



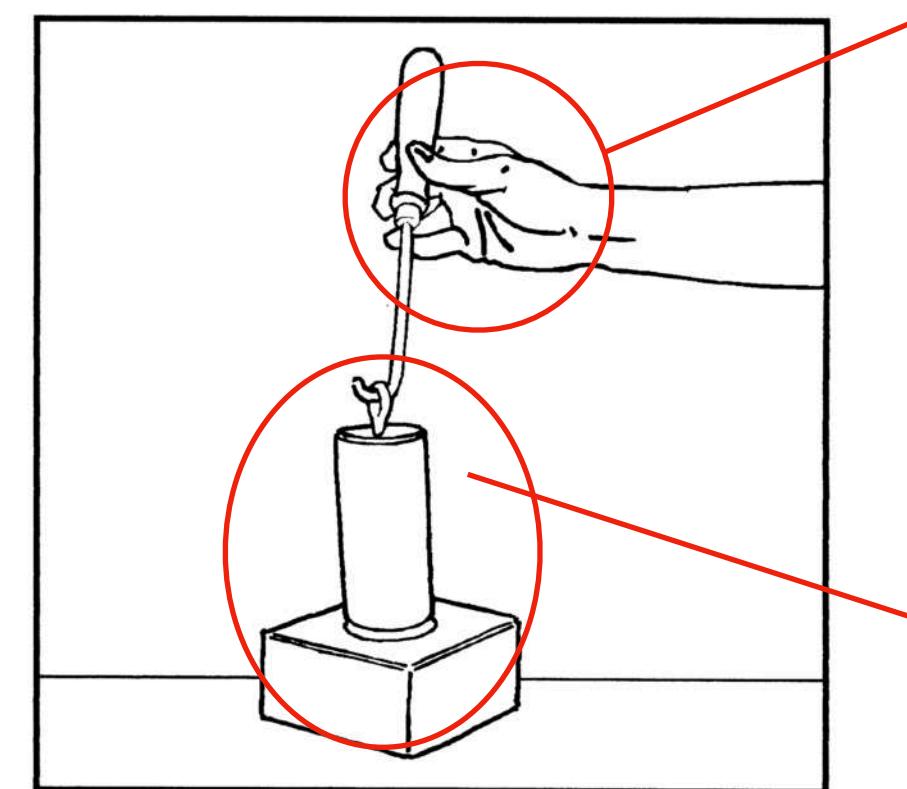
The neural bases of action semantics system: new insights from fMRI and neuropsychological data

Mathieu Lesourd, PhD

RMN Marseille, le 14 Septembre 2023

What is action semantics in the context of objects/tools?

Action tool knowledge



Semantic tool knowledge

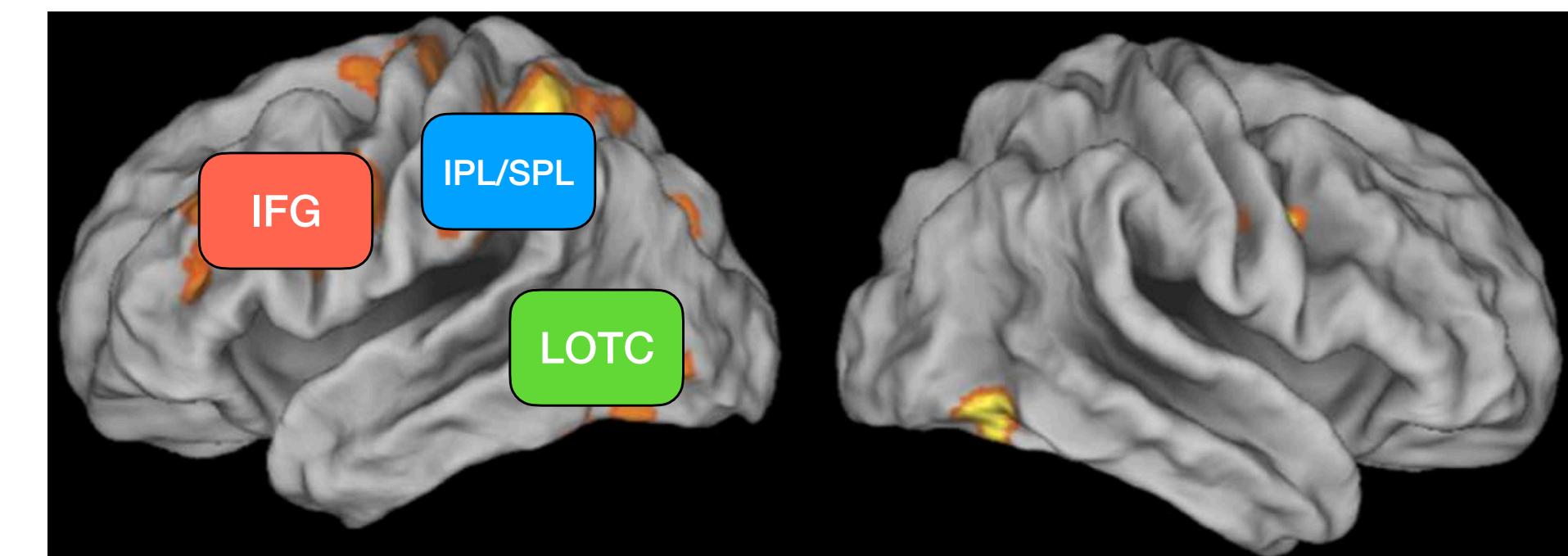
Information about how to manipulate tools (i.e., hand-tool centered) (Buxbaum, 2001, 2014; 2017; van Elk, 2014)

Hand posture (Sirigu, 1991)

Kinematics/Manipulation (Buxbaum et al., 2014)

Prototypical information about objects
(i.e., object-centered) (e.g., Roy & Square, 1985)

distributed across the Tool Processing Network (e.g.,
Garcea et al., 2018; Kleineberg et al., 2018; Lesourd et al.,
2023; Reynaud et al., 2016; 2019)





Available online at www.sciencedirect.com

ScienceDirect

Journal homepage: www.elsevier.com/locate/cortex

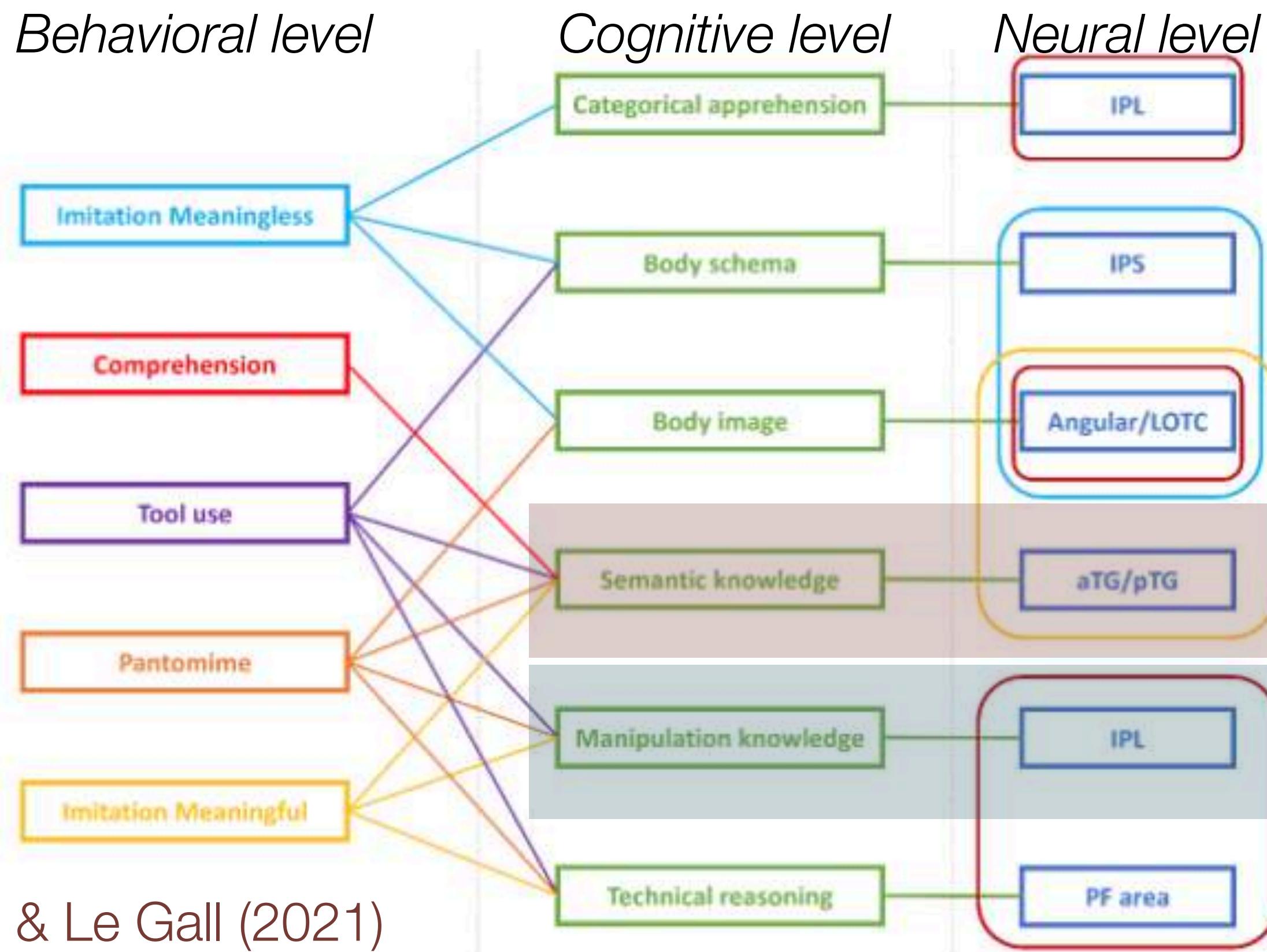


Special Issue “Apraxia”: Research Report

Using tools effectively despite defective hand posture: A single-case study

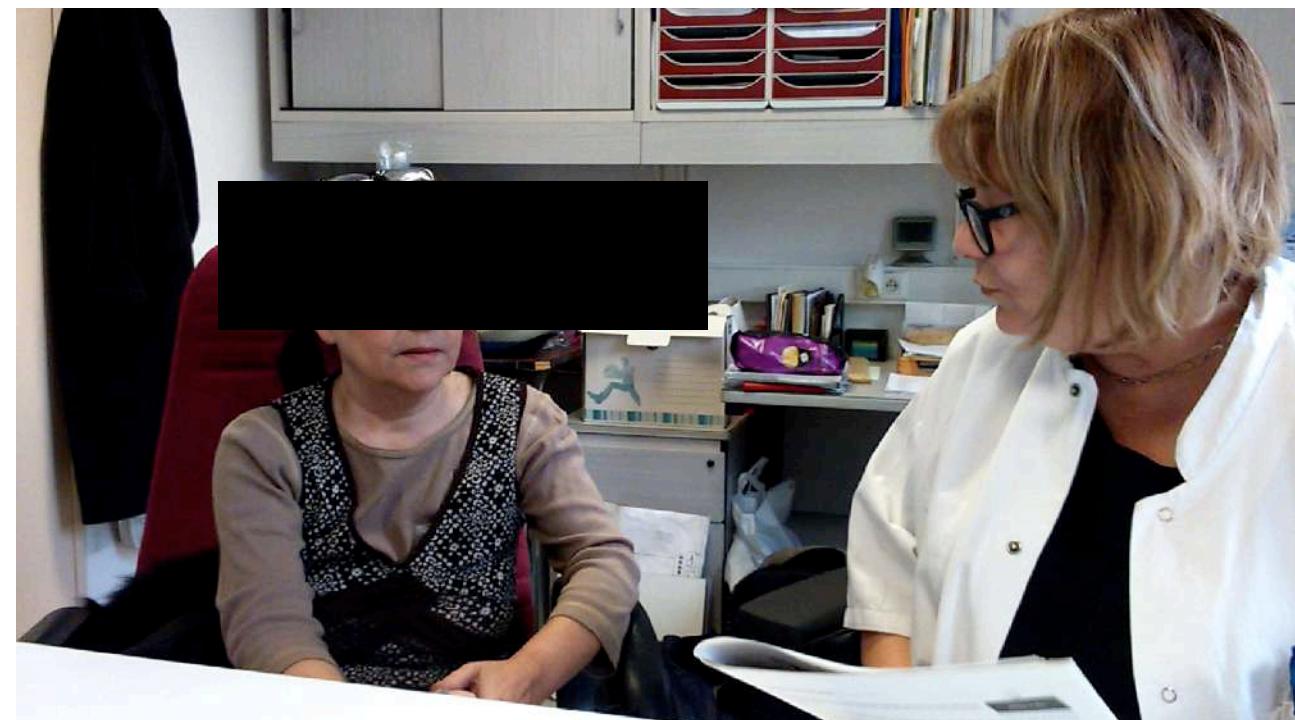


Mathieu Lesourd ^{a,*}, Bernadette Naëgelé ^b, Assia Jaillard ^c,
Olivier Detante ^{b,d} and François Osiurak ^{e,f}

