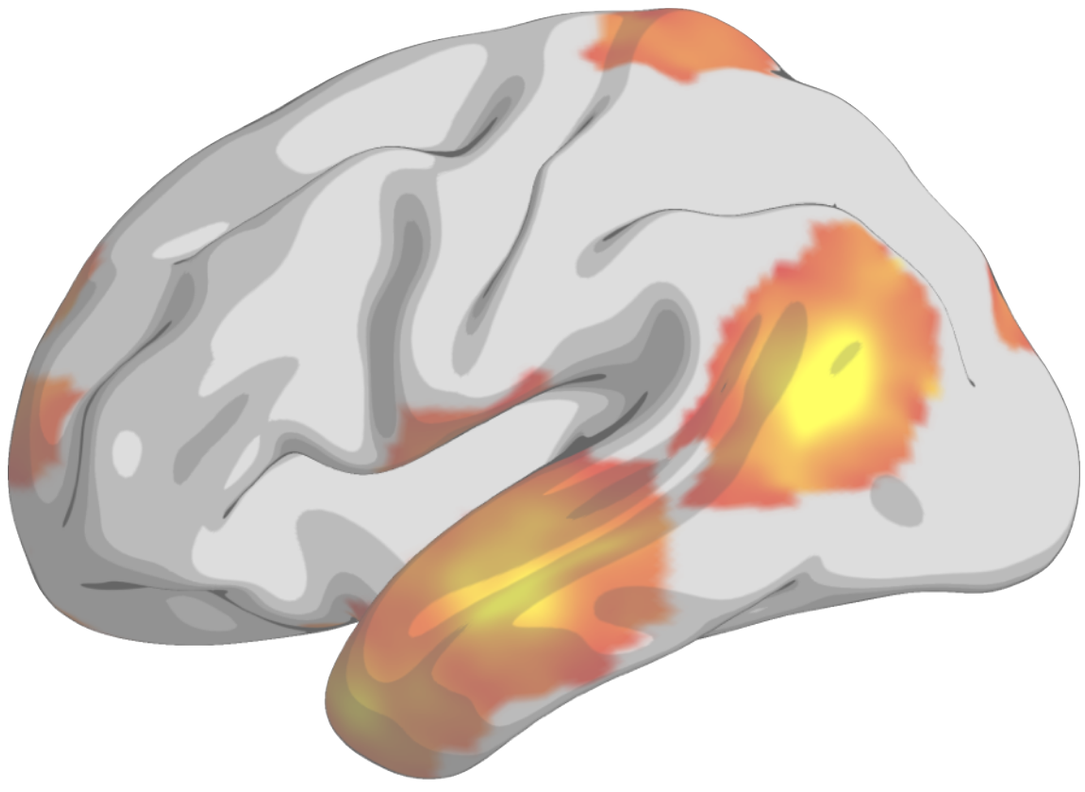
Growing technological opacity and the social brain

François Osiurak
University of Lyon, Lyon, France
Institut Universitaire de France, Paris, France



Opacity

Opacity can be defined as the degree to which information is ***not accessible*** for cognitive processing.

Mechanically transparent

Mechanically opaque

Subjective

It depends on individual characteristics or experience

Opacity

….can take several forms

How was this object made?

What knowledge do others have of it?

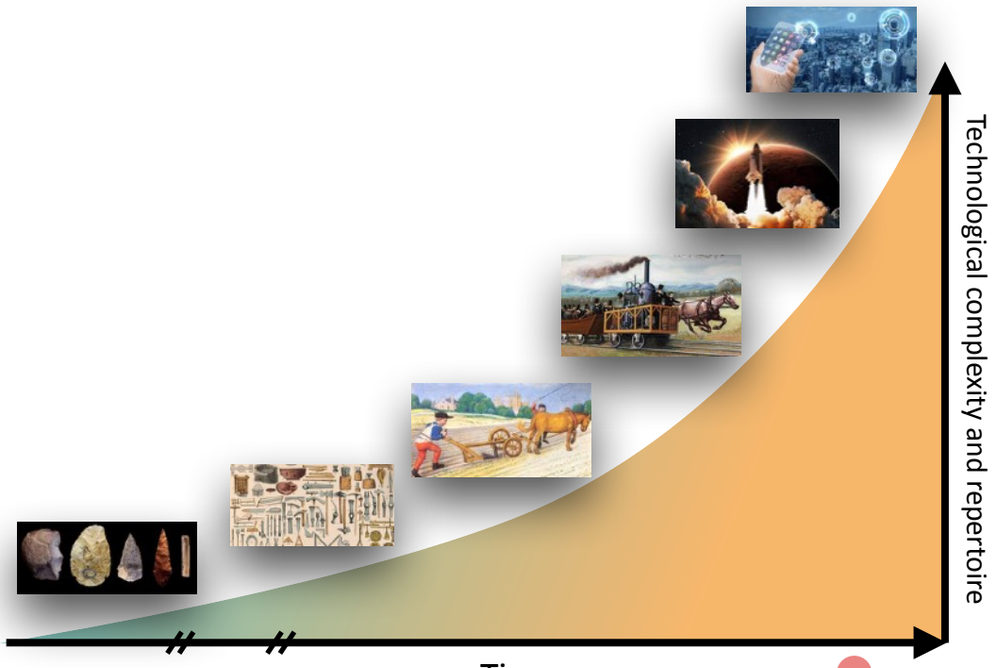
How does it work?

Making process

Transactive process

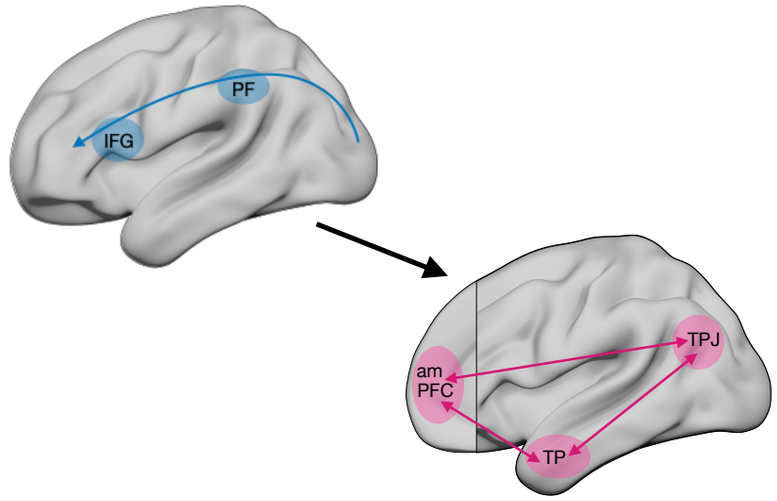
Using process

Overview



Coevolution with cognition

Technical brain



Social brain

Opacity

Opacity

Opacity

Tool making

Cultural specialization

Tool use

Not new: Csibra, Wegner, Keil, Dennett…

Technical versus social brain

Laws	Physical	Physical
	x	Psychological
Class of stimuli	Inanimate (non-intentional objects)	Animate (intentional agents)

Perceptual properties

Biological motion *Self-propulsion* *Deformation*

Hand *Face*

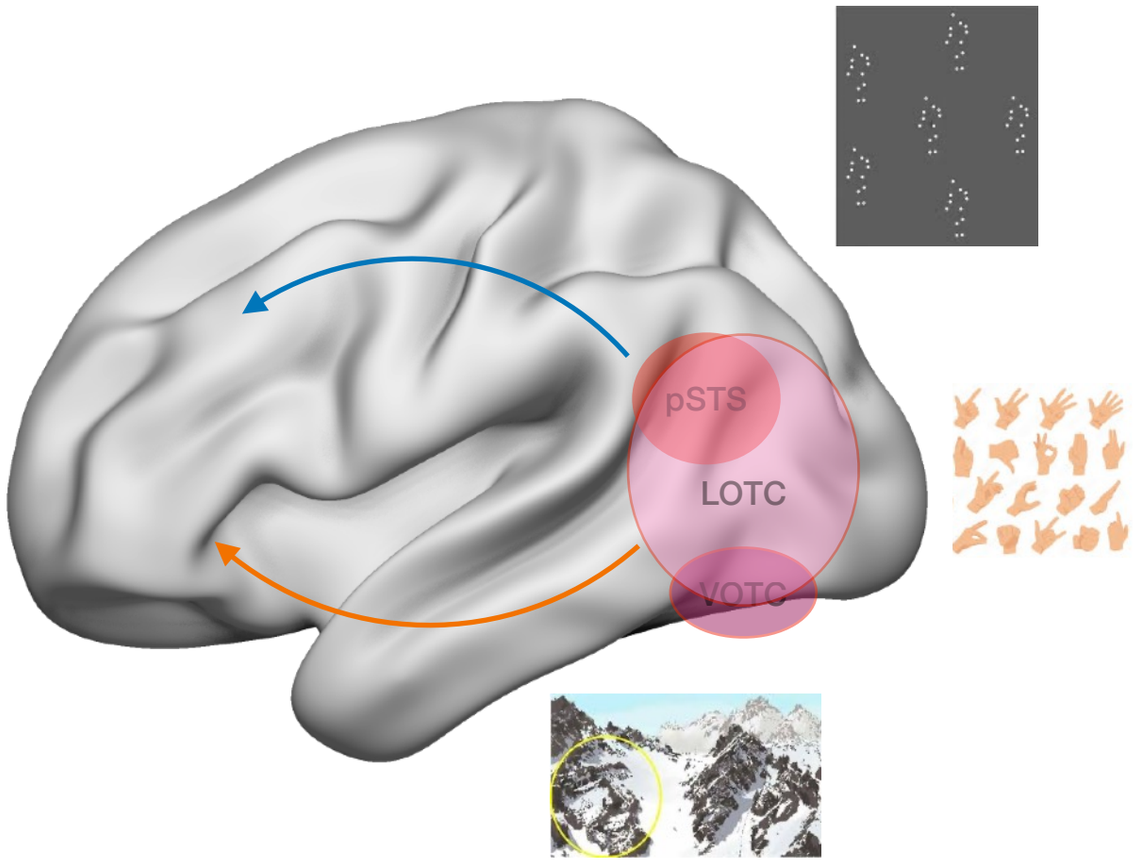
Perceptual signals (Bottom-up)

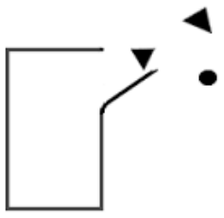
Class of stimuli	Inanimate (non-intentional objects)	Animate (intentional agents)

Perceptual properties

Biological motion *Self-propulsion* *Deformation*

Hand *Face*





animate/intentional vs inanimate/non-intentional object detection systems

Laws	Physical	Physical
	x	Psychological
Class of stimuli	Inanimate (non-intentional objects)	Animate (intentional agents)
Opacity	(Mostly) mechanically transparent	(Always) mechanically opaque

Universal laws => reliable

Not universal laws => unreliable

Precise understanding: x causes y…

Causal certainty

Causal uncertainty

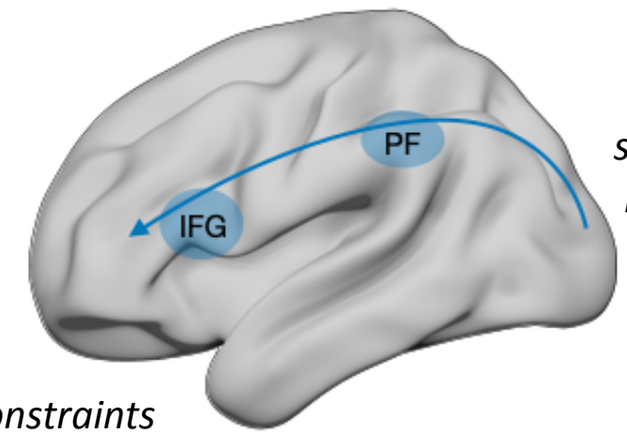
Vague understanding: wants to, intends to…

Causal uncertainty (Top-down)

Opacity	(Mostly) mechanically transparent	(Always) mechanically opaque

Precise understanding: x causes y… ← *Causal certainty* … *Causal uncertainty* → *Vague understanding: wants to, intends to…*

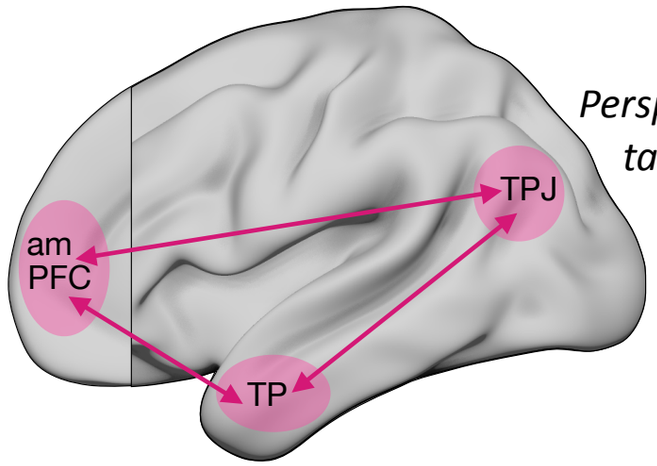
Technical brain



Mental simulation of mechanistic actions

Constraints integration

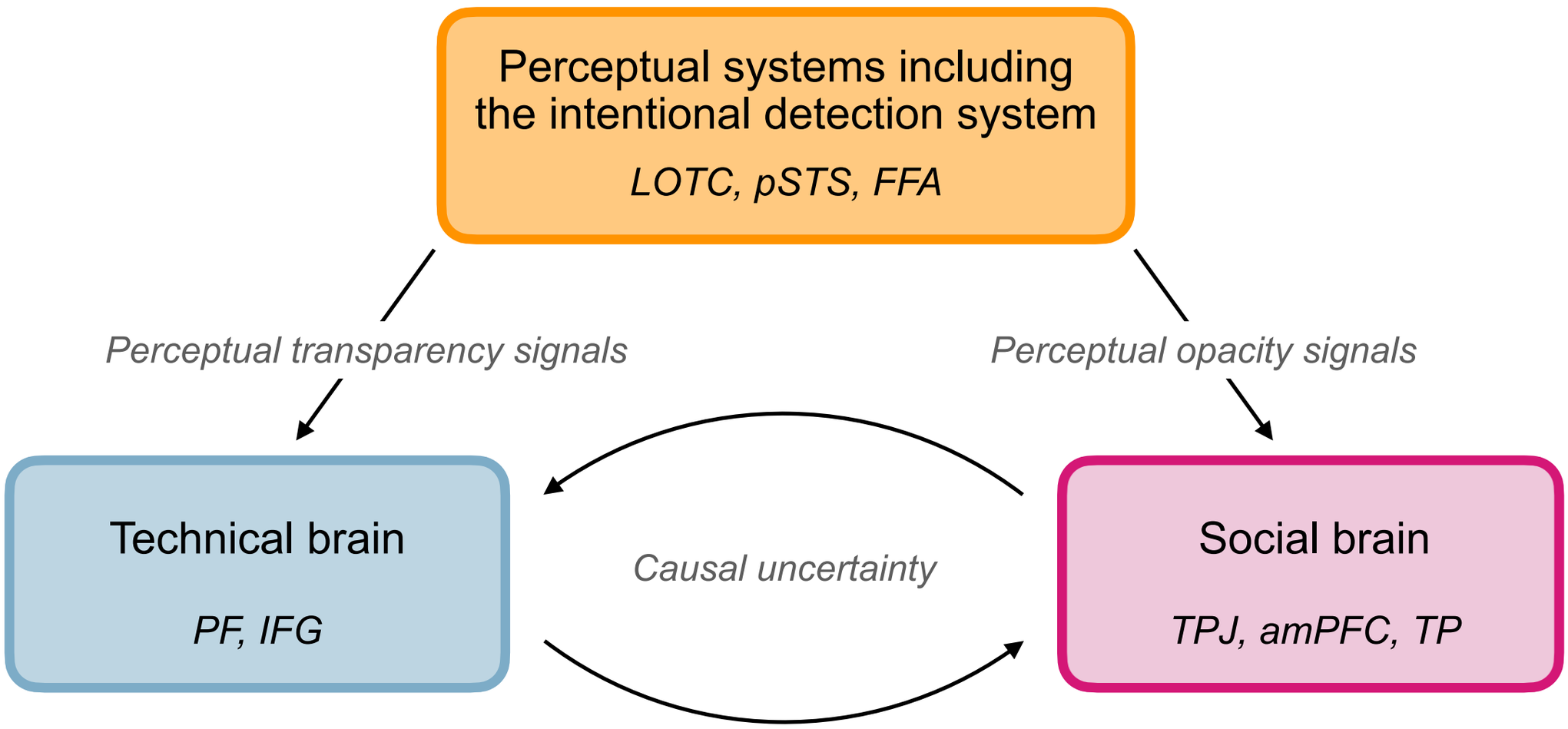
Social brain



Theory of mind

Perspective taking

(Social) Semantic memory
Knowledge about persons, groups, social behavior, etc.



Osiurak & Federico (under revision, Perspectives on Psychological Science)

Perspective | Published: 24 November 2025

How physical information is used to make sense of the psychological world

Shari Liu ✉, Seda Karakose-Akbiyik, Joseph Outa & Minjae J. Kim

Nature Reviews Psychology **5**, 59–73 (2026) | Cite this article

Table 1. The computational goals and principles, representations, and cortical systems associated with naive physics and naive psychology. *Abbreviations*: TPJ (temporoparietal junction), SPL/IPL (superior and inferior parietal lobule), PMC (premotor cortex), PC (precuneus), MPFC (medial prefrontal cortex).

