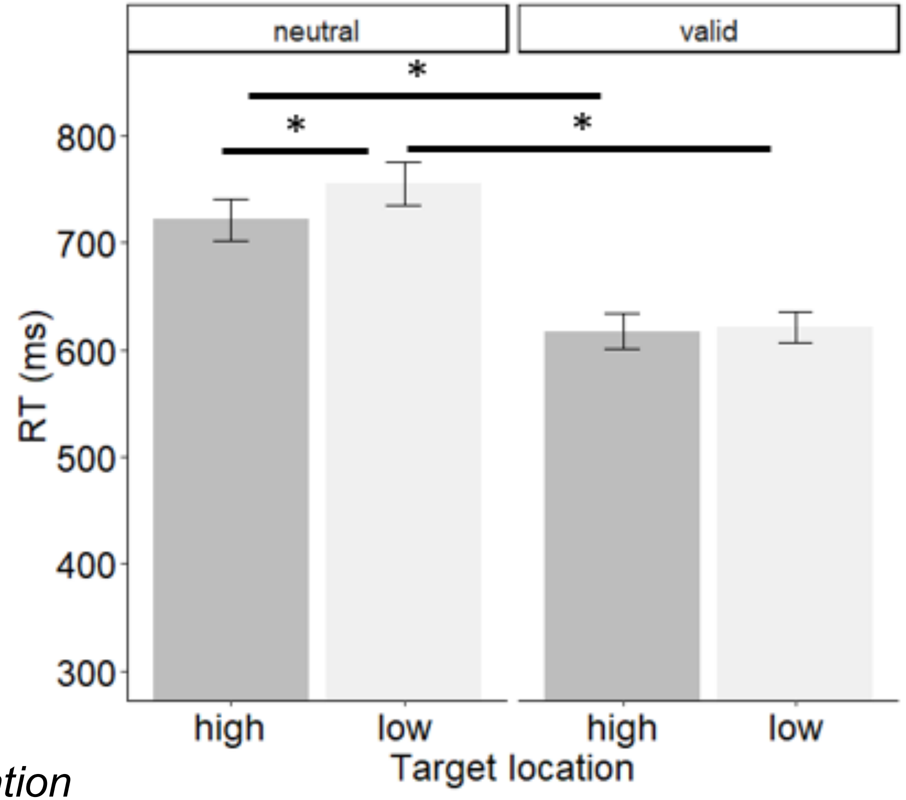
Behavioral and EEG results

Exp 3a – *Combined* (EC + SL)

Exp 3b – *Combined* (EC + SL) + *EEG*

- Statistical learning (SL) effectively shapes attentional deployment across spatial locations. However, SL effects only emerge significantly in the absence of a strong top-down control (i.e., in neutral cue conditions).