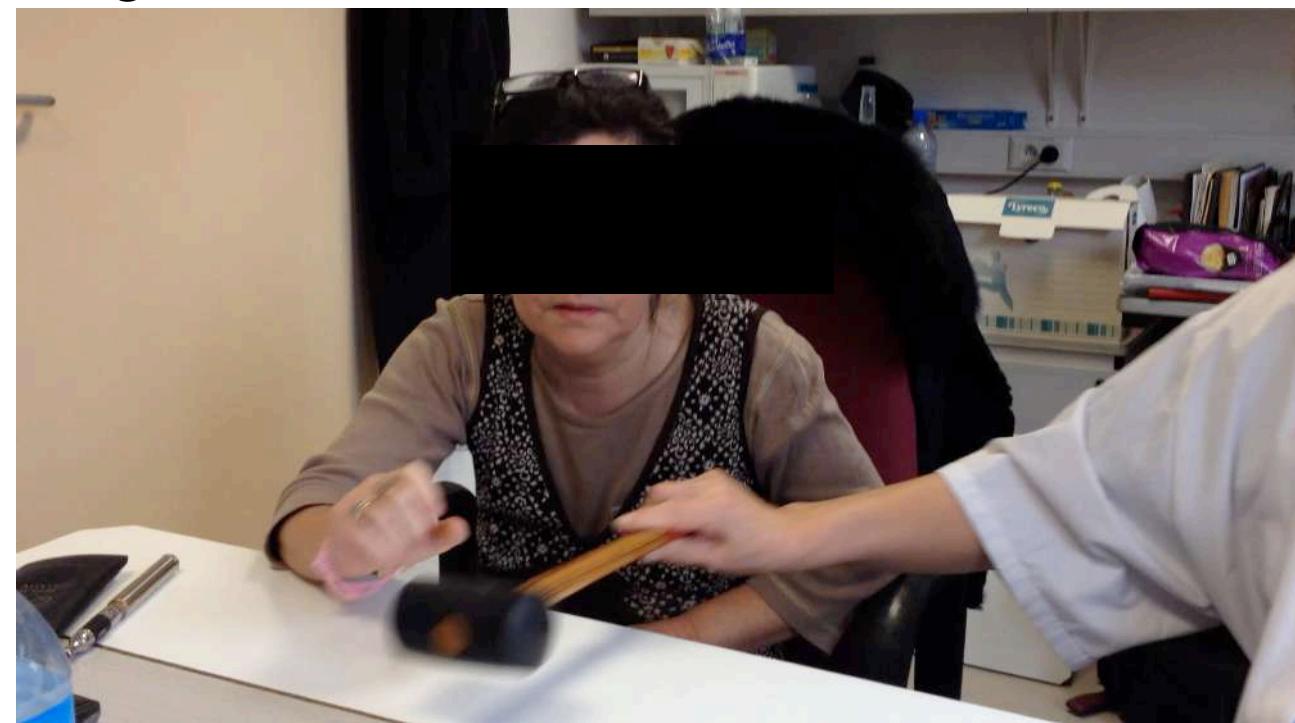


Baumard & Le Gall (2021)

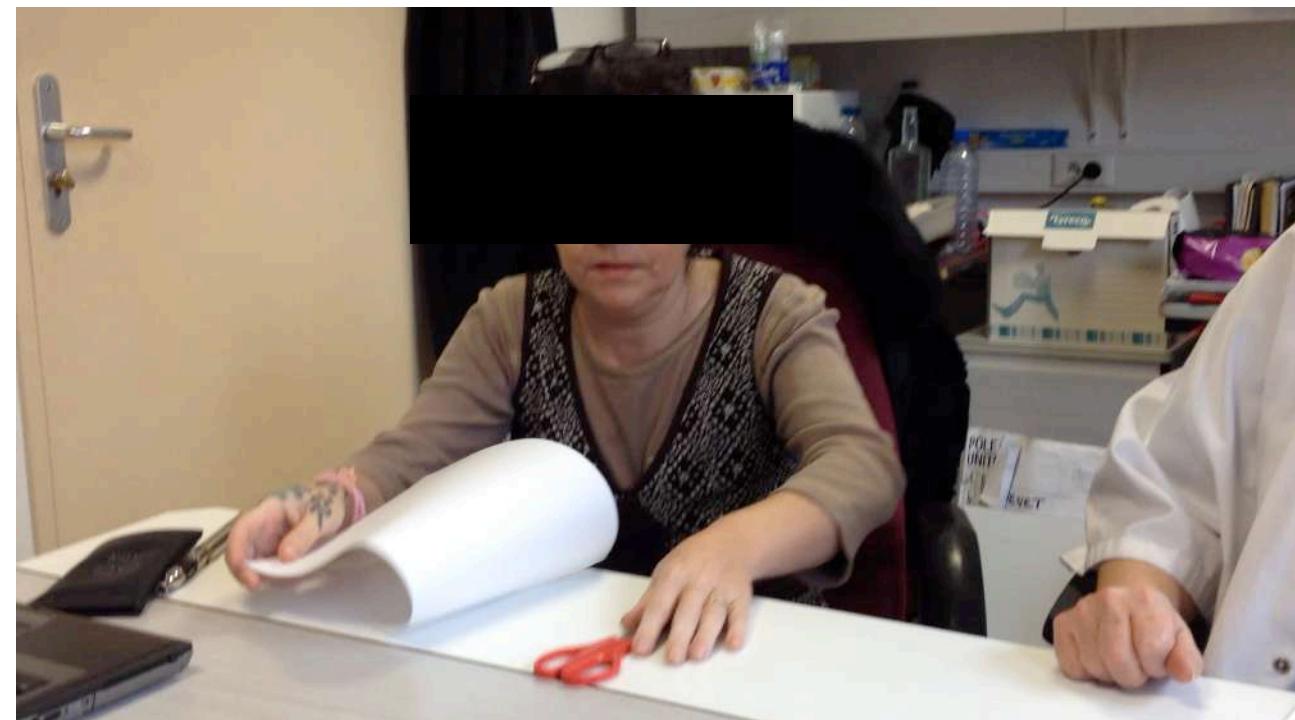
Pantomime of tool use



Single tool use



Real tool use

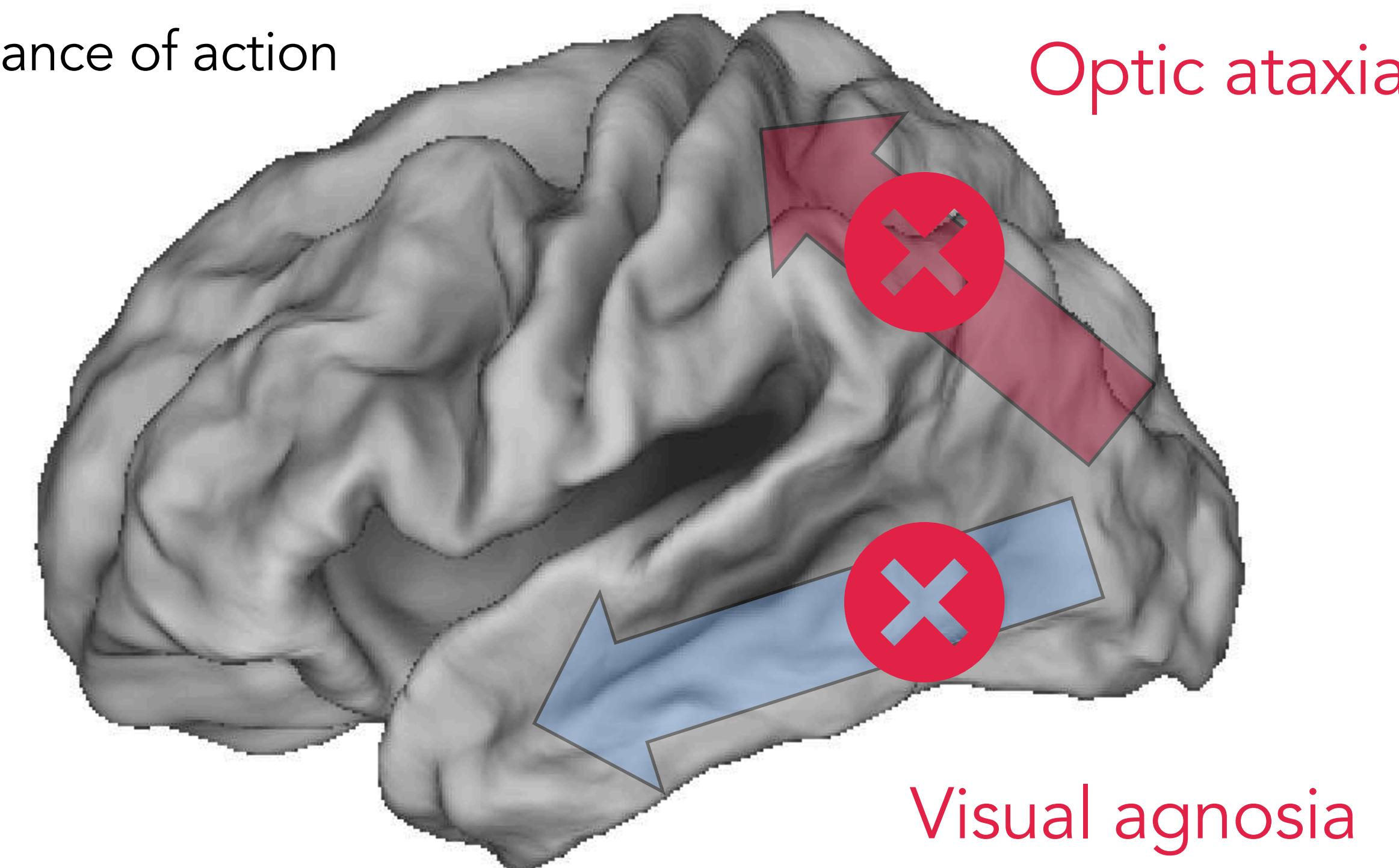


Two stream model (Goodale & Milner, 1992; Ungerleider & Mishkin, 1982)

Dorsal stream

Vision-for-action (« where »)

