

Cours 2025-2026:

**Qu'est-ce que la conscience
et quels sont ses mécanismes cérébraux ?**

What is consciousness, and what are its neuronal mechanisms?

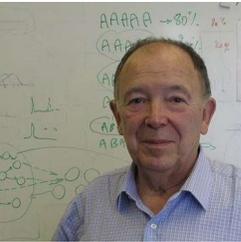
Stanislas Dehaene

Chaire de Psychologie Cognitive Expérimentale

Cours n°4

La “distillation” des corrélats neuronaux de la perception consciente

Distilling the neural correlates of conscious perception



Jean-Pierre Changeux

Ignition : a key prediction of the global neuronal workspace (GNW) hypothesis

Dehaene & Changeux, PNAS 1998 ; Dehaene & Naccache, Cognition 2001

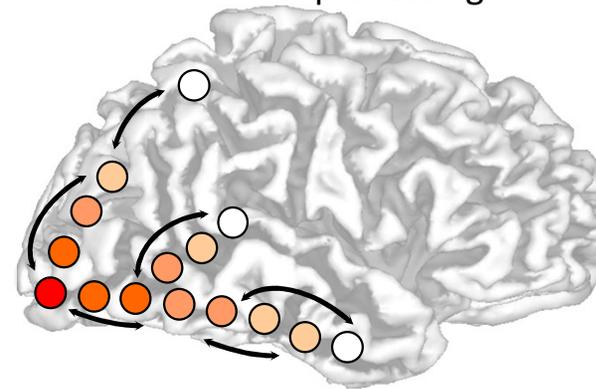


Lionel Naccache

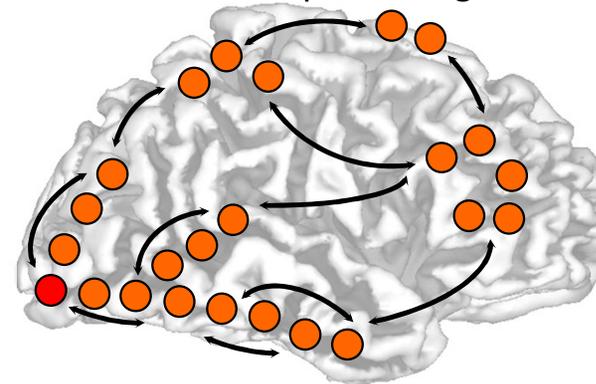
Predictions of the GNW framework : Conscious access is

- A **phase transition**: the sudden “**ignition**” of a **subset** of workspace neurons, **distributed** in prefrontal and other associative cortices, that **broadcast top-down signals** back to all processors.
- A sudden bout of **metastable** activity **lasting at least ~100-200 ms**, which **mobilizes** and **synchronizes** distant processors.
- A **thalamo-cortical** state.
- Not an isotropic state of global activity (which would be epilepsy), but a well-delimited state where **only a subset of neurons** are activated, whose topology (a neural vector) defines the **conscious content**.
- Ignition should be **present whenever we consciously perceive** some piece of information, but it should be prolonged if we need to consciously process it (GNW as a **flexible router**)

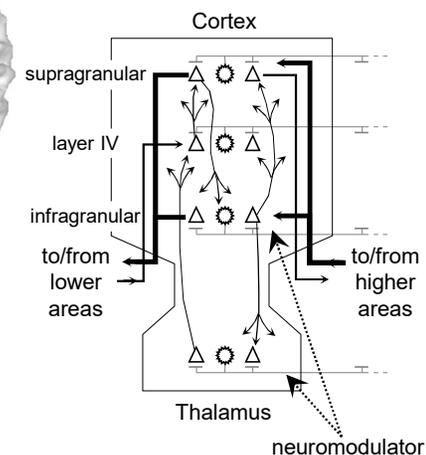
subliminal processing



conscious processing



Thalamocortical column



Today : Distilling the neural correlates of consciousness

Aru, J., Bachmann, T., Singer, W., & Melloni, L. (2012). Distilling the neural correlates of consciousness. *Neurosci Biobehav Rev*, 36(2), 737-746.

In most previous studies, the participants (human or animal) are asked to report (verbally or non-verbally) whether they have consciously perceived the stimulus or not.

This task is useful in order to have the same physical stimulus, at threshold, and sort out seen versus unseen trials.

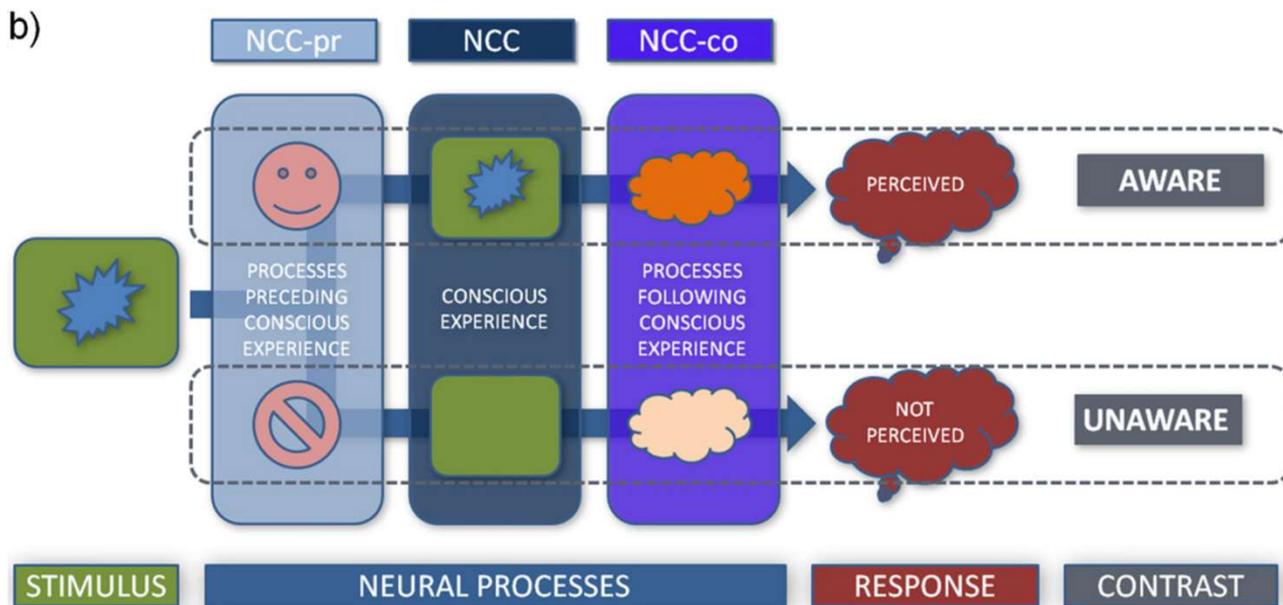
Furthermore, the decision and motor responses are usually well matched on seen and unseen trials.

However, the very act of reporting may add unnecessary cognitive processes (working memory, decision).

Aru et al. argue that experimental designs should endeavor to separate the “neural correlates of consciousness proper” from any processes preceding or following conscious experience.

From this moment on, several scientists started to doubt that

- Prefrontal activation is needed for conscious perception
- The P3b component of event-related potentials is a signature of consciousness.



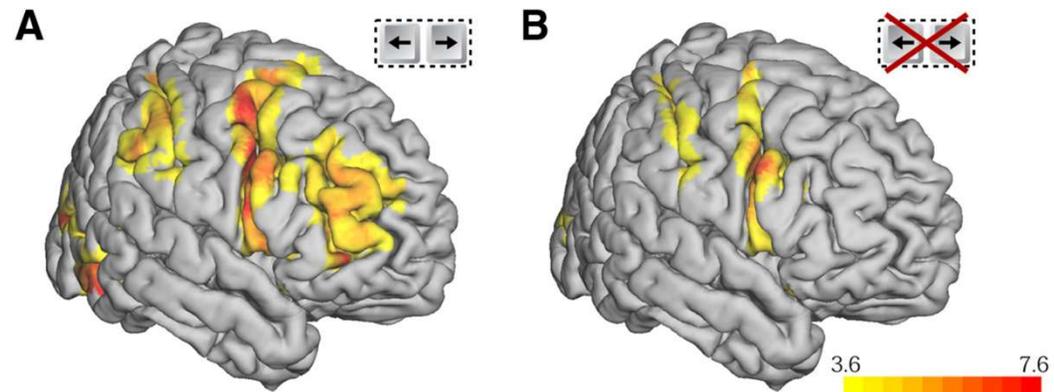
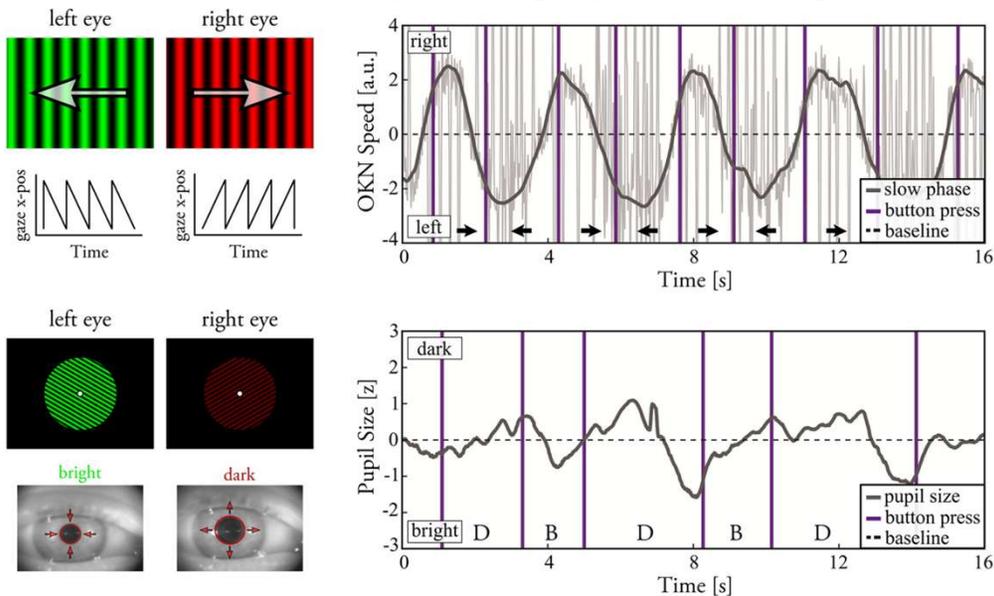
The concept of “no-report paradigm”, and the doubts about prefrontal cortex

Tsuchiya, N., Wilke, M., Frässle, S., & Lamme, V. A. F. (2015). No-Report Paradigms : Extracting the True Neural Correlates of Consciousness. *Trends in Cognitive Sciences*, 19(12), 757-770. <https://doi.org/10.1016/j.tics.2015.10.002>

Frässle, S., Sommer, J., Jansen, A., Naber, M., & Einhäuser, W. (2014). Binocular Rivalry : Frontal Activity Relates to Introspection and Action But Not to Perception. *Journal of Neuroscience*, 34(5), 1738-1747. <https://doi.org/10.1523/JNEUROSCI.4403-13.2014>

It is possible to monitor consciousness surreptitiously, without asking for an overt report.

For instance, during binocular rivalry, both nystagmus and pupil size correlate with subjective reports of which image is dominant, and may replace those reports.



Transitions involving overt report (left) trigger parieto-frontal activity, which is significantly diminished under no-report conditions (right).

“We conclude that frontal areas are linked to active report and introspection rather than to rivalry itself.” But... note that sensitivity could be an issue; and the activity is around transitions, not content-specific.

More sensitive techniques detect stimulus-specific conscious contents in PFC

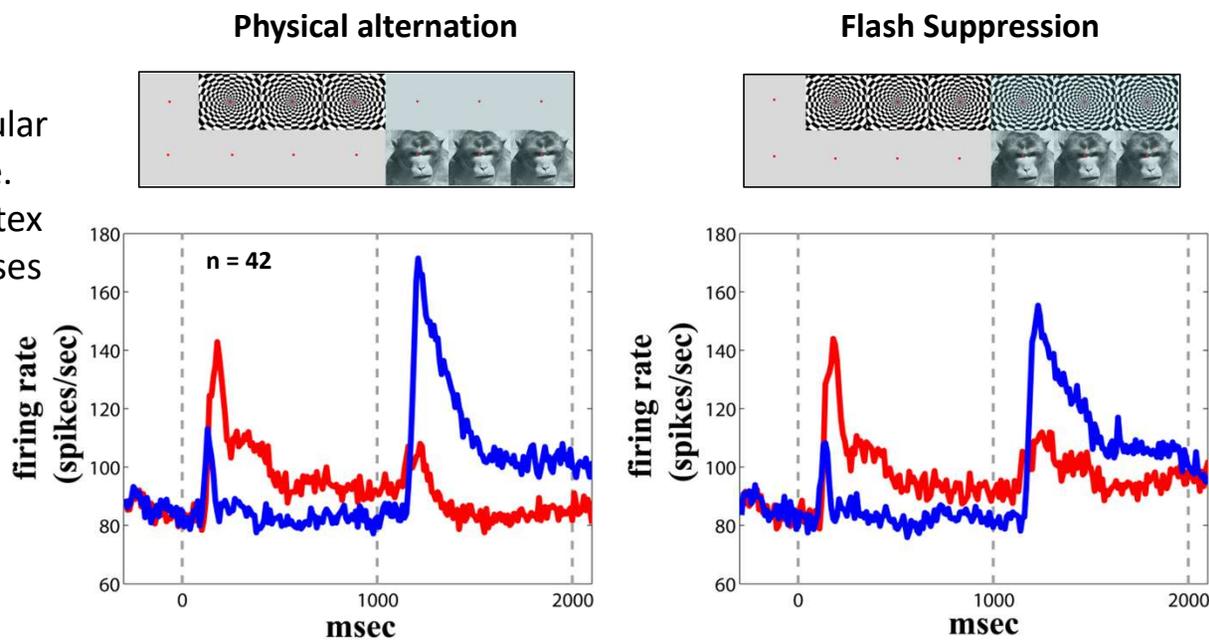
Panagiotaropoulos, T. I., Deco, G., Kapoor, V., & Logothetis, N. K. (2012). Neuronal discharges and gamma oscillations explicitly reflect visual consciousness in the lateral prefrontal cortex. *Neuron*, 74(5), 924-935. <https://doi.org/10.1016/j.neuron.2012.04.013>

Could PFC activity be due solely to the decision or the report ?

No! PFC contains cell assemblies coding for the perceived stimuli in no-report paradigms.

The flash suppression paradigm is a form of binocular rivalry that does not require a behavioral response.

Nevertheless, neurons in the lateral prefrontal cortex show stimulus-specific, ignition-like neural responses



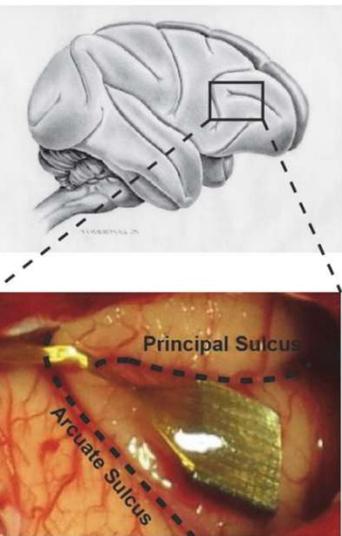
Preferred to non preferred

Non preferred to preferred

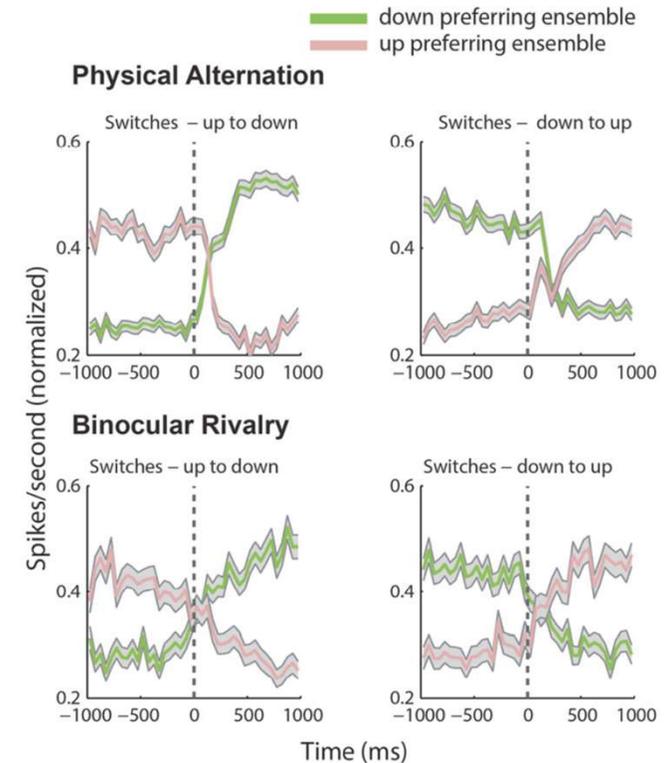
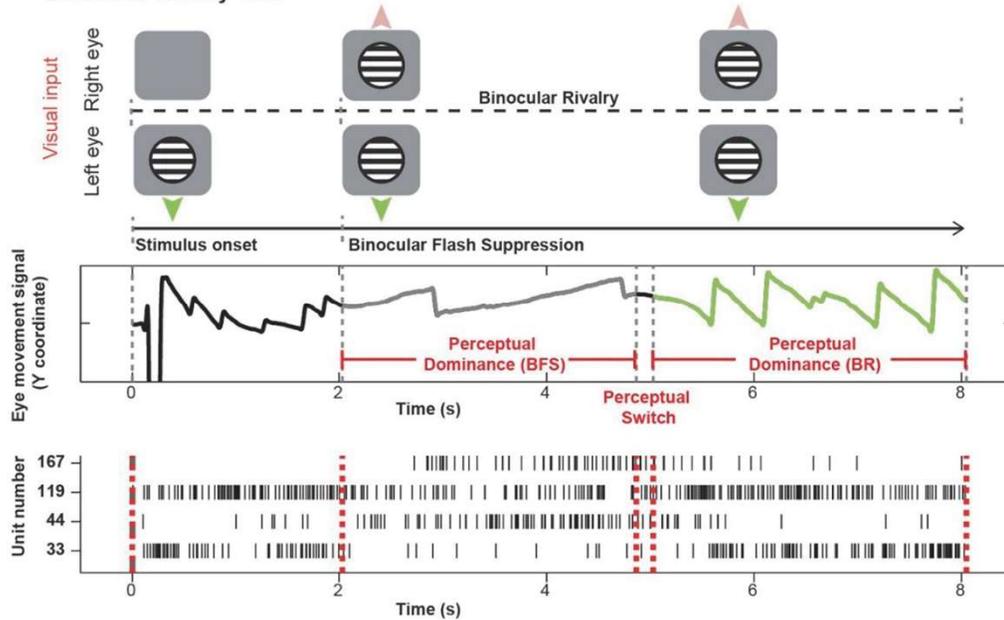
Even in a no-report paradigm, the prefrontal cortex contains a neuronal code for the consciously perceived content

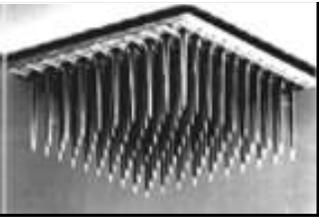
Kapoor, Dwarakanath... Panagiotaropoulos & Logothetis, Nature Communications 2022