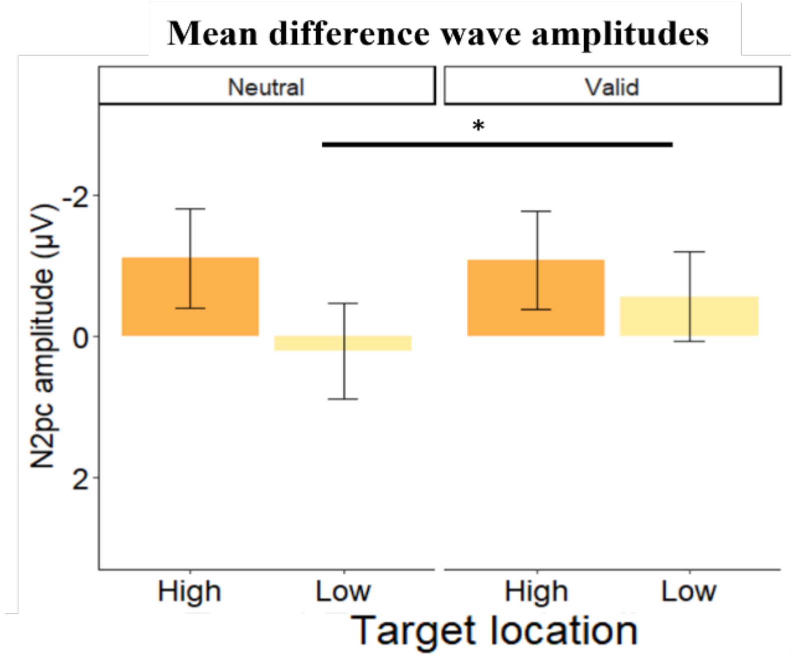


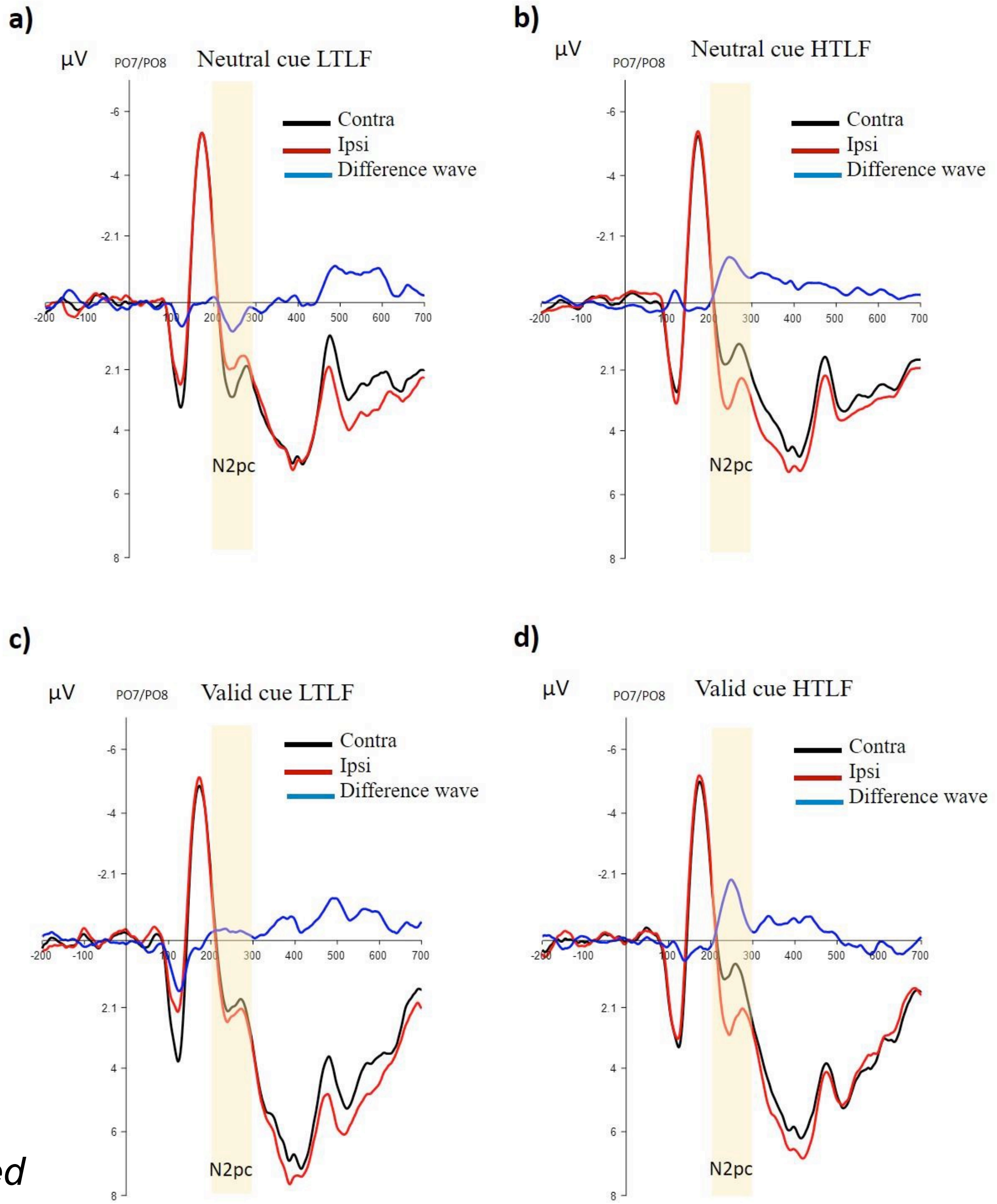
Dolci et al., *in preparation*

EEG results

Exp 3b – *Combined* (EC + SL) + *EEG*

- A larger N2pc is elicited by targets following a valid (vs. neutral) cue. This effect interacts with SL, with a significant increase in the N2pc amplitude for validly cued targets only at low target frequency locations.