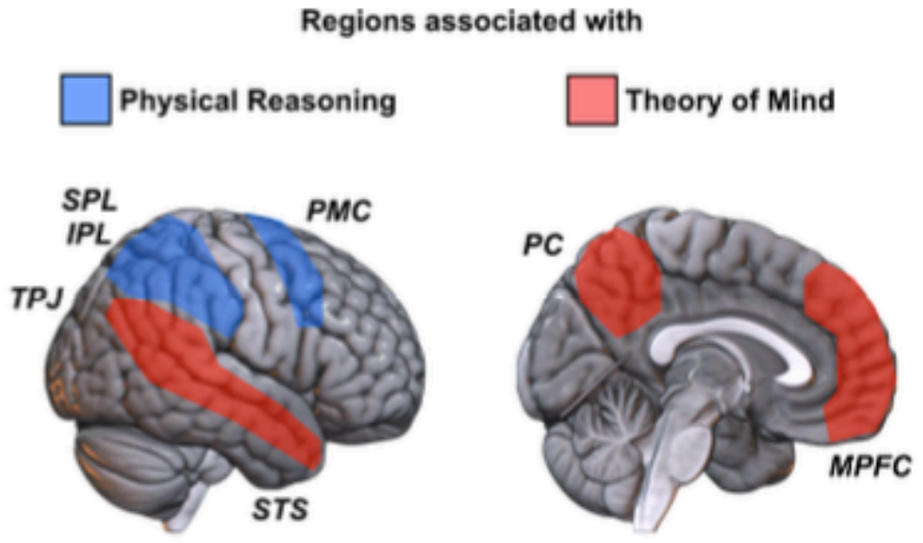
	Naive physics	**Naive psychology**
General computational goal	Explain, predict and intervene on…	
	… the physical states and motions of objects	…the mental states and behaviors of agents
Key representations	OBJECT: an inanimate permanent body that persists through space and time OBJECT PROPERTIES: position, shape, mass, material RELATIONAL PROPERTIES: express interactions between objects; contact, support, containment, adhesion KINEMATIC / DYNAMIC PROPERTIES: speed, velocity, force	AGENT: an animate entity that can change its own behaviors (i.e. act) at some cost, and has a perspective on (i.e. mental states about) the world MENTAL STATE: appraisal of a world state (e.g. cost, desire, emotion, knowledge, belief); in some cases a propositional attitude about that state ("she thinks the book is in the cabinet") UTILITY: agents plan over this variable, composed of reward and cost
Causal law	Approximate Newtonian dynamics	Approximate rational planning
Judgments supported	**Explanation**: *Why?*; **Prediction**: *What will happen next?* **Counterfactuals**: *What would have happened, if X were true?* **Intervention**: *What should I do, to make X happen?*	
	What is the mass, material, viscosity, and elasticity of this thing? Will it fall or stay stable? Why did it break, bounce, or flow the way it did?	What does she want, believe, or feel? What is she trying to do? Why did she do that?

Perspective | Published: 24 November 2025

How physical information is used to make sense of the psychological world

Shari Liu ✉, Seda Karakose-Akbiyik, Joseph Outa & Minjae J. Kim

Nature Reviews Psychology **5**, 59–73 (2026) | Cite this article

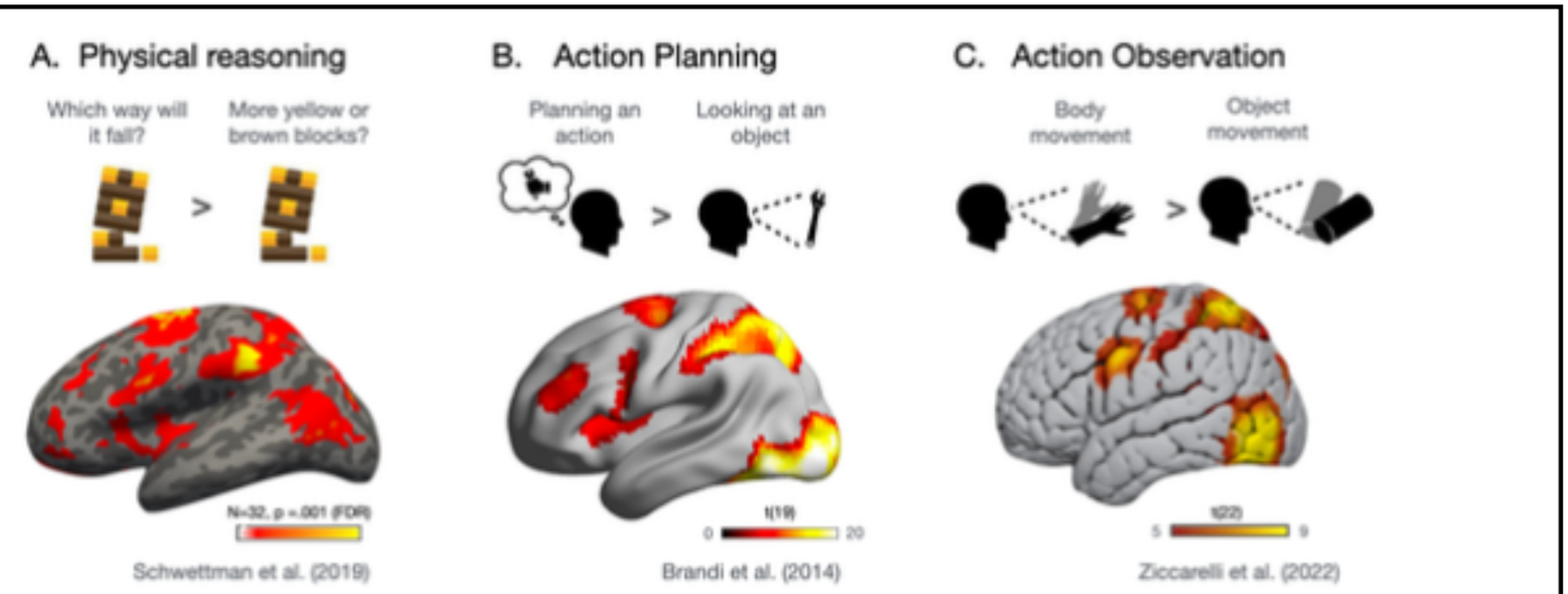
Cortical systems	Network of regions spanning frontal and parietal cortices including premotor cortex, inferior and superior parietal lobule	Network of regions including the temporoparietal junction, superior temporal sulcus, precuneus, and medial prefrontal cortex
		

Perspective | Published: 24 November 2025

How physical information is used to make sense of the psychological world

Shari Liu ✉, Seda Karakose-Akbiyik, Joseph Outa & Minjae J. Kim

Nature Reviews Psychology **5**, 59–73 (2026) | Cite this article

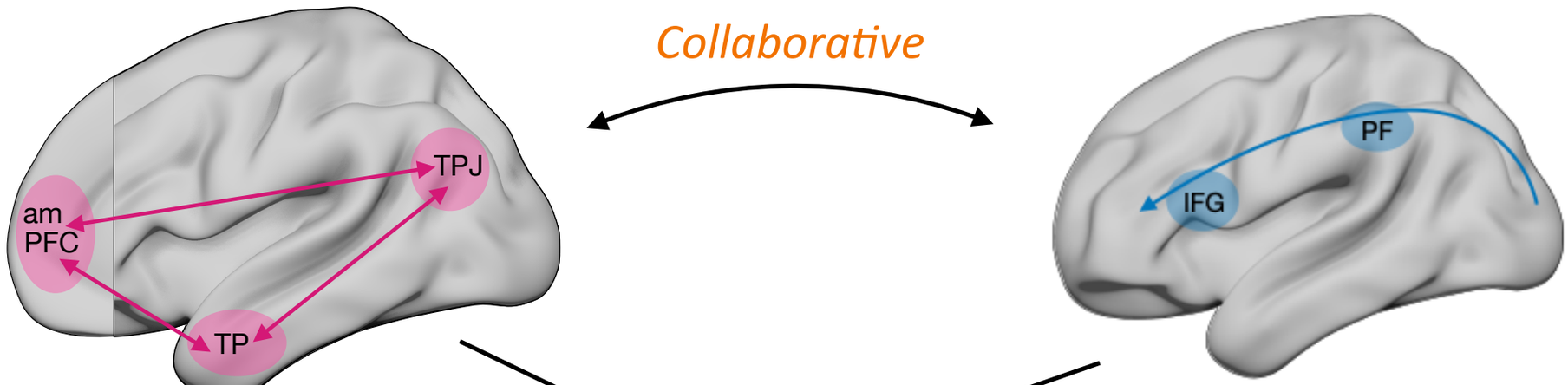


These findings raise the possibility that the processes engaged by action observation, action planning and tool use, and physical reasoning may draw on a shared capacity: understanding how objects and agents (other people and ourselves) interact (see also [120]). These regions also exhibit strong intrinsic

Interactions

Social brain

Technical brain



Collaborative

Competitive

Long term

Short term

Long-term competition

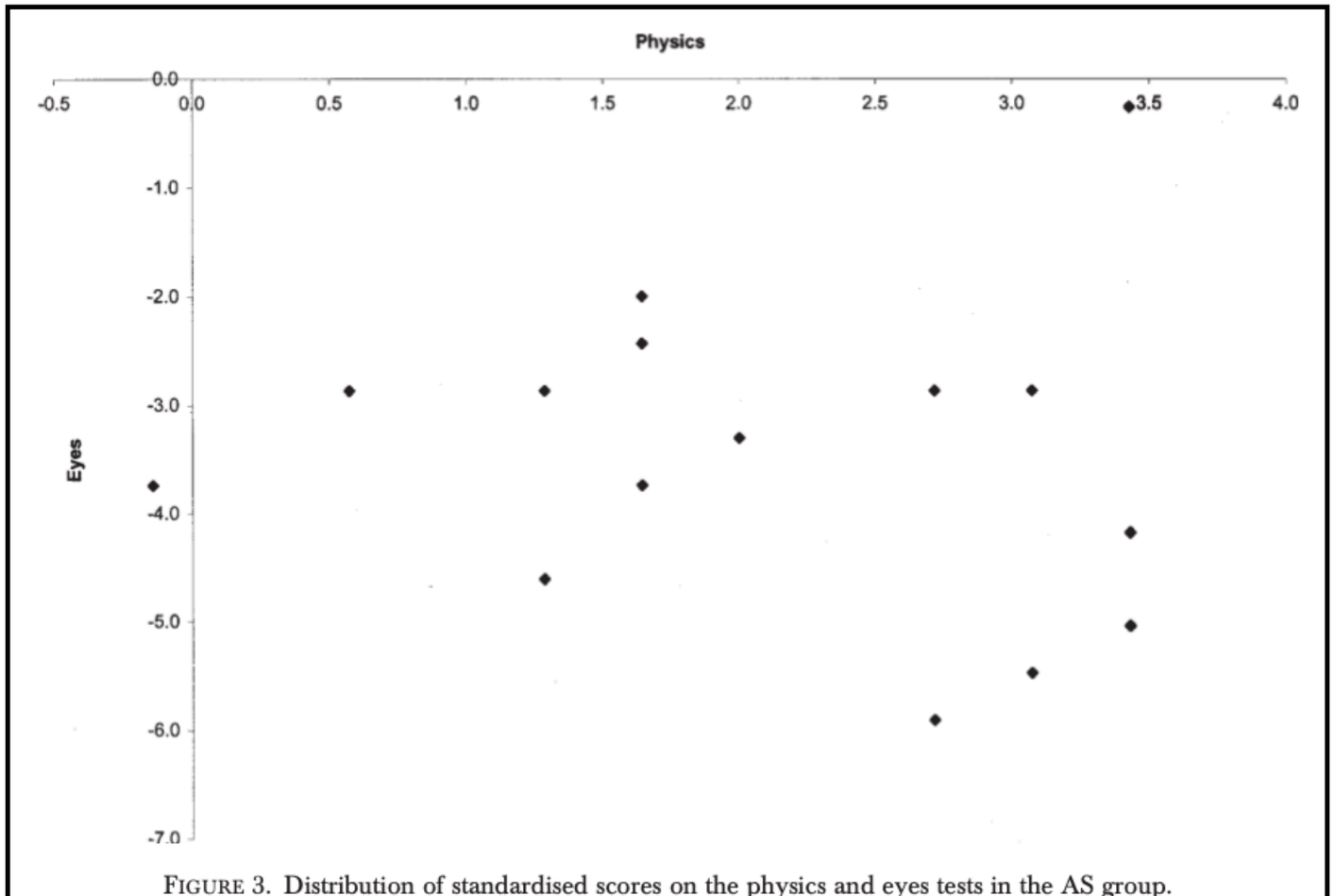
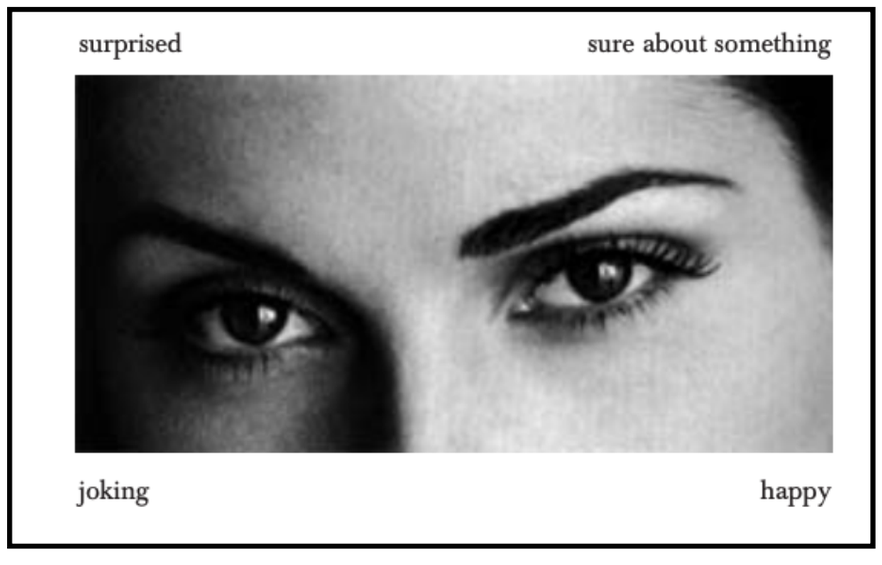
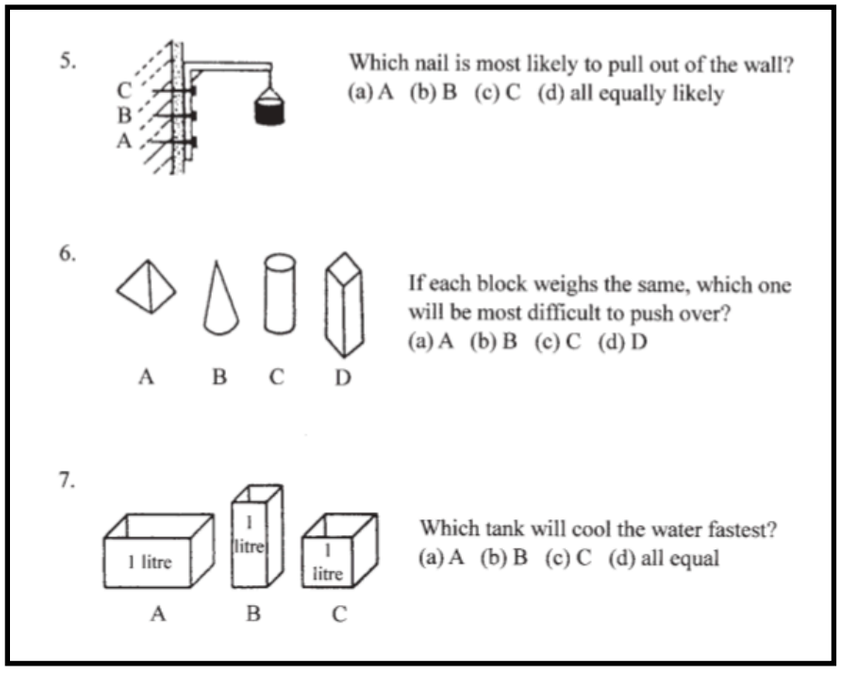


FIGURE 3. Distribution of standardised scores on the physics and eyes tests in the AS group.

A test of correlation between folk psychology and folk physics in the normal group was not possible since different groups of children were given each of these tests. In the group with AS, the two tasks were strongly inversely correlated (r=-0.63, p=0.001).

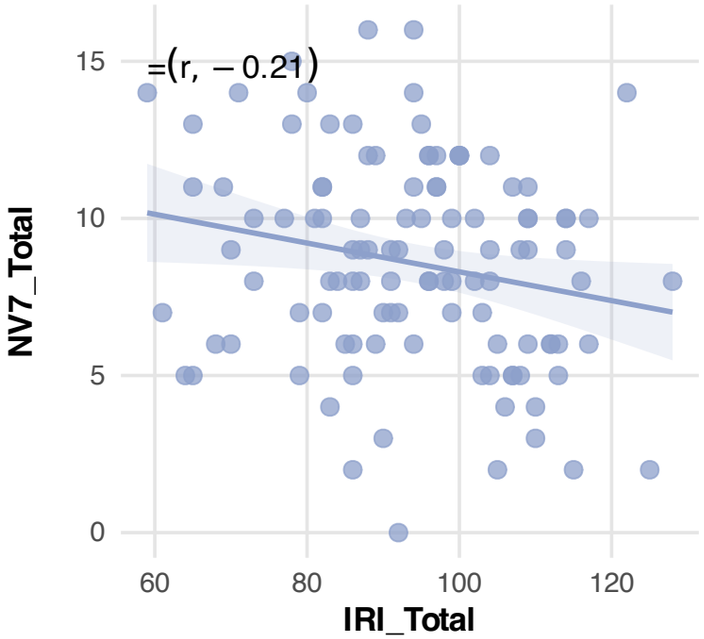




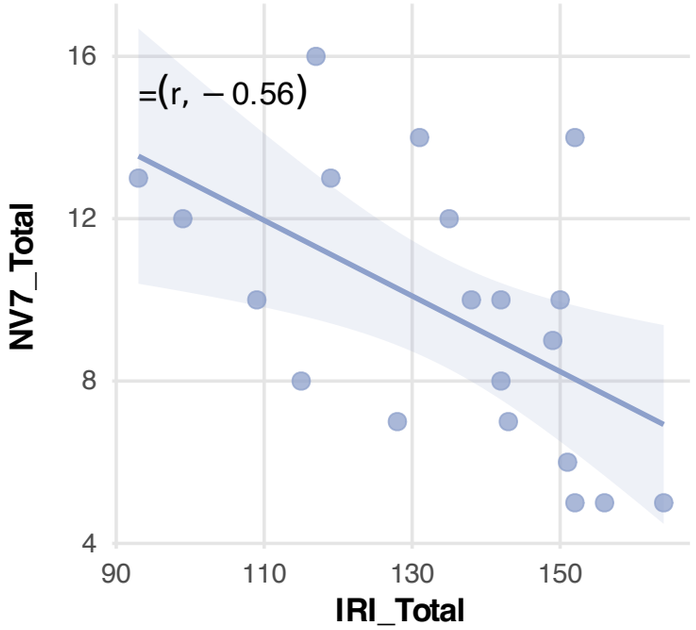
Baron-Cohen et al. (2001)

Long-term competition

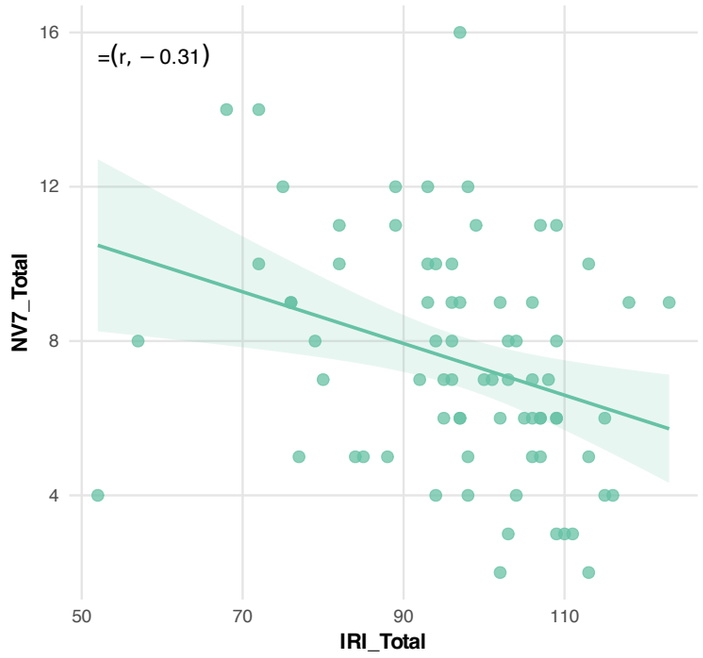
n = 110



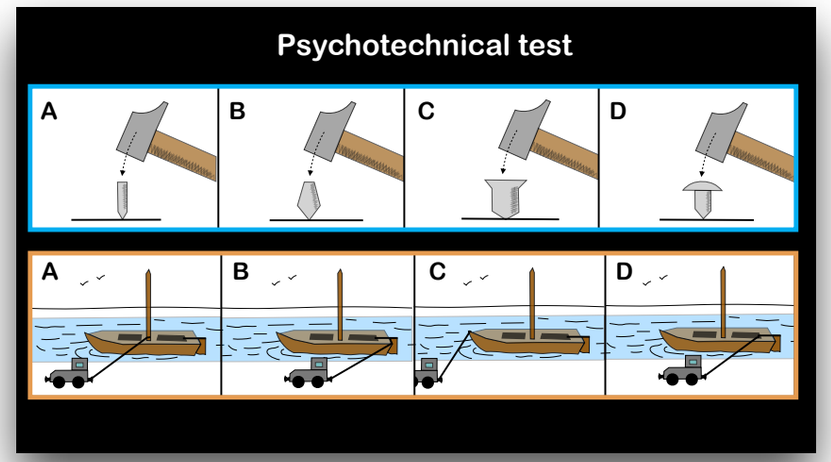
n = 19



n = 74



NV7



Interpersonal reactivity index (IRI)

"I daydream and fantasize, with some regularity, about things that might happen to me. »,

"I often have tender, concerned feelings for people less fortunate than me.",

"Sometimes I don't feel very sorry for other people when they are having problems.",

"I really get involved with the feelings of the characters in a novel."