Here, the perception of an ambiguous, rivaling stimulus (up/down) is measured implicitly by eye movements (nystagmus). PFC neurons coding for upward and downward motion switch on and off, for both spontaneous and physical perceptual switches



b Binocular Rivalry Trial





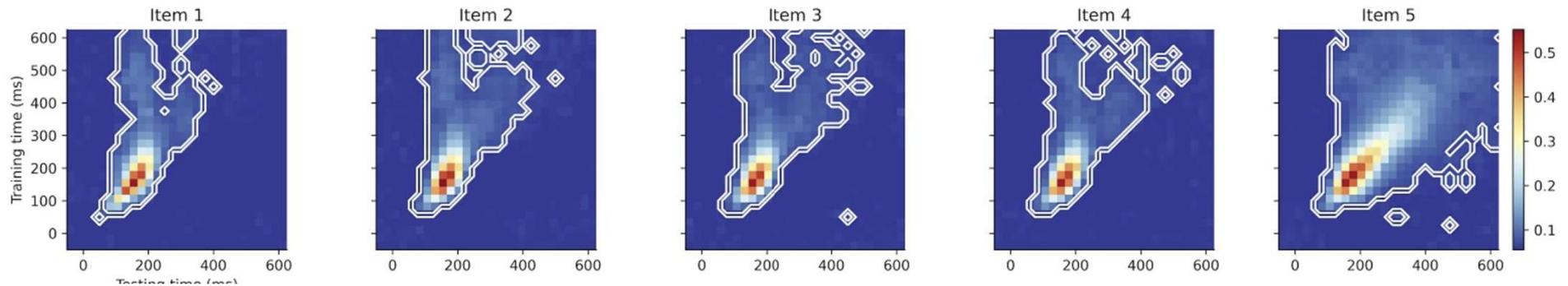
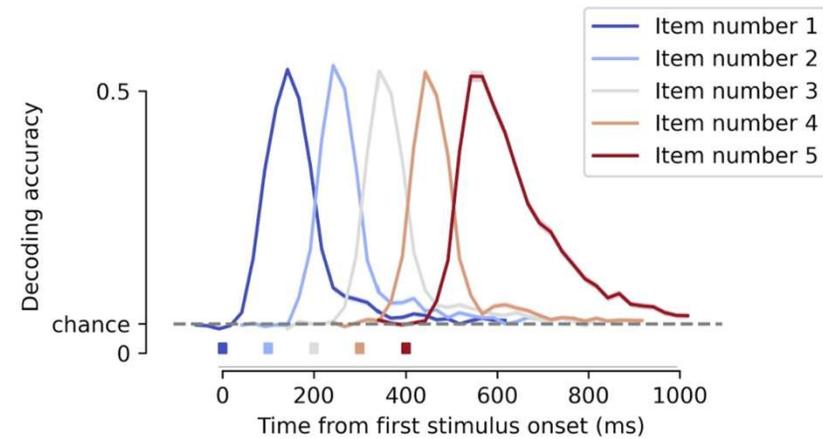
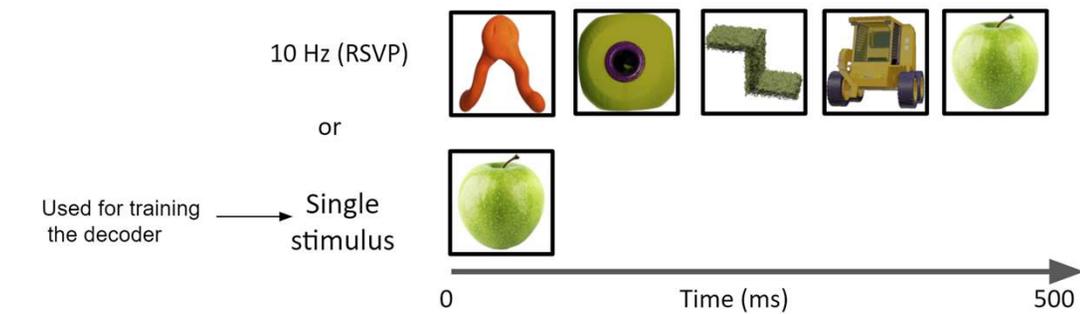
PFC encodes all stimuli in a fast visual stream

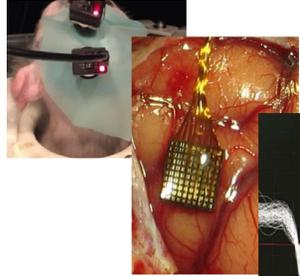
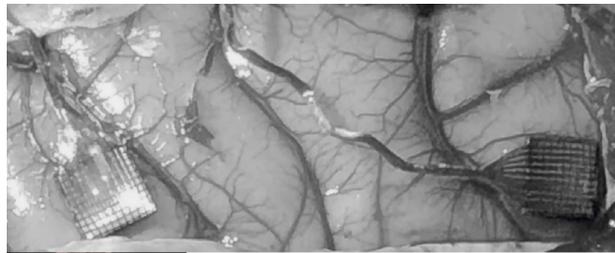
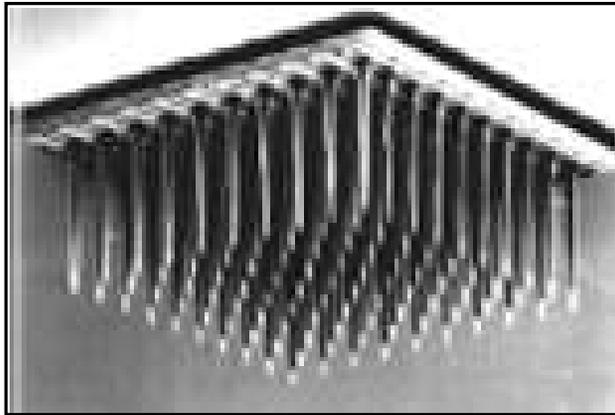
Bellet, J., Gay, M., Dwarakanath, A., Jarraya, B., van Kerkoerle, T., Dehaene, S., & Panagiotaropoulos, T. I. (2022). Decoding rapidly presented visual stimuli from prefrontal ensembles without report nor post-perceptual processing. *Neuroscience of Consciousness*, 2022(1), niac005. <https://doi.org/10.1093/nc/niac005>



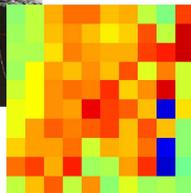
According to Global Neuronal Workspace theory, there should be an assembly of PFC neurons for every conscious content -- even during **passive viewing in a no-report paradigm**.

Indeed, we can decode any of 10-15 pictures from PFC cell assemblies. Even when they are in a fast visual stream (5 pictures in half a second, 100 ms SOA). The late amplification is present, but radically shortened.





Single neurons



Mesoscopic level
(4x4mm, 0.4mm
spatial resolution)

A visual local-global paradigm in PFC neurons



Marie Bellet

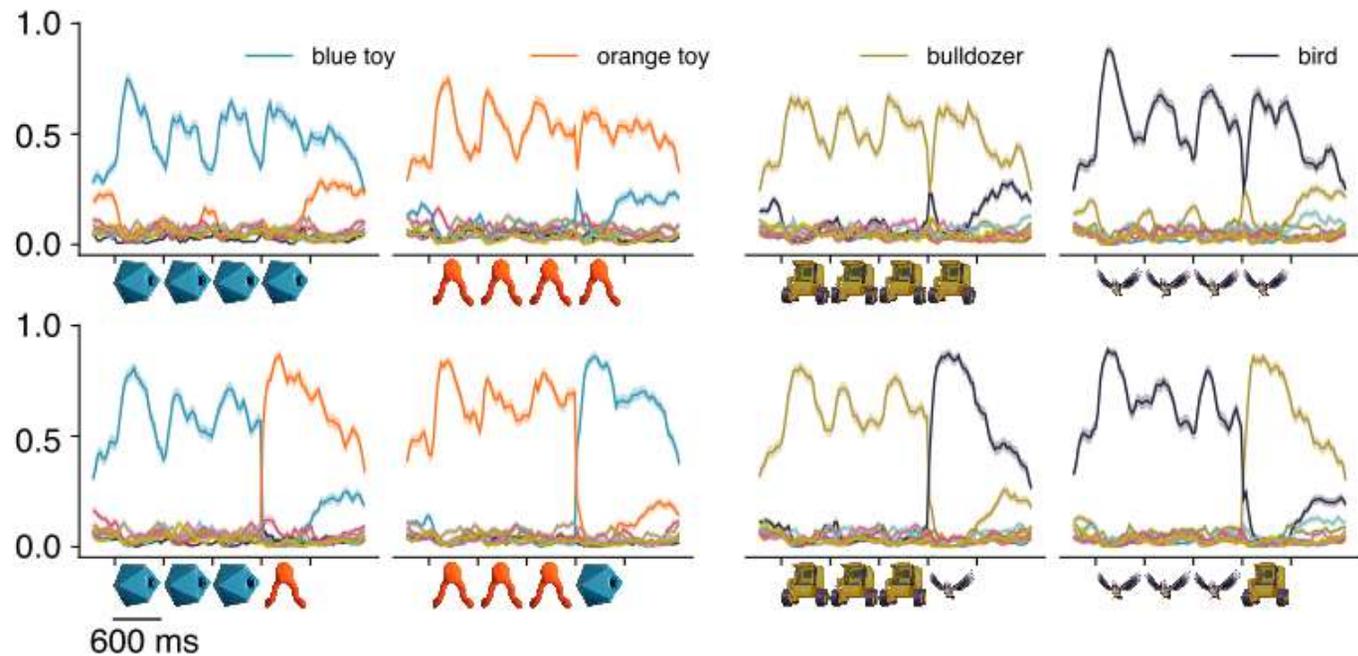


Fanis Panagiotaropoulos



Timo
van Kerkoerle

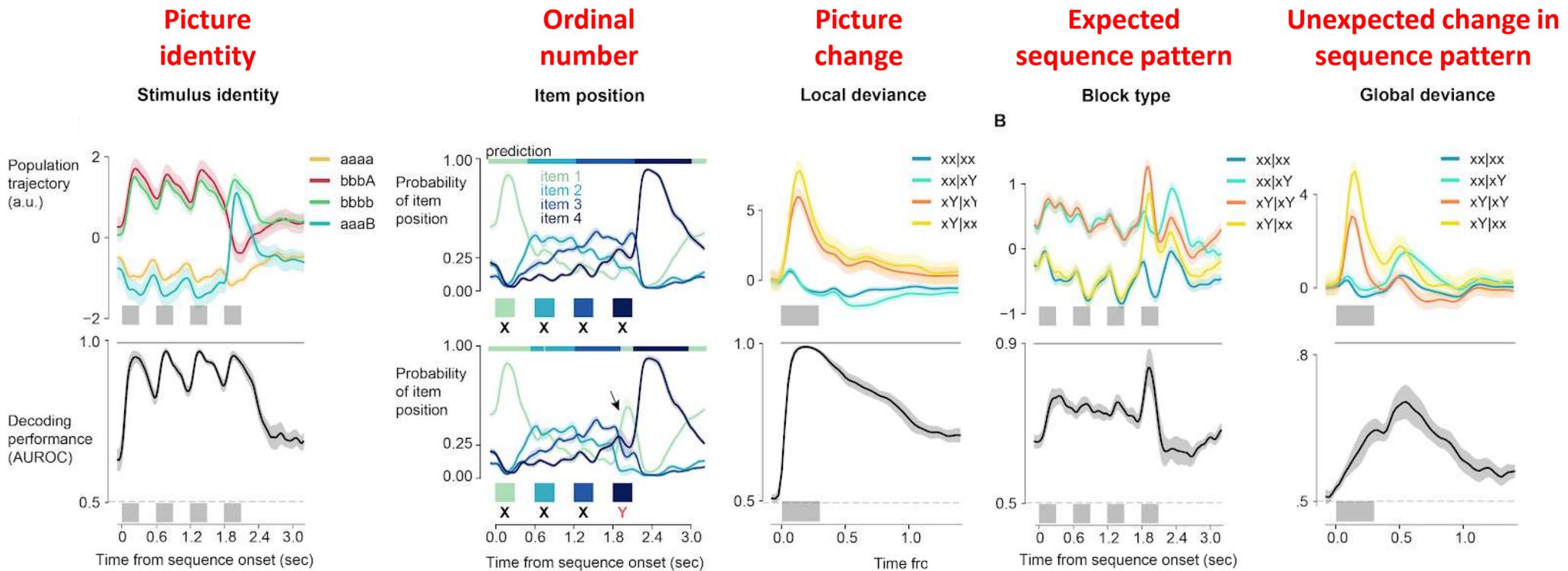
Prefrontal cortex neurons encode the **identity** of each sequence item.



Evidence that « whatever the monkey is conscious of, the prefrontal cortex encodes »

Prefrontal cortex should contain a vector code for every conscious feature, even in the absence of report.

Example: how is a sequence of pictures (“AAAB”) encoded in PFC? (local-global paradigm)

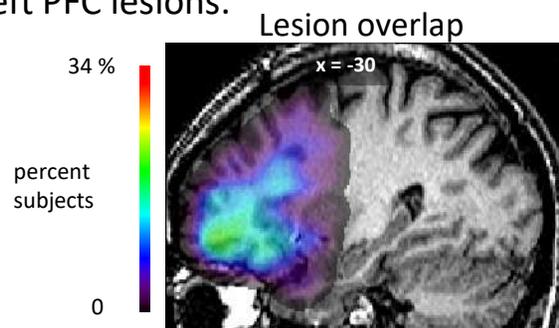


Bellet, M. E., Gay, M., Bellet, J., Jarraya, B., Dehaene, S., Kerkoerle, T. van, & Panagiotaropoulos, T. I. (2024). Spontaneously emerging internal models of visual sequences combine abstract and event-specific information in the prefrontal cortex. *Cell Reports*, 43(3). <https://doi.org/10.1016/j.celrep.2024.113952>

Causal role of prefrontal cortex in subjective perception

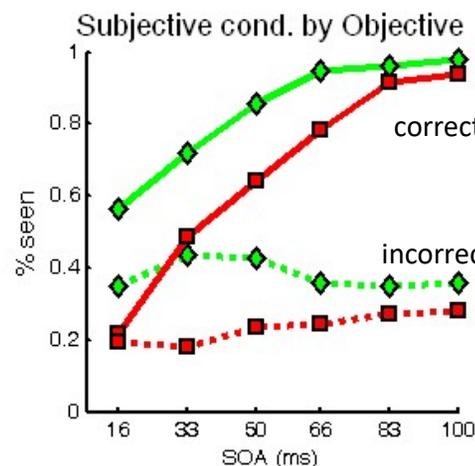
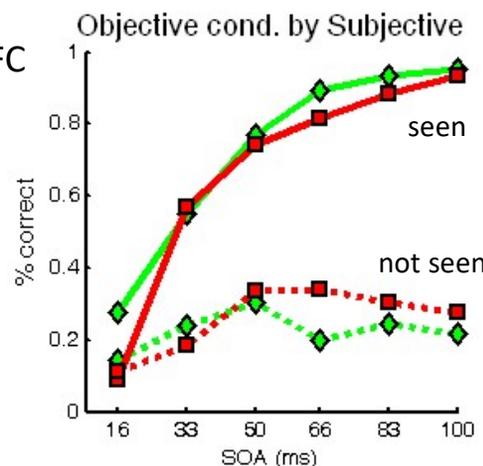
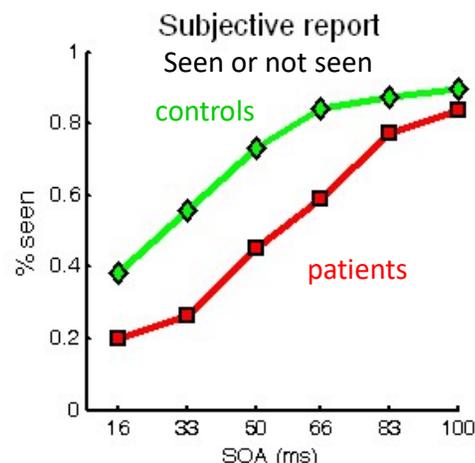
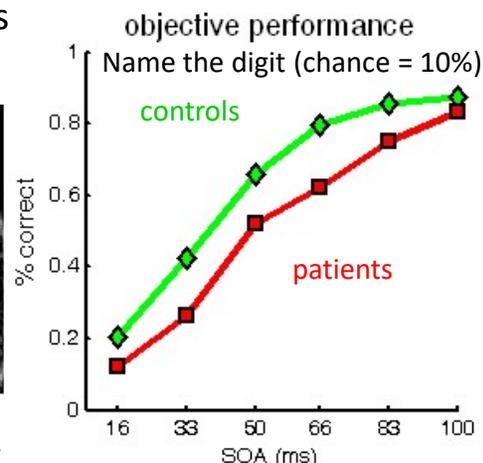
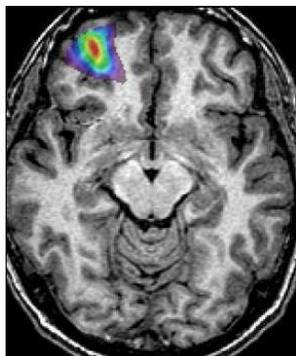
Del Cul, A., Dehaene, S., Reyes, P., Bravo, E., & Slachevsky, A. (2009). Causal role of prefrontal cortex in the threshold for access to consciousness. *Brain*, 132, 2531-2540.

Perception of masked digits in 15 patients with left PFC lesions.



The masking threshold is elevated – they do not see as well as controls.
The threshold correlates with anterior PFC lesions.

Correlation with threshold



Prefrontal lesions affect both objective and subjective performance

However, objective performance is **normal** once conditioned on subjective performance.

→ Non-conscious routes are intact

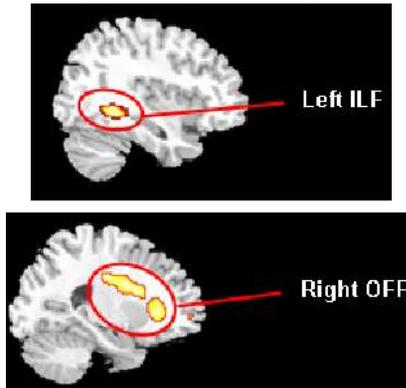
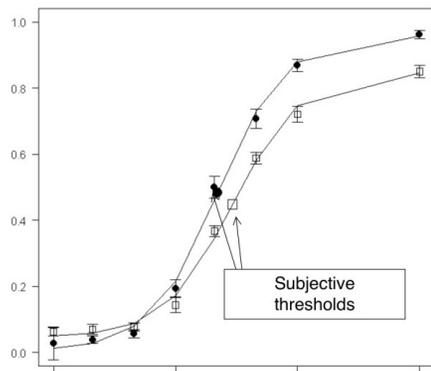
Conversely, even for equal objective performance, subjective perception is reduced.