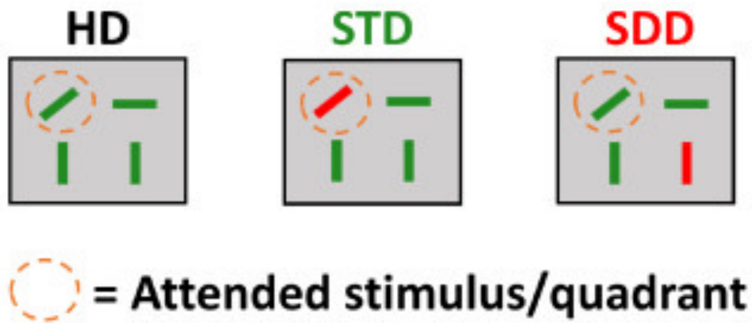


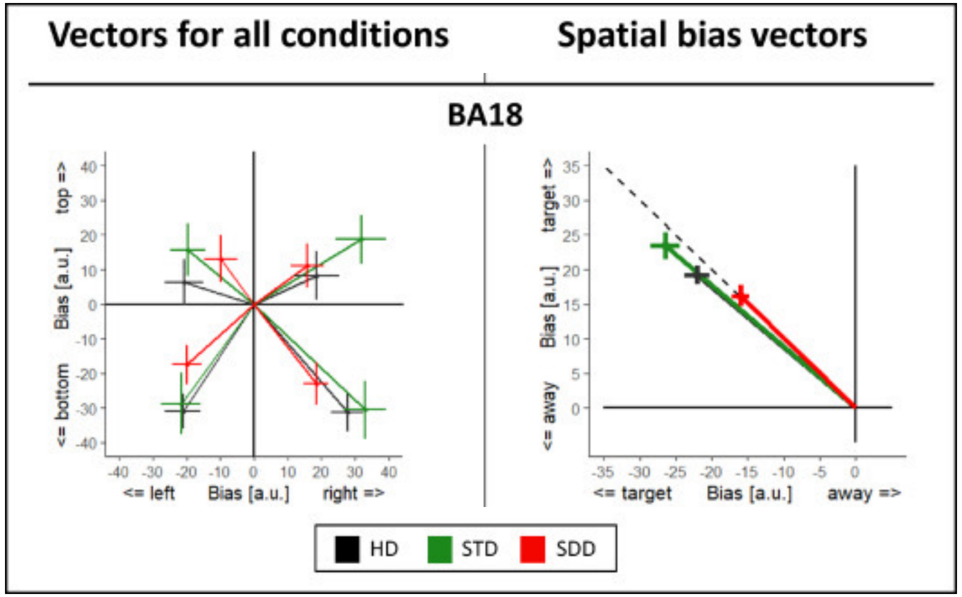


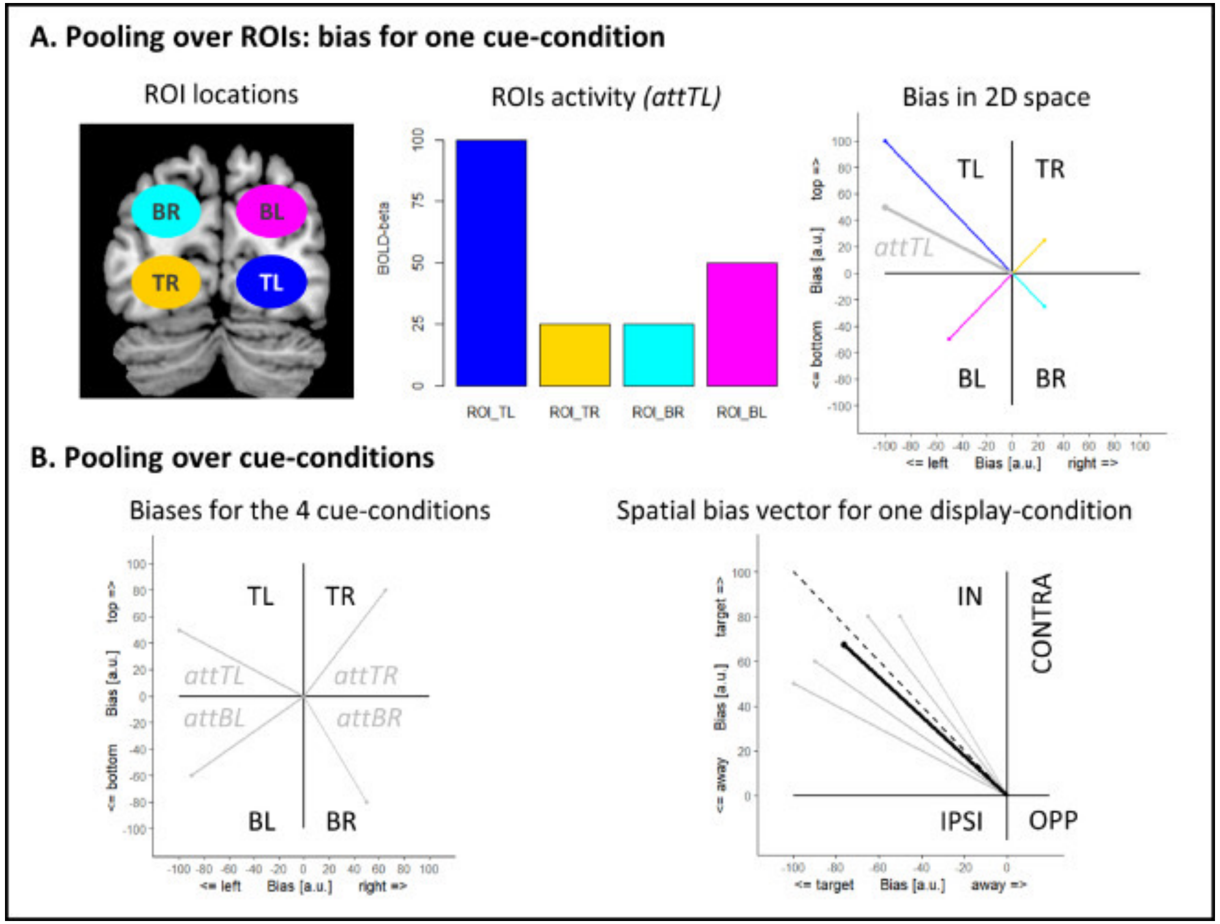
Dolci et al., *submitted*

Behavioral and fMRI results

Exp 6 – *Combined* (EC + salience)