Unpublished data

Short-term competition

NeuroImage 66 (2013) 385–401

Contents lists available at SciVerse ScienceDirect

NeuroImage

journal homepage: www.elsevier.com/locate/ynimg

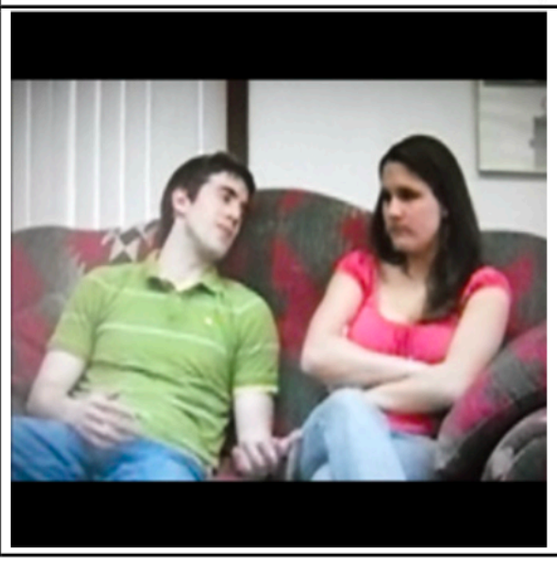
fMRI reveals reciprocal inhibition between social and physical cognitive domains

Anthony I. Jack [a,*], Abigail J. Dawson [a], Katelyn L. Begany [a], Regina L. Leckie [a], Kevin P. Barry [a], Angela H. Ciccia [b], Abraham Z. Snyder [c]

ABSTRACT

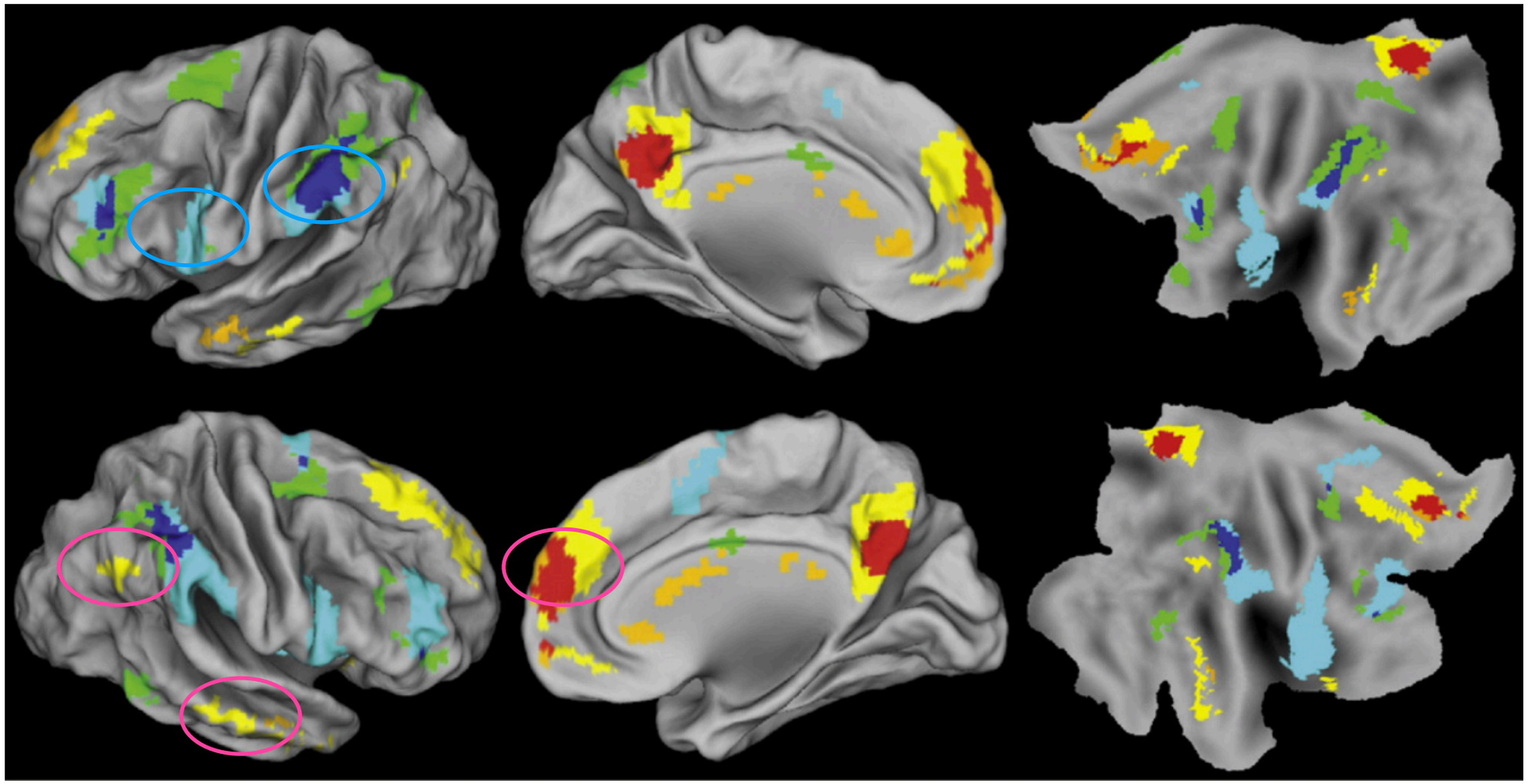
Two lines of evidence indicate that there exists a reciprocal inhibitory relationship between opposed brain networks. First, most attention-demanding cognitive tasks activate a stereotypical set of brain areas, known as the task-positive network and simultaneously deactivate a different set of brain regions, commonly referred to as the task negative or default mode network. Second, functional connectivity analyses show that these same opposed networks are anti-correlated in the resting state. We hypothesize that these reciprocally inhibitory effects reflect two incompatible cognitive modes, each of which may be directed towards understanding the external world. Thus, engaging one mode activates one set of regions and suppresses activity in the other. We test this hypothesis by identifying two types of problem-solving task which, on the basis of prior work, have been consistently associated with the task positive and task negative regions: tasks requiring social cognition, i.e., reasoning about the mental states of other persons, and tasks requiring physical cognition, i.e., reasoning about the causal/mechanical properties of inanimate objects. Social and mechanical reasoning tasks were presented to neurologically normal participants during fMRI. Each task type was presented using both text and video clips. Regardless of presentation modality, we observed clear evidence of reciprocal suppression: social tasks deactivated regions associated with mechanical reasoning and mechanical tasks deactivated regions associated with social reasoning. These findings are not explained by self-referential processes, task engagement, mental simulation, mental time travel or external vs. internal attention, all factors previously hypothesized to explain default mode network activity.

Short-term competition

Mechanical Movie		**Would water flow if there was a large hole in the tube?**	**No**
Social Movie		**Does he think that she is angry?**	**No**

Jack et al. (2013, NeuroImage)

Short-term competition



Negative correlation with Social

Overlap

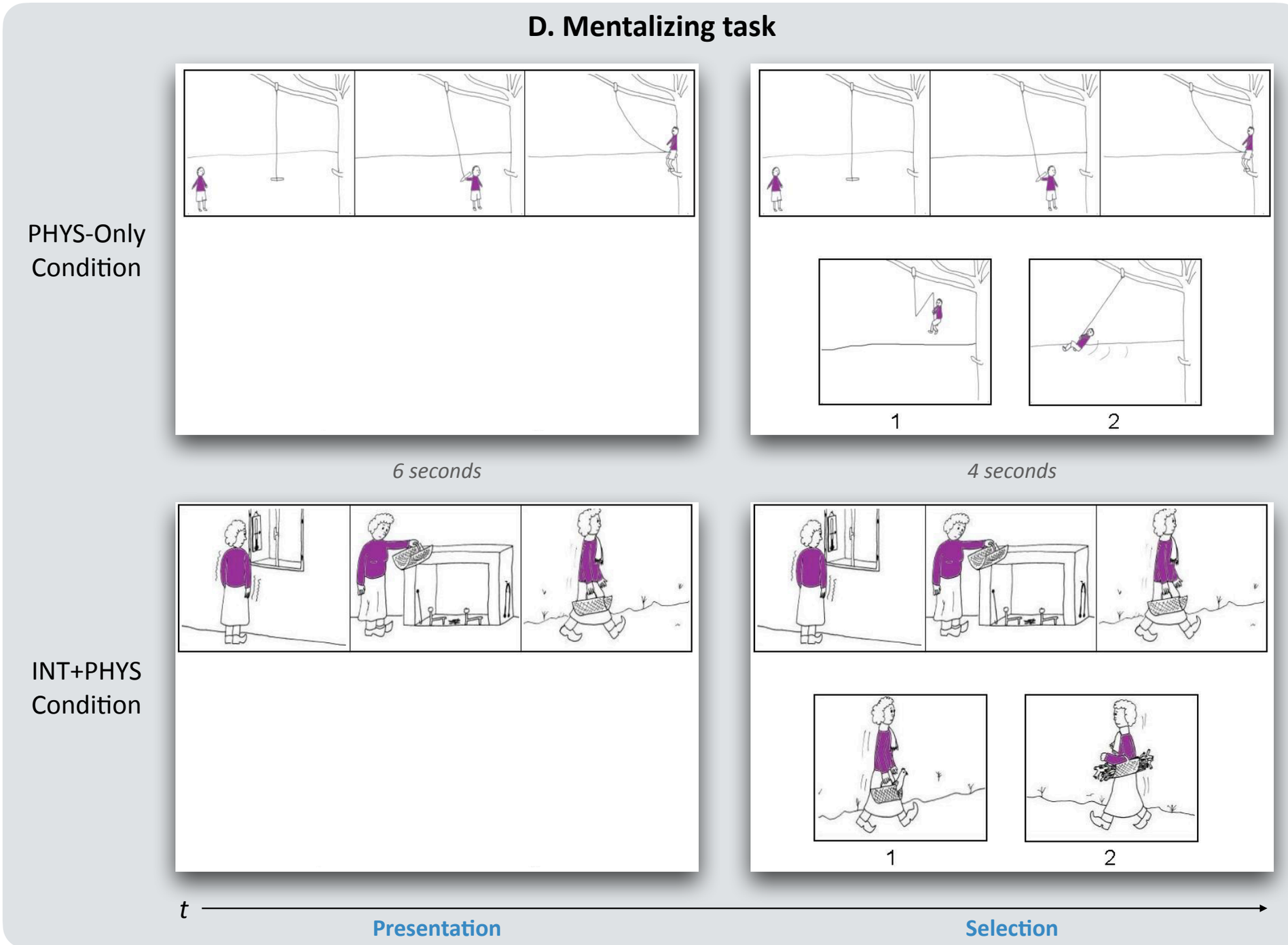
Physics > Rest, Social < Rest, fixed effects

Negative correlation with Physics

Overlap

Social > Rest, Physics < Rest, fixed effects

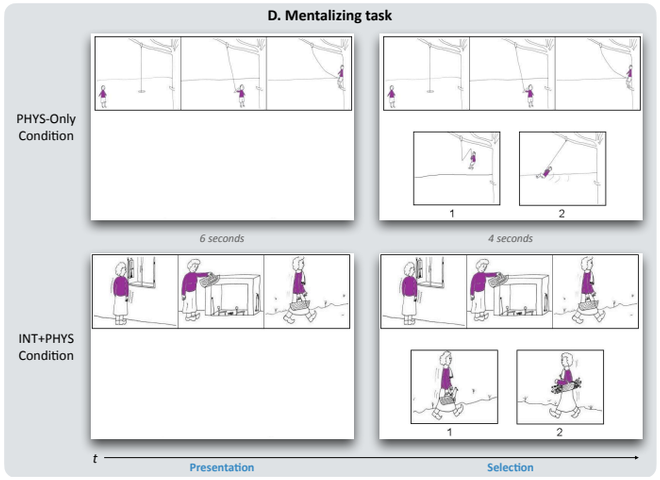
Jack et al. (2013, NeuroImage)



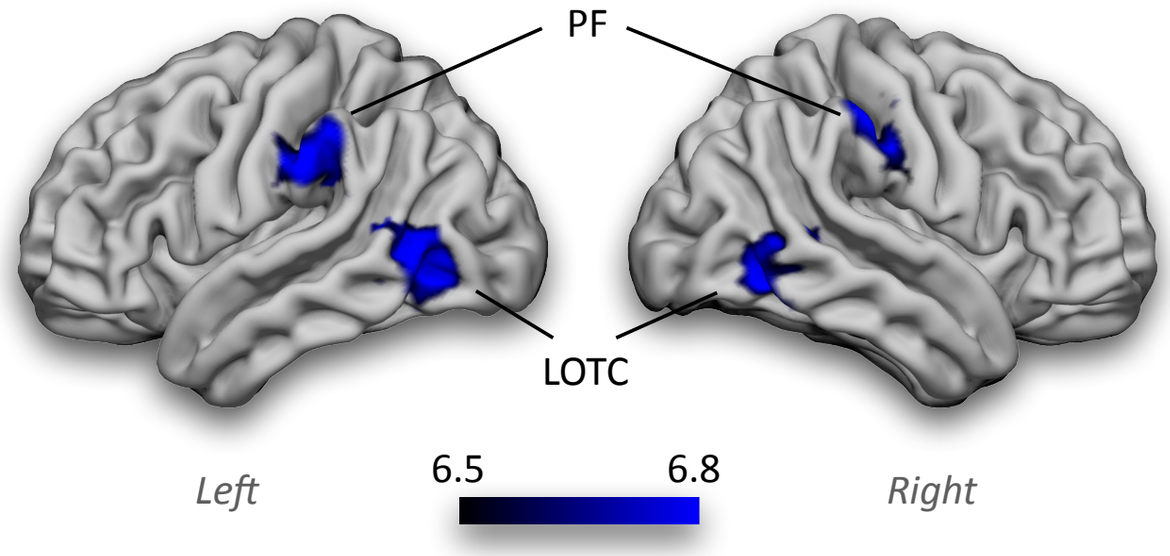
Initial study: Vollm et al. (2006; NeuroImage)

Osiurak et al. (2025, eLife)