Online visual guidance of action

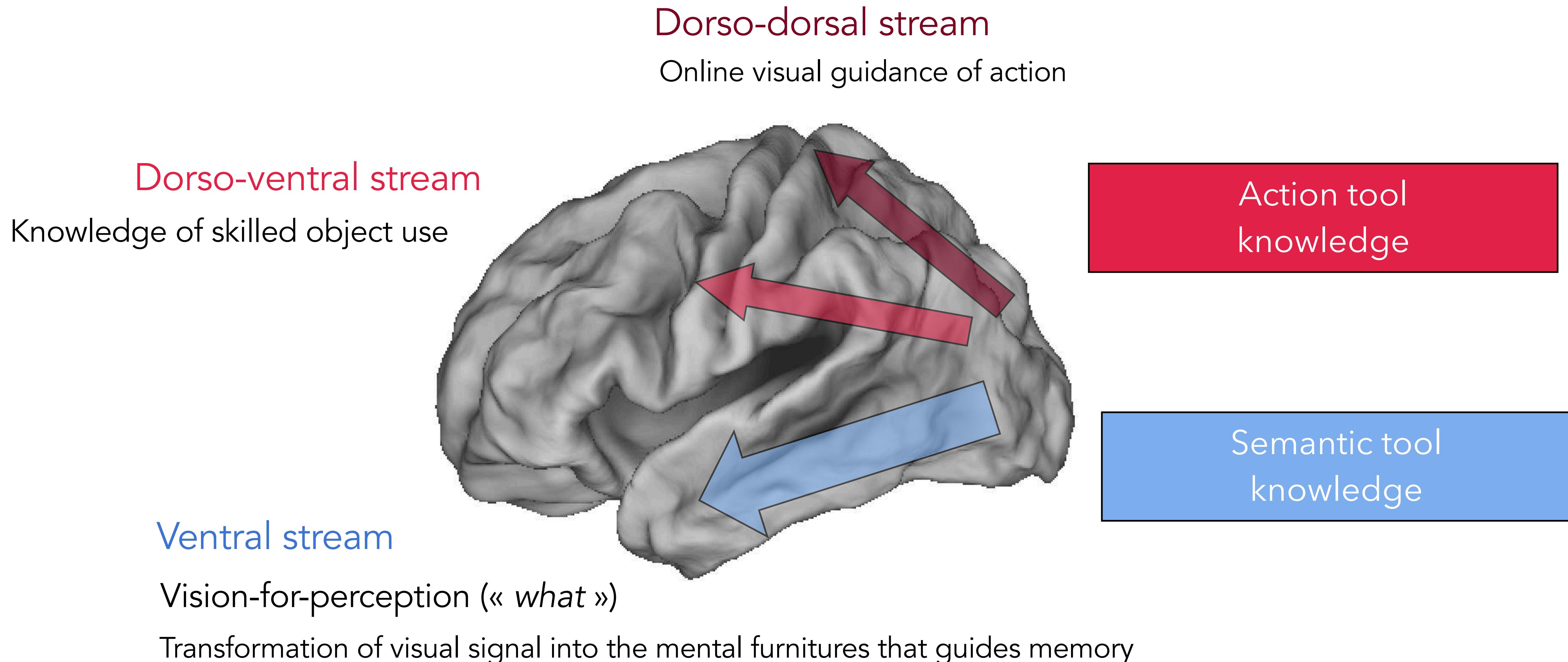


Ventral stream

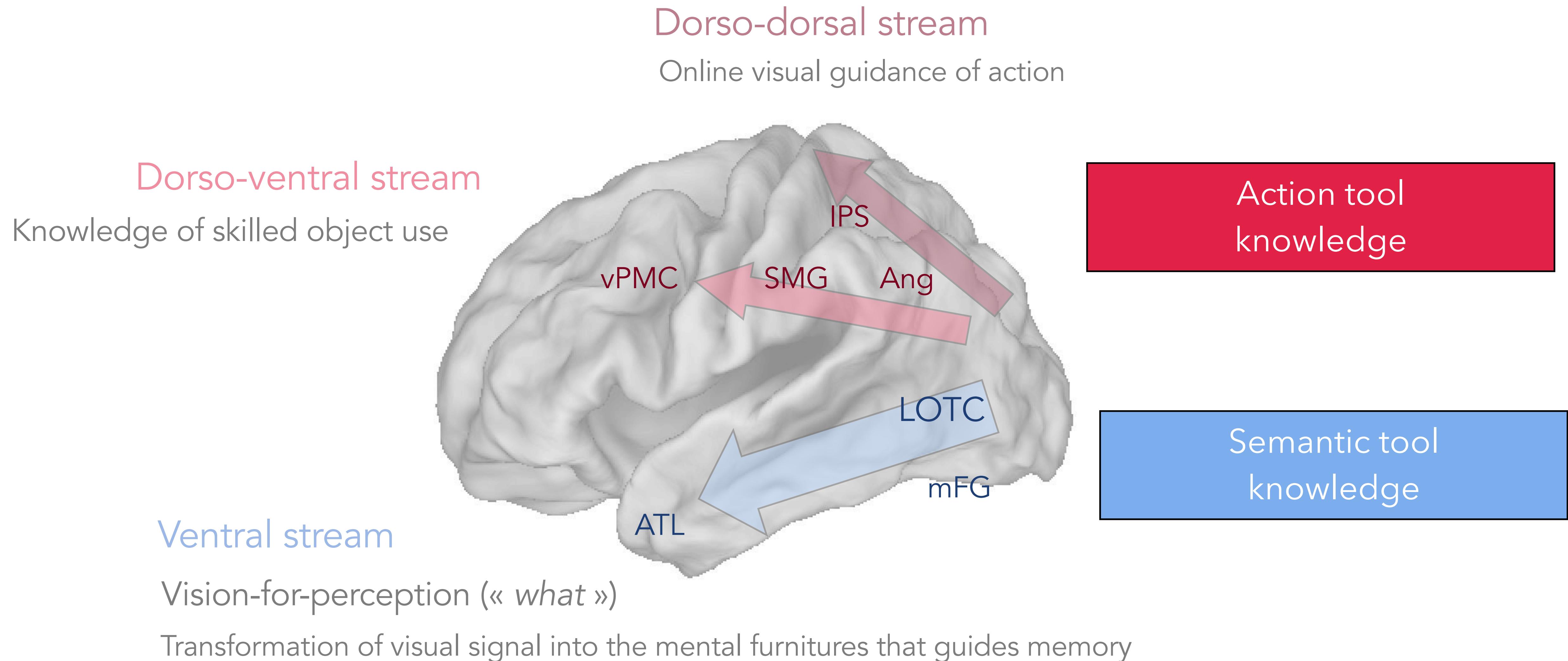
Vision-for-perception (« what »)

Transformation of visual signal into the mental furnitures that guides memory

New account of the two stream model (Binkofski & Buxbaum, 2013)

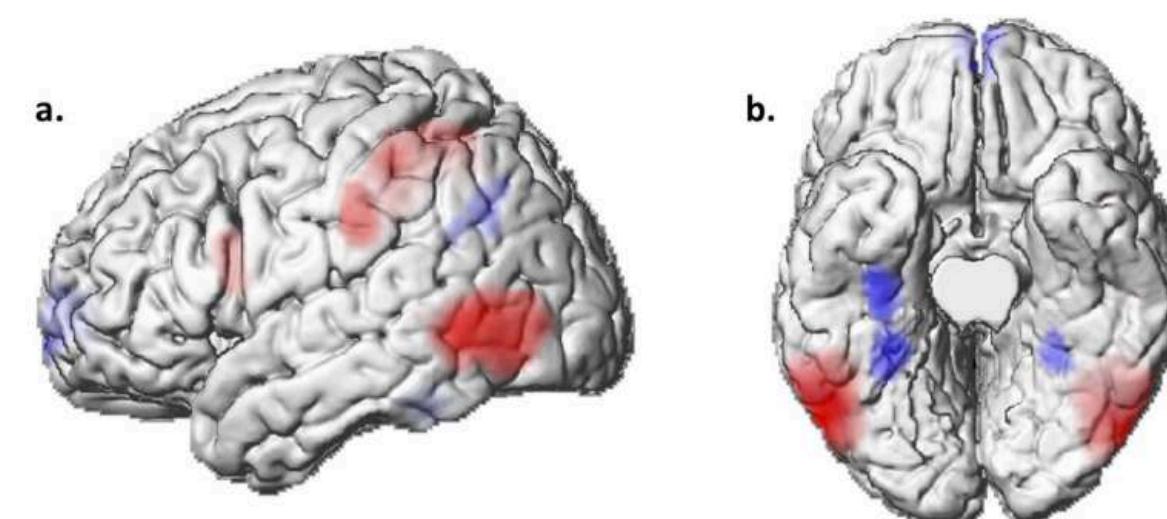
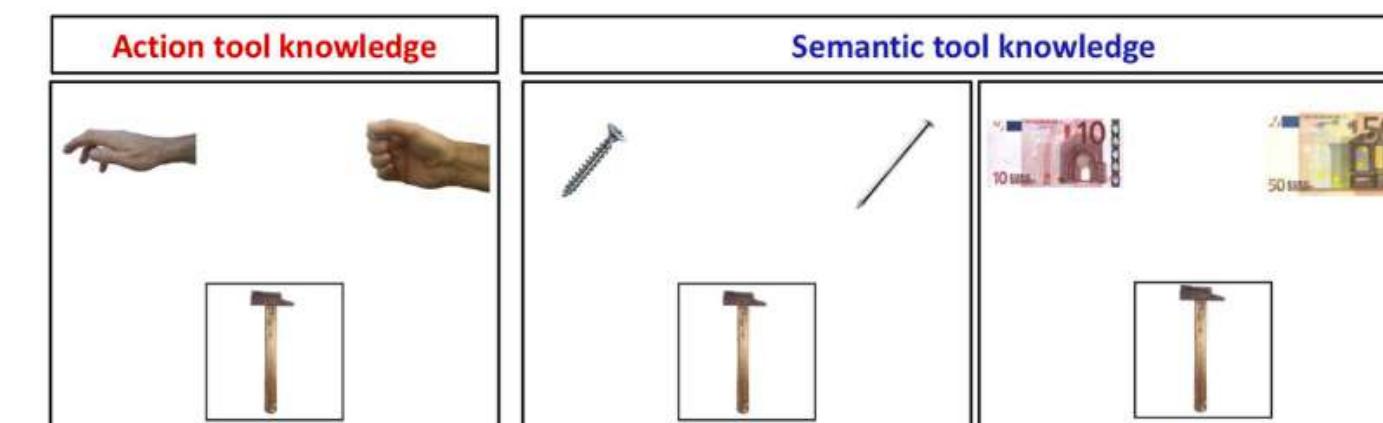


New account of the two stream model (Binkofski & Buxbaum, 2013)



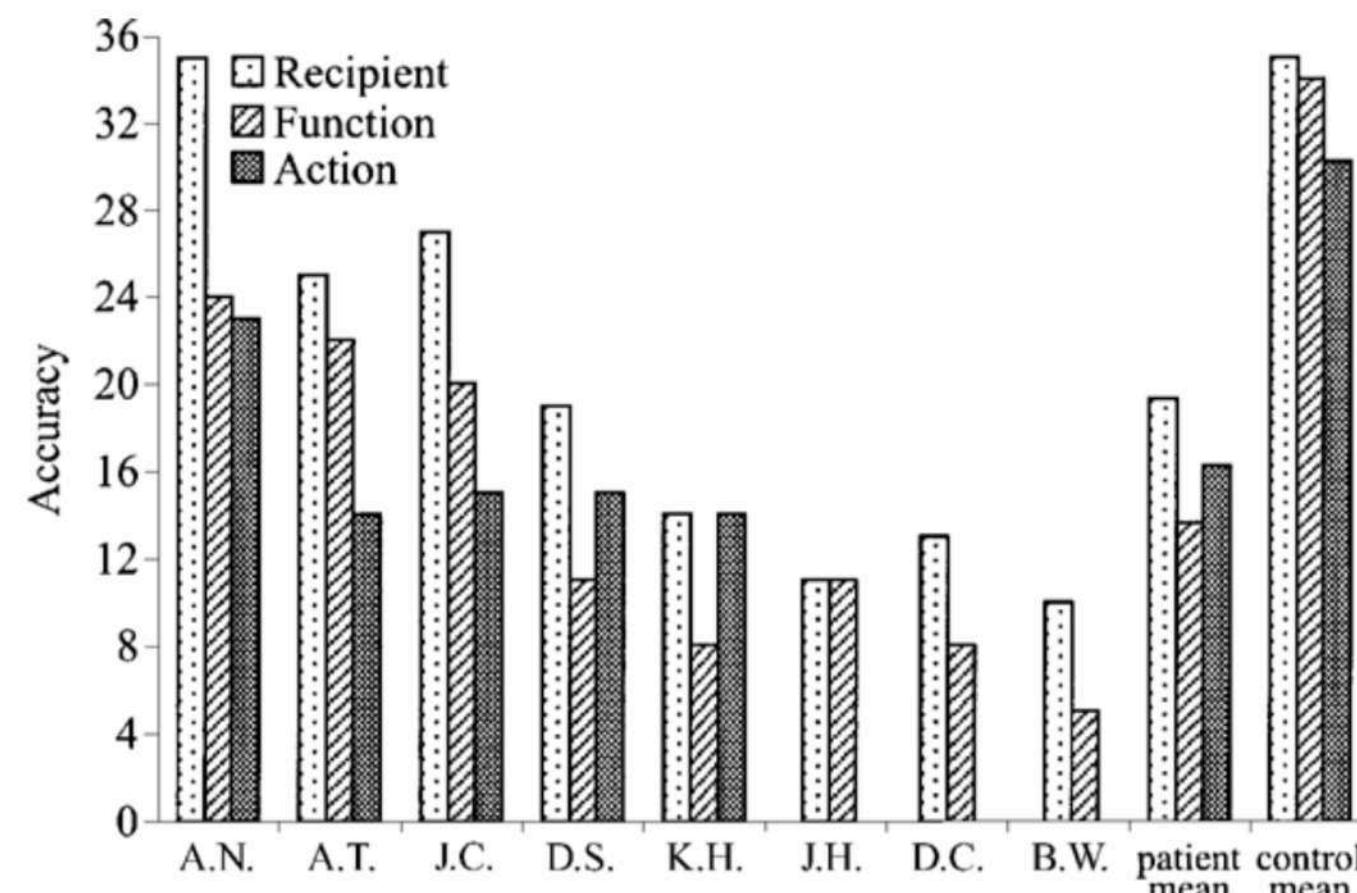
The lateral Occipitotemporal cortex in action (Lingnau & Downing 2015)