→ Specific deficit of C

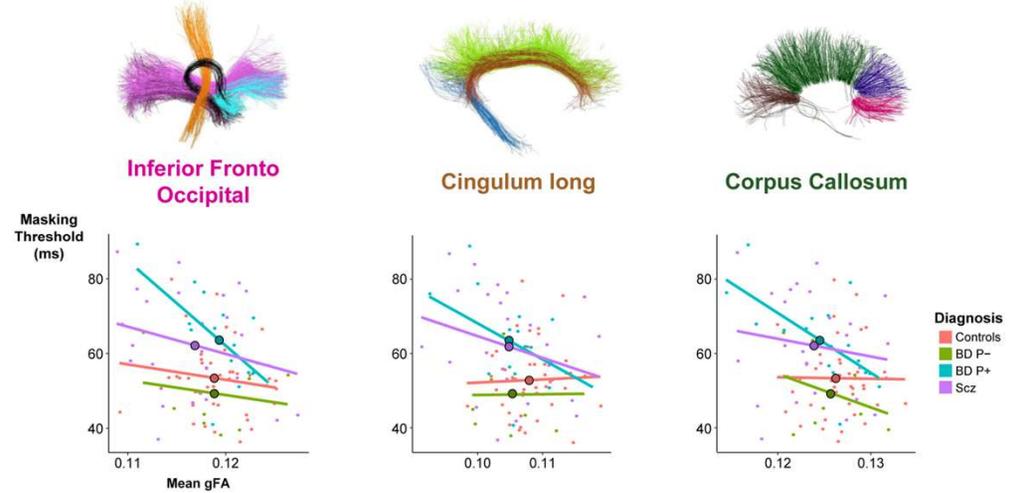
Reduced ignition in other pathologies with anomalies in long-distance connectivity

Subjective and objective thresholds for masking are abnormally elevated:

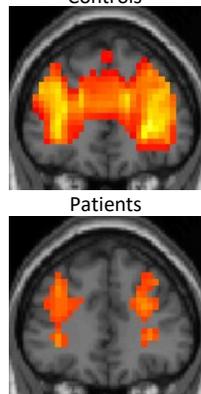
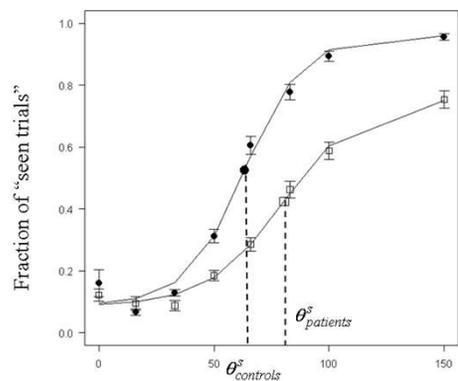
In multiple sclerosis, where it correlates with damage to long-distance fiber tracts (Reuter et al., *Neuropsychologia*, 2007)



In schizophrenia, the consciousness threshold correlates with fractional anisotropy anomalies in 3 GNW-related long-distance fiber tracts. (Berkovitch et al., Dehaene & Houenou, *J. Neurosci* 2021)



In schizophrenia, where prefronto-cingulate activation is reduced (Del Cul, Dehaene & Leboyer, *Arch Gen Psychiatry* 2006)





The Cogitate “adversarial collaboration”



Lucia Melloni



Liad Mudrik



Michael Pitts

Slides courtesy of Lucia Melloni



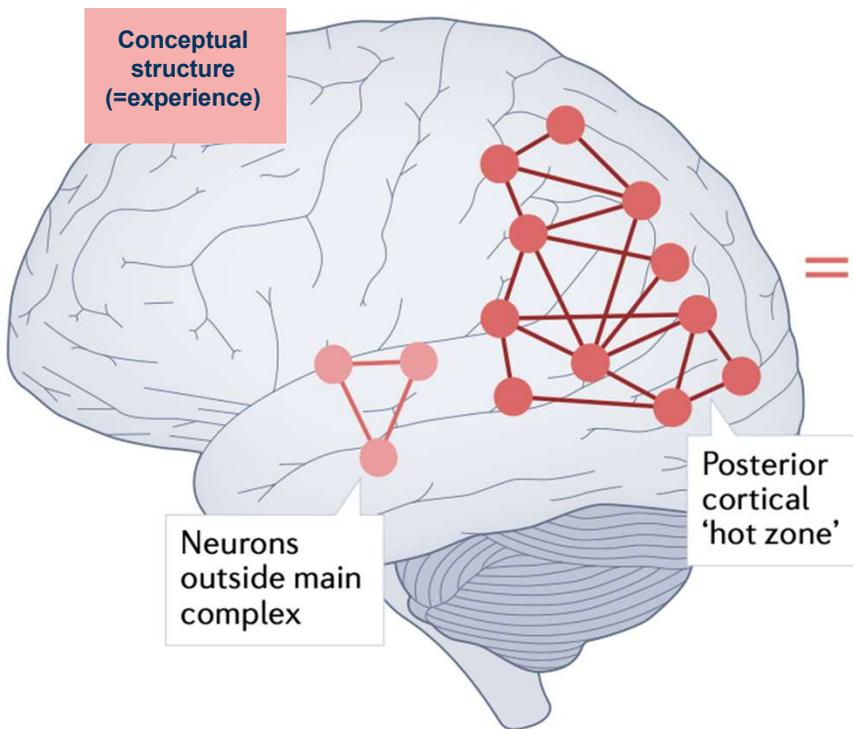
Seattle, 2018

... Nature, 2025



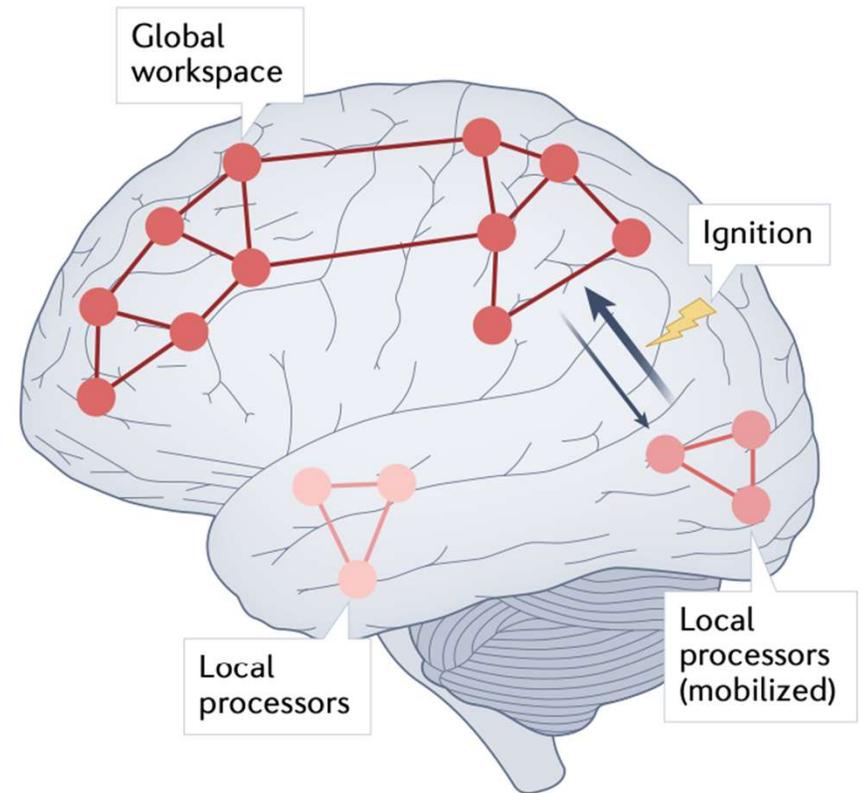
The goal : testing the constrasting predictions of two theories

Integrated Information Theory



VS

Global Neuronal Workspace Theory



Two complementary experiments (but only one has been published so far)

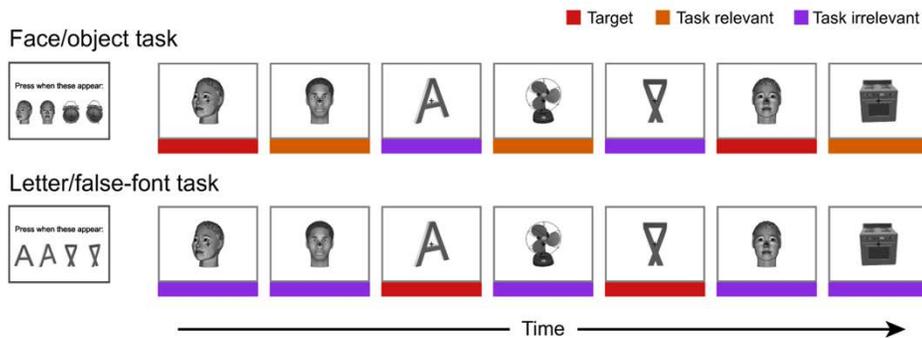
With preregistration, including a very clear statement of the model predictions and what would constitute a violation of them.

Melloni, L. et al (2023). An adversarial collaboration protocol for testing contrasting predictions of global neuronal workspace and integrated information theory. *PLOS ONE*, 18(2), e0268577.

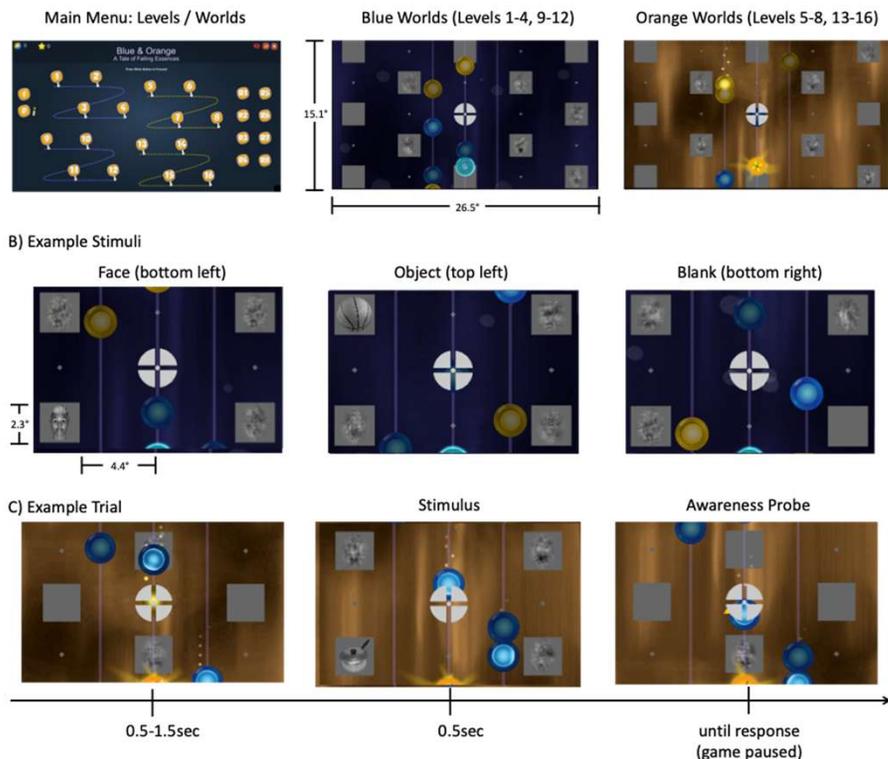
Cogitate Consortium et al. (2025). Adversarial testing of global neuronal workspace and integrated information theories of consciousness. *Nature*, 1-10.

EXPERIMENT 1: Mere perception, irrespective of task

- Which brain mechanisms encode the **rich aspects** of conscious perception?
- Which are present **irrespective of task**?
- How is a percept maintained **over time**?



EXPERIMENT 2: Using inattention to contrast seen and unseen stimuli



The Cogitate team



Oscar Ferrante



Urszula Gorska



Simon Henin



Rony Hirschhorn



Aya Khalaf



Niccolò Bonacchi



Hal Blumenfeld



Tanya Brown



Sasha Devore



Alex Lepauvre



Ling Liu



Yamil Vidal



Katarina Bendtz



David Richter



Ole Jensen



Gabriel Kreiman



Floris de Lange



Huan Luo



Csaba Kozma



Jay Jeschke



Alia Seedat



Tara Ghafari



Lucia Melloni



Liad Mudrik



Michael Pitts



Dorottya Hetenyi



Sarah Kusch



Stephanie Montenegro



Abdo Sharaf



Melanie Boly



Christof Koch



Giulio Tononi



Stanislas Dehaene



Monique Smulders



Shujun Yang



Hao Zhou



Sylvain Baillet



David Chalmers



Radoslaw Cichy



Francis Fallon



Michael Kahana

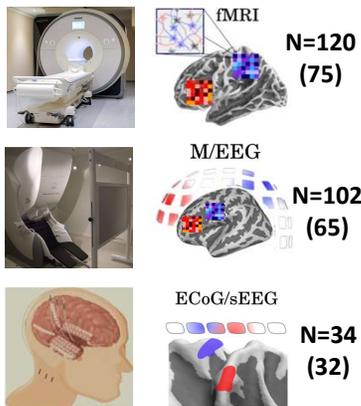


Fanis Panagiotaropolous



Essa Yacoub





Design of Experiment 1

Logic = using 3 techniques (fMRI, M/EEG, and intracranial recordings) to monitor the activation evoked by visible stimuli. Stimuli varied along 4 decodable dimensions : Category (faces, objects, letters or false fonts), Identity, Orientation, and Duration.

On different blocks, attend either to faces & objects, or to letters & false fonts (thus making the other images visible but task irrelevant).

Category x 4



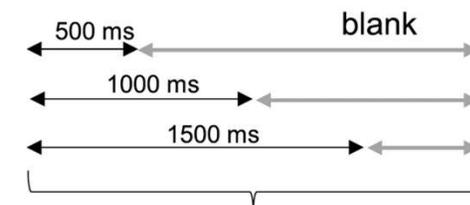
Identity x 20



Orientation x 3

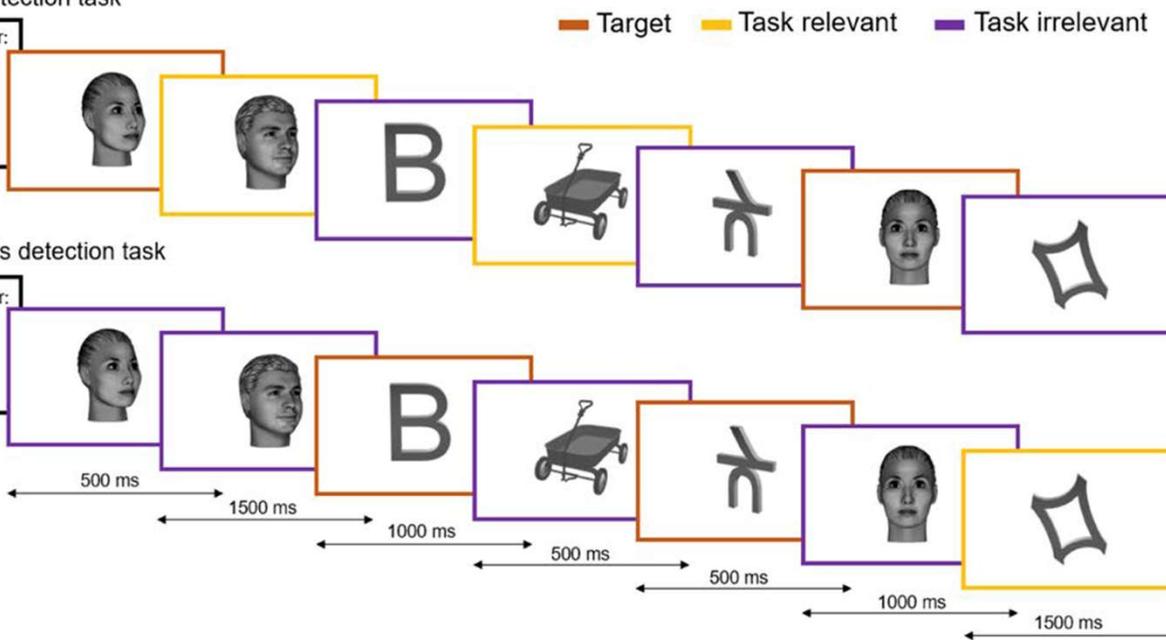
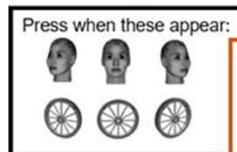


Stimulus duration x 3

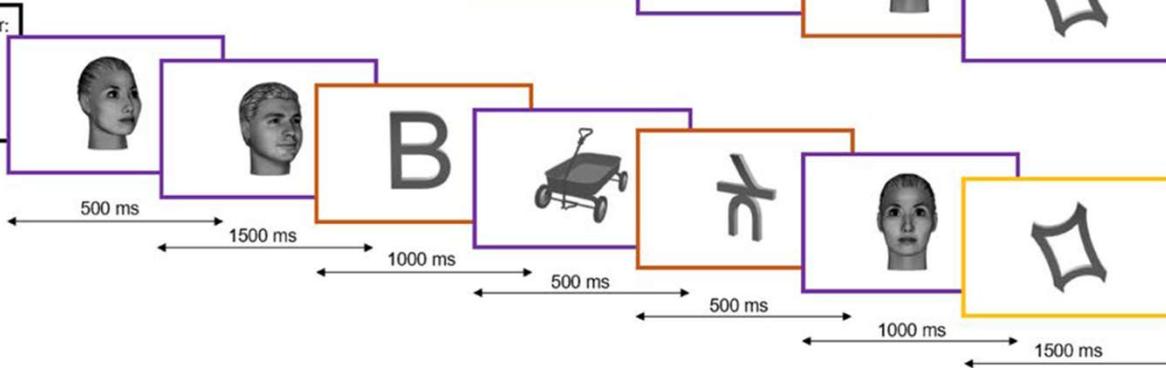
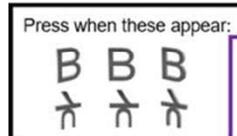


Overall trial length 2 s

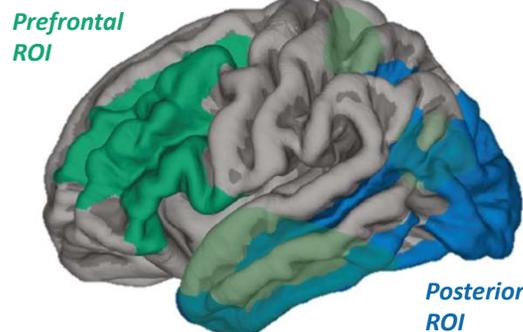
Faces vs objects detection task



Letters vs false fonts detection task



Which areas can decode conscious contents, regardless of task ?

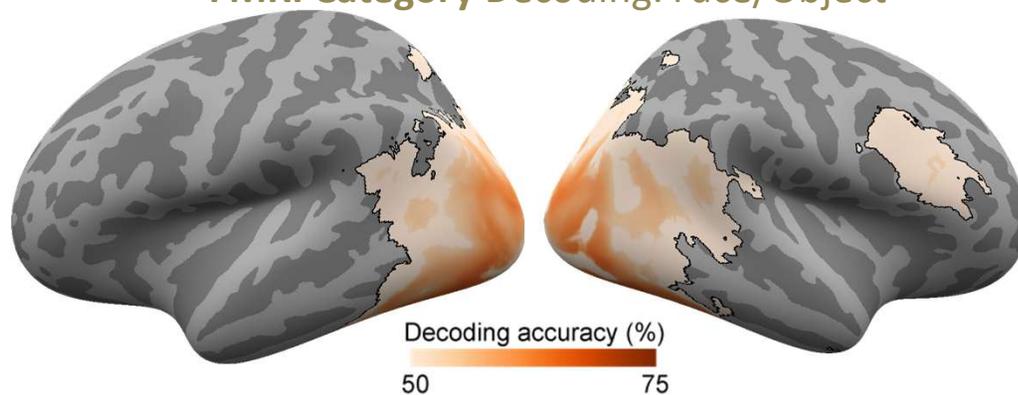


Before the experiment, the two theorists provided the regions that they predicted would be key for conscious experience.