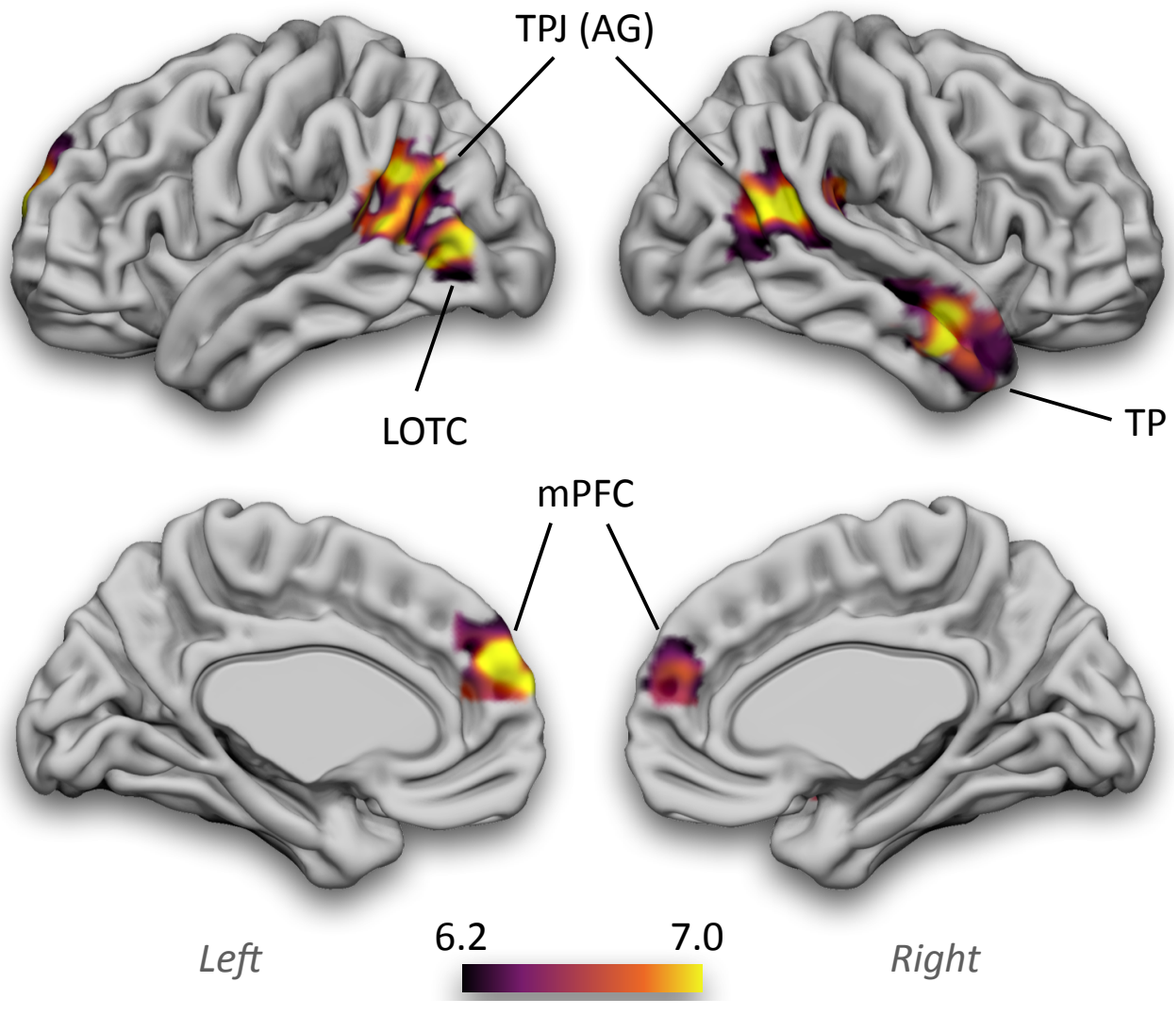
Collaboration



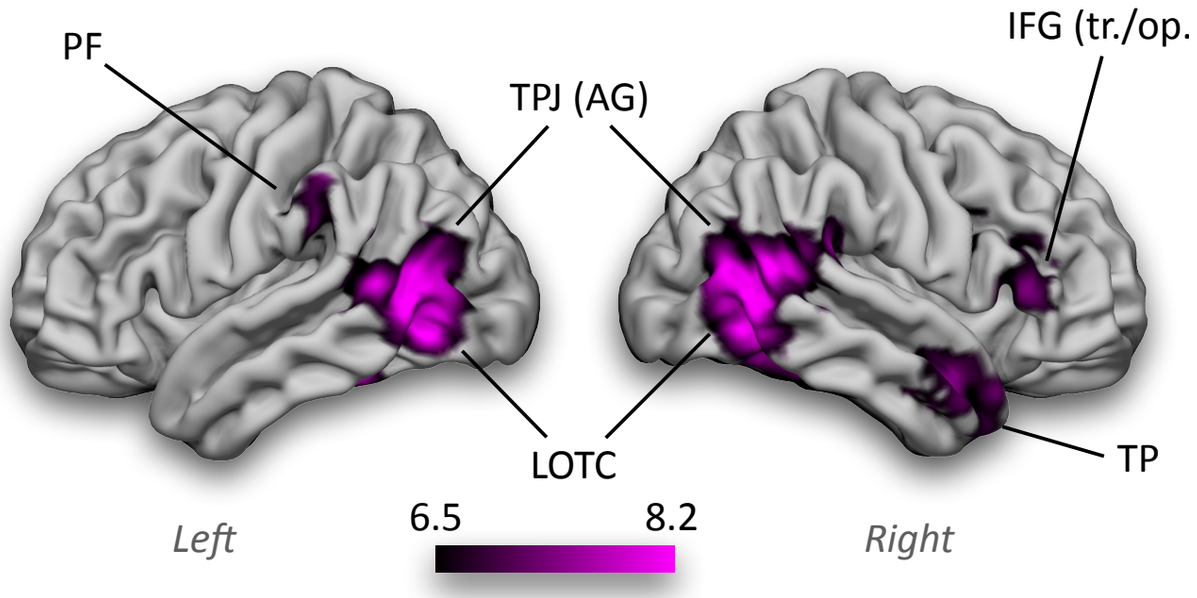
D. Mentalizing task: PHYS-Only condition



F. Mentalizing task: INT+PHYS > PHYS-Only

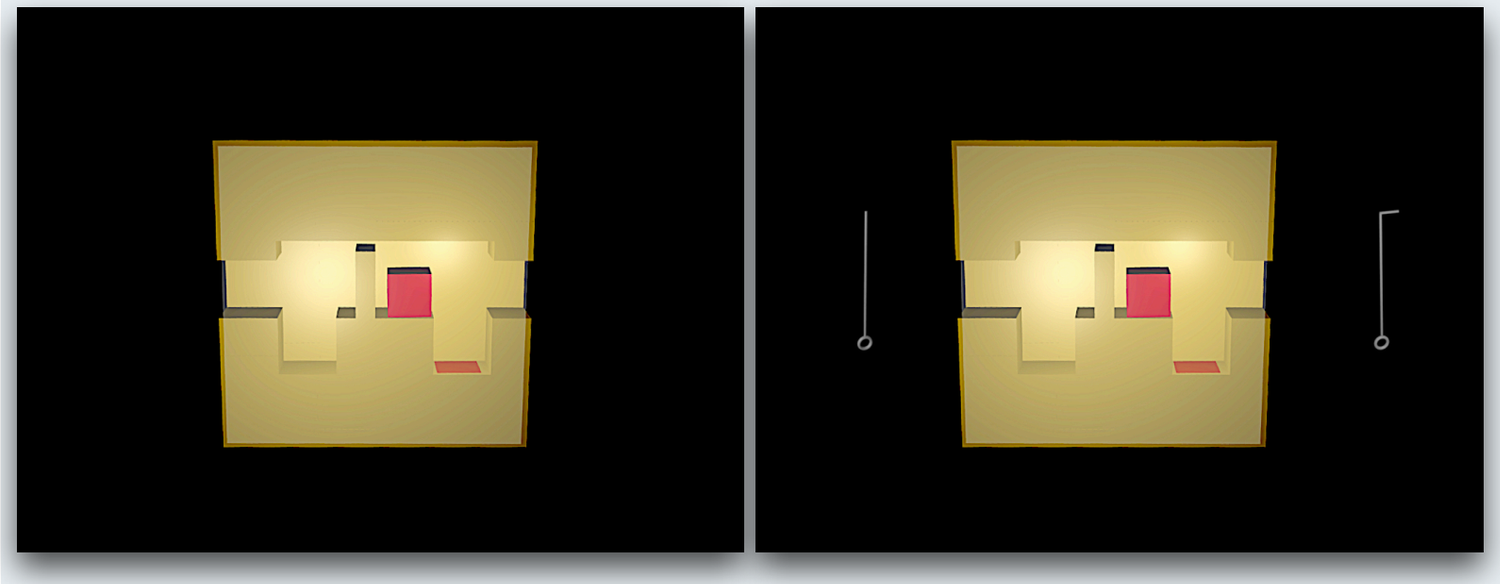


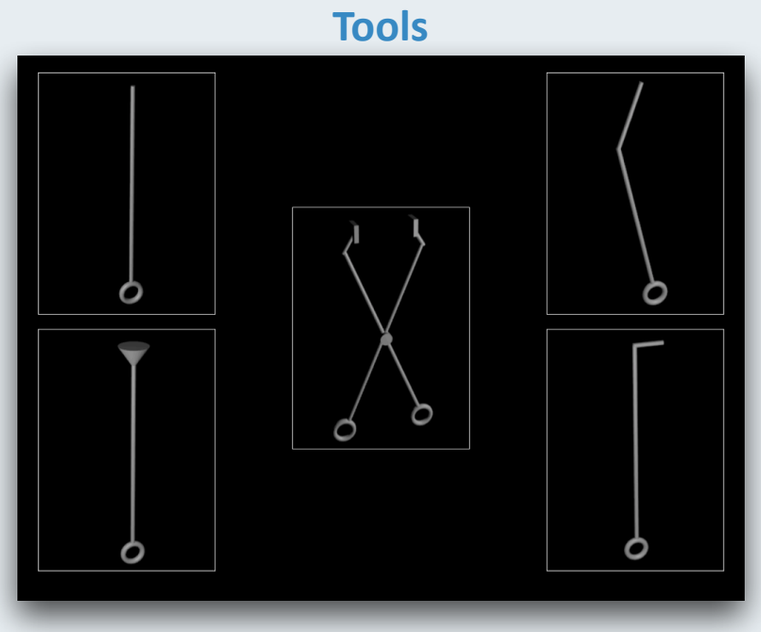
E. Mentalizing task: INT+PHYS condition



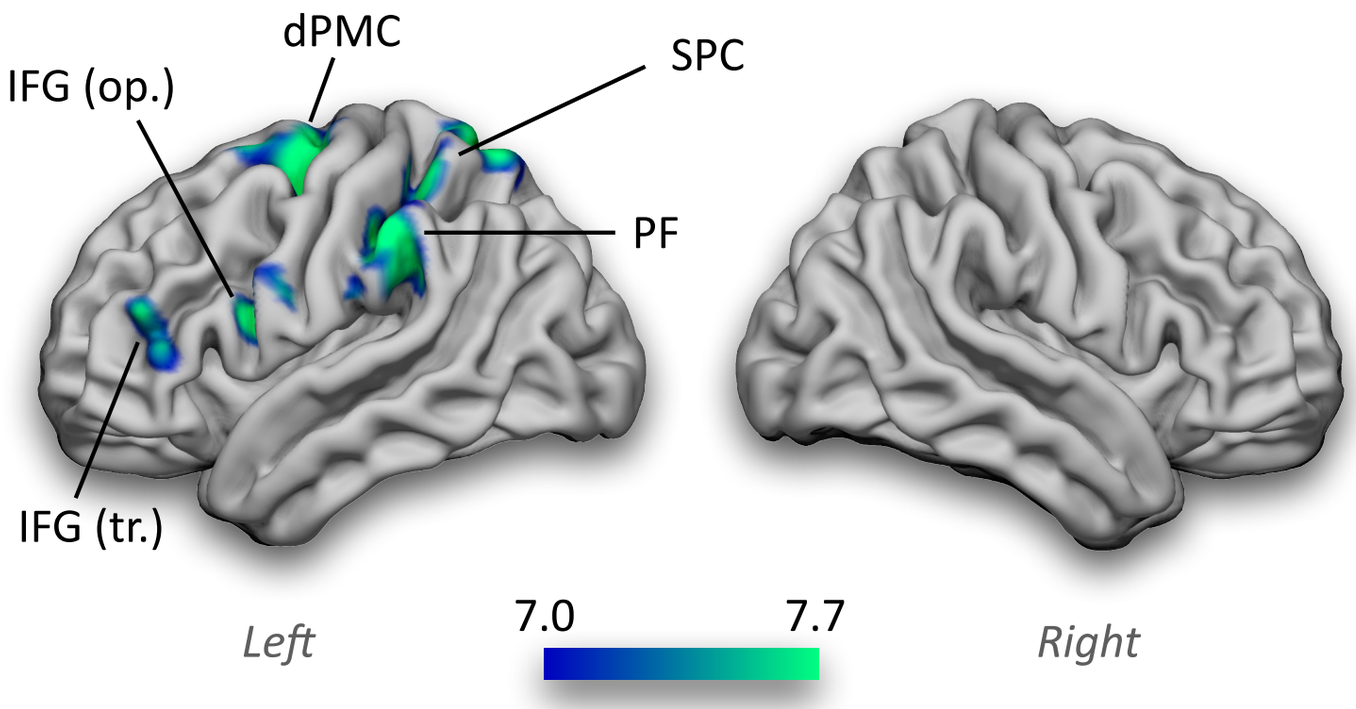
Osiurak et al. (2025, eLife)

A. Mechanical problem-solving task



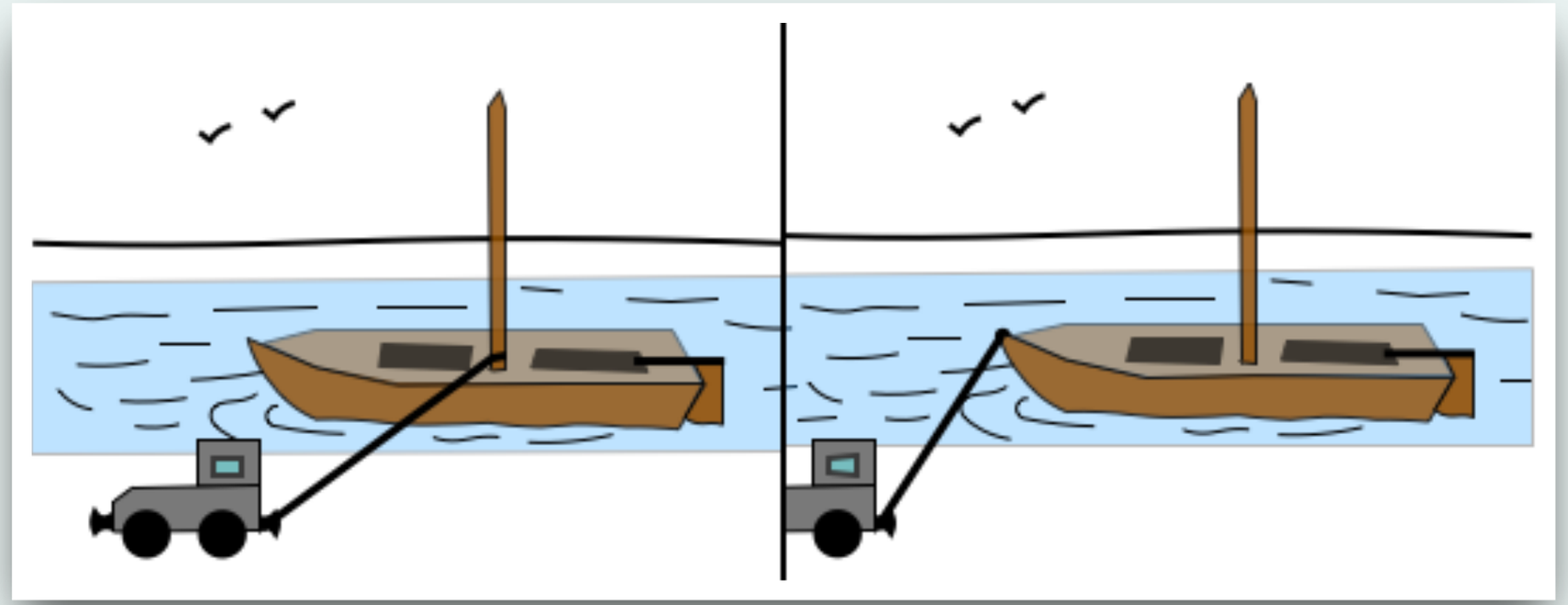


A. Mechanical problem-solving task

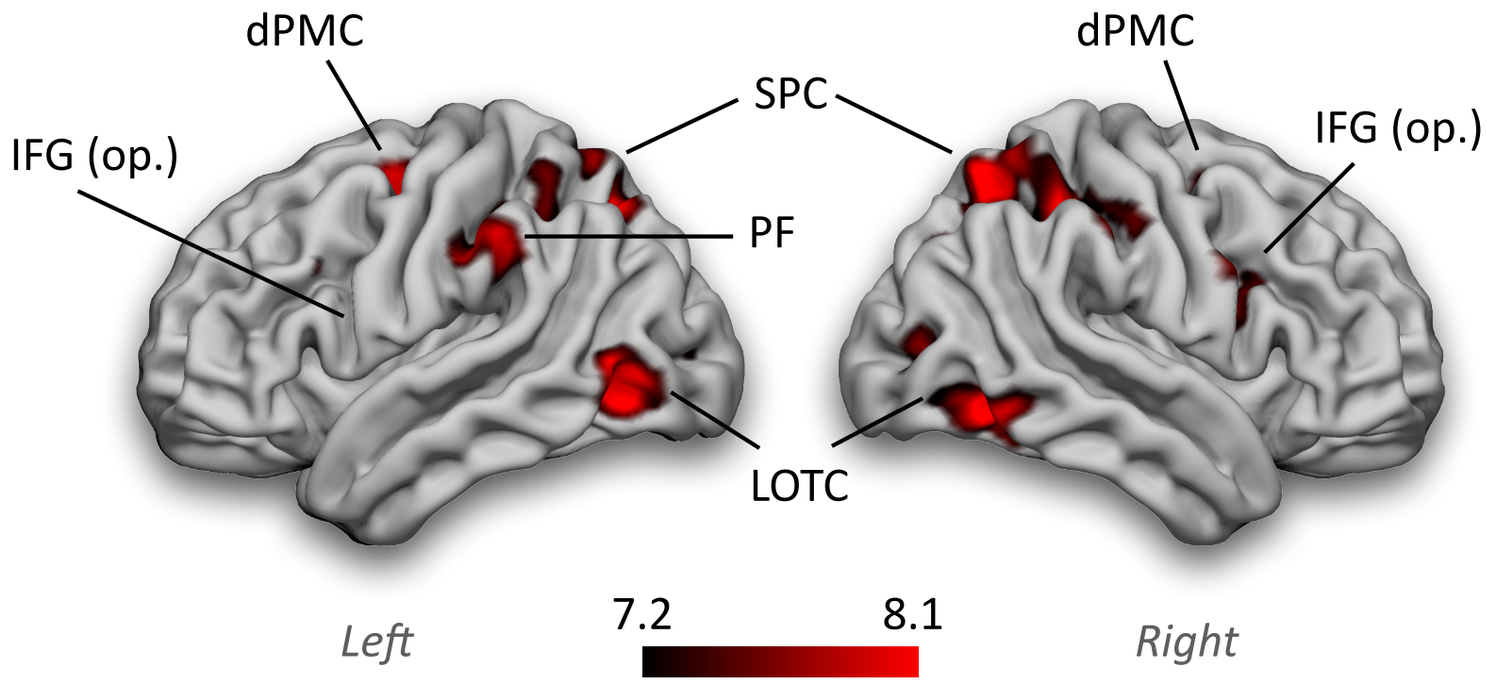


Osiurak et al. (2025, eLife)