fMRI in
healthy subjects



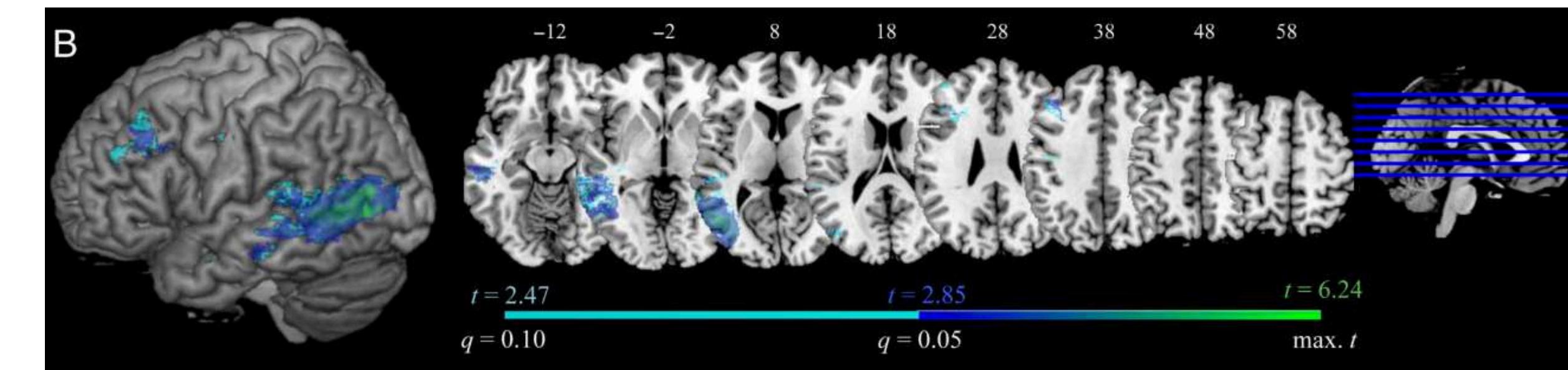
Kleineberg et al. (2018)

Semantic
dementia



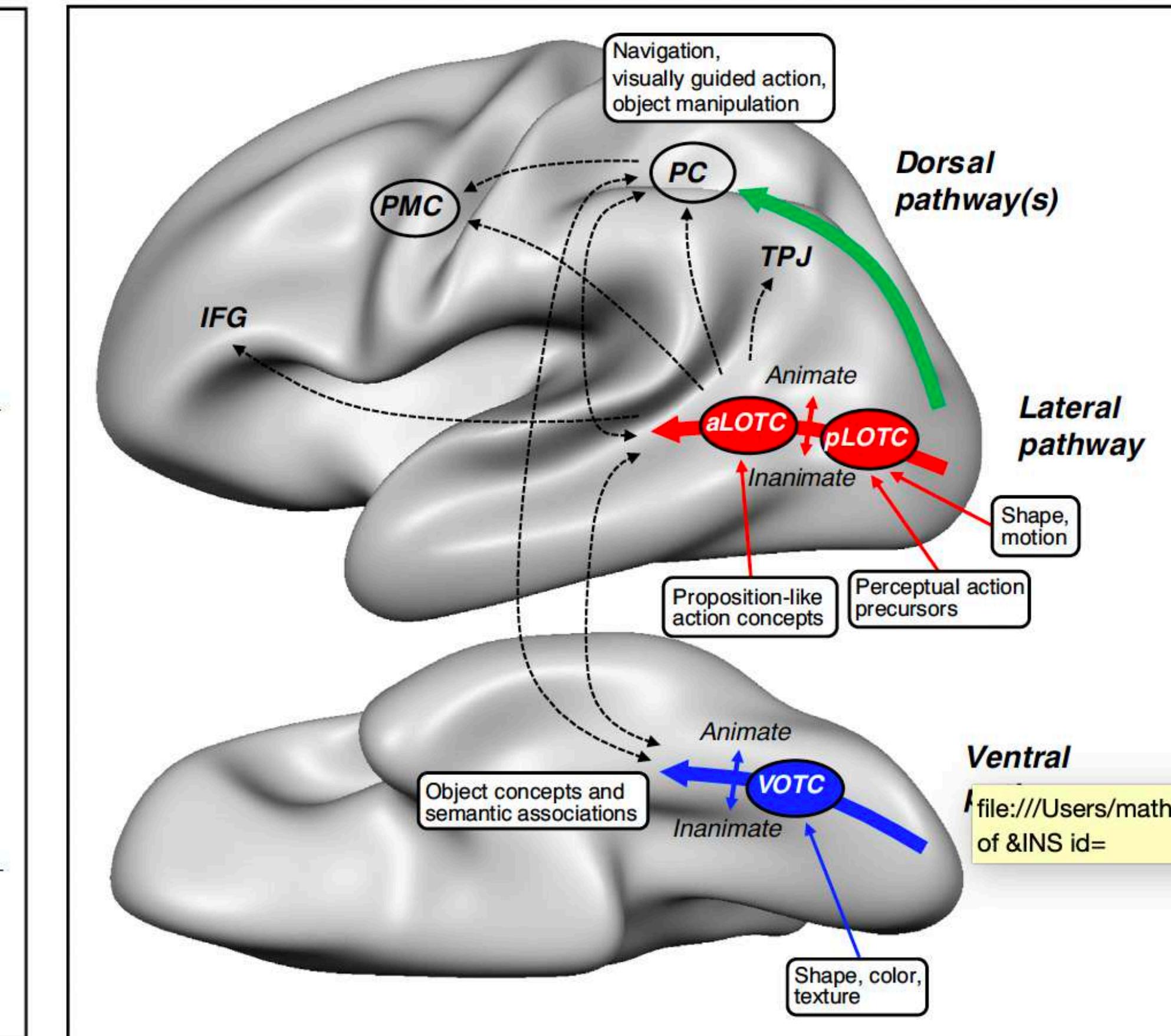
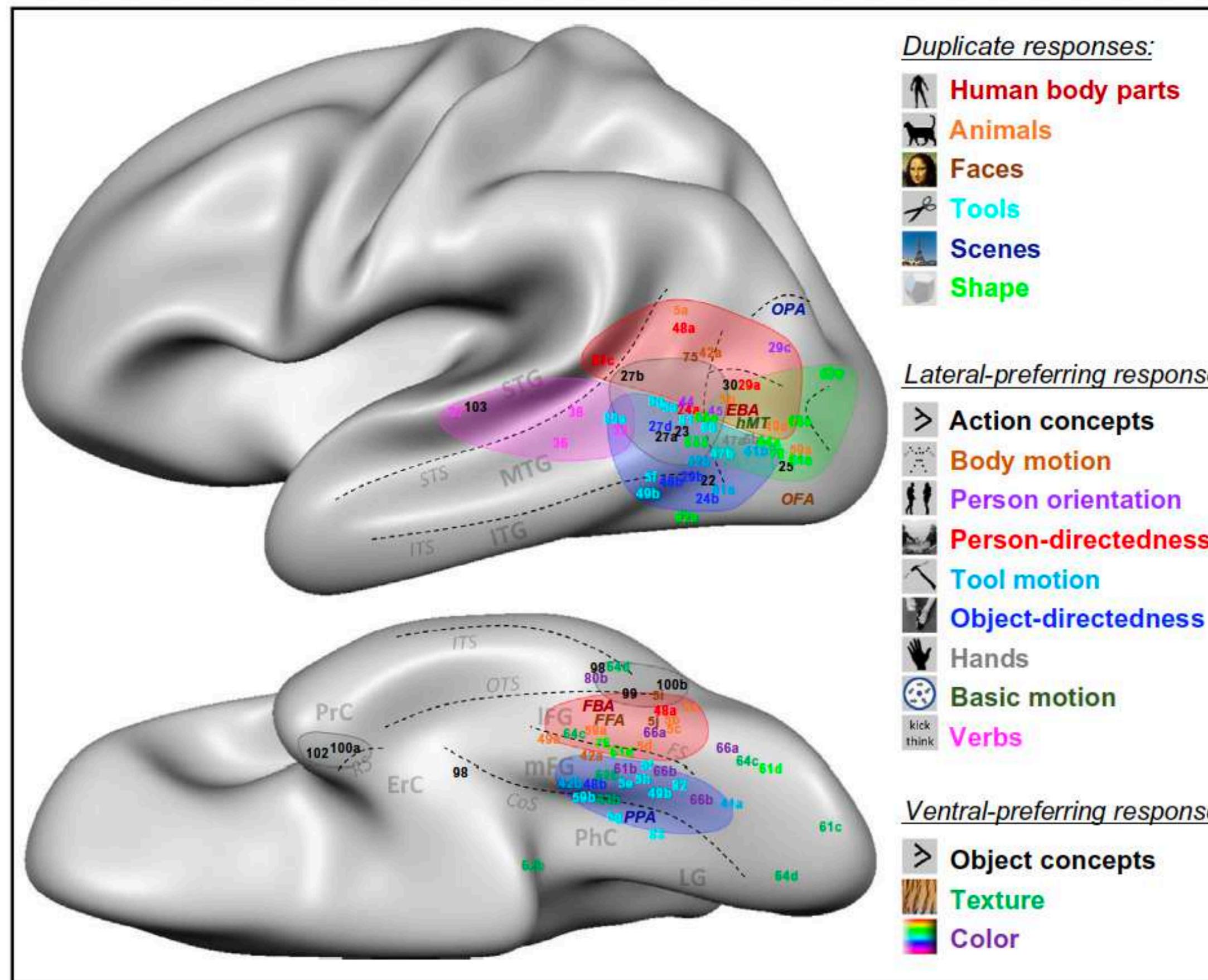
Hodges et al. (2000); Bozeat et al. (2002);
Baumard et al. 2016; Lesourd et al. (2017)

Left brain-damaged patients



Tarhan et al. (2015); Kalénine et al. (2016); Buxbaum et al. (2014);
Kalénine et al. (2010); Martin et al. (2017)

The lateral Occipitotemporal cortex in action (Lingnau & Downing 2015)



Wurm & Caramazza 2021; Wurm & Lingnau 2015; Wurm et al., 2017; Lesourd et al., 2023; Lingnau & Downing, 2015

Functional organization of action tool and semantic tool across the TPN

Contents lists available at [ScienceDirect](#)