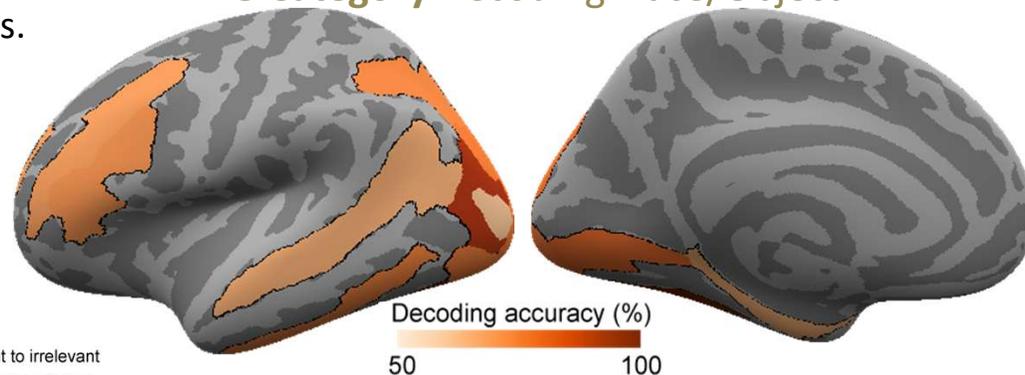
Results: Posterior visual areas could decode category, but that is pretty trivial, given the presence of category-specific areas. What is more important is that category could also be decoded from PFC.

As predicted, there was a transient code in PFC, which generalized across relevant and irrelevant images.

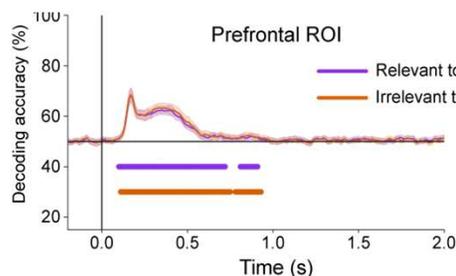
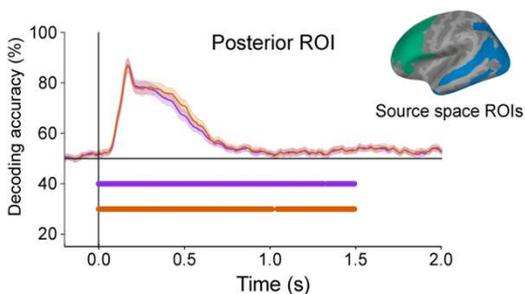
FMRI Category Decoding: Face/Object



iEEG Category Decoding: Face/Object



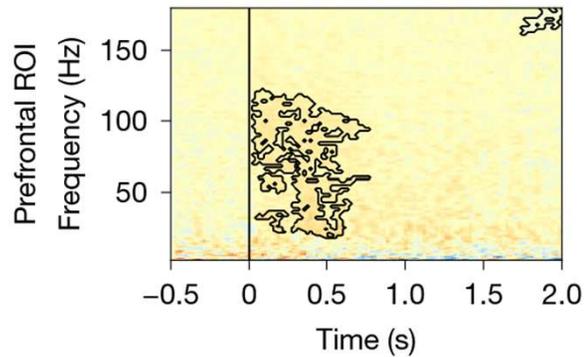
Other dimensions (identity, orientation) were hard to decode from PFC... but this is not surprising, given the coarse spatial resolution (see e.g. Panagiotaropoulos et al for detailed neuronal codes for conscious contents)



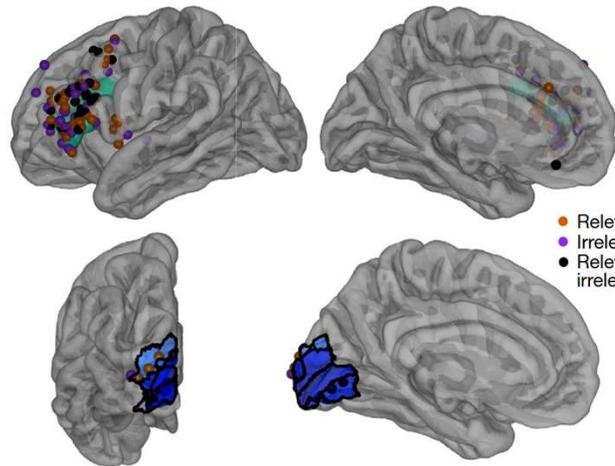
Which areas show increased functional connectivity during conscious perception?

During conscious ignition, GNW predicted **broadcasting**, i.e. a **transient** increase in **long-distance functional connectivity** of the relevant posterior processors (e.g. fusiform face area, FFA) and **prefrontal and parietal cortices**. IIT predicted an increase of functional connectivity only with V1-V2, and sustained for the duration of the stimulus.

Dynamic functional connectivity in intracranial EEG

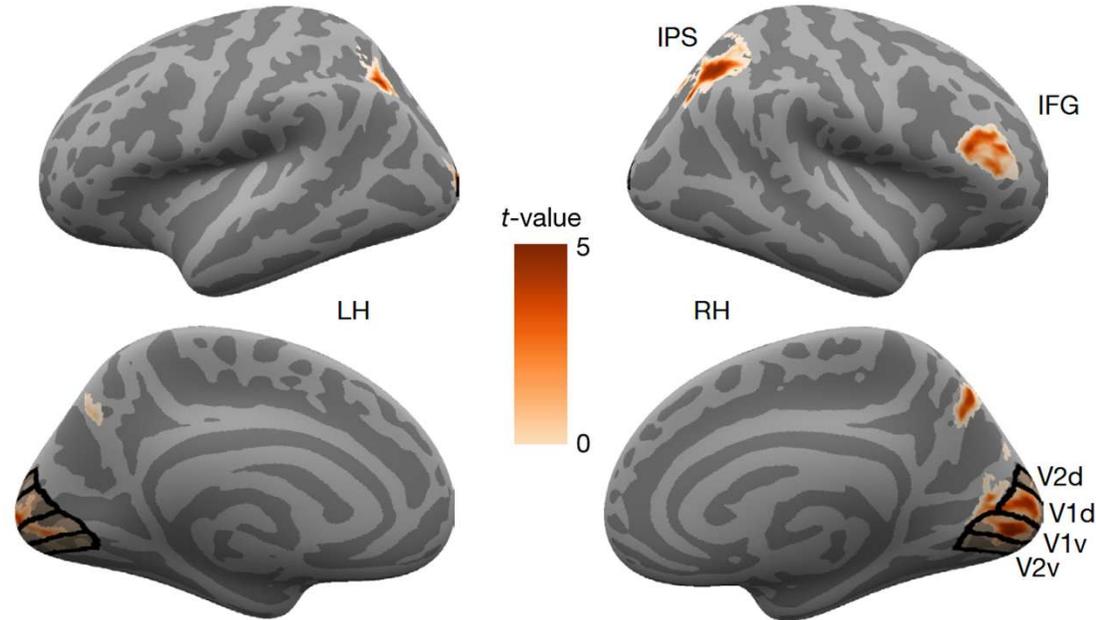


In both intracranial and functional MRI data, functional connectivity was found with prefrontal cortex (at least for faces – not much with objects). In time resolved data (intracranial and MEG), the burst of increased connectivity was always short-lived (compatible with ignition).



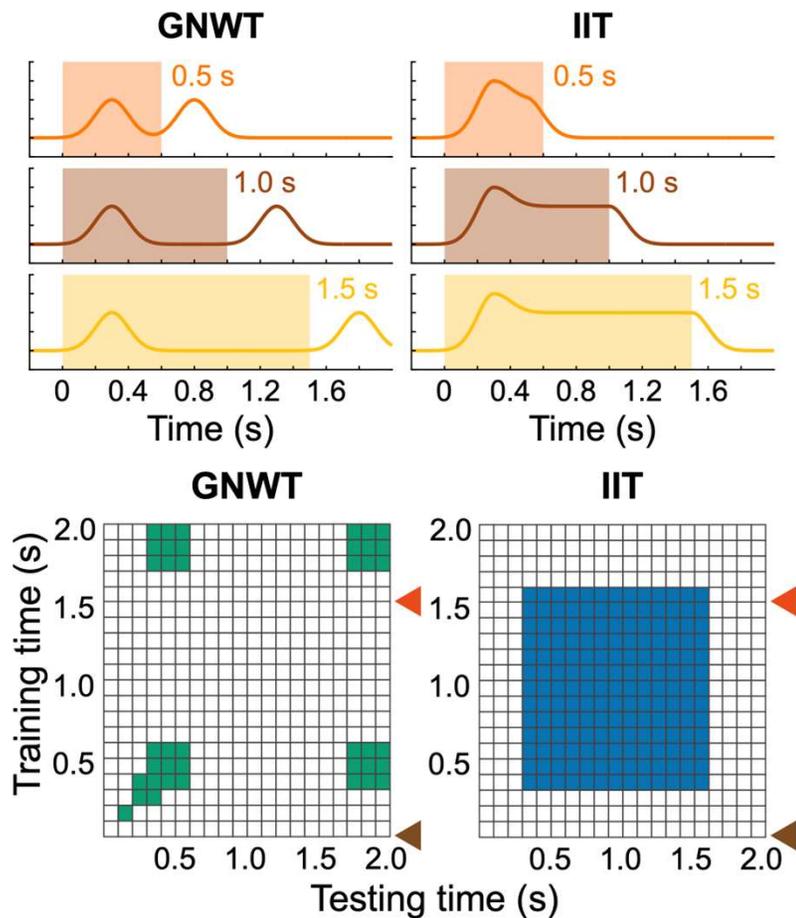
- Relevant only
- Irrelevant only
- Relevant and irrelevant

Psychophysiological interaction with FFA in fMRI data



What is the duration of activation ?

Melloni, L., Mudrik, L., Pitts, M., Bendtz, K., Ferrante, O., Gorska, U., Hirschhorn, R., Khalaf, A., Kozma, C., Lepauvre, A., Liu, L., Mazumder, D., Richter, D., Zhou, H., Blumenfeld, H., Boly, M., Chalmers, D. J., Devore, S., Fallon, F., ... Tononi, G. (2023). An adversarial collaboration protocol for testing contrasting predictions of global neuronal workspace and integrated information theory. *PLOS ONE*, 18(2), e0268577. <https://doi.org/10.1371/journal.pone.0268577>



The two theories made different predictions about duration:

- IIT makes the naïve prediction that, as long as a stimulus is present, it generates a conscious experience.
- GNW predicts a **transient, metastable** burst of ignition whenever a new stimulus is consciously perceived... but not necessarily for longer.

“The global ignition is thought to only reflect an update signal that refreshes the internal model. Such a refresh is needed only when new sensory information is not fully predicted by the internal model. During periods where sensory information is stable or can be fully predicted by the internal model (in the case, say, of a constant picture or a regularly repeated sound), then no refresh is needed, and the workspace is free to orient to other conscious thoughts [...] [Course 6 will explain activity-silent working memory].

Conscious working memory retrieval would occur only during short activity bursts, for instance towards the end of a working memory delay when content-specific spiking activity re-emerges [...]

GNW does not assume that the neural workspace remains active throughout a durable conscious experience, but at moments when conscious refreshes occur. [...]

As a consequence, a brief ignition is also expected at the offset of the stimuli (**if this offset is consciously detected**) when there is also a prediction error that requires updating the conscious internal model.”

Note: this is NOT a core prediction of GNW; it depends on where attention is.

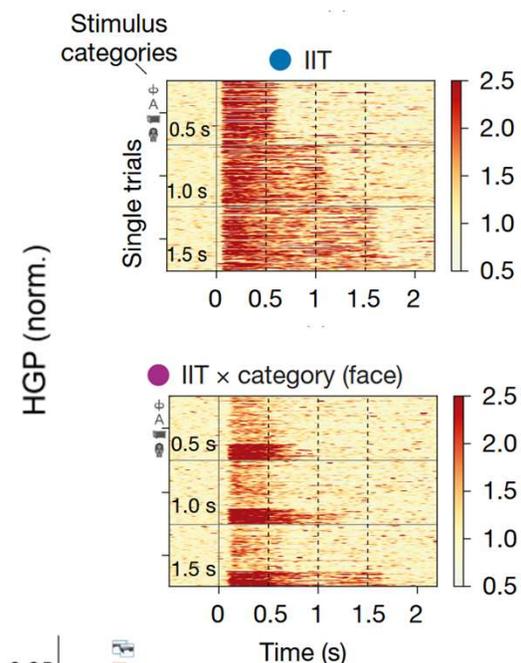
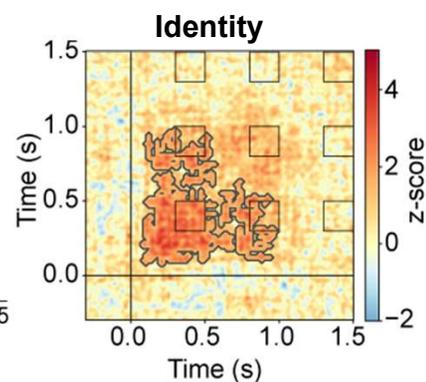
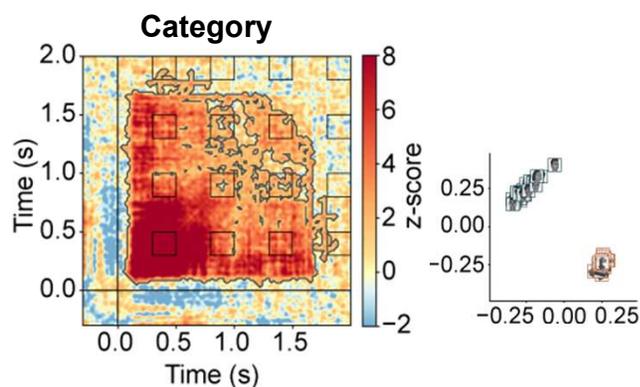
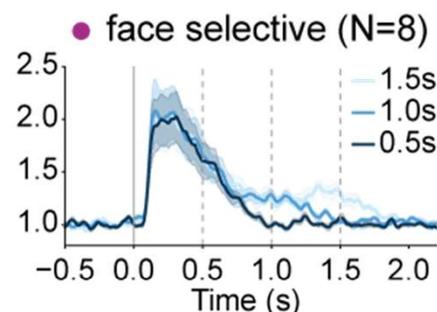
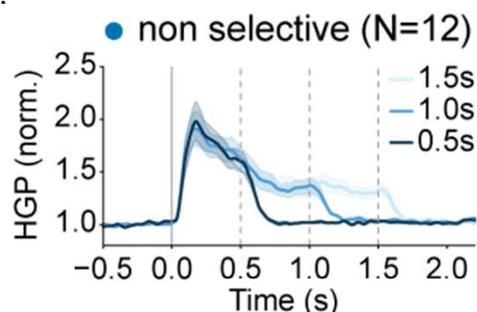
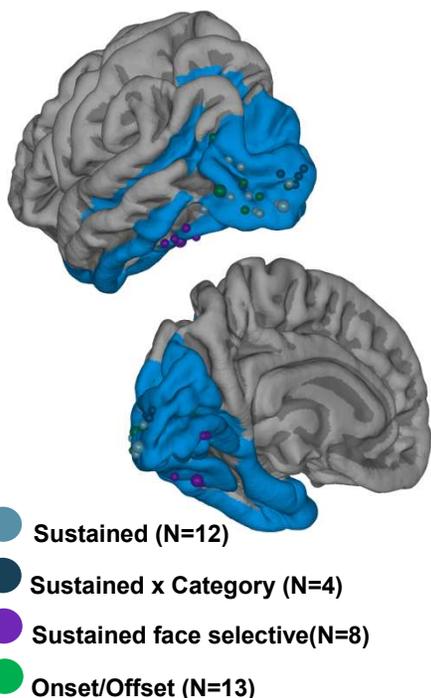
What is the duration of activation ?

Cogitate Consortium, Ferrante, ... Melloni, L. (2025). Adversarial testing of global neuronal workspace and integrated information theories of consciousness. *Nature*, 1-10. <https://doi.org/10.1038/s41586-025-08888-1>

In posterior areas, activation is sustained during the duration of the stimulus (though most electrodes show primarily a large transient).

This pattern is misleadingly labeled as “IIT” in the Nature paper.

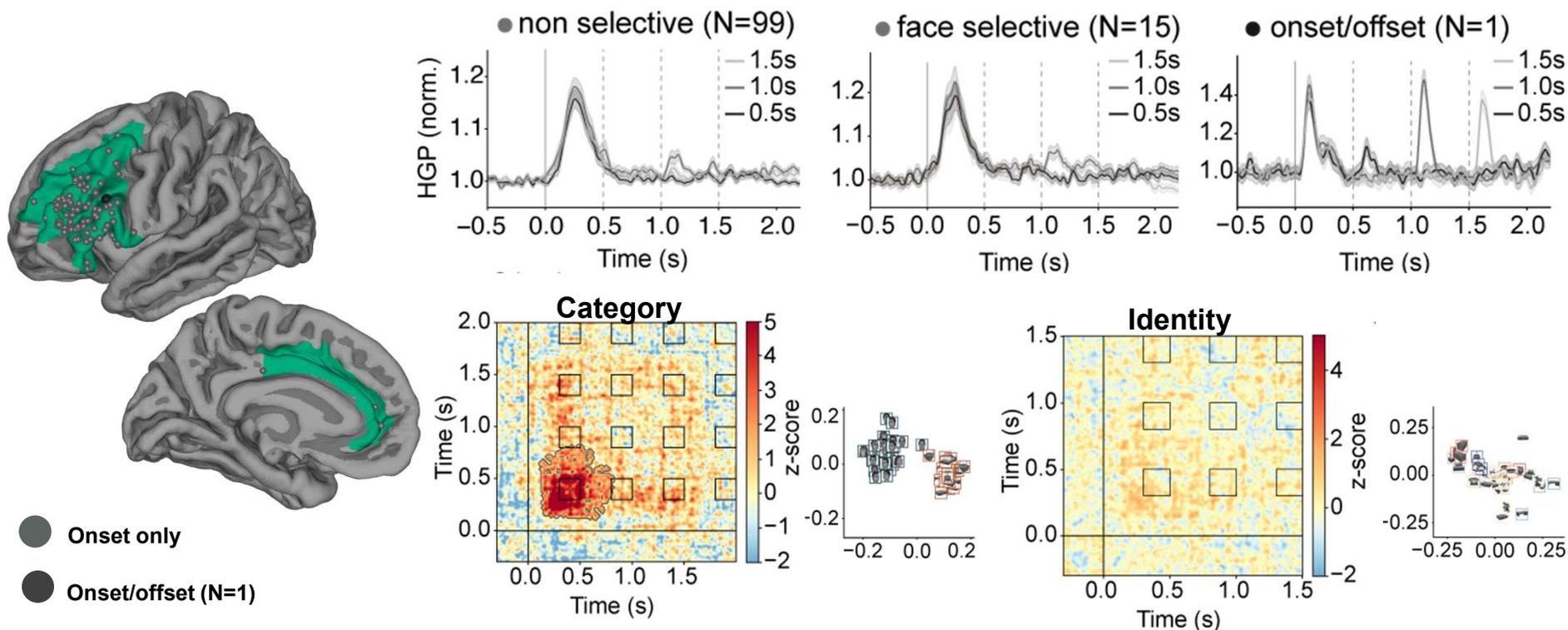
In truth, such a temporal profile is expected, not only under IIT, but under the (well-proven) hypothesis that visual neurons can act as non-conscious, automatic processors and can respond in a purely bottom-up, even during general anesthesia.



What is the duration of activation ?

Cogitate Consortium, Ferrante, ... Melloni, L. (2025). Adversarial testing of global neuronal workspace and integrated information theories of consciousness. *Nature*, 1-10. <https://doi.org/10.1038/s41586-025-08888-1>

In prefrontal and cingulate cortex, activity is transient and independent of duration... exactly as predicted by GNW ! (ignition).
The prediction that did *not* work is the existence of an offset response. Only a single electrode showed this profile in PFC.