B. Psychotechnical task

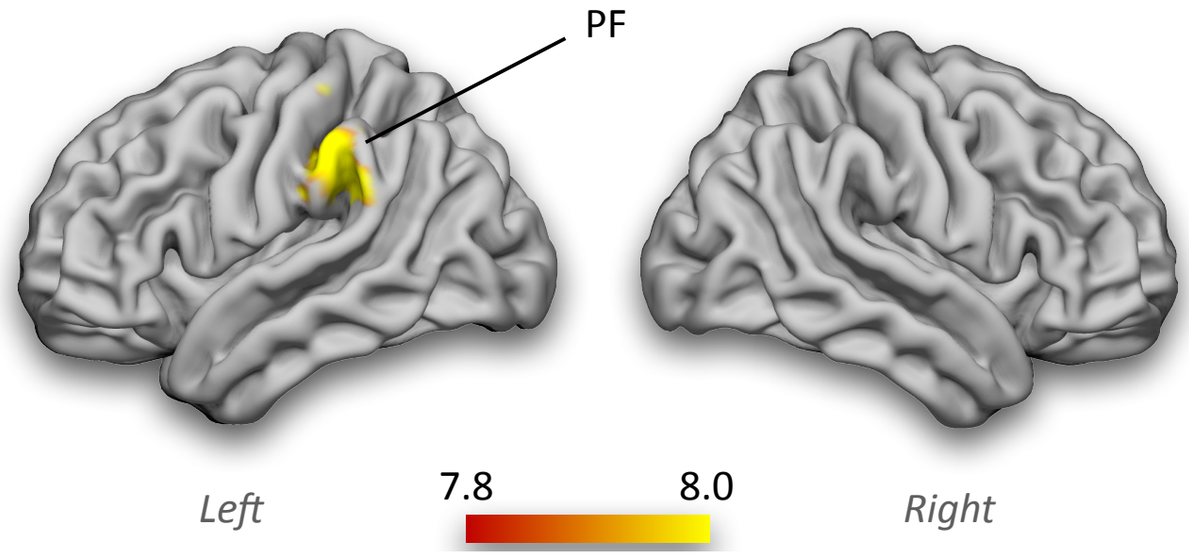


B. Psychotechnical task

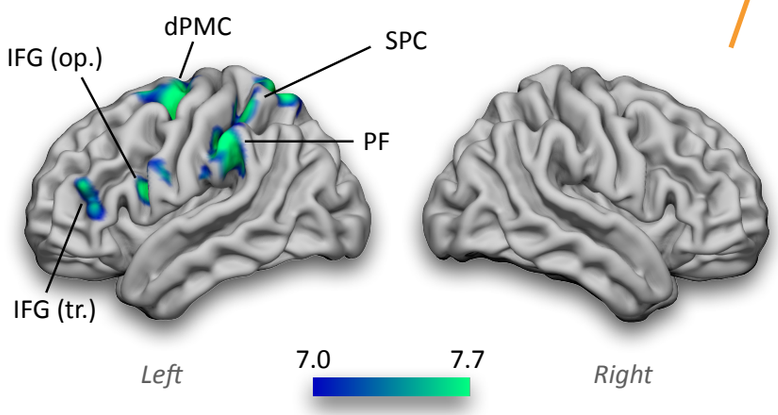


Osiurak et al. (2025, eLife)

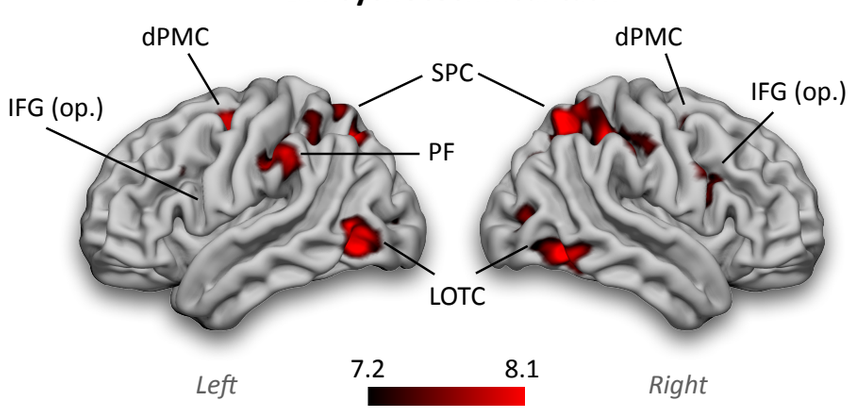
G. Conjunction analysis (A and B and D and E)



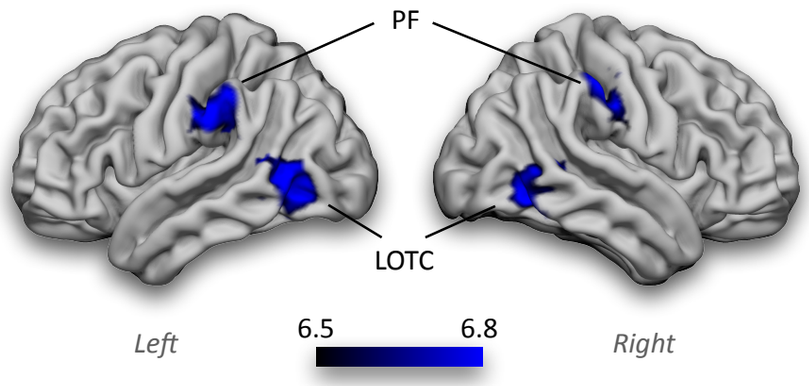
A. Mechanical problem-solving task



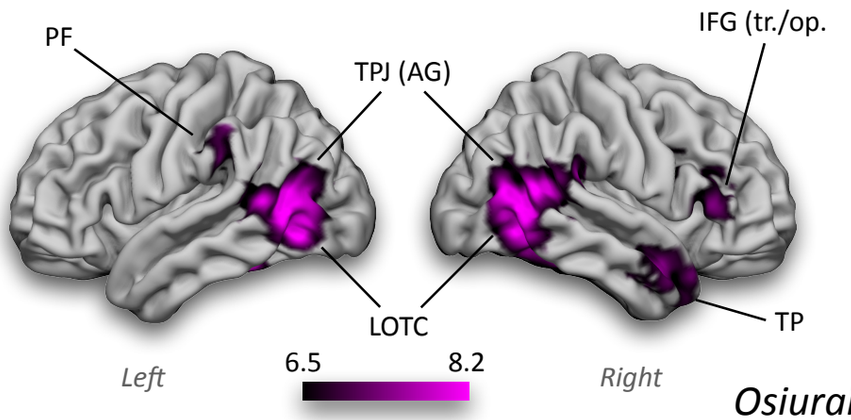
B. Psychotechnical task



D. Mentalizing task: PHYS-Only condition



E. Mentalizing task: INT+PHYS condition



Osiurak et al. (2025, eLife)

Opacity and tool use

Transparent

Opaque

Mechanical tools

Basic machines

Digital machines

Machines

AI/ robots

Technology

Biology

Intentional agents

No movement without physical contact — Self-propulsion

'Handle' to allow motor-to-mechanical transfer — Communication organs

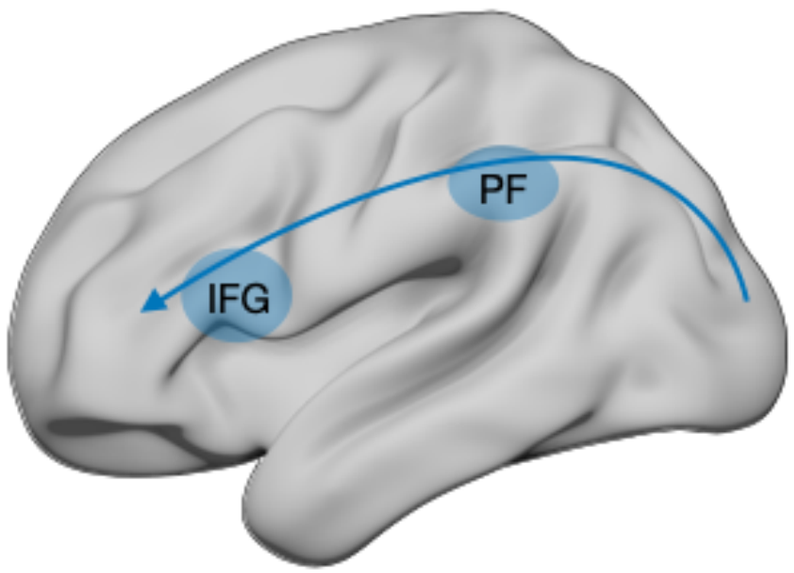
Noise provoked by our actions — Spontaneous noise

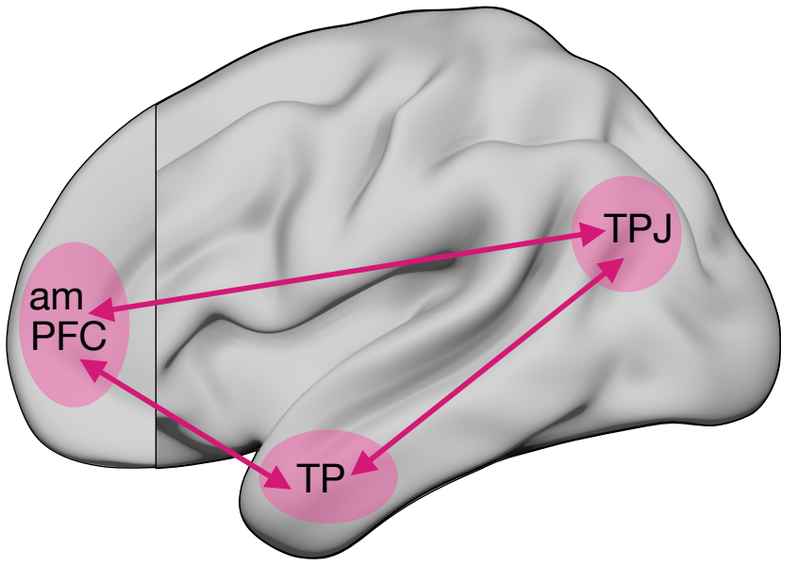
Do not need energy to work — Need energy to work

Mono-functional — Multi-functional

Technical brain

Social brain





Osiurak & Federico (under revision, Perspectives on Psychological Science)

Review
Trends in Cognitive Sciences 14 (2010) 383–388
Cell PRESS

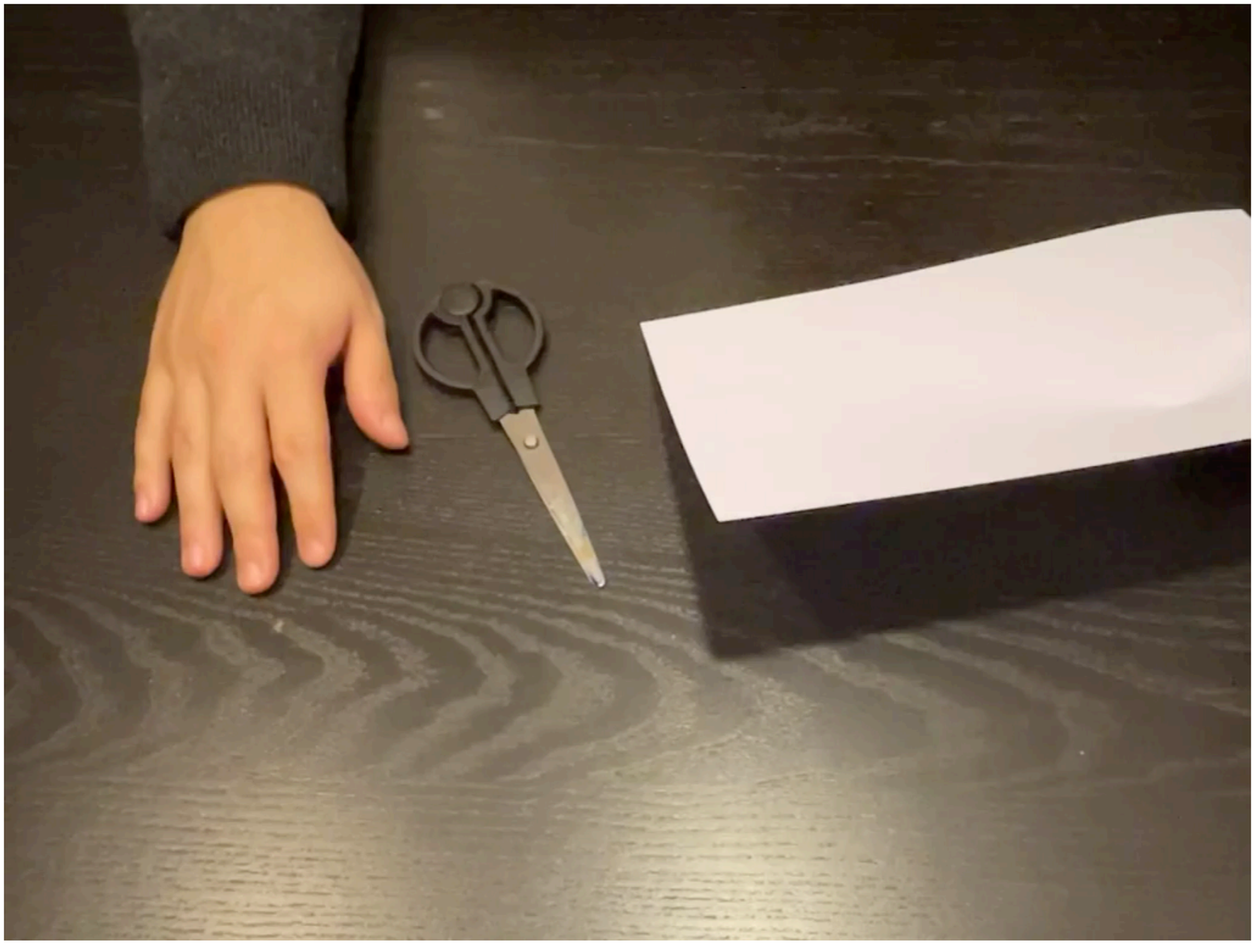
Causes and consequences of mind perception

Adam Waytz[1], Kurt Gray[2], Nicholas Epley[3] and Daniel M. Wegner[4]

"People consistently use mental states to explain both human and non-human actions, particularly when they are unable to generate more elaborate causal explanations".

Instructions:

Tool action vs no-tool action



Tool condition

Federico et al. (2025; NeuroImage)

Instructions:

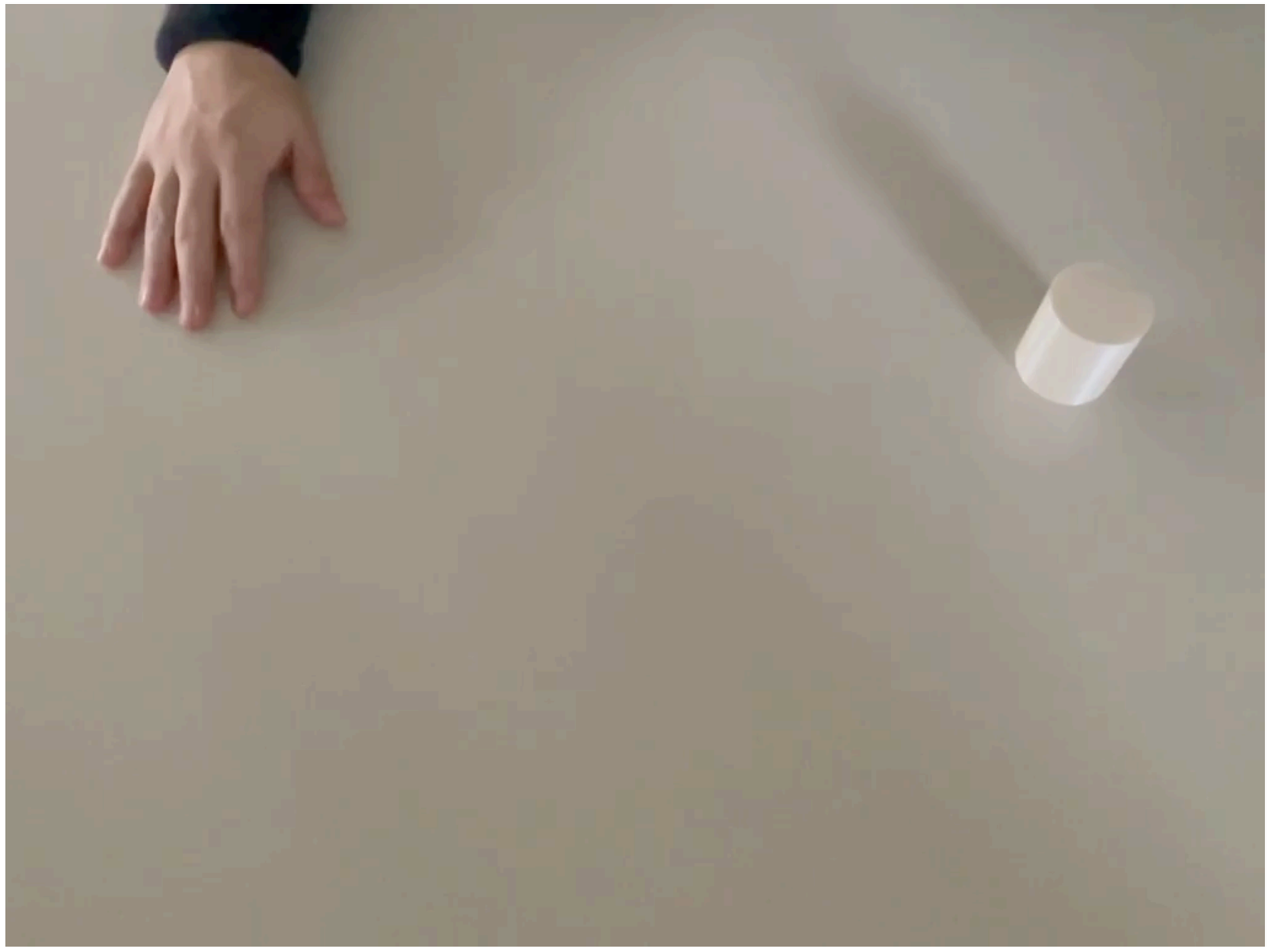
Tool action vs no-tool action

Machine condition

Federico et al. (2025; NeuroImage)