Neuropsychologia

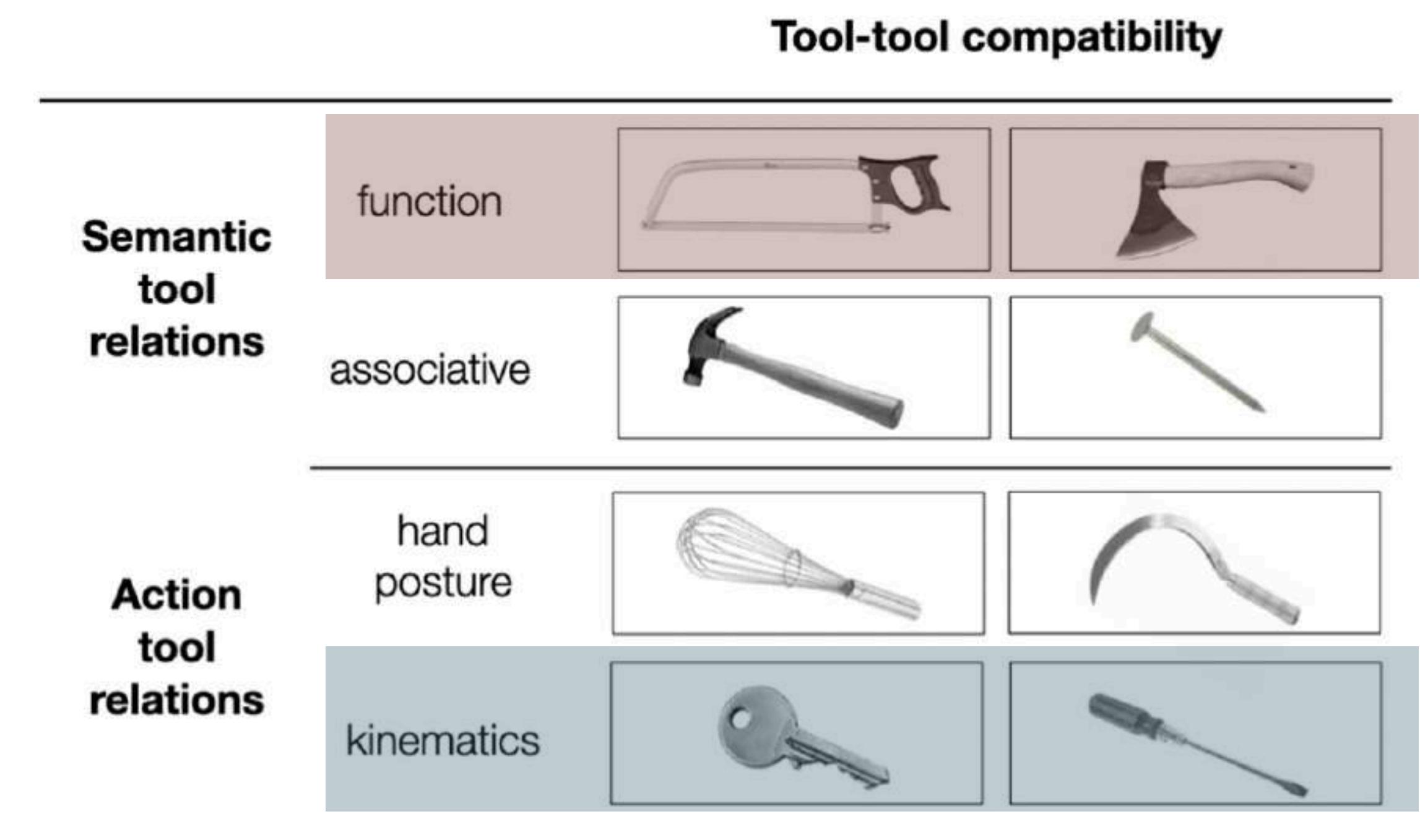
journal homepage: www.elsevier.com/locate/neuropsychologia

Review article

Semantic and action tool knowledge in the brain: Identifying common and distinct networks

Mathieu Lesourd ^{a,b,*}, Mathieu Servant ^{a,b}, Josselin Baumard ^c, Emanuelle Reynaud ^d, Charlotte Ecochard ^e, Fawzi Trari Medjaoui ^e, Angela Bartolo ^{f,g}, François Osiurak ^{d,g}

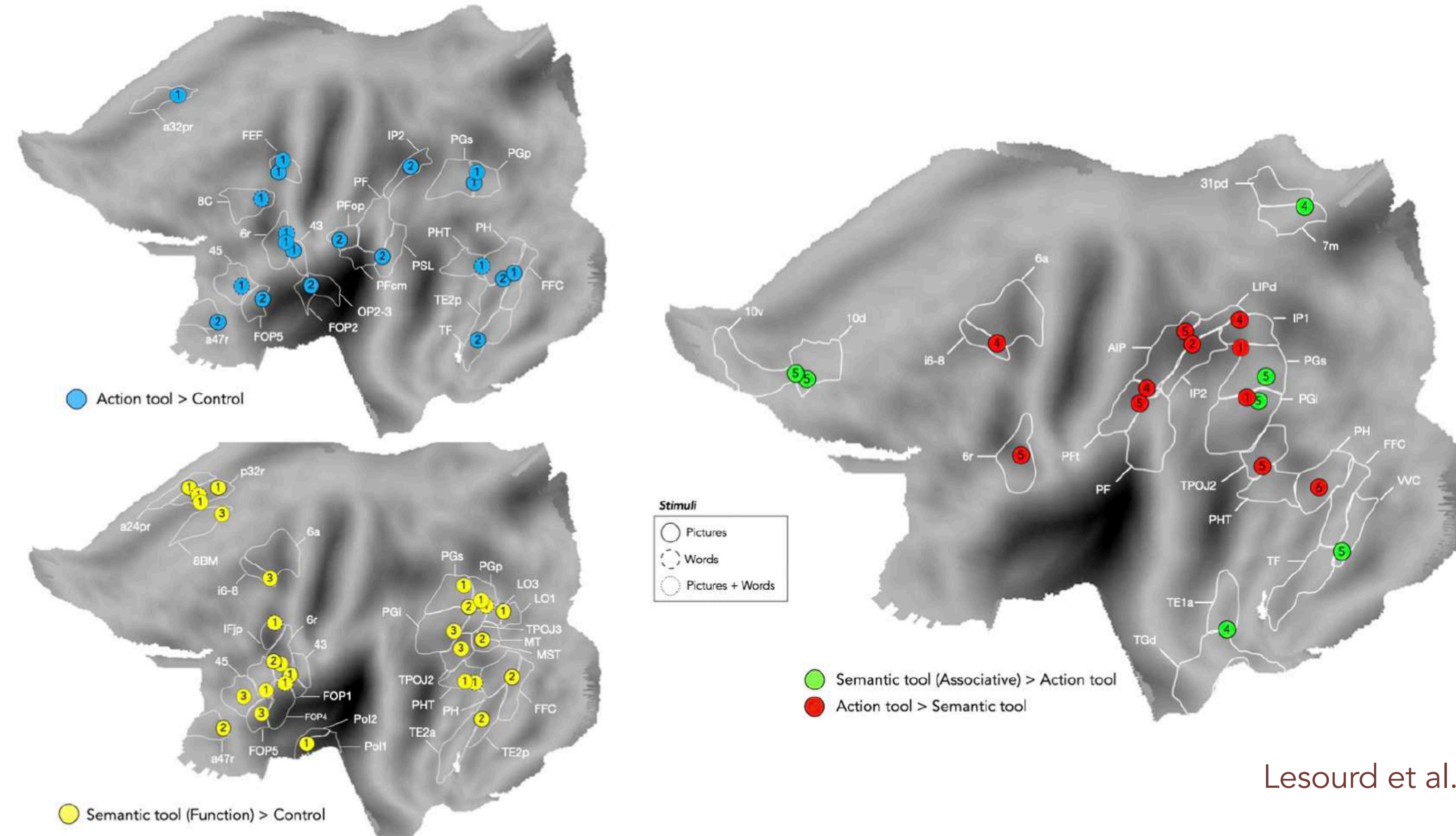
^a Laboratoire de Recherches Intégratives en Neurosciences et Psychologie Cognitive, Université Bourgogne Franche-Comté, F-25000, Besançon, France
^b MSHE Ledoux, CNRS, Université de Bourgogne Franche-Comté, F-25000, Besançon, France
^c Normandie Univ, UNIROUEN, CRFDP, Rouen, France
^d Laboratoire d'Étude des Mécanismes Cognitifs (EA 3082), Université Lyon 2, Bron, France
^e Hôpital Nord Franche-Comté, Soins de Suite et Réadaptation, France
^f Univ. Lille, CNRS, UMR 9193 - SCALab - Sciences Cognitives et Sciences Affectives, F-59000, Lille, France
^g Institut Universitaire de France (IUF), France



Lesourd et al. (2021)

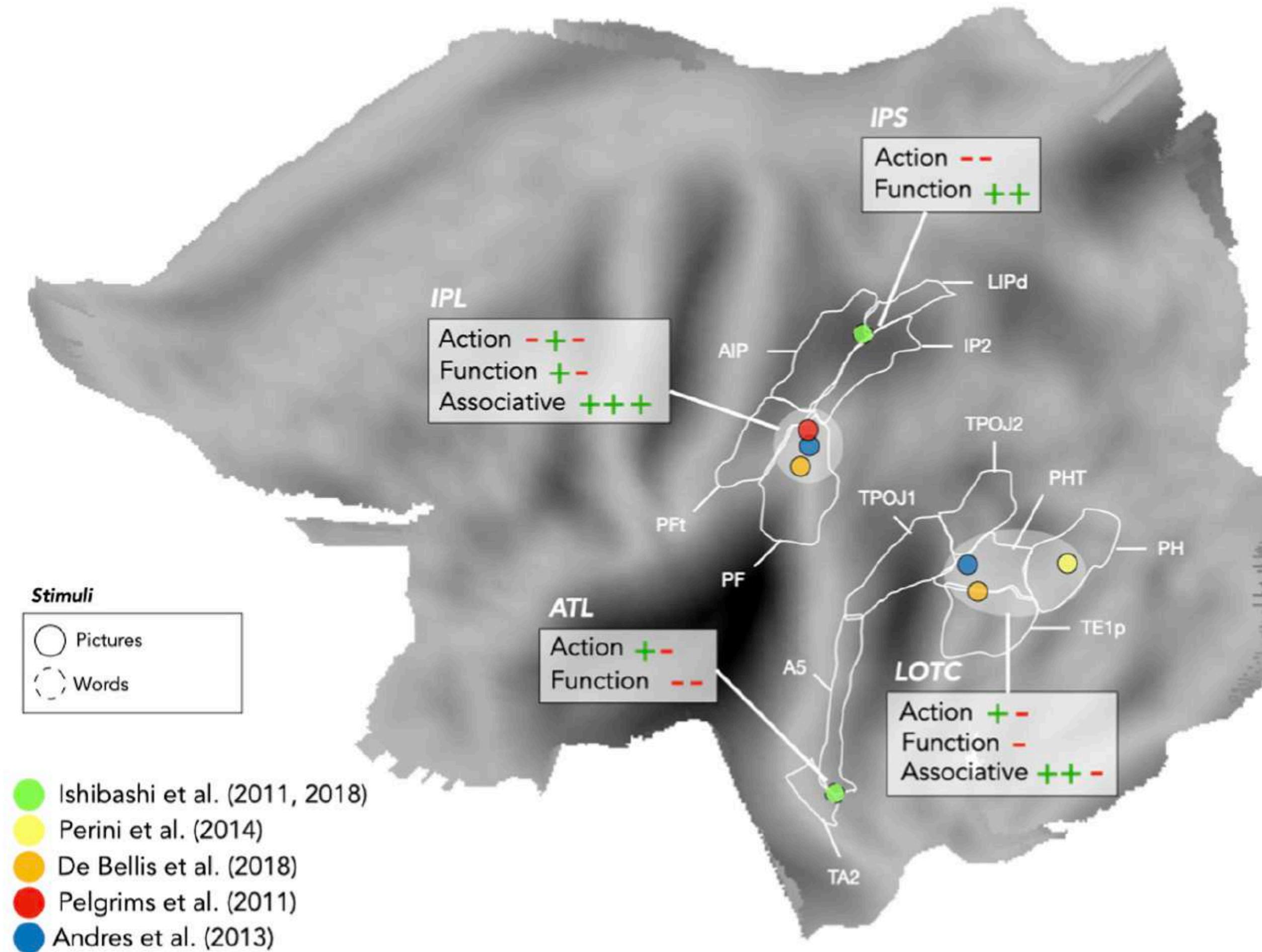
Functional organization of action tool and semantic tool across the TPN

fMRI studies ($n = 6$; 97 healthy subjects; 61 activation peaks)