Discussion of the Cogitate experiment 1 from the GNW perspective

Cogitate Consortium, Ferrante, ... Melloni, L. (2025). Adversarial testing of global neuronal workspace and integrated information theories of consciousness. *Nature*, 1-10. <https://doi.org/10.1038/s41586-025-08888-1> (see pages 122-124 of Supplementary materials!!)

The results confirm that PFC exhibits a **content-specific, metastable bout of activity (“ignition”)** for about ~200 ms, even **for task-irrelevant stimuli**, irrespective of stimulus duration, with a concomitant transient increase in **long-distance functional correlation** with face- and object-selective posterior areas.

Thus, with suitably sensitive experiments, content-specific PFC regions do show a transient ignition even for irrelevant stimuli – countering the previous conclusions by Frässle et al.

Note that those findings were **unpredicted by IIT but predicted by GNWT**. There is a considerable **asymmetry** in the specificity of the theories’ predictions. None of the massive mathematical backbone of IIT, such as the ϕ measure of awareness, was tested in the present experiment. Instead, what are presented as unique predictions of IIT (posterior visual activation throughout stimulus duration) are just what any physiologist familiar with the bottom-up response properties of those regions would predict, since visual neurons still respond selectively during inattention or general anesthesia. Such responses are equally predicted by GNWT, but attributed to non-conscious processing.

Unfortunately, it is impossible to decide which of the activations reflected conscious versus non-conscious processing, because **the experimental design did not contrast conscious versus non-conscious conditions**.

The present experiment relied on the seemingly innocuous hypothesis that stimuli were “indubitably consciously experienced” for their entire duration. However, it is well known that perfectly visible stimuli, depending on attention orientation, may fail to be seen (attentional blink, inattention blindness) or may become conscious at a time decoupled from stimulus presentation (psychological refractory period, retro-cueing). Here, it seems likely that **participants only briefly gained awareness of the images** (since they remembered them later), but then reoriented their conscious thoughts to other topics, **without attending to image offset** (making this offset more relevant, for instance by turning it into an occlusion event where an object hides behind a screen, could yield different results).

The idea that we are always consciously aware of what is under our eyes is an illusion

Consciousness is not a faithful reflection of the external world.

Inattentional blindness (cf Mack & Rock)

Change blindness.

We are not conscious of our eye blinks.

Our consciousness can lag behind the world by hundreds of milliseconds (we will see this in course 5).

Or on the contrary, an attentional cue can help us recover a long past stimulus (retrocueing, discovered by Claire Sergent).

Thus, the idea that we are always consciously aware of what's under our eyes, for the entire duration of the stimulus, is a **naïve idea**.

The brief prefrontal ignition seen by Cogitate may actually fit with the duration of conscious experience



The Changing Room Illusion

2021 Second prize

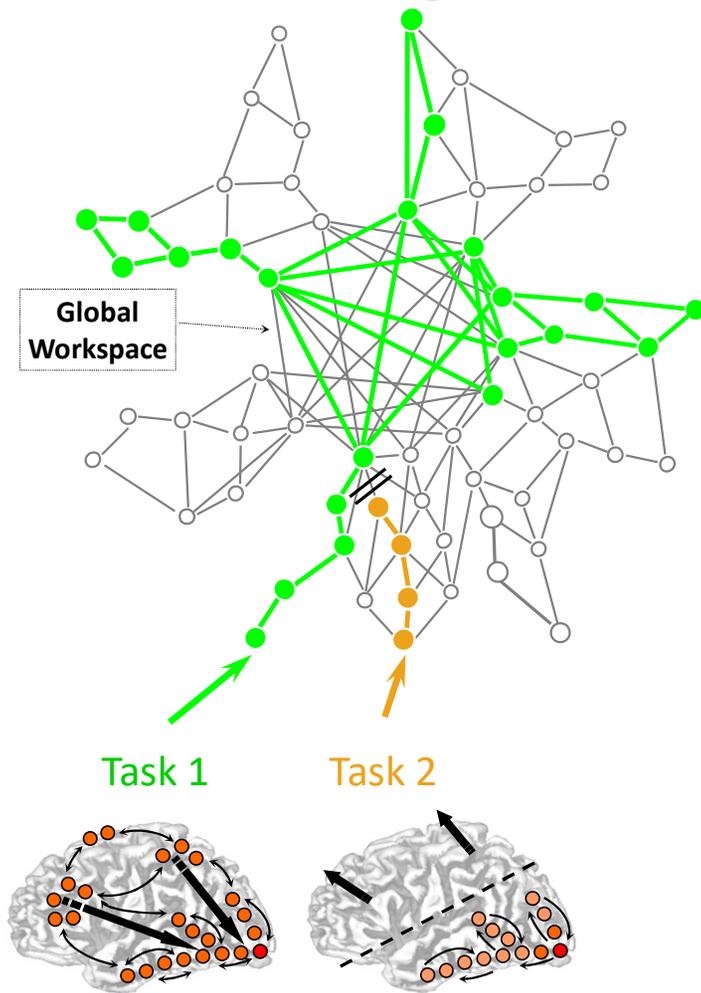
Michael A. Cohen - "The Changing Room Illusion"

Institution: Amherst College/MIT

USA



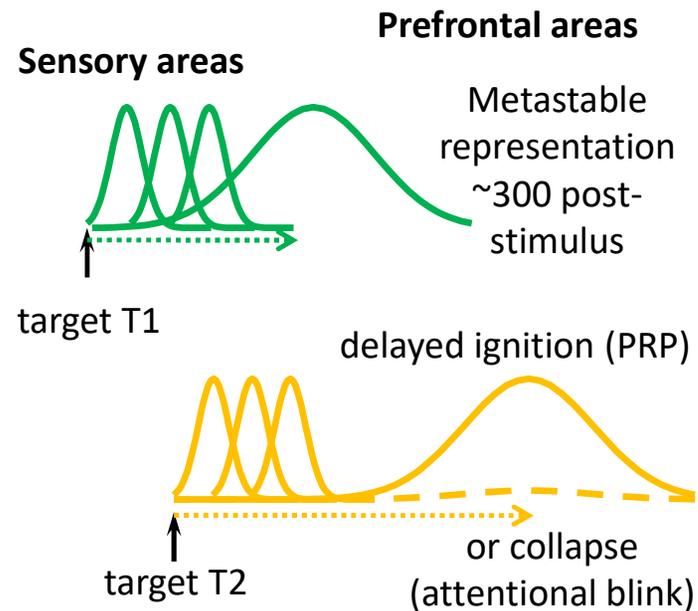
One way to evaluate the duration of conscious perception : How long does it interfere with a second task ?



Prediction: the Global Workspace acts as a bottleneck and only lets a single content at a time.

During a **dual-task collision**, only the late part of the activation should :

- **be delayed** (Psychological Refractory Period, PRP)
- or **collapse** (Attentional Blink, AB)



Evaluating whether and for how long the Cogitate stimuli occupy the global workspace

Lepauvre, A., Engeser, M., Stanislas Dehaene, & Melloni, L. (2026). The timing of conscious access revealed by psychological refractory period interference.

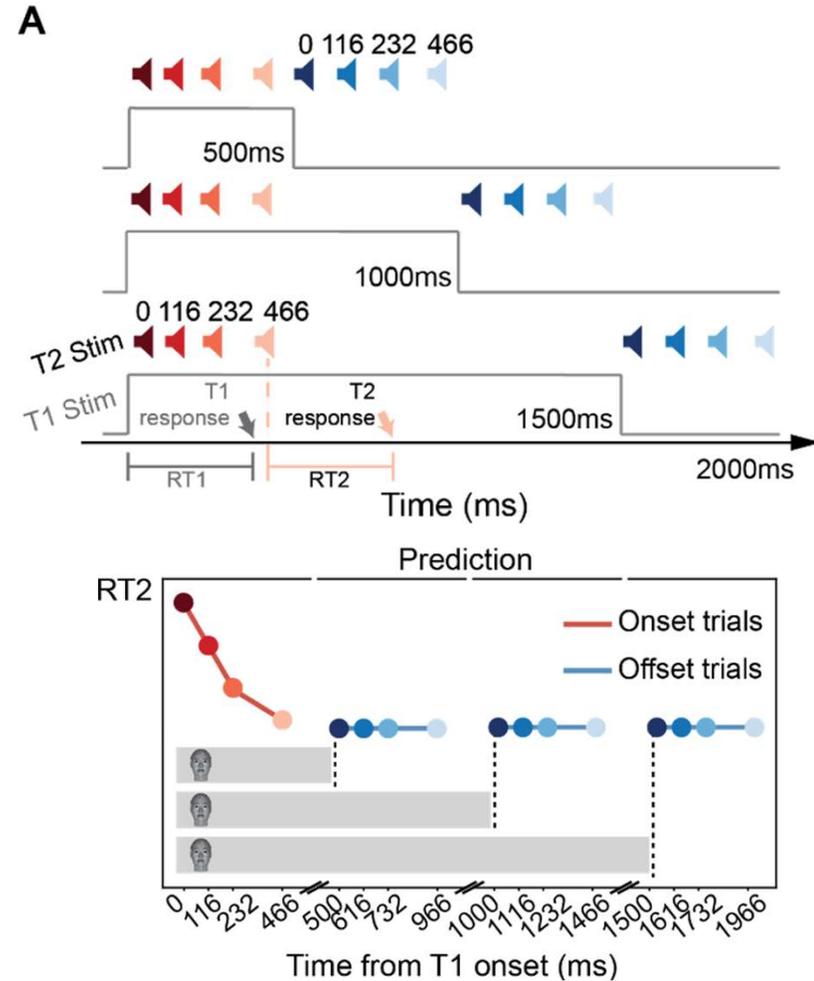
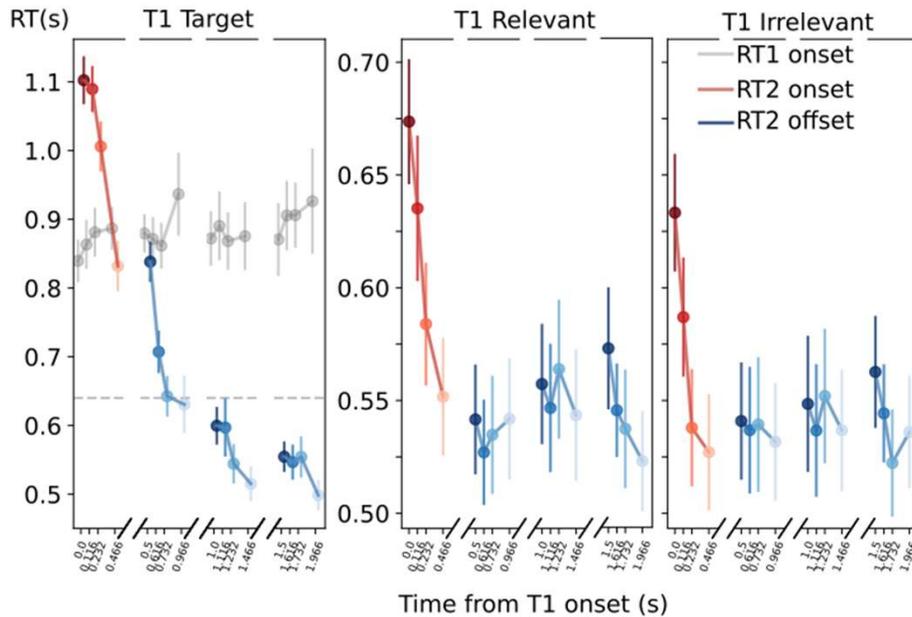
Logic = Use a dual task to examine how long the visual stimuli (task-relevant or irrelevant) interfere with a second auditory decision task – separately at onset and at offset.

Predictions.

Visual onsets should induce a “psychological refractory period” effect, even for non-target stimuli (for which there is no T1 response!).

Visual offsets should not induce a PRP.

Results: indeed, a large PRP is observed for Targets, but also for non-targets. The very small effect at offset could be due to expectations rather than PRP.



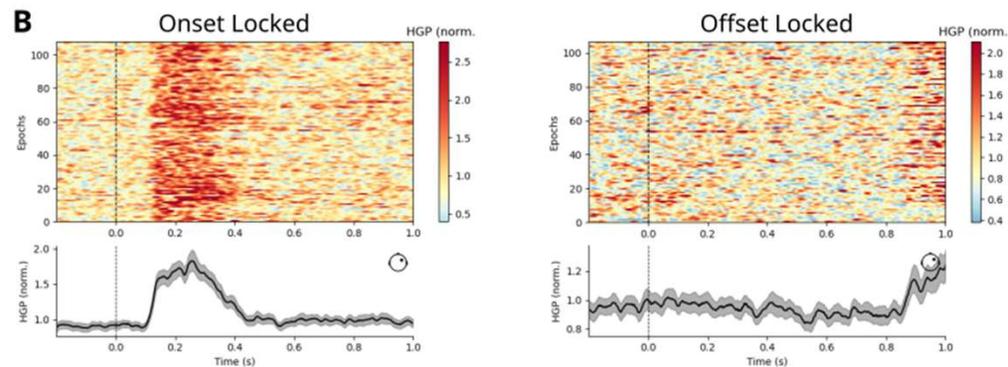
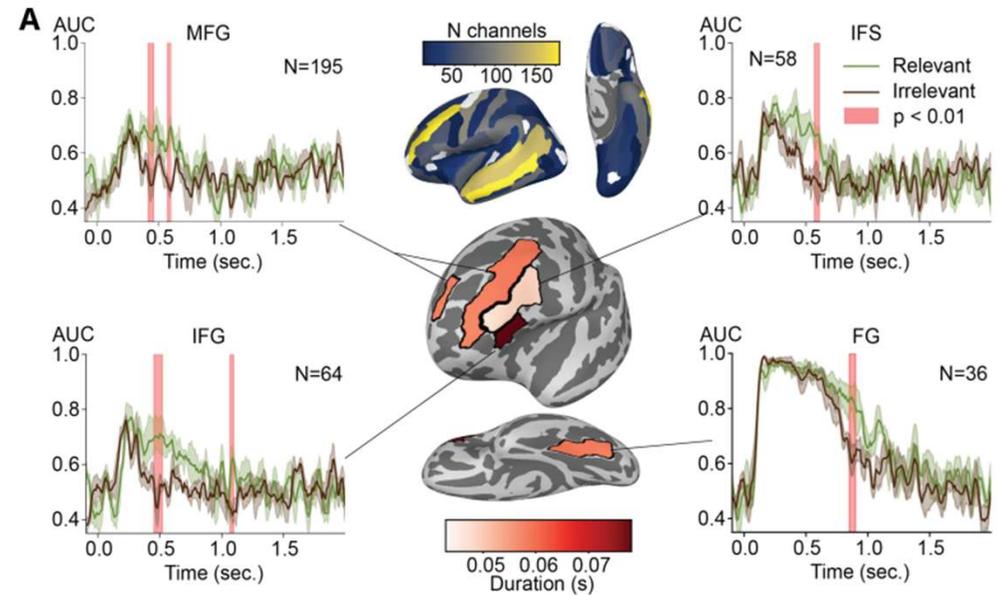
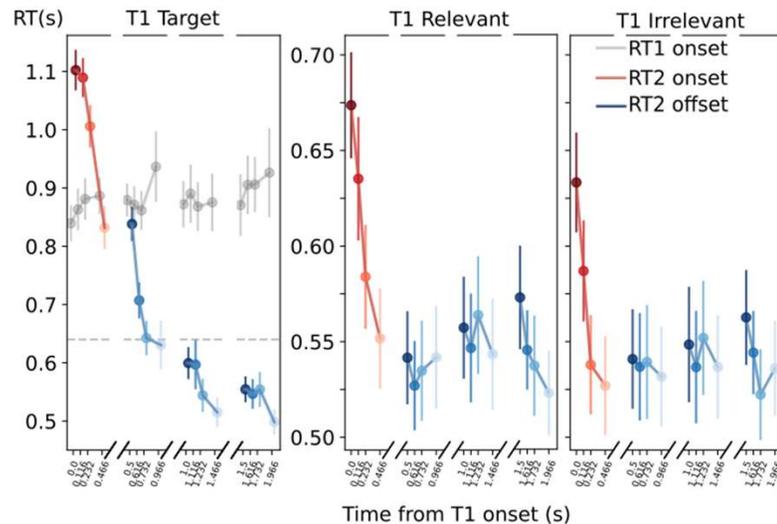
Evaluating whether and for how long the Cogitate stimuli occupy the global workspace

Lepauvre, A., Engeser, M., Stanislas Dehaene, & Melloni, L. (2026). The timing of conscious access revealed by psychological refractory period interference.

Those results fit with the brief bout of content-specific activation in PFC (even quantitatively).

The curves at right show the decoding of faces vs objects, separately for relevant and irrelevant non-target trials. In all cases, PFC is activated for a fixed duration, regardless of stimulus duration (not so for fusiform gyrus [FG]!).

Those results fit perfectly with GNW predictions and support the association between PFC and central-stage processing underlying conscious access in no-report conditions.



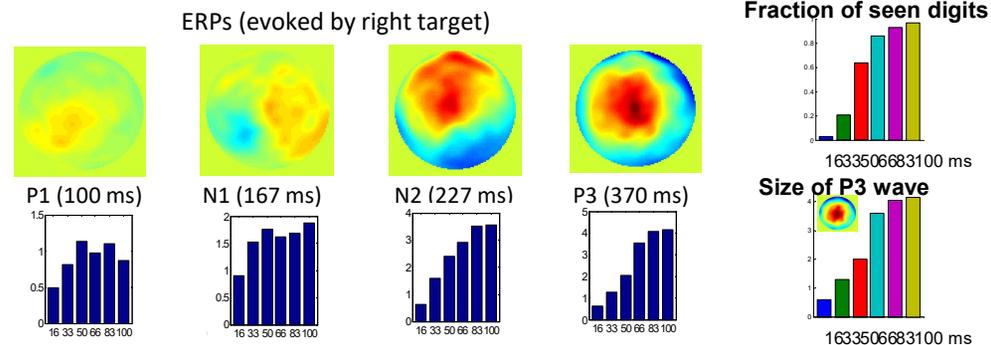
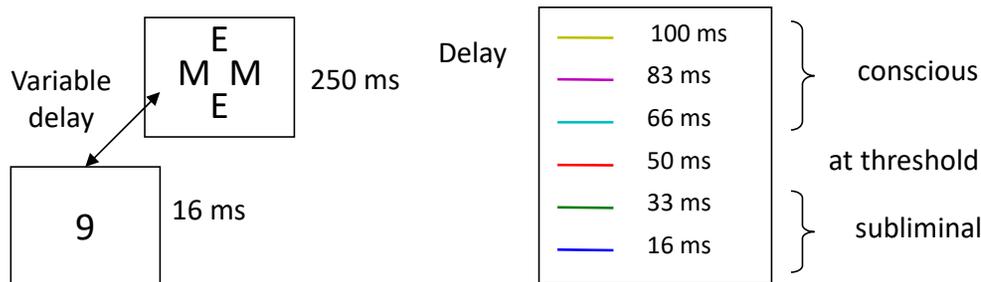
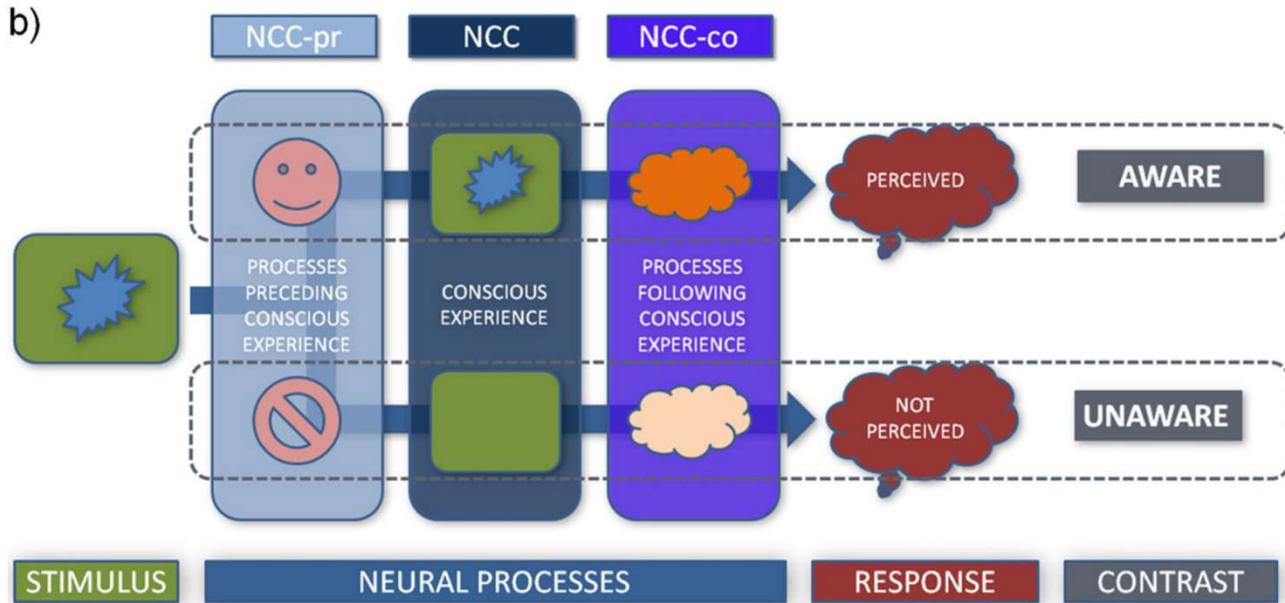
Distilling the neural correlates of consciousness : the P3b controversy

Aru, J., Bachmann, T., Singer, W., & Melloni, L. (2012). Distilling the neural correlates of consciousness. *Neurosci Biobehav Rev*, 36(2), 737-746.