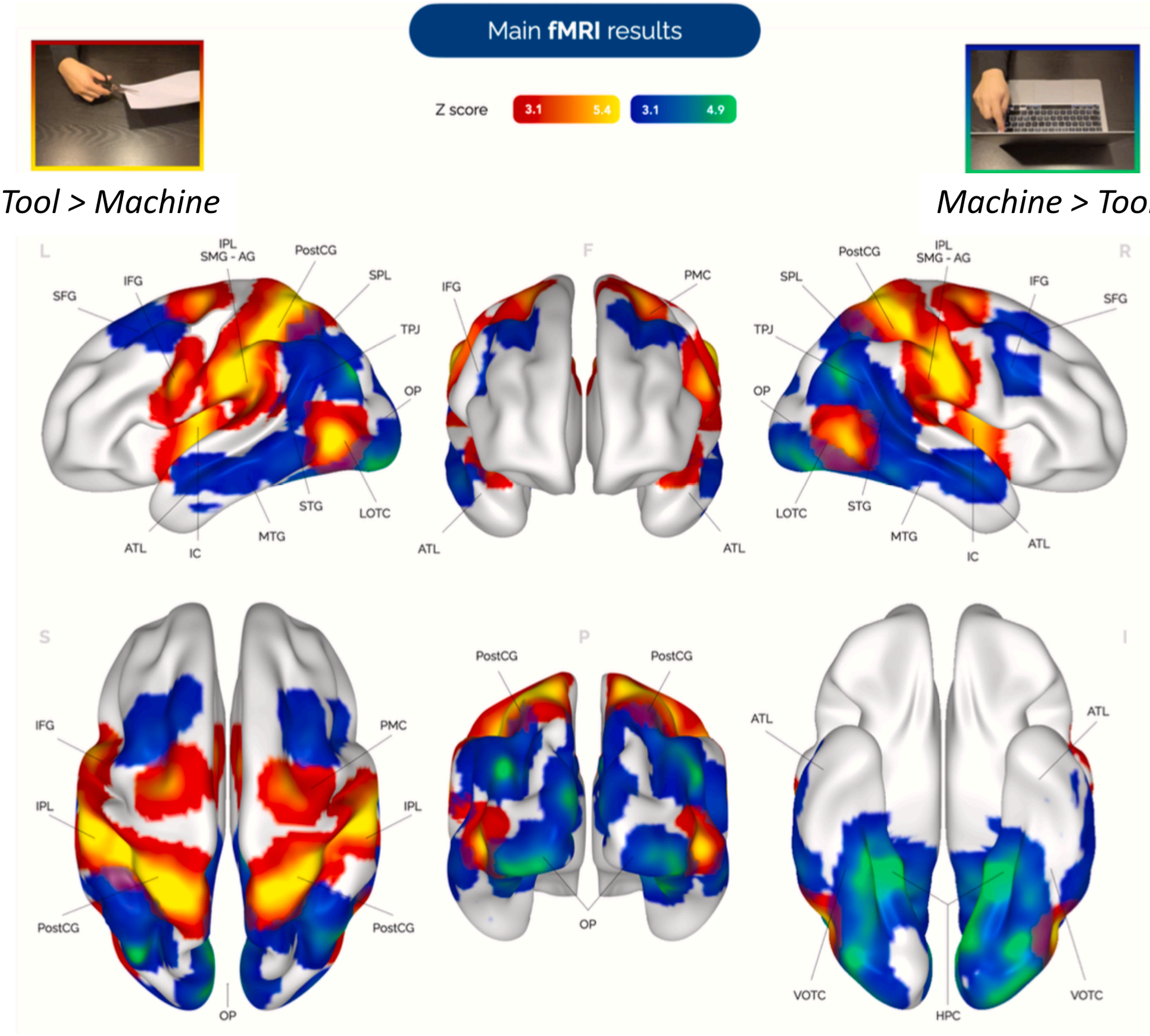
Instructions:

Tool action vs no-tool action

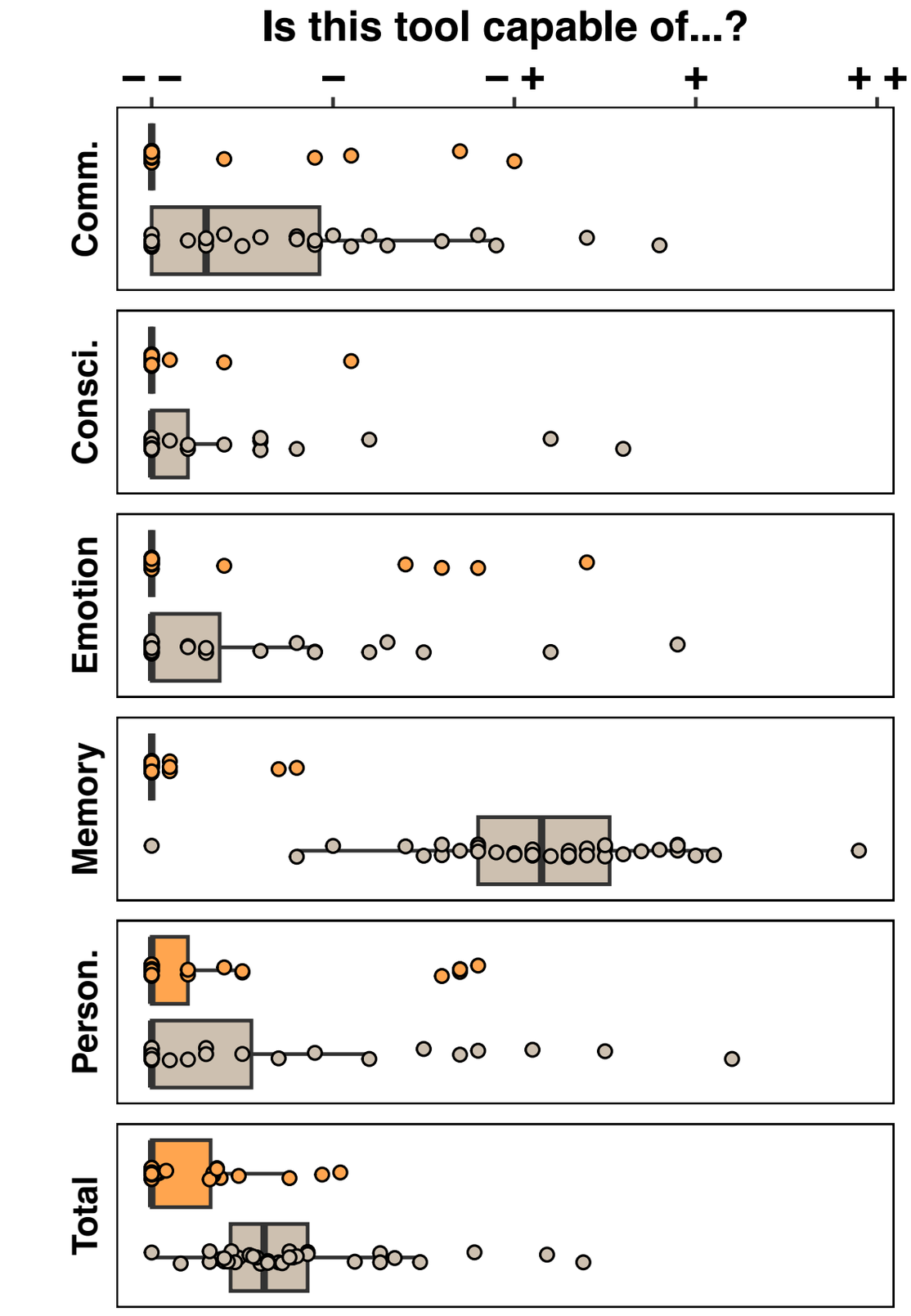


Control condition

Federico et al. (2025; NeuroImage)



Federico et al. (2025; NeuroImage)



Federico et al. (2025; NeuroImage)

Instructions:

Work vs do not work

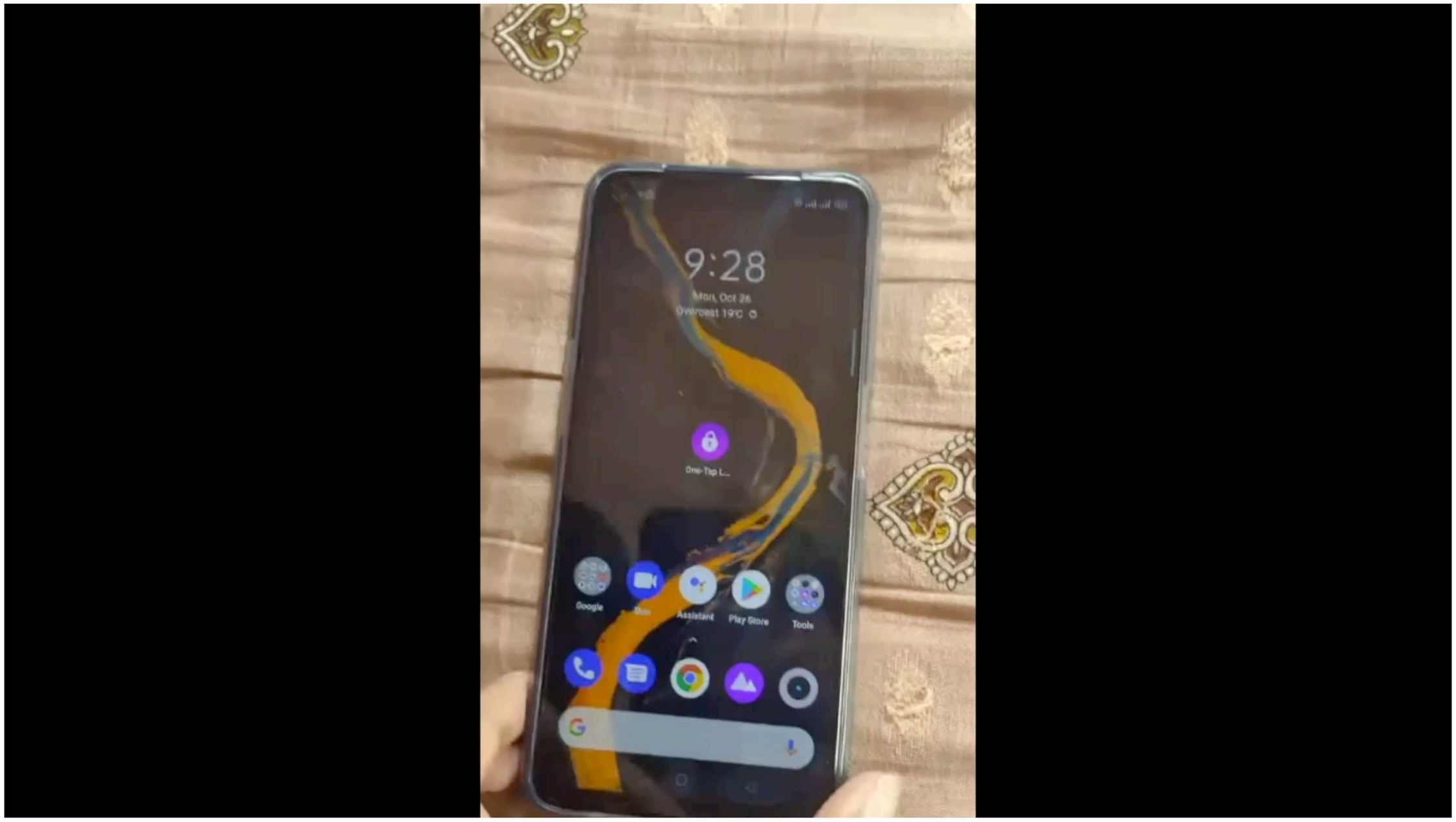
Machine condition (work) → *Opaque*

20 participants; 160 videoclips

Osiurak et al. (in progress)

Instructions:

Work vs do not work



Machine condition (Do not work) → *Opaque*

Osiurak et al. (in progress)

Instructions:

Work vs do not work

Tool condition (work) → *Transparent*

Osiurak et al. (in progress)

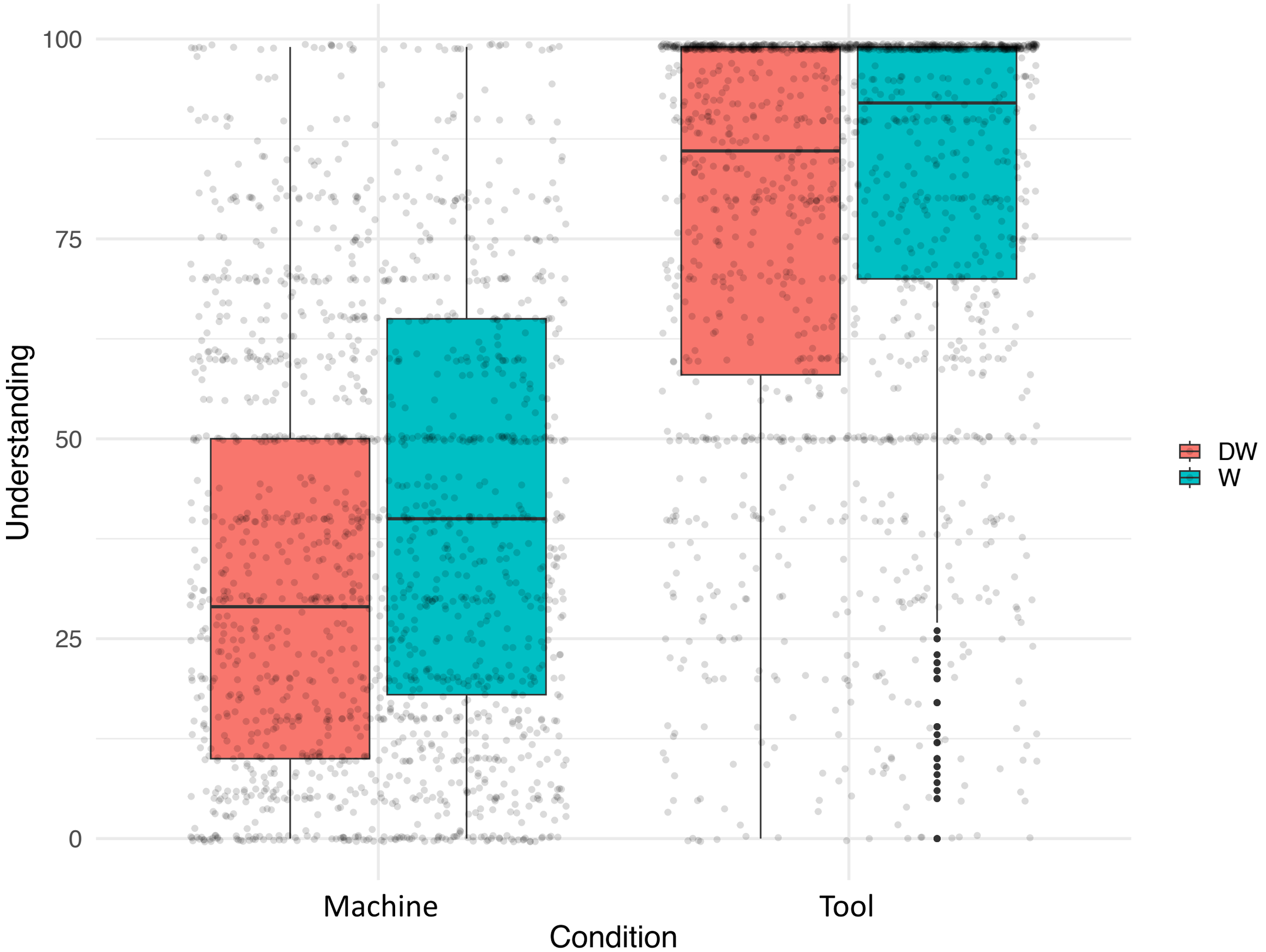
Instructions:

Work vs do not work

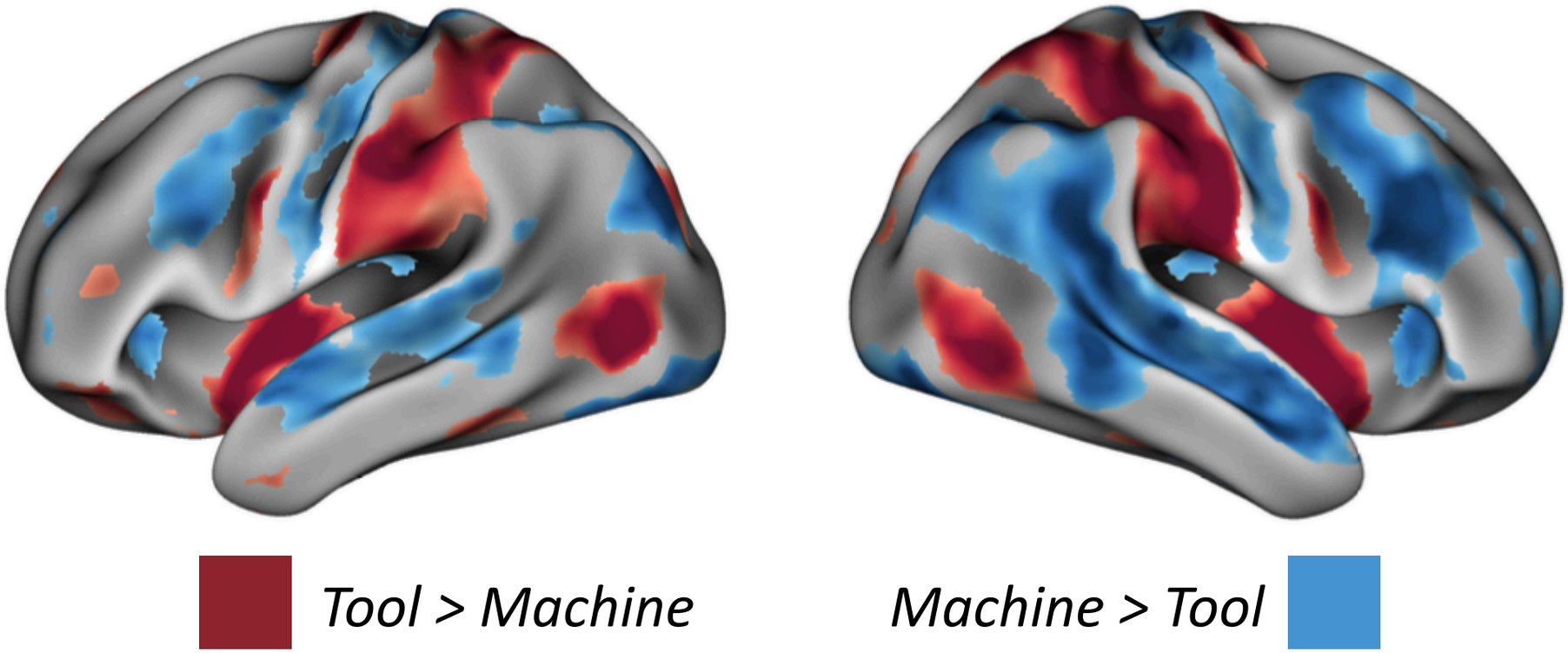
Tool condition
(Do not work)

→ *Transparent*

Osiurak et al. (in progress)