Functional organization of action tool and semantic tool across the TPN

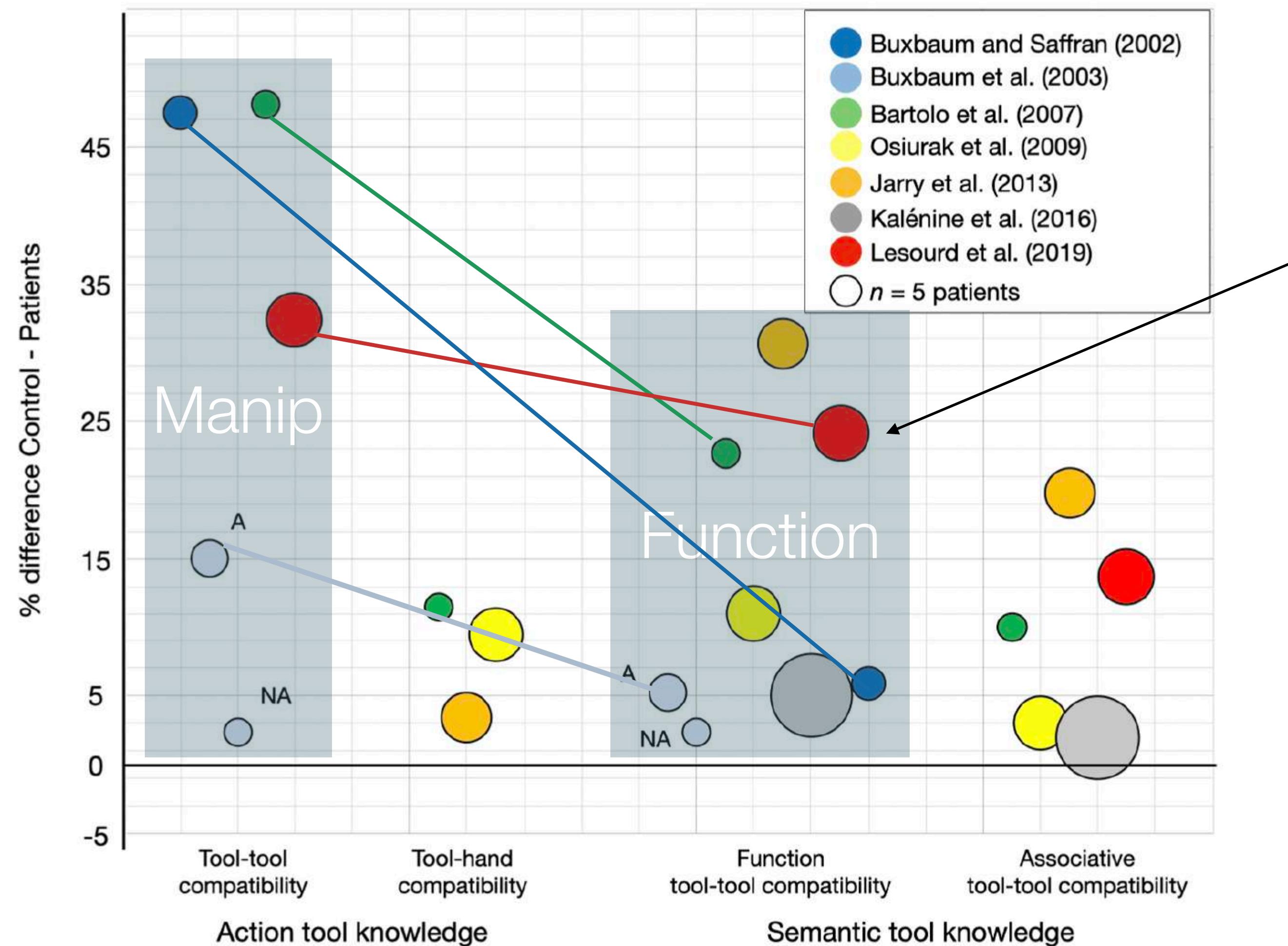
rTMS studies ($n = 6$; 114 healthy subjects; 9 stimulation sites)



Lesourd et al. (2021)

Functional organization of action tool and semantic tool across the TPN

Left brain-damaged patients ($n = 7$ studies; 138 LBD patients)



Lesourd et al. (2019)

- 24% of patients showing dissociations
- All have Function > Manipulation

Lesourd et al. (2021)

Functional organization of action tool and semantic tool across the TPN

The image shows a thumbnail of a journal article from 'Cerebral Cortex'. The title is 'Involvement of the posterior tool processing network during explicit retrieval of action tool and semantic tool knowledge: an fMRI study'. The authors listed are Mathieu Lesourd, Emanuelle Reynaud, Jordan Navarro, Vivien Gaujoux, Alexandrine Faye-Védrines, Boris Alexandre, Josselin Baumard, Giovanni Federico, Franck Lamberton, Danielle Ibarrola, Yves Rossetti, and François Osiurak. The journal information includes 'Cerebral Cortex, 2023, 1–17' and the DOI 'https://doi.org/10.1093/cercor/bhac522'. The Oxford University Press logo is visible in the top left corner.

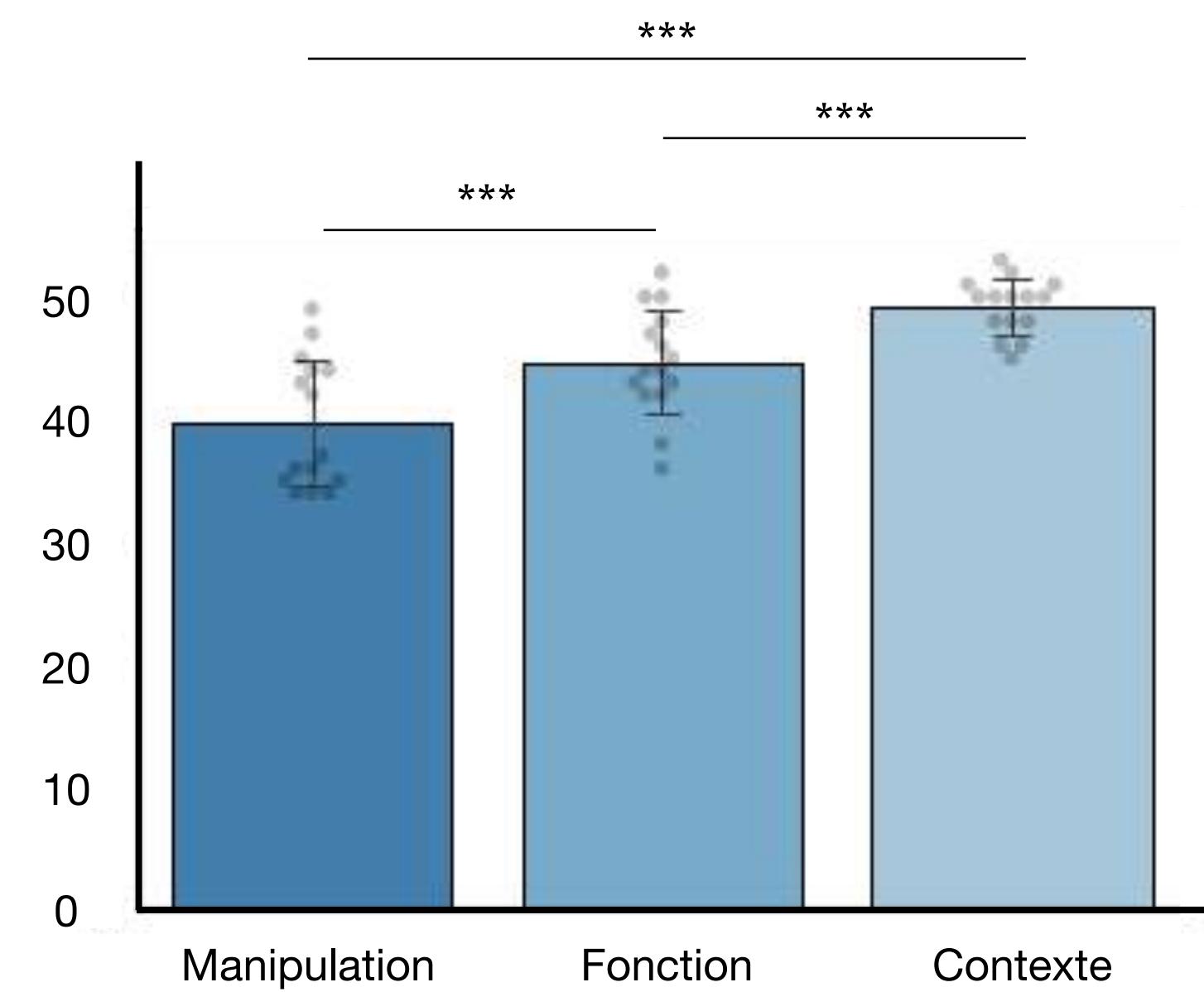
- fMRI study with Manipulation and Function matching tasks
- Involvement of ventral and dorso-ventral pathways
 - IPL: Manipulation (Buxbaum, 2001; van Elk, 2014)
 - LOTC: Manipulation et function (Lingnau & Downing, 2015)
- Functional coupling between IPL and LOTC

Functional organization of action tool and semantic tool across the TPN

Participants

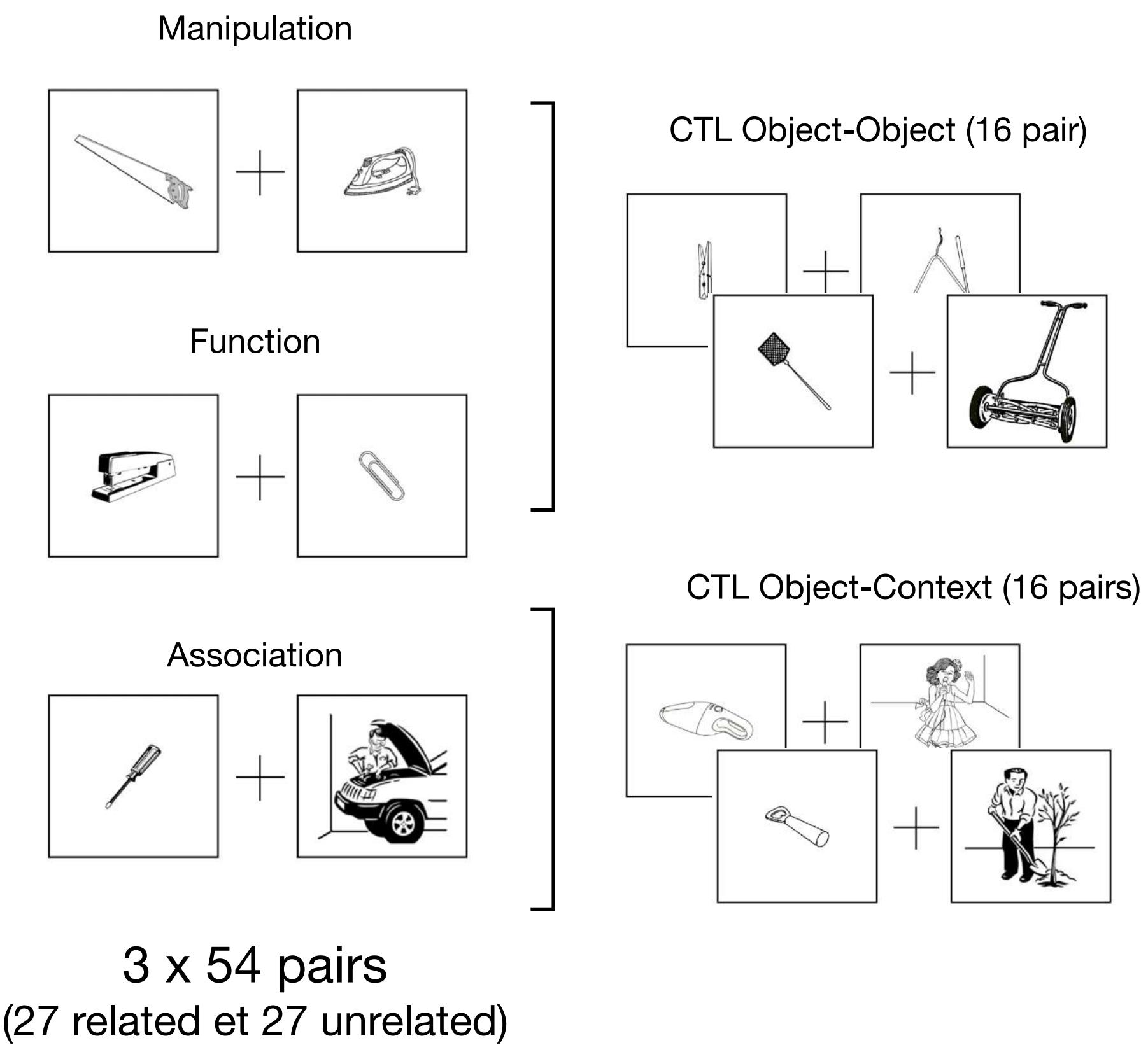
$n = 35$, $M_{age} = 24.2$, $SD_{age} = 4.0$
range = 18-36
21f; 34 right-handers

Pretest ($n = 15$ participants)