Aru et al. argue that experimental designs should endeavor to separate the “neural correlates of consciousness proper” from any processes preceding or following conscious experience.

How does this apply to the P3b, which was proposed as a possible signature of consciousness?

Previous data already suggested that the P3b “does not follow conscious perception when subjects already have a conscious working memory representation of the target stimulus (Melloni et al., 2011).”



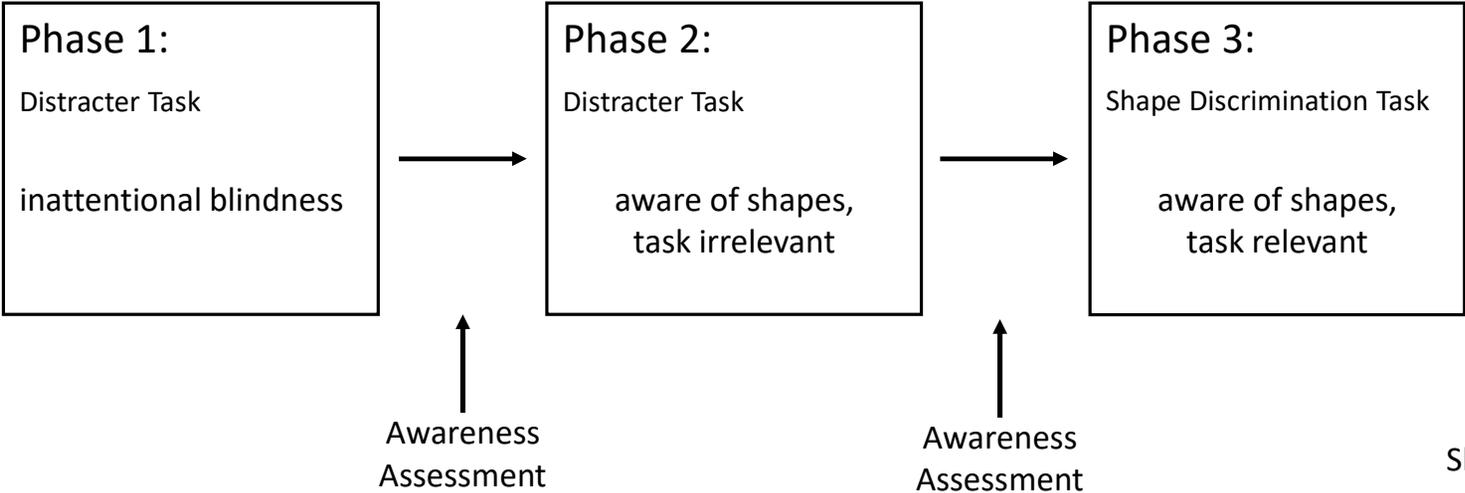
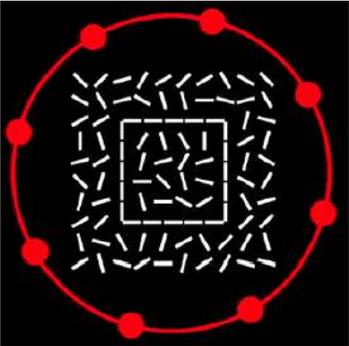
Dissociating consciousness from task relevance: Michael Pitt's 3-phase paradigm

Pitts, M. A., Martínez, A., & Hillyard, S. A. (2012). Visual Processing of Contour Patterns under Conditions of Inattentional Blindness. *Journal of Cognitive Neuroscience*, 24(2), 287-303. https://doi.org/10.1162/jocn_a_00111



Simons & Chabris (1999)

Taking inspiration from the inattentional blindness literature, Michael Pitts sought to image the neural fate of the same stimuli when they are unseen and when they are seen (yet still task-irrelevant).



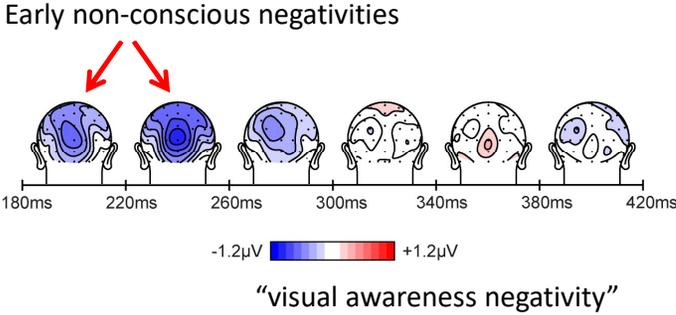
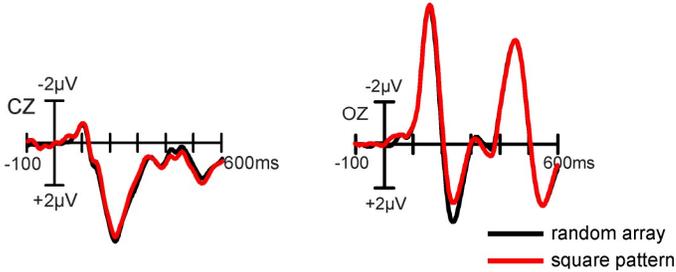
Michael Pitts

Slides courtesy of Michael Pitts

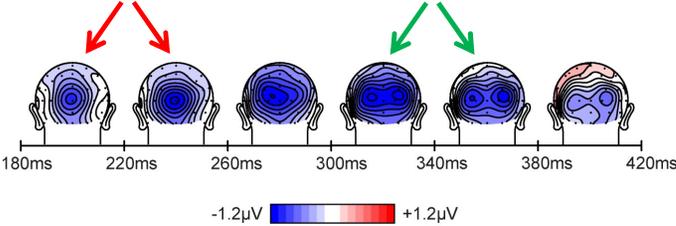
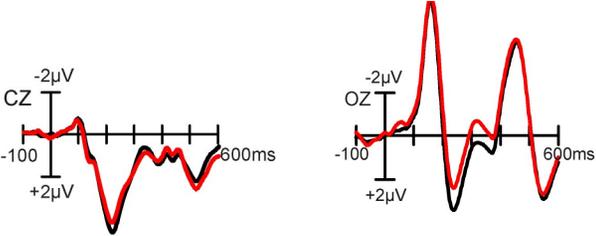
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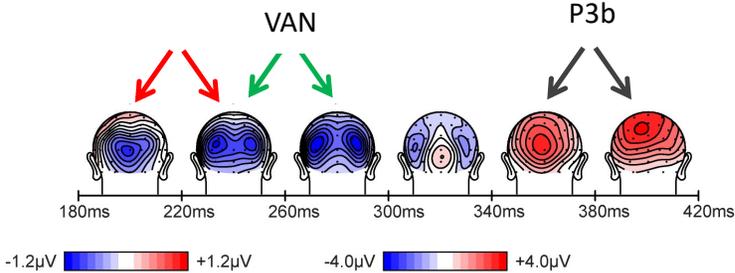
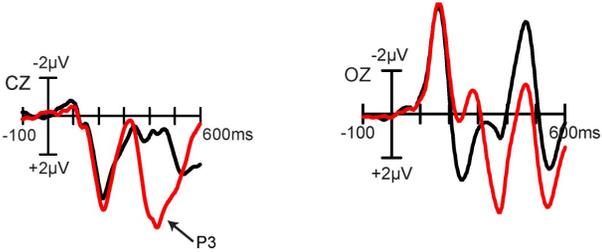
Phase 1: inattentional blindness



Phase 2: aware, task irrelevant



Phase 3: aware, task relevant



Proposed conclusion :

The P3b is present whenever there is conscious **processing**

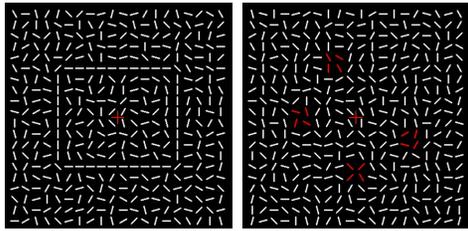
but it is not necessarily present under conditions of “**mere awareness**”, distilled from post-processing.

→ The P3b is not always a 100% reliable signature of conscious perception.

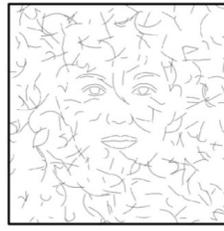
Dissociating consciousness from task relevance: Mounting evidence that the P3B is not always present whenever consciousness is

Possible critiques and their refutations :

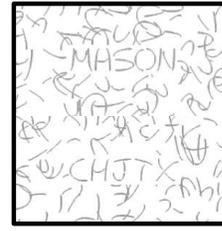
- Consciousness is not guaranteed on every trial.
... but when asked, people report seeing on 50-100% of phase 2 trials.
- Consciousness may be delayed by the primary task. Could this have caused the P3b to be so diluted and delayed as to become invisible?



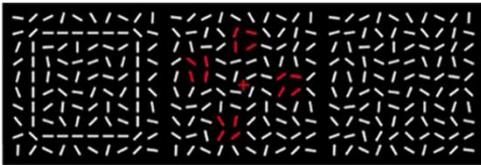
Pitts et al. (2014)



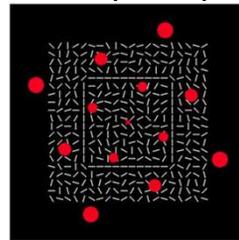
Shafto & Pitts
(2015)



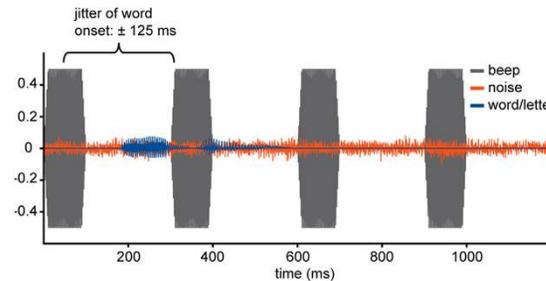
Schelonka et al. (2017)



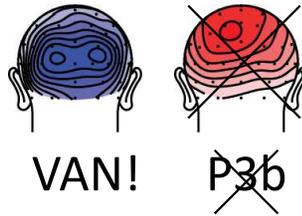
Harris, Dux, & Mattingley (2020)



Schlossmacher et al.
(2020)



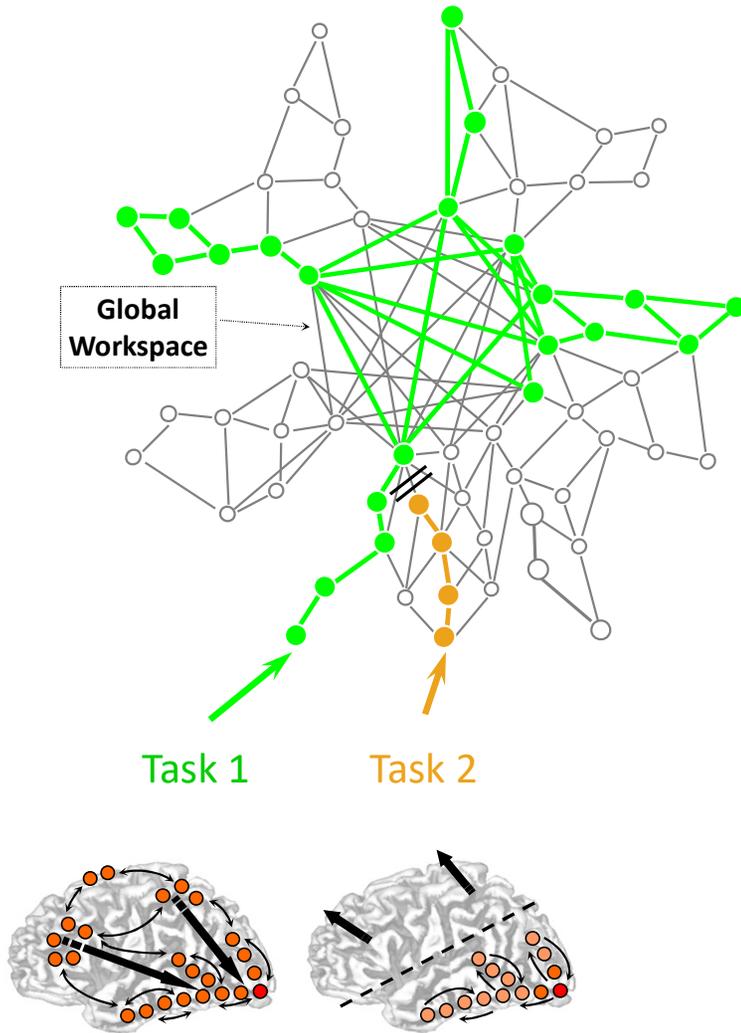
Schlossmacher et al. (2021)



results: VAN!

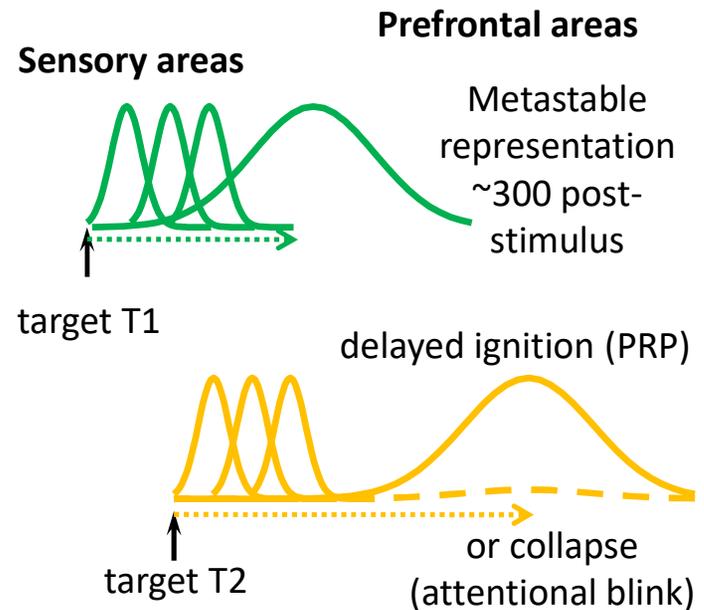
~~P3b~~

Collisions in consciousness

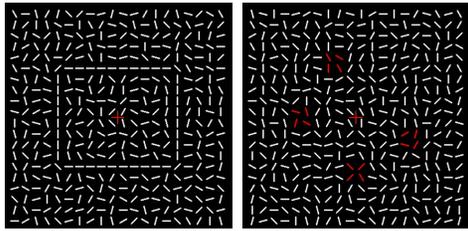


During a **dual-task collision**, only the late part of the activation should :

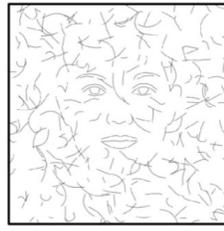
- **be delayed** (Psychological Refractory Period, PRP)
- or **collapse** (Attentional Blink, AB)



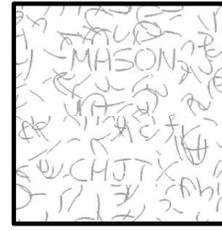
Dissociating consciousness from task relevance: Mounting evidence that the P3B is not always present whenever consciousness is



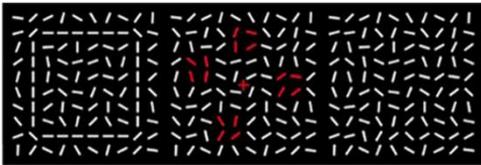
Pitts et al. (2014)



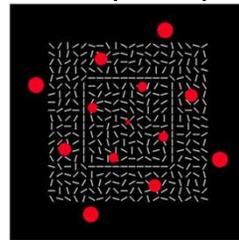
Shafto & Pitts
(2015)



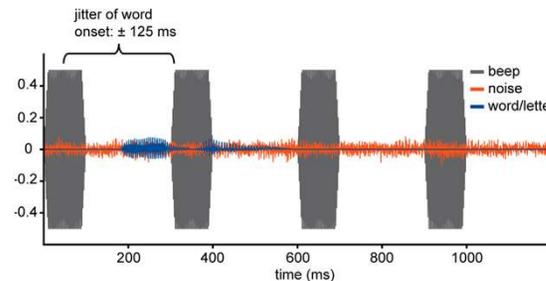
Schelonka et al. (2017)



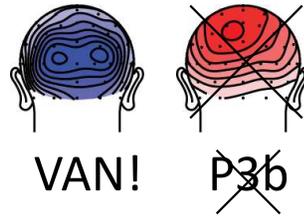
Harris, Dux, & Mattingley (2020)



Schlossmacher et al.
(2020)



Schlossmacher et al. (2021)



results: VAN! ~~P3b~~

Possible critiques :

- Consciousness is not guaranteed on every trial.

... but when asked, people report seeing on 50-100% of phase 2 trials.

- Consciousness may be delayed. Could this have caused the P3b to be so diluted and delayed as to become invisible?

... but the VAN was indeed delayed in phase 2... but there was no trace of a P3b even in a 600 ms window.

Furthermore, note that the targets for the primary distracter task are rare, and in phase 2, Pitts et al. only analyze ERPs on non-target trials. Thus, subjects are only lightly distracted.

→ This interpretation seems unlikely.