Osiurak et al. (in progress)



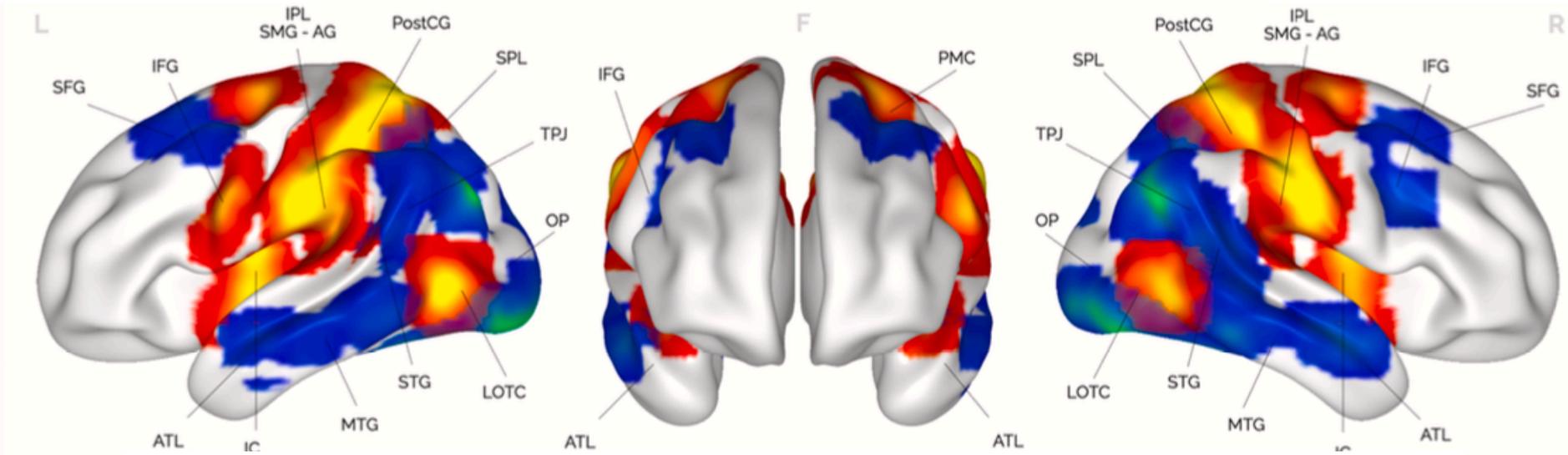
Osiurak et al. (in progress)

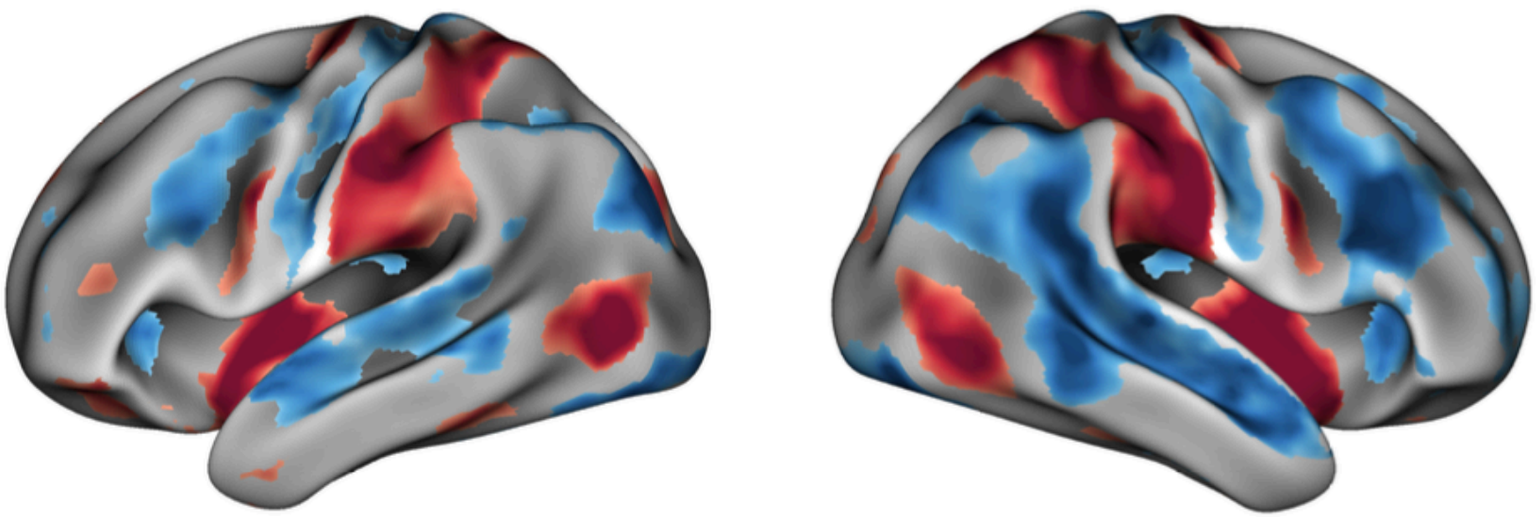
Main **fMRI** results

Z score 3.1 5.4 3.1 4.9

Tool > Machine

Machine > Tool



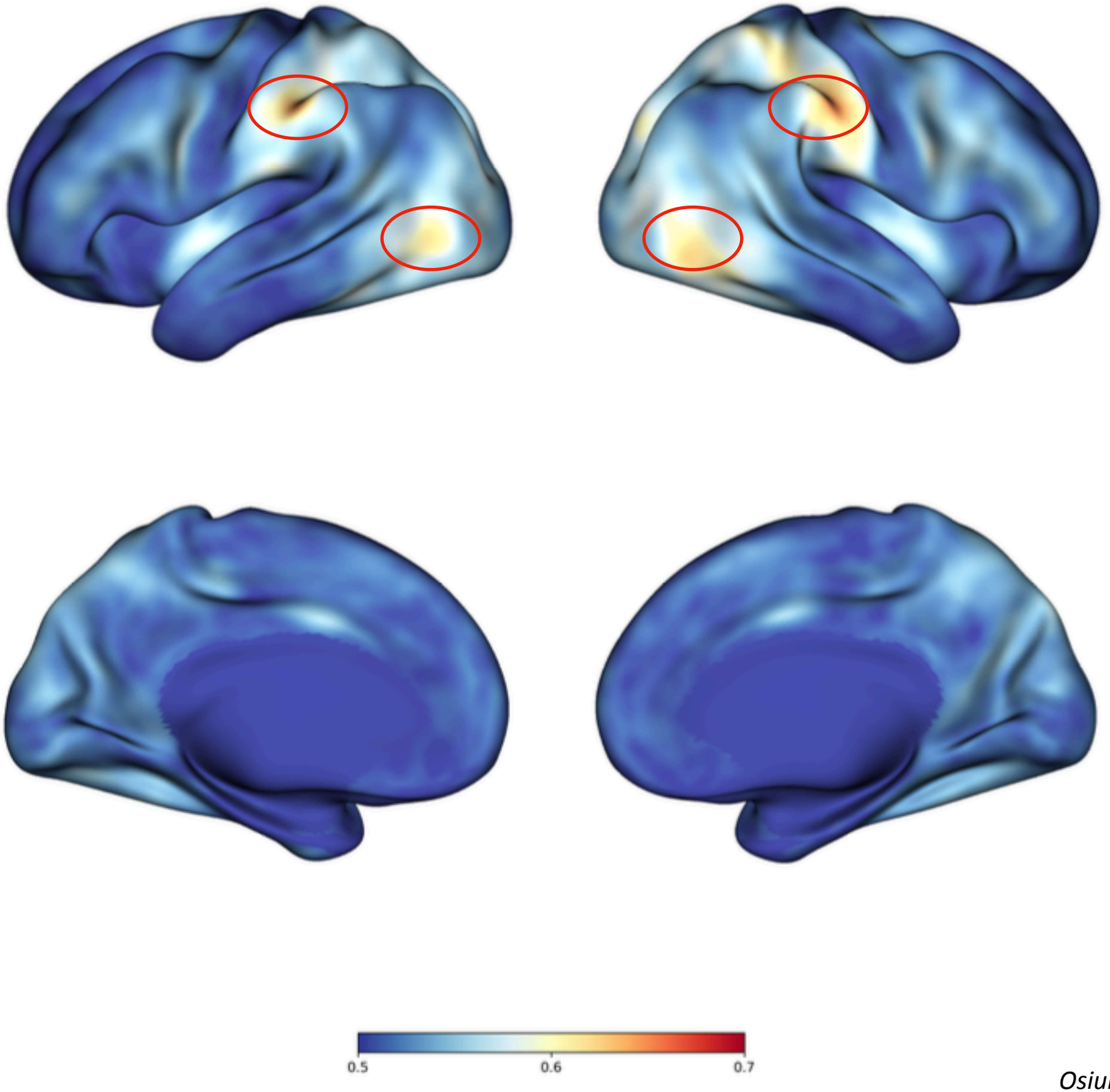


Tool > Machine

Machine > Tool

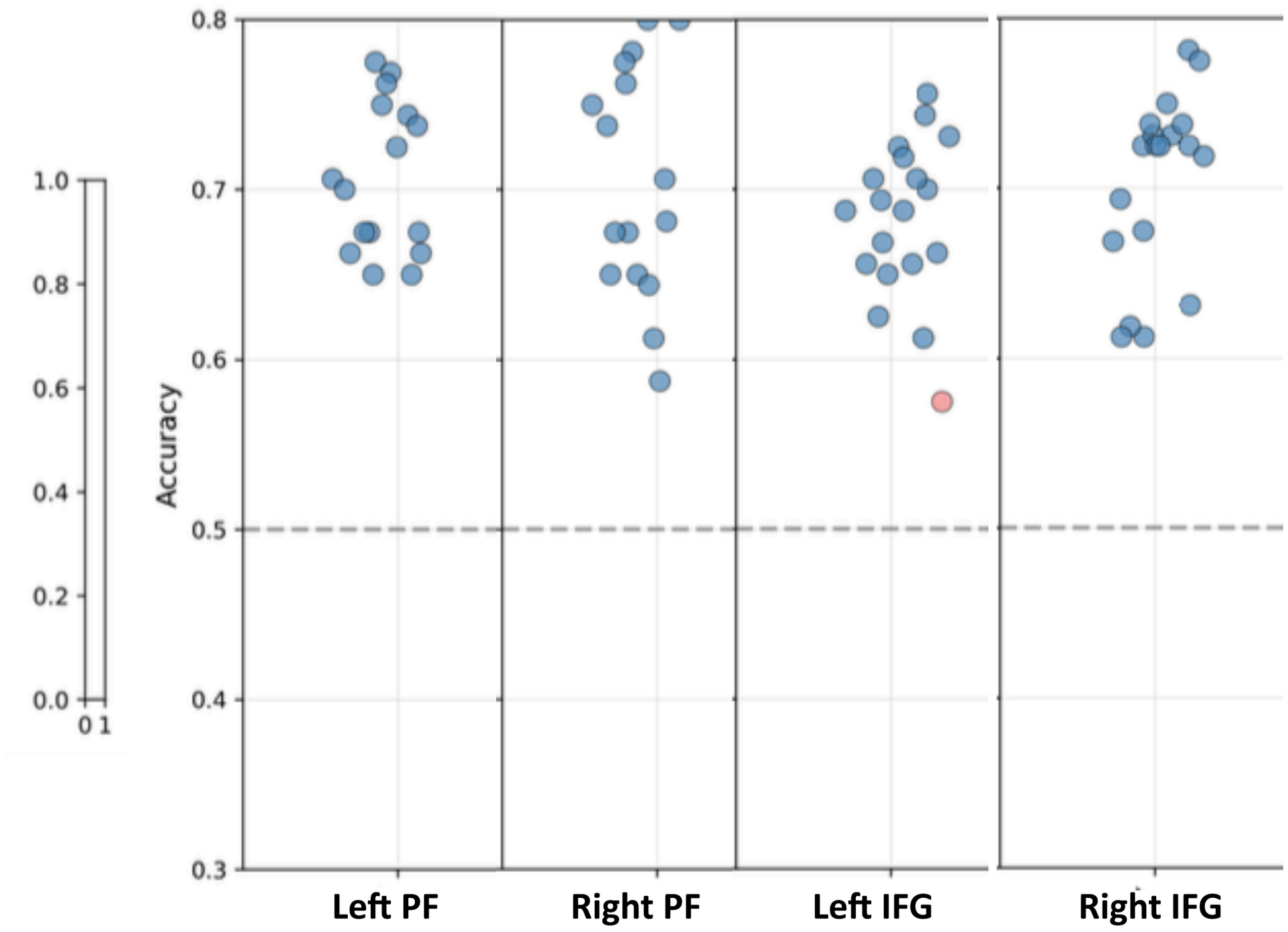
Osiurak et al. (in progress)

Tool vs Machine



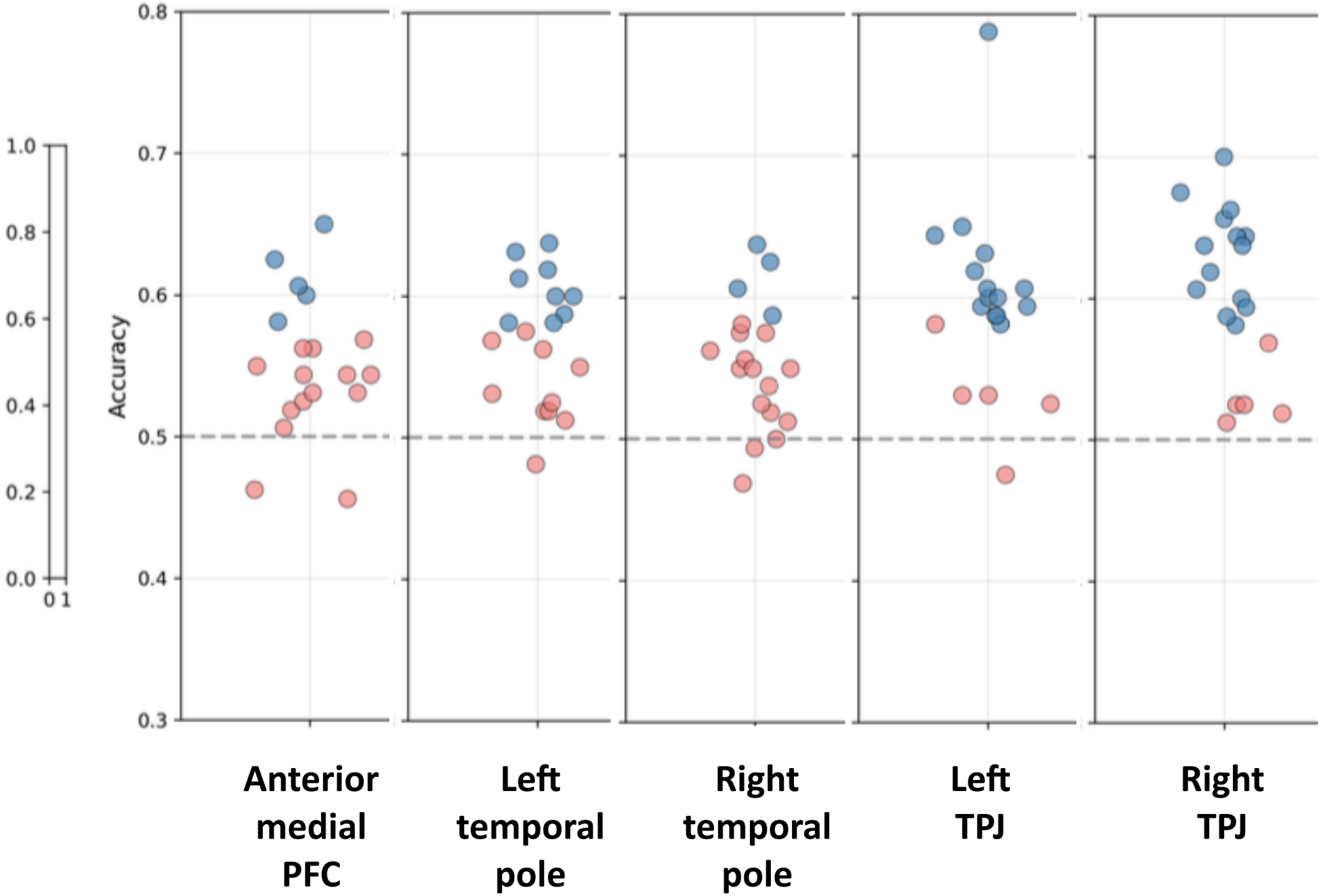
Osiurak et al. (in progress)

Tool vs Machine



Osiurak et al. (in progress)

Tool vs Machine



Osiurak et al. (in progress)