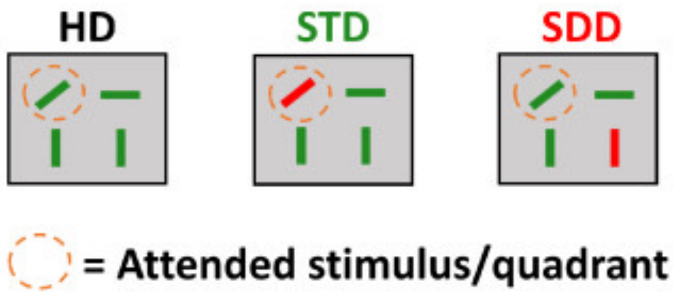
- **Spatial biases** are directed towards the target quadrant, reflecting top-down guidance. The presence of a salient distractor (SDD) reduces the magnitude of the spatial bias, while the presence of a salient target (STD) strengthens it.

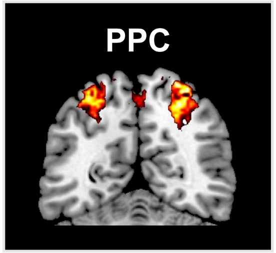
Beffara et al., 2022

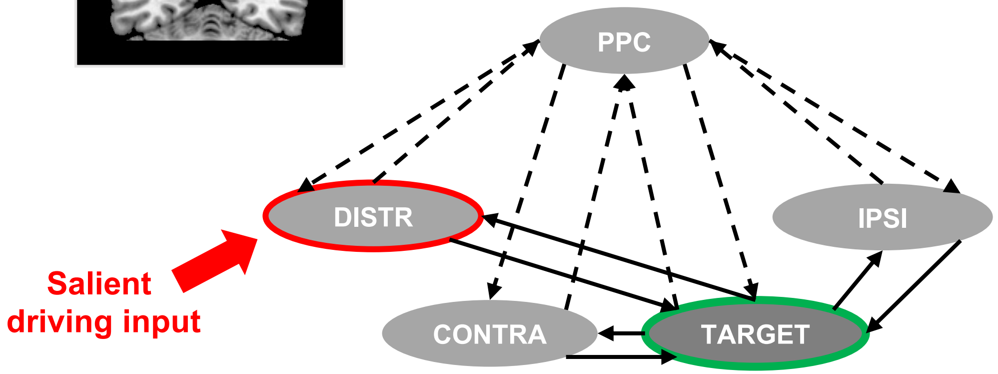
Behavioral and fMRI results

Exp 6 – *Combined* (EC + salience)

Dynamic Causal Modeling (DCM)