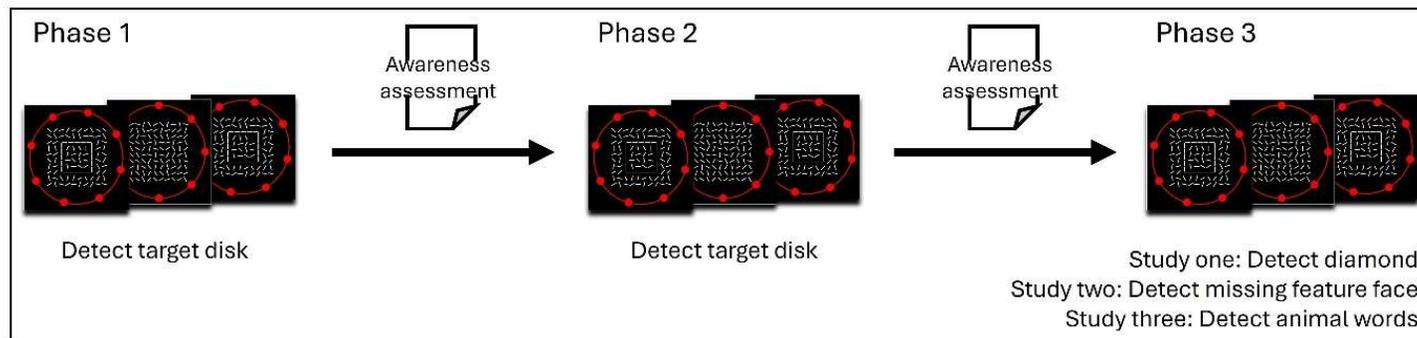
- Still, the difference between phase 1 and phase 2 may reflect in part enhanced pre-conscious processing and active inhibition rather than conscious processing.

Metastability and cross-time generalization are still present and are good signatures of conscious access in the absence of a P3b

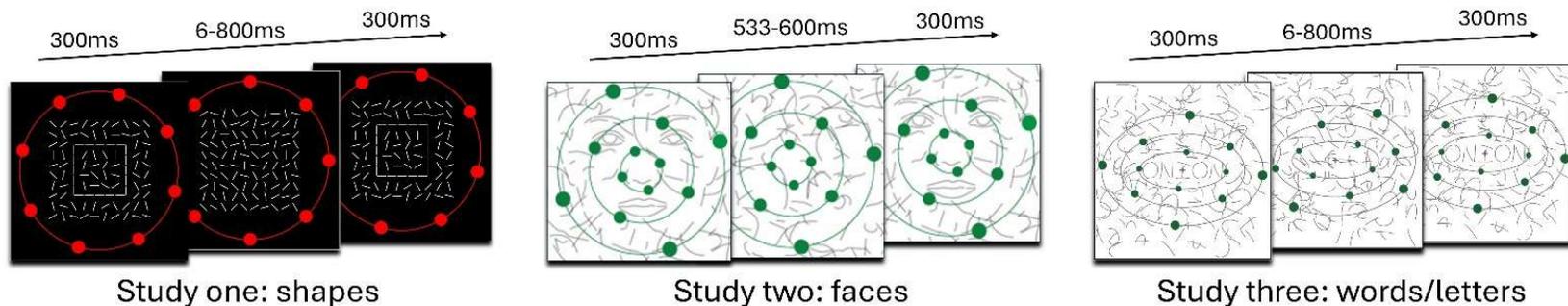
Hutchinson, B., Dehaene, S., Slagter, H. A., & Pitts, M. (2026). A late meta-stable code of conscious access in the absence of report. submitted.

Idea = reanalyze previous data, using multi-variate decoding to test the GNW prediction of a period of metastable activity under conscious conditions.

A: Three phase experimental design



B: Stimulus sequence

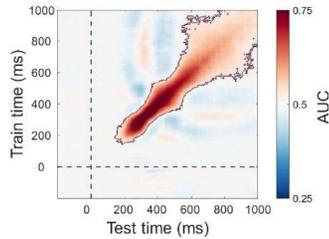


Metastability and cross-time generalization as better signatures of conscious access in the absence of a P3b

Hutchinson, B., Dehaene, S., Slagter, H. A., & Pitts, M. (2026). A late meta-stable code of conscious access in the absence of report. submitted.

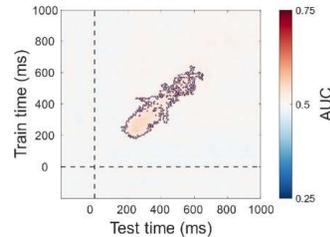
Phase 3: Aware,
report (P3b)

A: Study one (shapes)



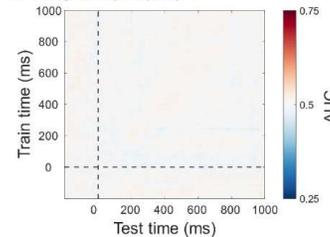
Phase 2: Aware,
no report (no P3b)

A: Study one (shapes)



Phase 1: Unaware,

A: Study one (shapes)

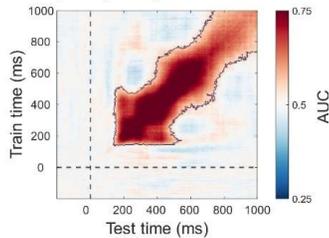


In all 3 experiments, a “thick diagonal” indicates the presence of a series of metastable representations, after 200 ms, whenever the subject is aware of the picture.

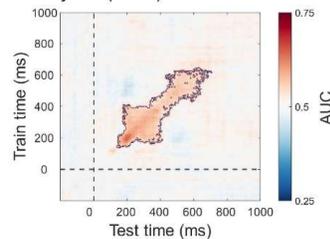
Conclusion:

- The P3b is not always a reliable marker of conscious access. It may rather reflect conscious **processing** and may disappear when conscious processing is minimal (stimuli are already known, repeated, or task irrelevant).
- The broader GNW hypothesis of late access to a metastable representation, however, is still tenable.

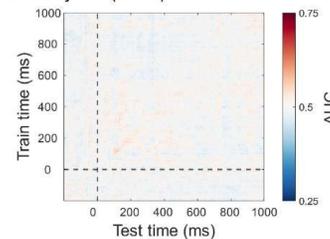
B: Study two (faces)



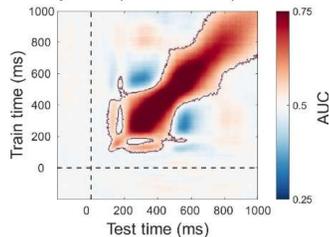
B: Study two (faces)



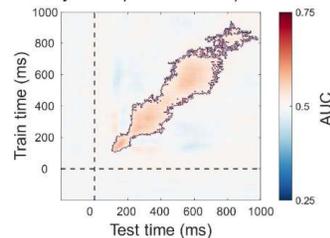
B: Study two (faces)



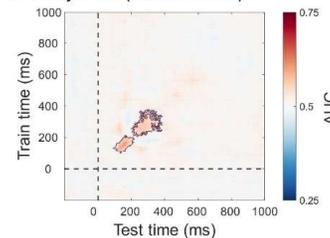
C: Study three (words/letters)



C: Study three (words/letters)



C: Study three (words/letters)



Prefrontal ignition? The 3-phase paradigm in simultaneous EEG+fMRI

Dellert, T., Müller-Bardorff, M., Schlossmacher, I., Pitts, M., Hofmann, D., Bruchmann, M., & Straube, T. (2021). Dissociating the Neural Correlates of Consciousness and Task Relevance in Face Perception Using Simultaneous EEG-fMRI. *The Journal of Neuroscience*, 41(37), 7864-7875.

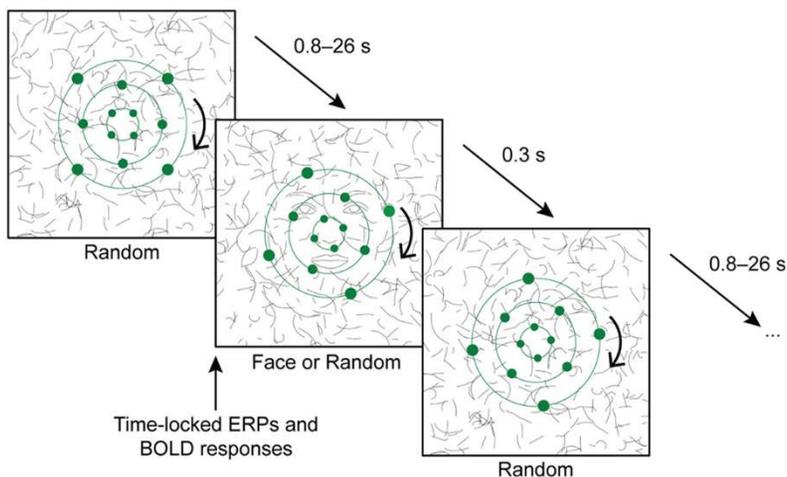
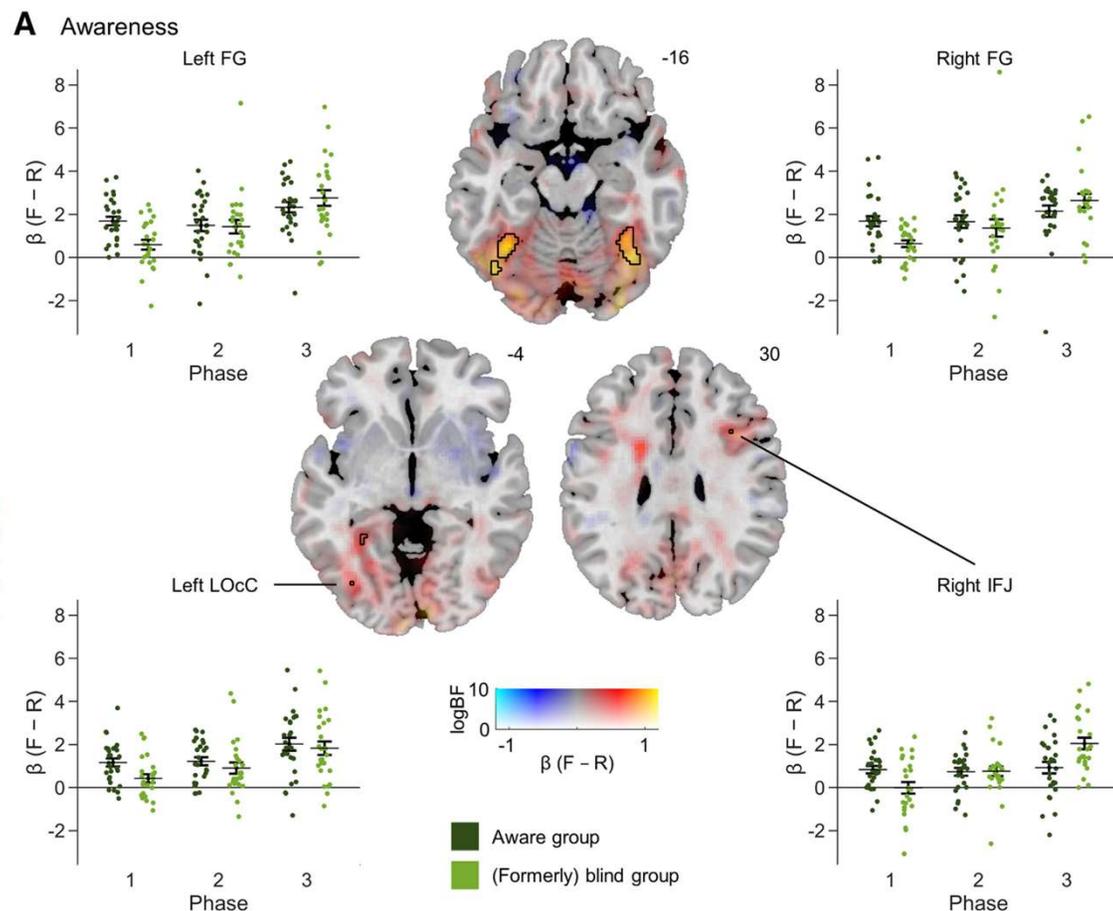


Figure 1. Stimulus presentation and tasks. In all three experimental phases, each trial began with random lines presented in the background, followed by a critical stimulus (a schematic face or random lines). ERPs and BOLD responses were time locked to these critical stimuli. In the foreground, green dots continuously rotated around three concentric rings. For the distractor dot task in phases 1 and 2, participants were asked to respond whenever one of the dots briefly illuminated. For the face task in phase 3, participants were instructed to respond whenever they detected a face with a missing feature (e.g., an eye). Adapted from Shafto and Pitts (2015).

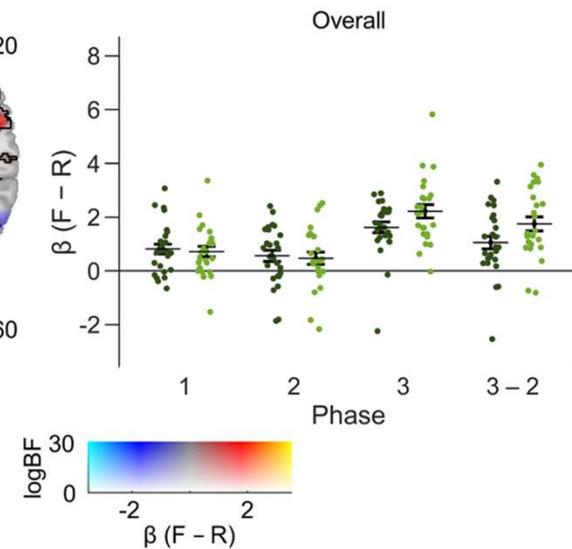
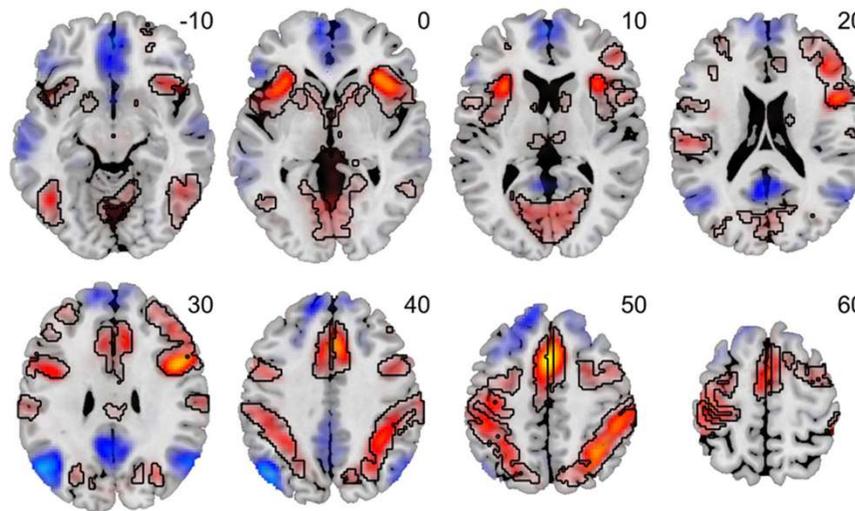
Prefrontal cortex is (weakly) activated in the face – random contrast, whenever subjects are aware (a few in phase 1, all in phases 2 and 3)



The 3-phase paradigm in simultaneous EEG+fMRI

Dellert, T., Müller-Bardorff, M., Schlossmacher, I., Pitts, M., Hofmann, D., Bruchmann, M., & Straube, T. (2021). Dissociating the Neural Correlates of Consciousness and Task Relevance in Face Perception Using Simultaneous EEG-fMRI. *The Journal of Neuroscience*, 41(37), 7864-7875.

B Task relevance



Unsurprisingly, brain activation (for Faces – Random) becomes broader and more intense in a large fronto-parietal network during phase 3, when the stimuli become task-relevant.

The 3-phase paradigm in simultaneous EEG+fMRI

Dellert, T., Müller-Bardorff, M., Schlossmacher, I., Pitts, M., Hofmann, D., Bruchmann, M., & Straube, T. (2021). Dissociating the Neural Correlates of Consciousness and Task Relevance in Face Perception Using Simultaneous EEG-fMRI. *The Journal of Neuroscience*, 41(37), 7864-7875.

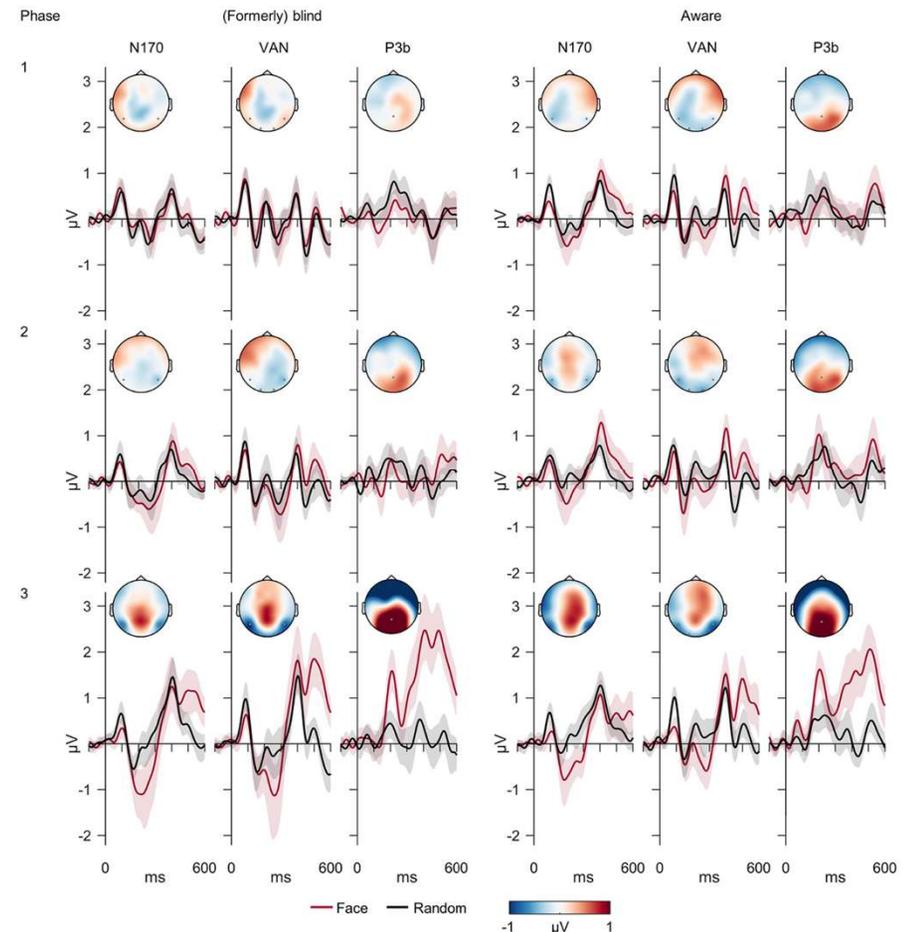
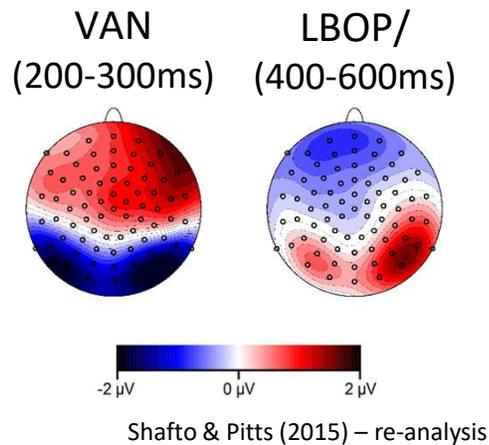
ERP recordings largely replicated all previous studies by Pitts.