Making technology to our own image

Improves again the deception of the social brain

Thanks to my collaborators…

Giovanni Federico
Naples, Italy

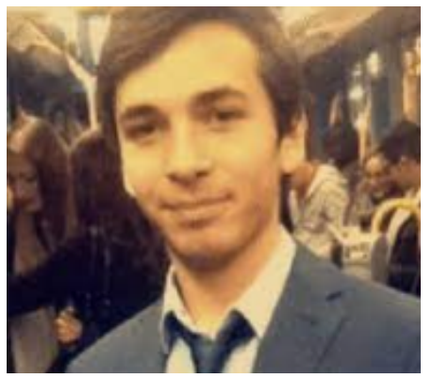
Mathieu Lesourd
Besançon, France

Nicolas Claidière
Aix-Marseille, France

Yves Rossetti
Lyon, France

… and PhD students

Alexandre Bluet
Göteborg, Sweden



Maximilien Metaireau
Besançon, France

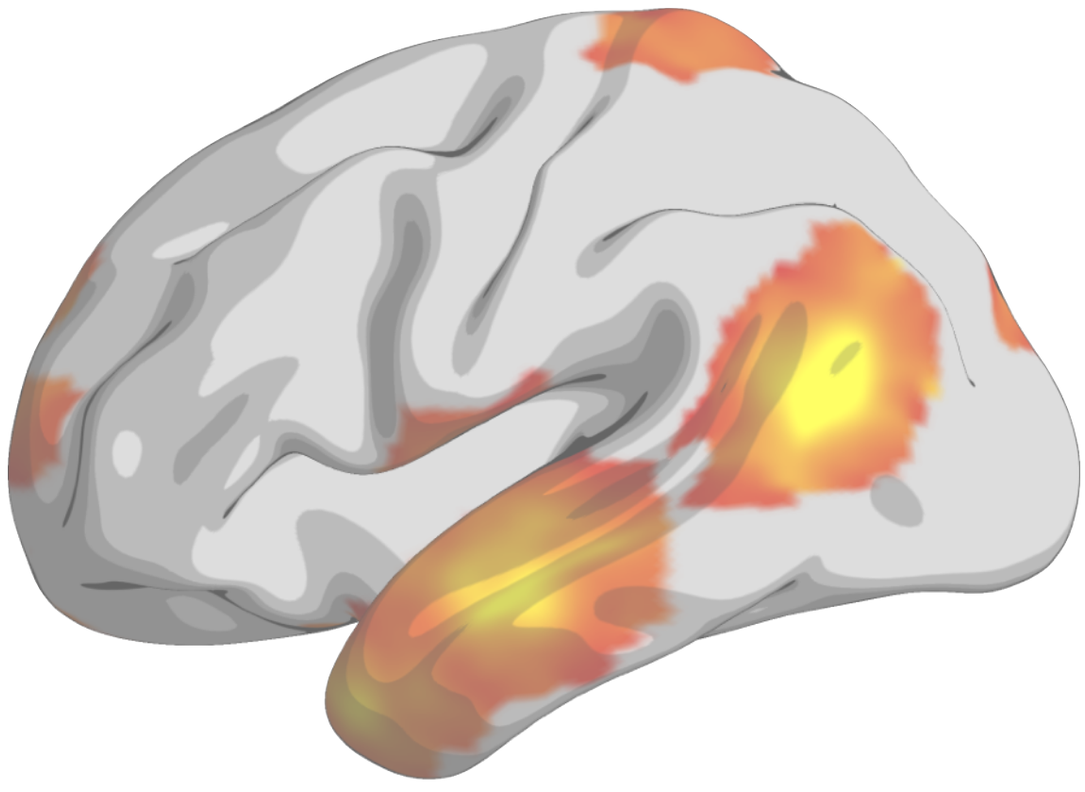
Chloé Bryche
Lyon, France

Nina Stauffert
Lyon, France

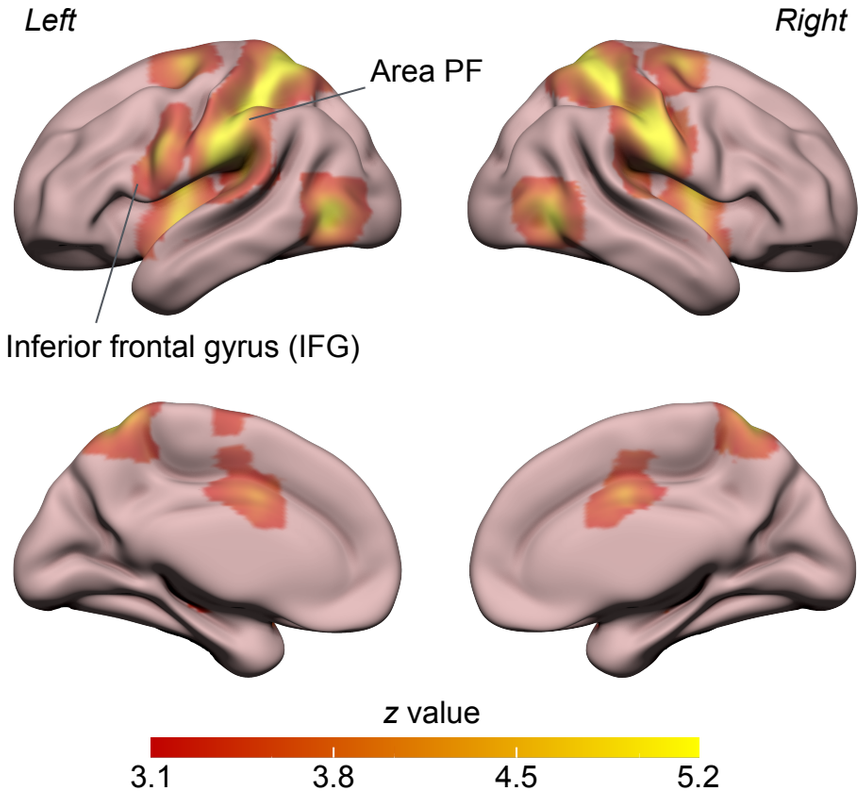
Anaïs Mercier
Lyon, France

Growing technological opacity and the social brain

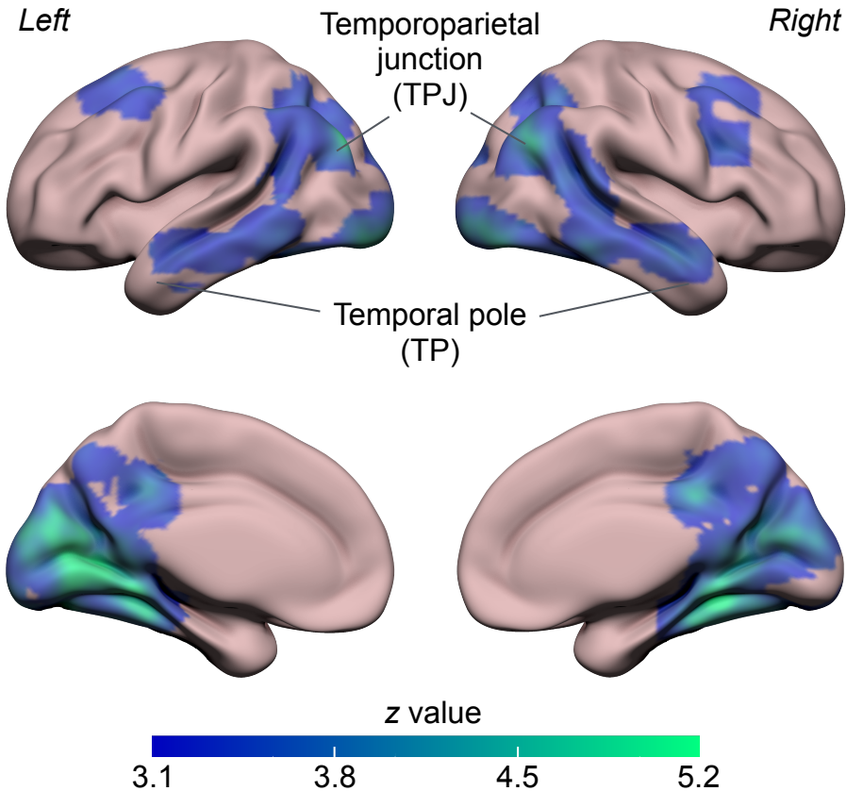
François Osiurak
University of Lyon, Lyon, France
Institut Universitaire de France, Paris, France



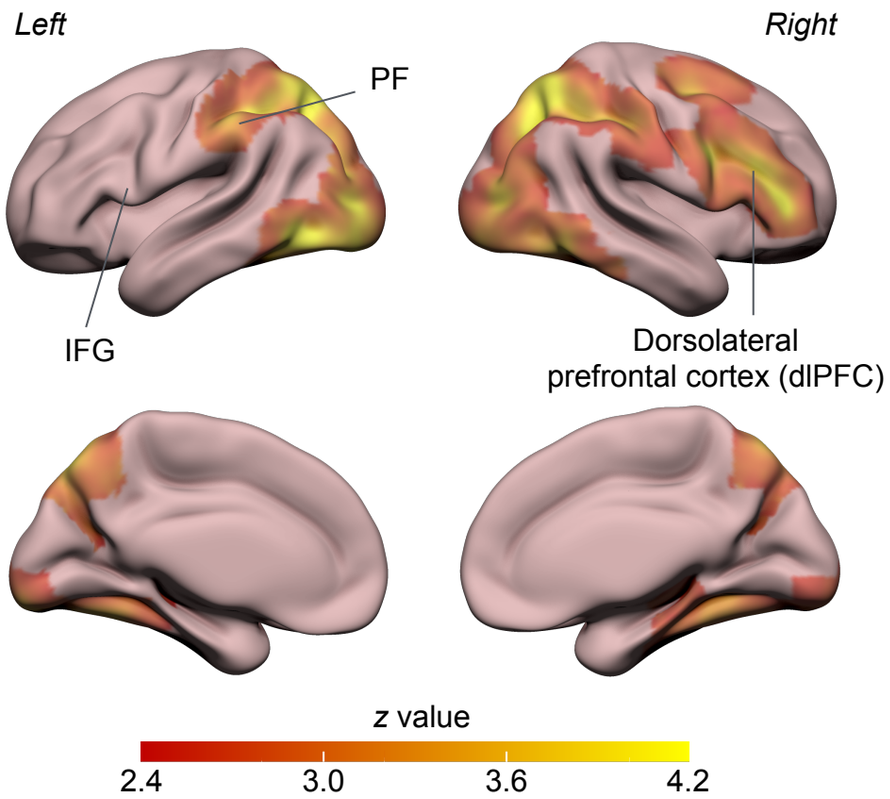
A. Mechanical > Digital



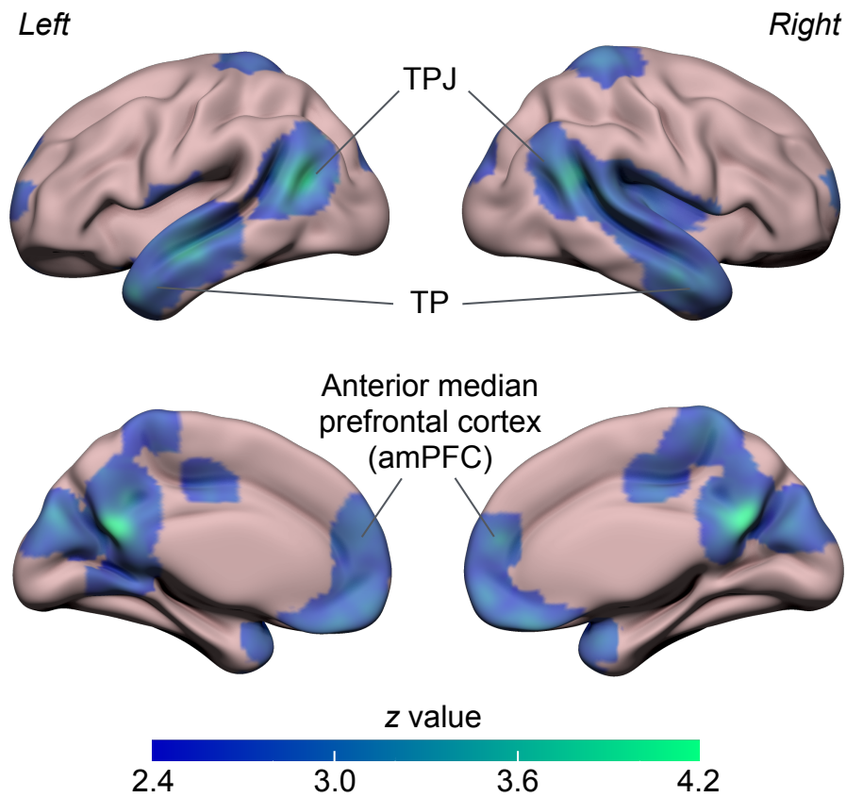
B. Digital > Mechanical

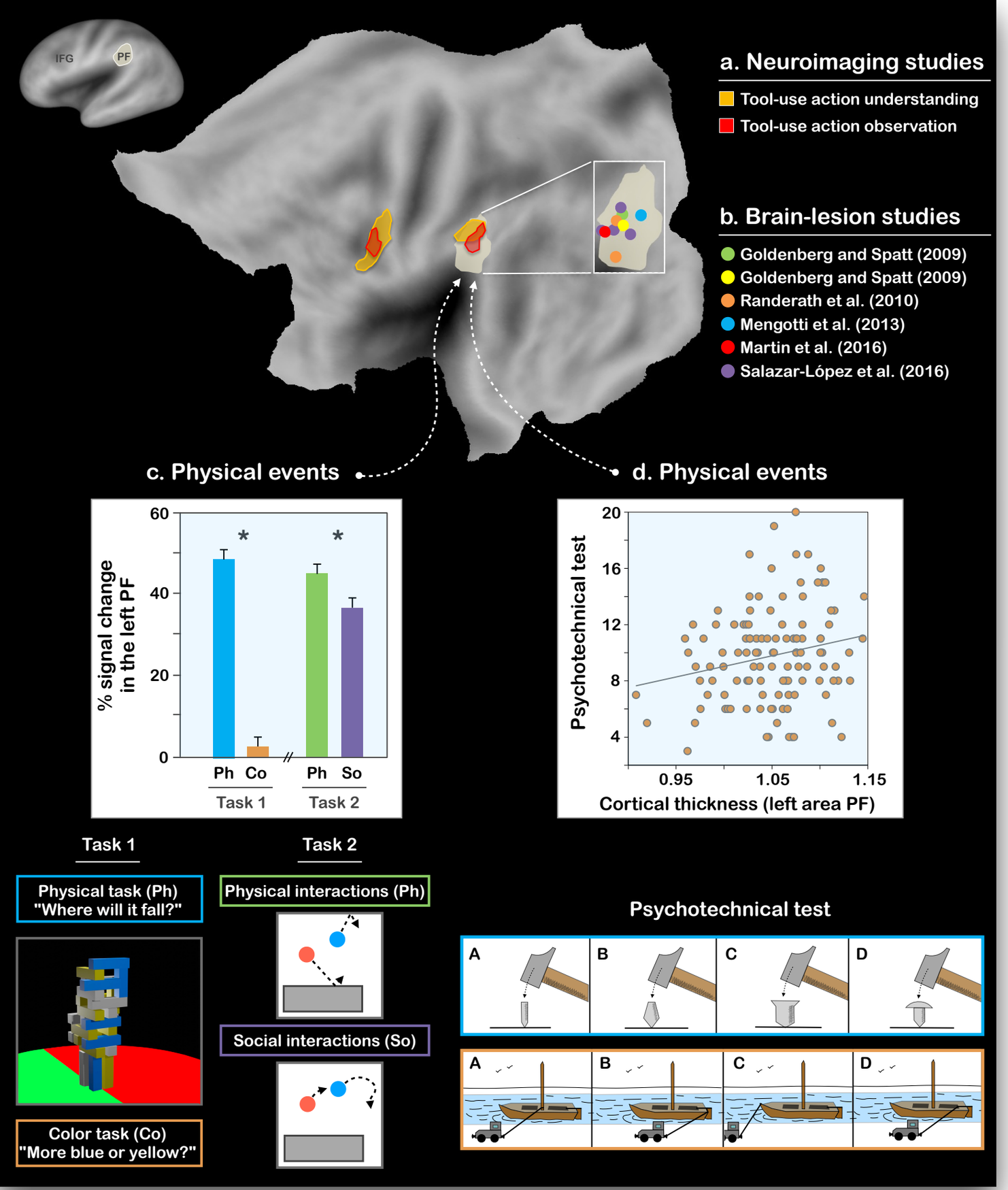


C. Alone > Delegation



D. Delegation > Alone

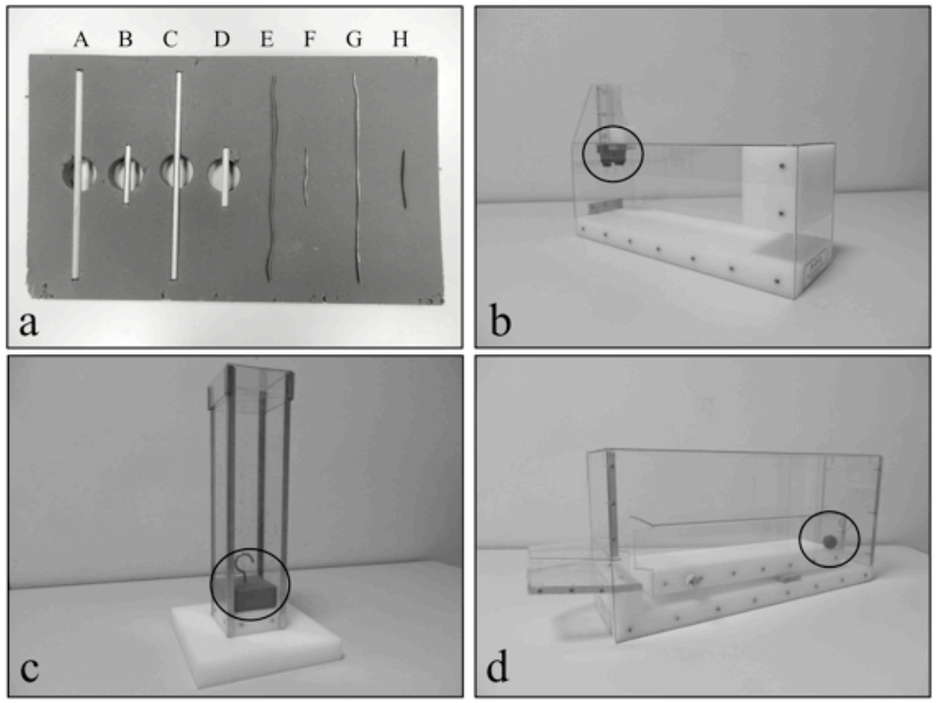


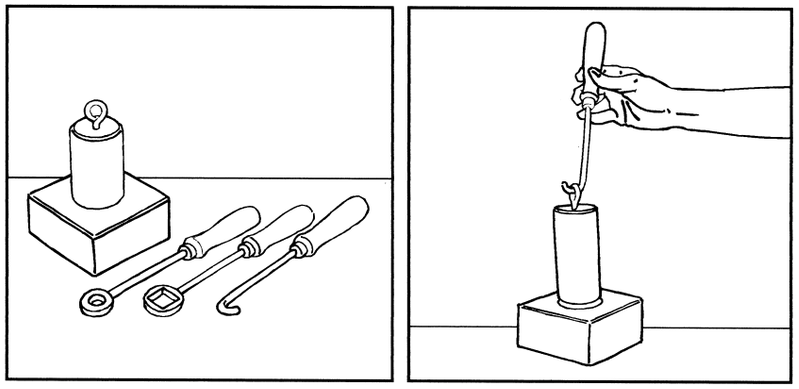


Osiurak, Federico, & Clairière (2023; Trends in Cognitive Sciences)
Federico et al. (2022; Scientific Reports)
Fischer et al. (2018; PNAS)

Familiar tool use

Mechanical problem solving (novel tool use)





Apraxia of tool use

Goldenberg's videos

12 weeks of training
3 days a week
20 to 40 min sessions

Step by step demonstration
or Training of details (teaching)

but…
on how to make tea

This was a **transfer** task

The activity is degraded over time (6 months after the rehabilitation),
if not practiced daily

Goldenberg et al. (1998, 2001)

Instructions:

Work vs do not work

Machine$_{Transparent}$ condition (Do not work) → *Transparent*

Osiurak et al. (in progress)