Tâche, $F(2,28) = 36.95$, $p < .001$, $\eta_p^2 = 0.73$

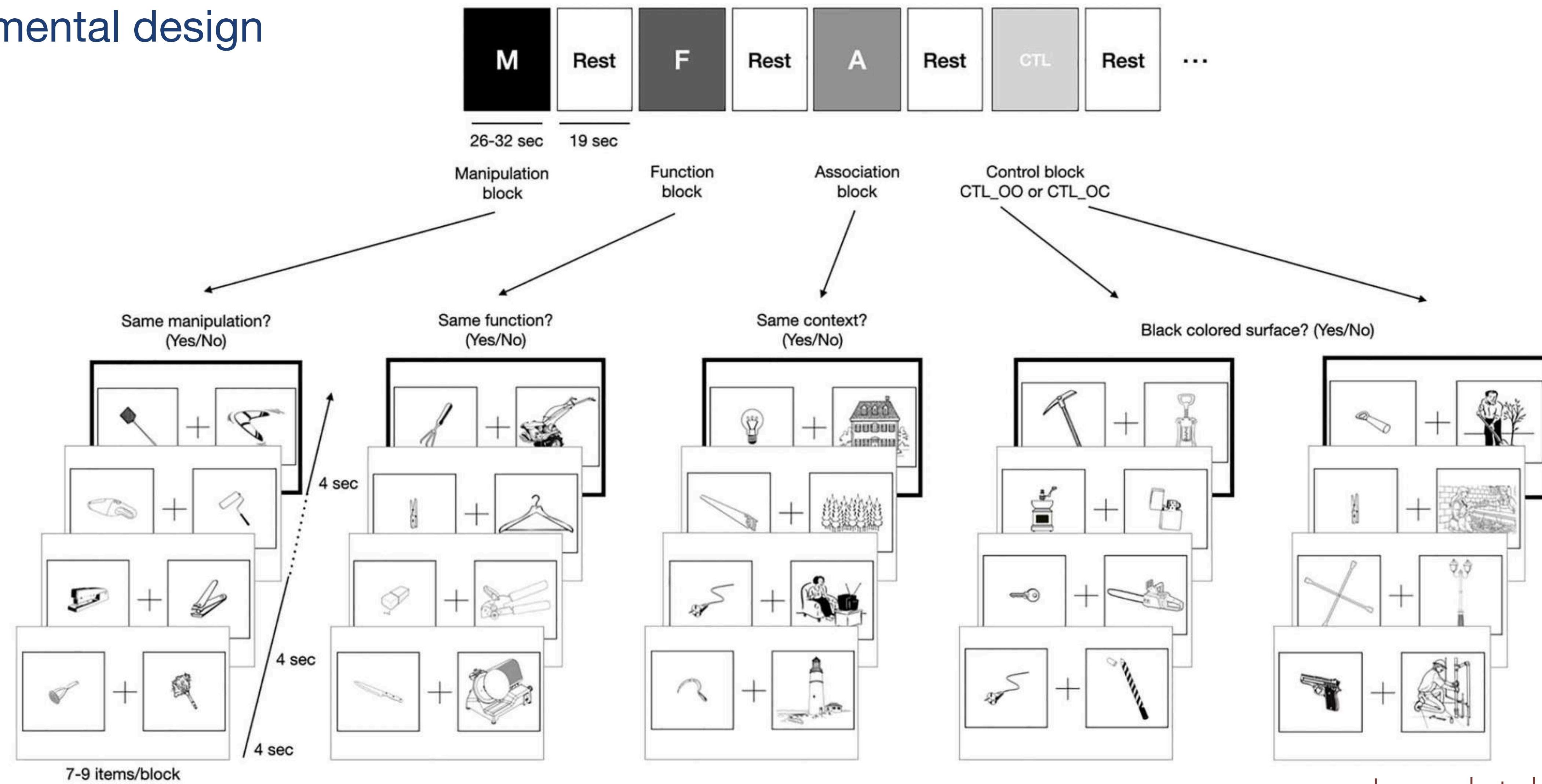
Stimuli



Lesourd et al. (2023)

Functional organization of action tool and semantic tool across the TPN

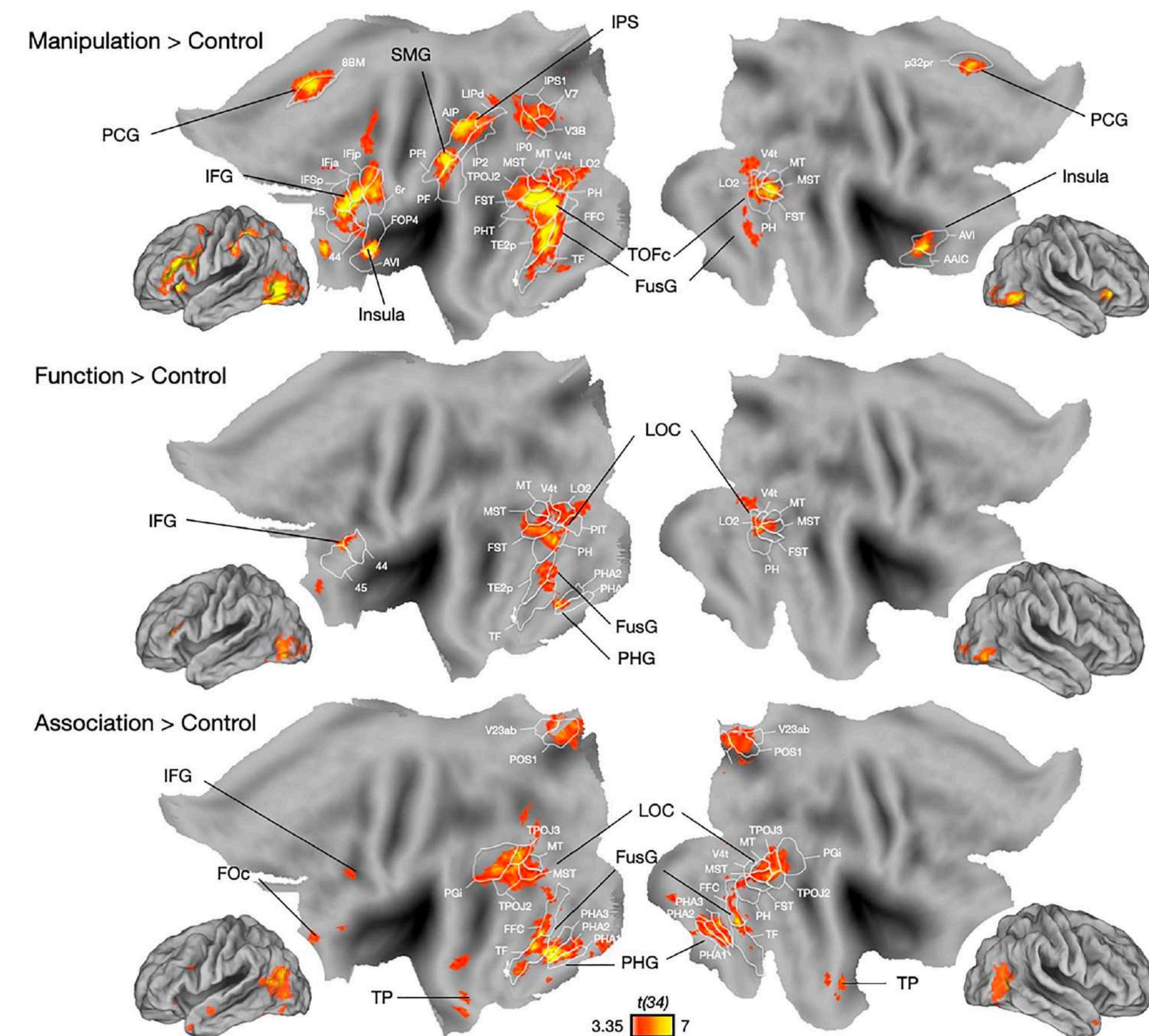
Experimental design



Functional organization of action tool and semantic tool across the TPN

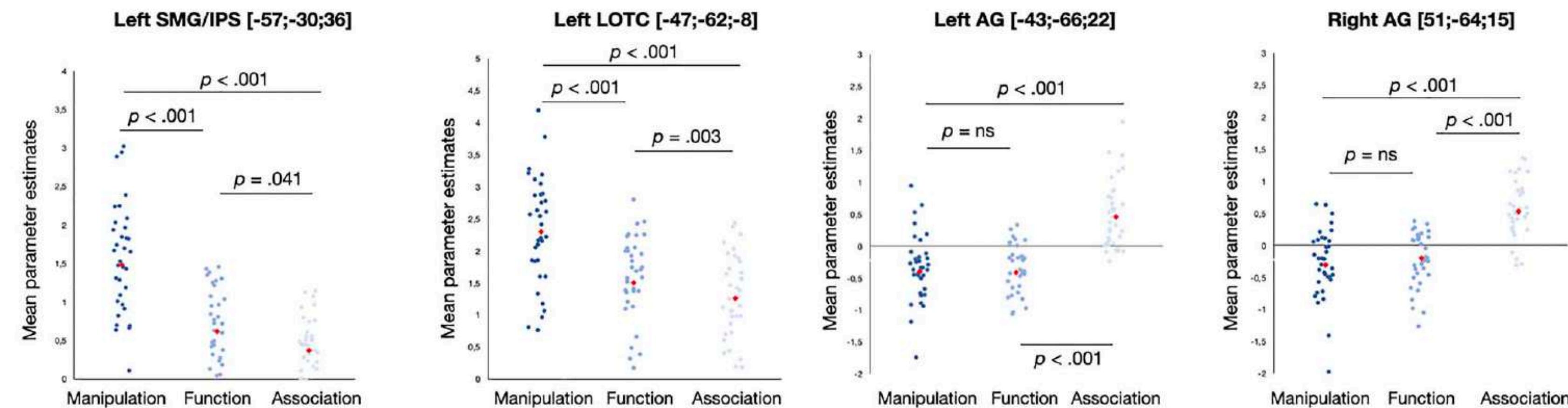
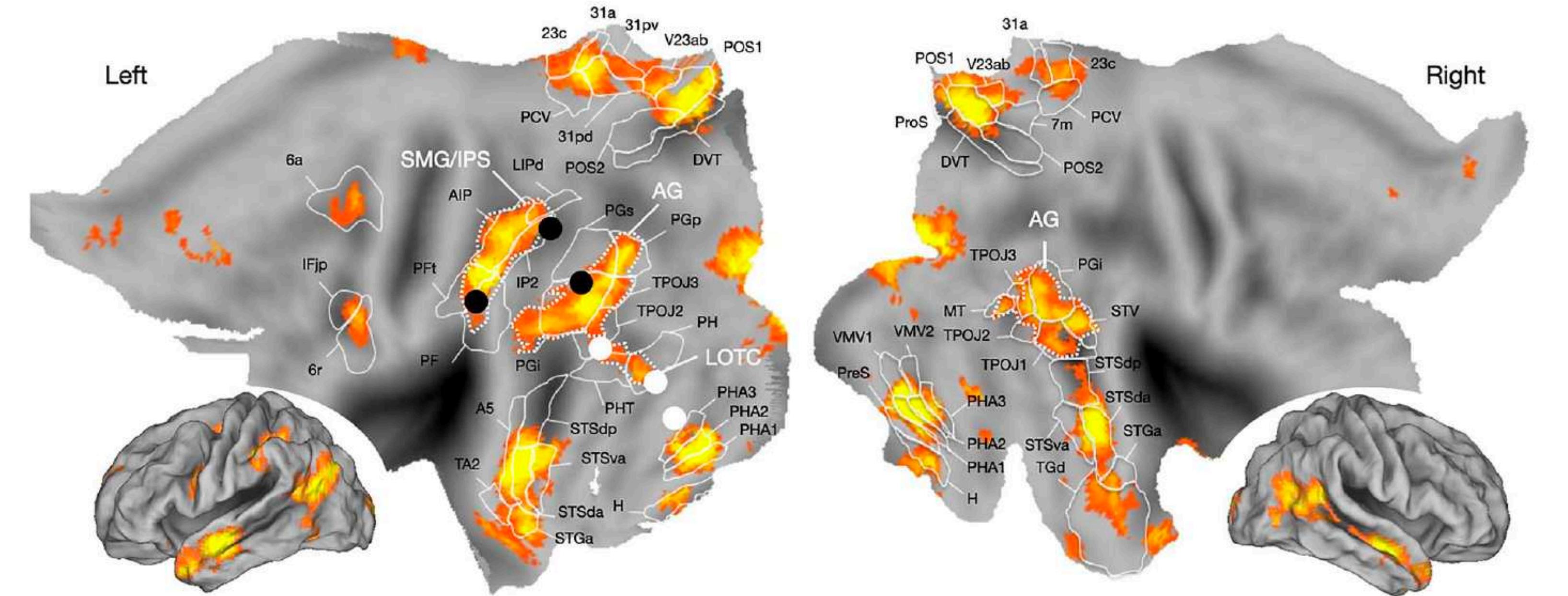
Results