However, there was a weak but rather consistent late frontocentral negativity (fcN2), together with a posterior positivity, which Michael Pitts calls « LBOP » (late bilateral occipital positivity) and repeatedly sees in multiple studies.

→ A marker of the weak prefrontal activation in MRI?

Conclusion of EEG-fMRI study :

Activation of the fronto-parietal workspace clearly depends on top-down attention and task-setting... but consciousness too. And when consciousness is present (phase 2), prefrontal activity is present. Still, the 3-phase paradigm is somewhat ambiguous and does not guarantee awareness on every trial or right after stimulus presentation... but this problem can be solved !



A glimpse of the Cogitate experiment 2 : inattentional blindness and a no-report paradigm

Faces or objects are presented while the participant is distracted by a difficult video game.

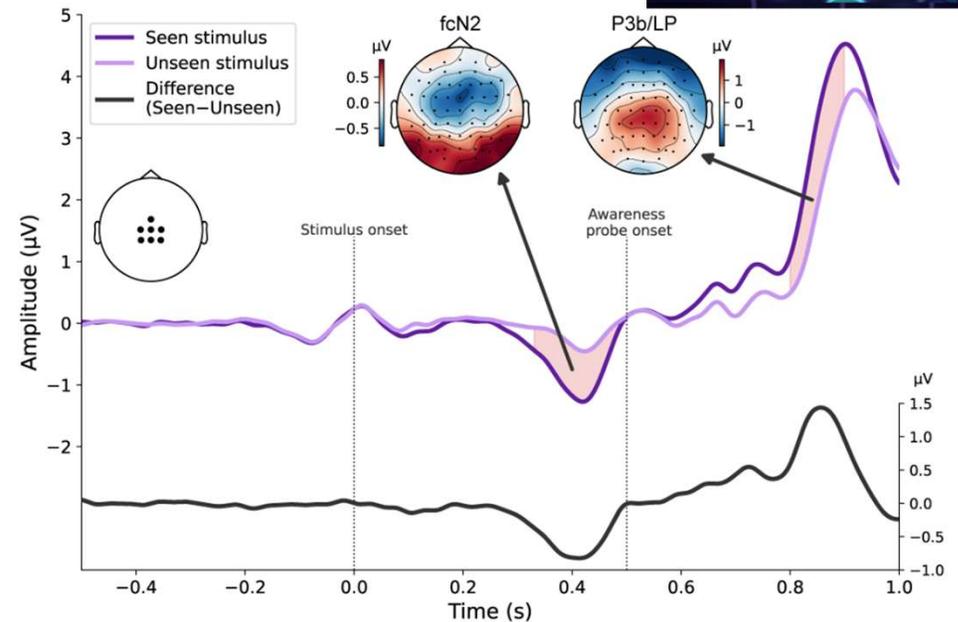
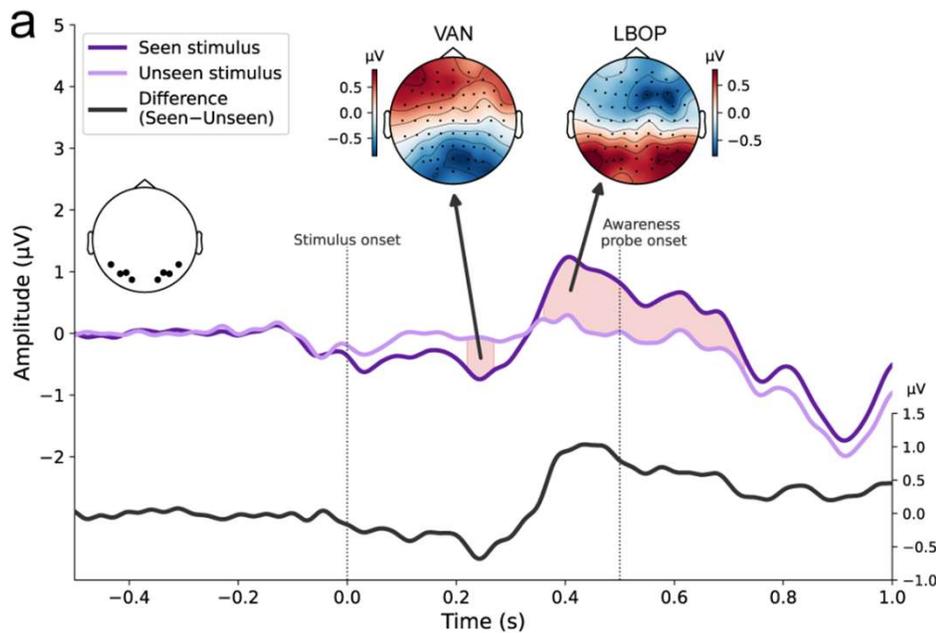
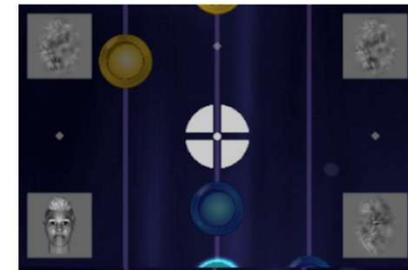
Most trials are no-report – but on rare trials, a probe appears to tell the participant to report seeing or not-seeing.

Crucially, the report probe is delayed until 500 ms after stimulus onset, thus dissociating the moment of conscious registration from the act of reporting (which is absent by default).

This design solves many problems associated with the 3-phase paradigm: we *can* classify stimuli as seen or unseen, and yet for 500 ms the evoked response is *not* affected by the reporting process.

The results revealed the Visual Awareness Negativity (VAN, starting ~200 ms) and LBOP/fcN2 (starting ~350 ms)... But crucially, the P3b is delayed until after the report probe appears.

Face (bottom left)

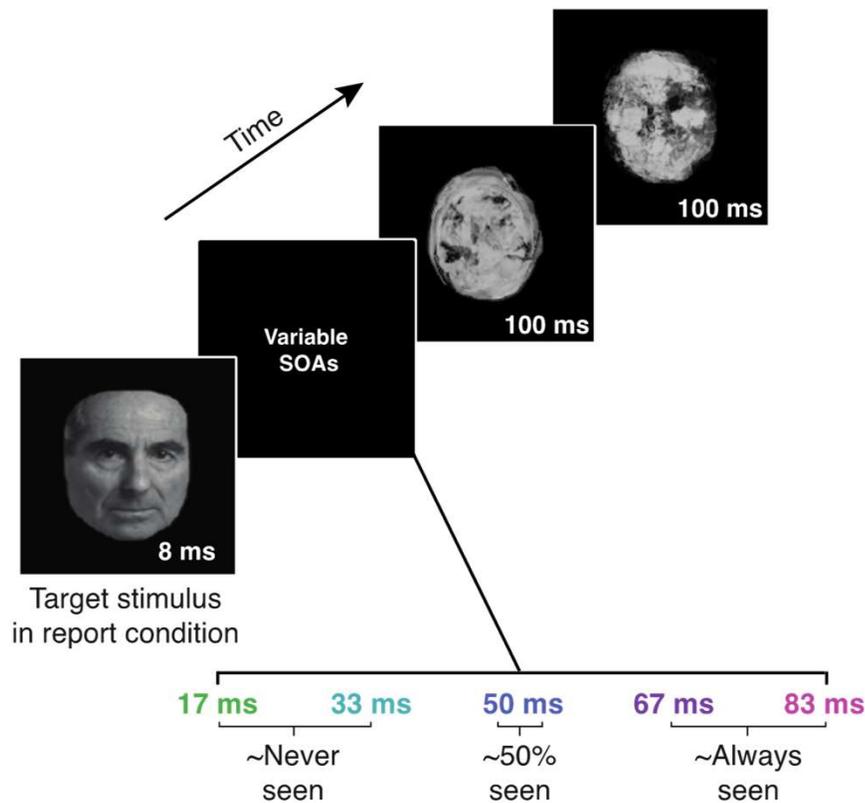


Bifurcation and non-linear ignition in a no-report paradigm

Cohen, M. A., Dembski, C., Ortego, K., Steinhilber, C., & Pitts, M. (2024). Neural signatures of visual awareness independent of postperceptual processing. *Cerebral Cortex*, 34(11), bhae415. <https://doi.org/10.1093/cercor/bhae415>

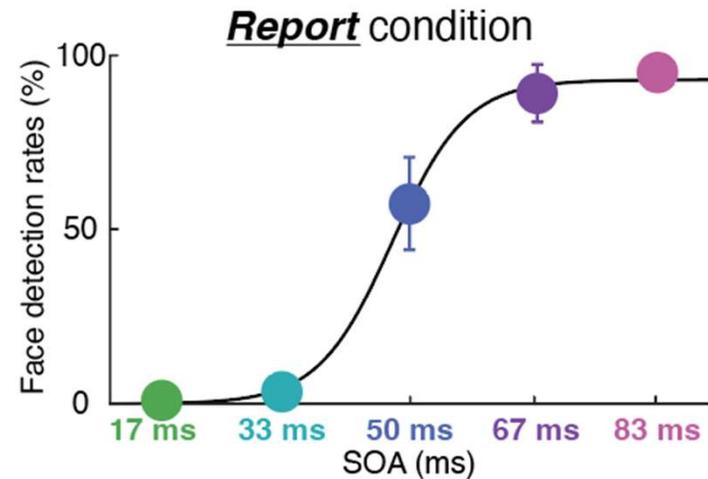


Michael Cohen
[Amherst / MIT]



Cohen et al. (2024) used variable-SOA masking similar to Del Cul et al. Crucially, in two different blocks, they asked either for a report (seen/unseen face) or no-report (detect a rare green circle).

Behavioral results (Non-linear face detection)



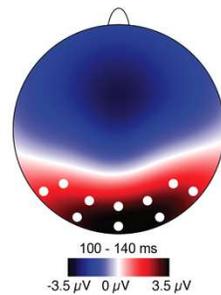
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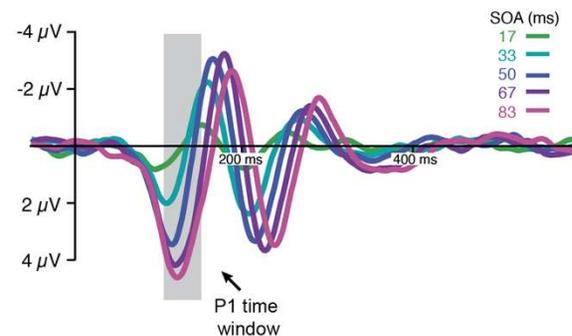
Early visual processing shows a continuous, linear processing of the face stimulus, largely independent of the task

A Linear P1 in the *no-report* condition

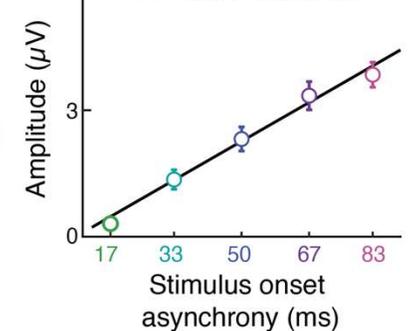
Scalp topography and P1 electrodes



Time course of ERP

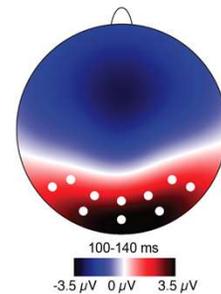


Mean voltage from P1 time window

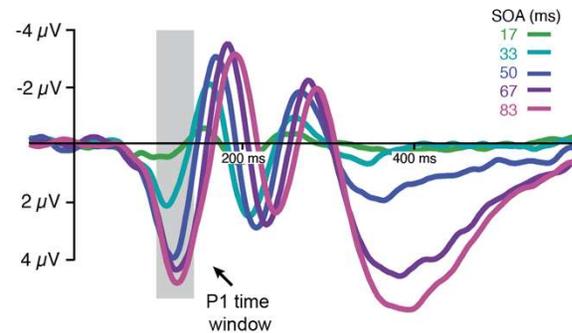


B Linear P1 in the *report* condition

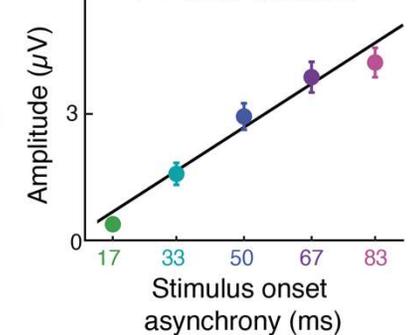
Scalp topography and P1 electrodes



Time course of ERP



Mean voltage from P1 time window



Bifurcation and non-linear ignition in a no-report paradigm

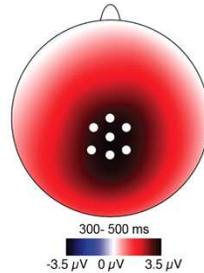
Cohen, M. A., Dembski, C., Ortego, K., Steinhilber, C., & Pitts, M. (2024). Neural signatures of visual awareness independent of postperceptual processing. *Cerebral Cortex*, 34(11), bhae415. <https://doi.org/10.1093/cercor/bhae415>

The P3b is nicely replicated in the report conditions

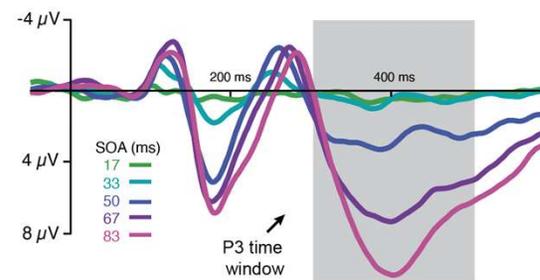
... but vanishes under no-report conditions.

B Non-linear, bifurcated P3 in the **report** condition

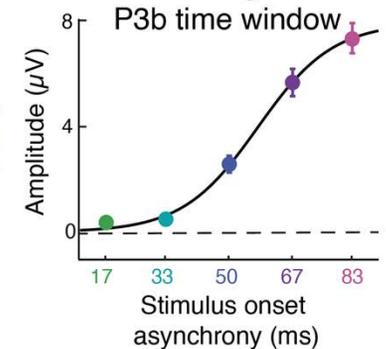
Scalp topography and P3b electrodes



Time course of ERP

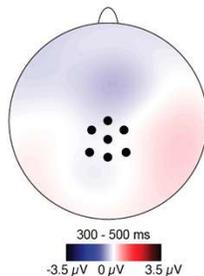


Mean voltage from P3b time window

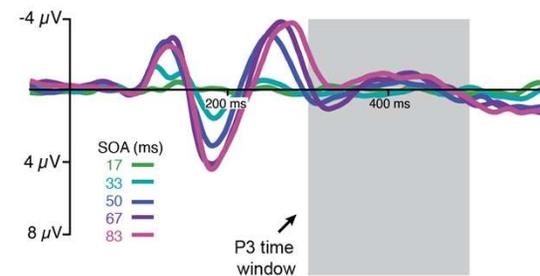


A No non-linear, bifurcated P3b in the **no-report** condition

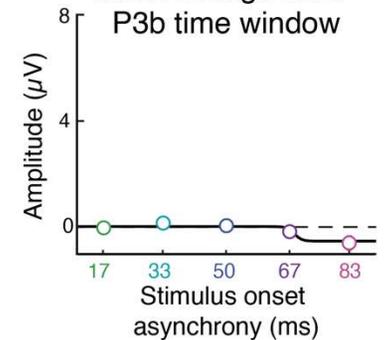
Scalp topography and P3b electrodes



Time course of ERP



Mean voltage from P3b time window



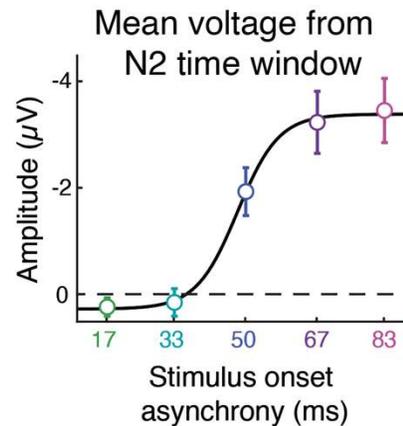
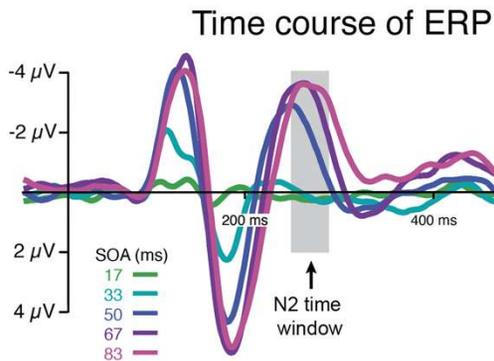
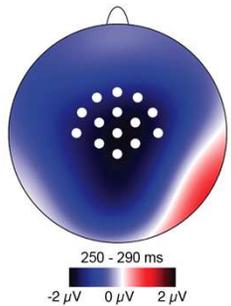
Bifurcation and non-linear ignition in a no-report paradigm

Cohen, M. A., Dembski, C., Ortego, K., Steinhilber, C., & Pitts, M. (2024). Neural signatures of visual awareness independent of postperceptual processing. *Cerebral Cortex*, 34(11), bhae415. <https://doi.org/10.1093/cercor/bhae415>

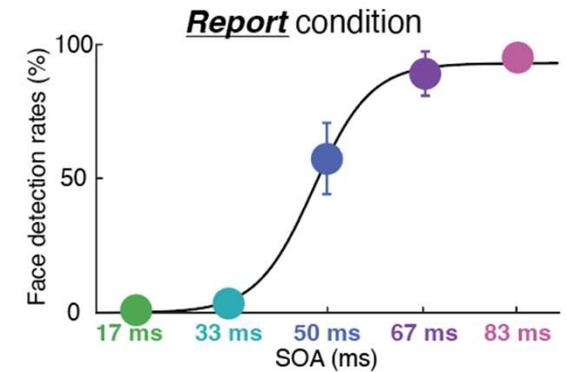
However, it's the N2 (~200-300 ms after the stimulus) that shows a non-linear ignition !

A Non-linear, bifurcated N2 in the *no-report* condition

Scalp topography and N2 electrodes



Behavioral results (Non-linear face detection)



Conclusion :

- Non-linear ignition is real and occurs under no-report conditions
- The P3b is not a universal signature of conscious ignition. Under no-report conditions (or when subjects expect the stimulus), it is replaced by **an earlier non-linear event** (N2 or Visual awareness negativity)
- The P3b is still a good signature of **conscious processing** – routinely used for instance as part of the local-global paradigm to detect patients with residual consciousness.
- We must distinguish **minimal conscious access** versus **conscious processing** (distillation is a good idea!).

Key GNW prediction remains valid : even under no-report conditions, prefrontal cortex is still be activated.

Conclusion : Distilling the neural correlates of consciousness

Aru, J., Bachmann, T., Singer, W., & Melloni, L. (2012). Distilling the neural correlates of consciousness. *Neurosci Biobehav Rev*, 36(2), 737-746.

Aru et al. were completely right : the act of reporting adds additional cerebral processes that are not strictly needed for conscious experience. **No-report paradigms** are a good idea!

The event-related potential called P3b is a good marker of **conscious processing**, but not necessarily the minimal brain activity associated with **conscious access**.

Nevertheless, even in no-report paradigms:

- The dynamics of brain activity continues to show a non-linear bifurcation towards a brief period of metastable activity
- Neuronal activity in prefrontal cortex seems to be present whenever there is conscious access
- Which prefrontal neurons are activated reflects the contents of conscious experience
- Prefrontal cortex plays a causal role in conscious access

Next week : the timing of conscious processing (spoiler : it may differ from the timing of the stimuli !).