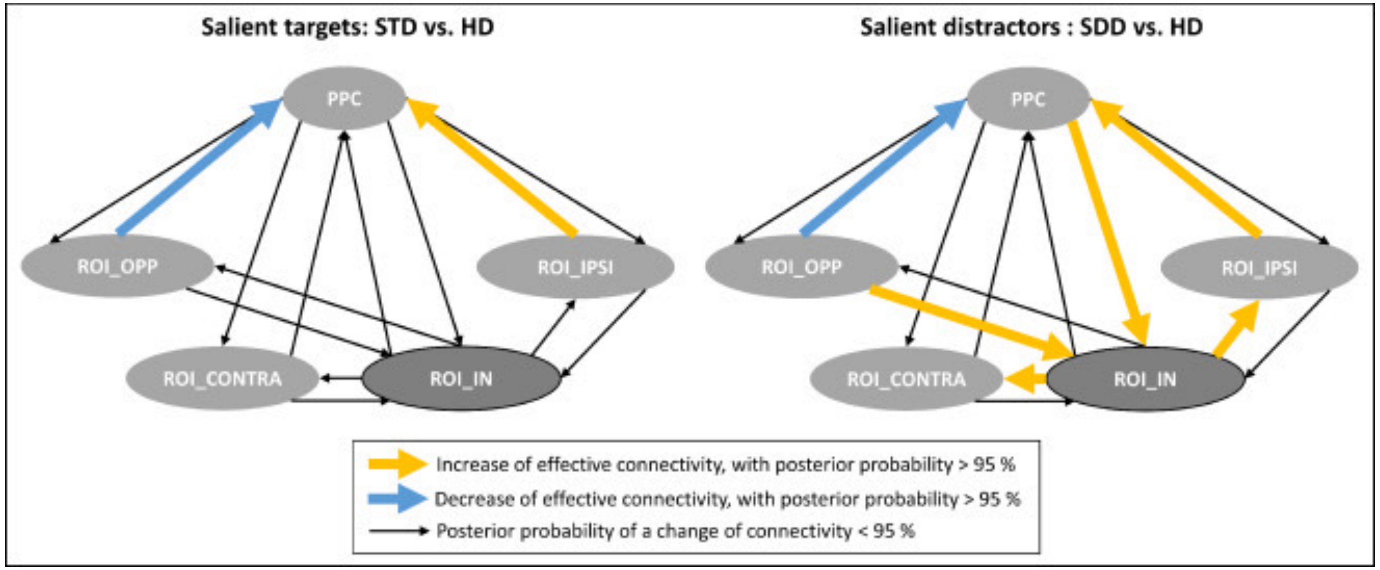






- Analyses of effective connectivity show that both occipito-parietal connectivity and lateral interactions within the occipital cortex contribute to the joint shaping of priorities by top-down and bottom-up sources for attentional control.

- The strength of critical connections is significantly modulated by the presence of salient targets or distractors in the search display.



Beffara et al., 2022

Sum up of the main results

- Clear and reliable effects of priority signals, when present in isolation (Dolci et al., *in preparation*).

- Overall predominance of the top-down biasing over other AC signals, when active together (Beffara et al., 2022; Beffara et al, *submitted*; Dolci et al., *in preparation*; Dolci et al., *submitted*; Rashal et al., 2022; Rashal et al., *submitted*).

- Top-down guidance prevents other AC signals from affecting behavior (gating effect), but not from affecting ongoing neural computations (Beffara et al., 2022; Beffara et al, *submitted*; Dolci et al., *in preparation*; Dolci et al., *submitted*; Rashal et al., 2022; Rashal et al., *submitted*).

- AC signals do interact at multiple levels in the brain, including via modulation of effective connectivity between the areas involved (Beffara et al., 2022; Beffara et al, *submitted*; Dolci et al., *submitted*; Rashal et al., 2022; Rashal et al., *submitted*).

Main achievements and further steps

1) We built up a simple experimental protocol "template" suitable for investigating the unique and combined influence of multiple **priority signals**, within a unified experimental framework in human and non-human primates and with multiple neuroscience techniques.

2) The evidence collected so far represents a first significant stride towards a deeper understanding of the functional and neural integration of different AC signals in the primate brain.

3) We still aim at enriching the dataset collected so far, including with behavioral and electrophysiological evidence in the behaving macaque monkey.

4) Thanks to **EBRAINS**, we started a data sharing process that will be of help to foster further efforts to synthetize, interpret and model the collected results at the service and with the help of other experts in this and related scientific fields.

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Thank you for your attention!

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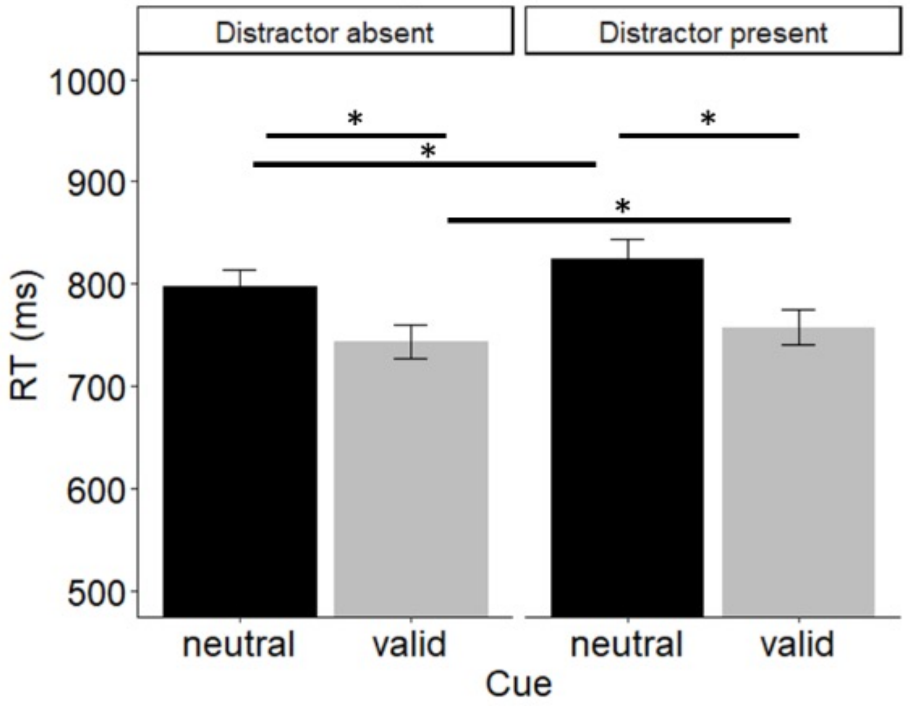
Behavioral results (supplementary)

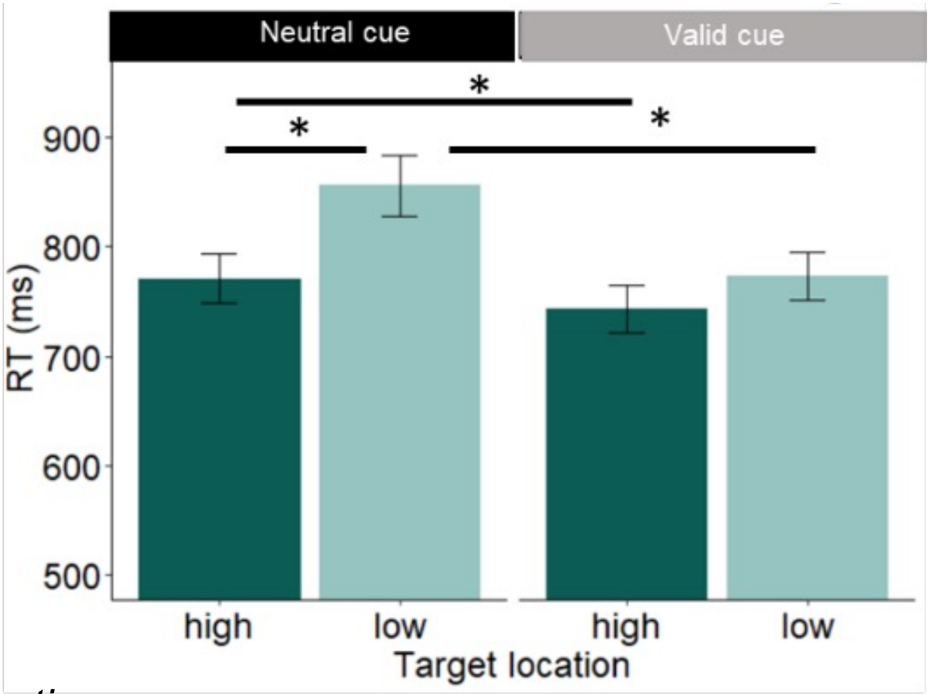
Exp 4 – *Broad EC*

- When top-down guidance is weaker, bottom-up signals modulate target selection also in validly cued conditions.

Exp 5 – *Combined* (broad EC + SL)

- SL effects only emerge significantly in the absence of valid cueing, even in the context of a weaker top-down modulation.





Dolci et al., *in preparation*