Simple contrasts



Functional organization of action tool and semantic tool across the TPN

Results ANOVA

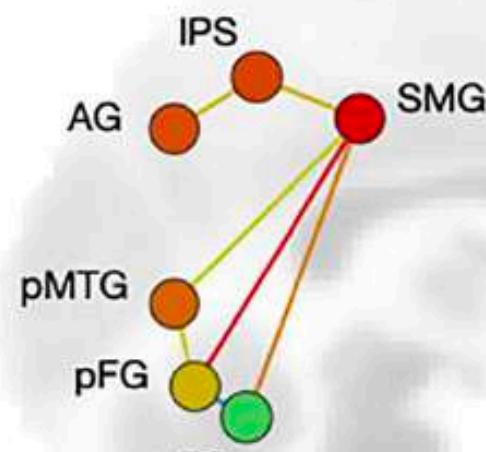


Functional organization of action tool and semantic tool across the TPN

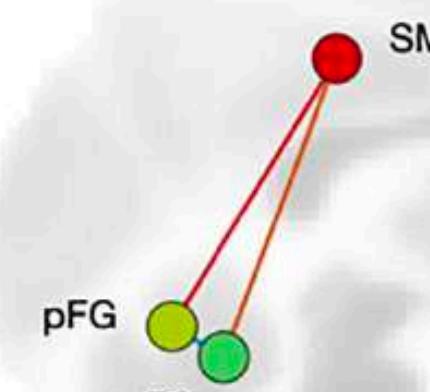
Results

Functional connectivity analysis (ROI-to-ROI; wGLM)

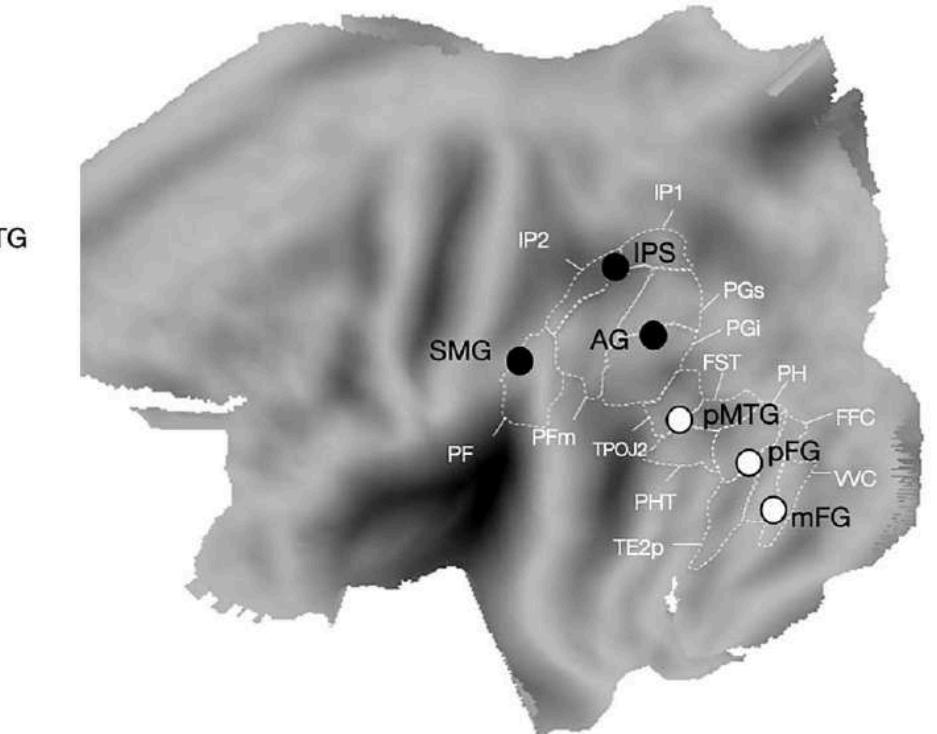
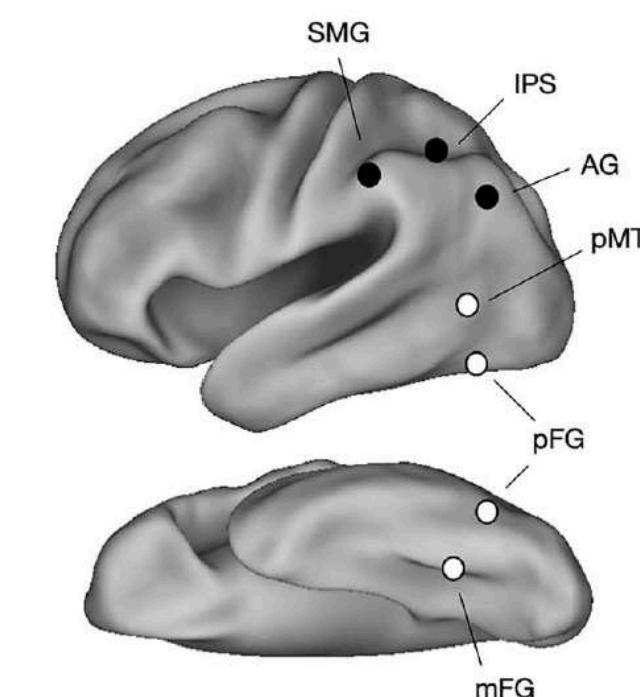
Manipulation



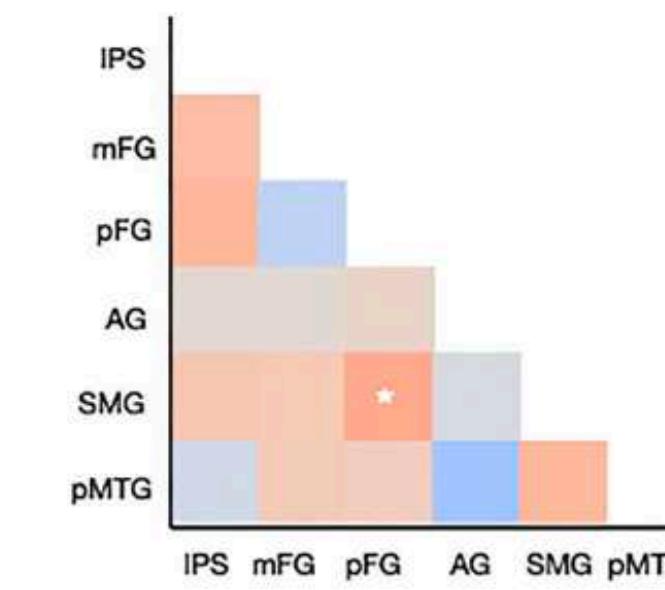
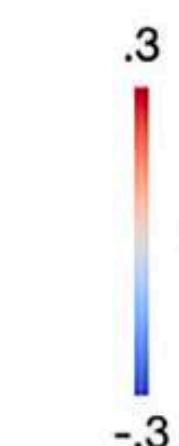
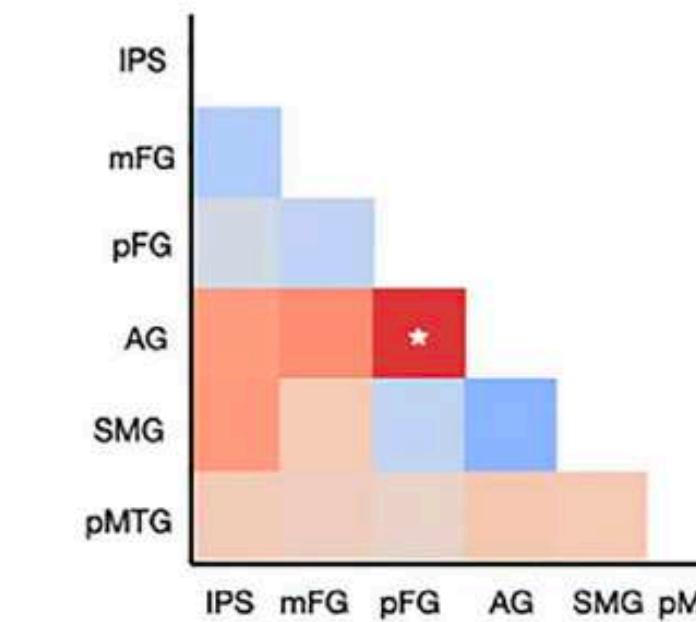
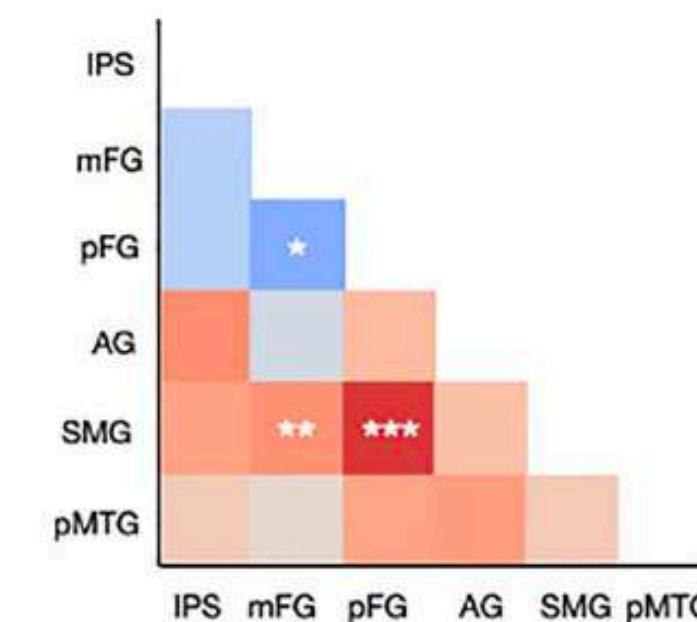
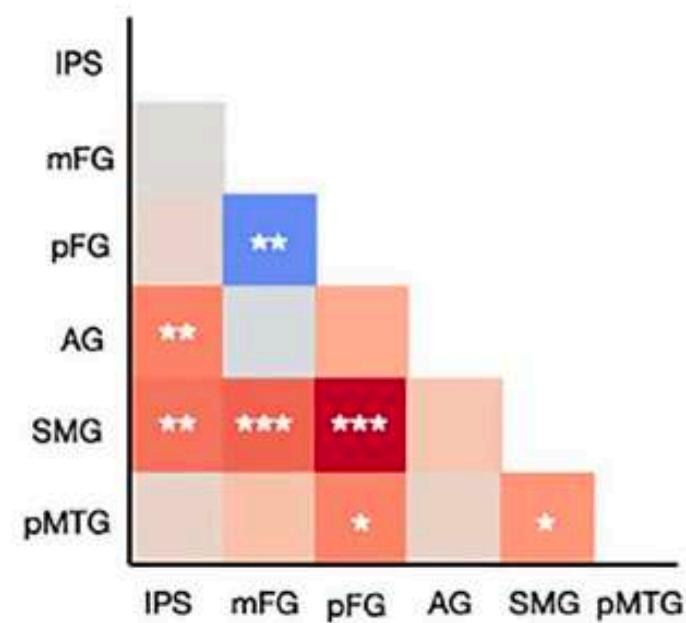
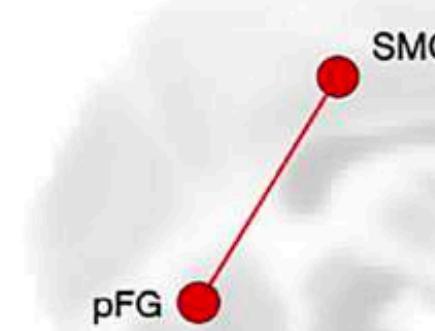
Function



Association



Manipulation > Function



Functional organization of action tool and semantic tool across the TPN

- Specificity IPL/SMG and LOTC for manipulation
 - Gradient Manipulation > Fonction
 - Abstract action representations (Lingnau & Downing, 2015; Reynaud et al., 2019, 2019; Wurm et al., 2017, 2019)
- Action semantics representations emerge from the functional coupling between LOTC and IPL (Hutchison et al., 2018)
- Are manipulation and function separable dimensions?
 - Dissociations... (Garcea et al., 2012; 2013; 2019; Chen et al., 2018)
 - ... are rare (for review Lesourd et al., 2021)

Exploring the effect of brain lesions in action and semantic tool representations

Method and design

Participants

	LBD (n = 30)	RBD (n = 30)	Controls (n = 30)
Age (years)	62.40 (15.59)	62.53 (17.27)	59.17 (16.74)
Sex (Male/Female)	15/15	14/16	11/19
MOCA (/30)	25.69 (2.95)^a	24.52 (3.88)	27.90 (1.75)
Education (years)	12.23 (3.84)	11.50 (1.89)	12.73 (2.30)
Handedness (Right/Left)	27/3	30/0	28/2
Lesion volume (cm ³)	9.38 (24.07)	22.85 (32.81)	-
Interval lesion onset (days)	127.60 (38.87)	133.00 (52.01) ^b	-

Bold values indicated significant differences between patients and controls

Italic values indicated significant differences between LBD and RBD patients

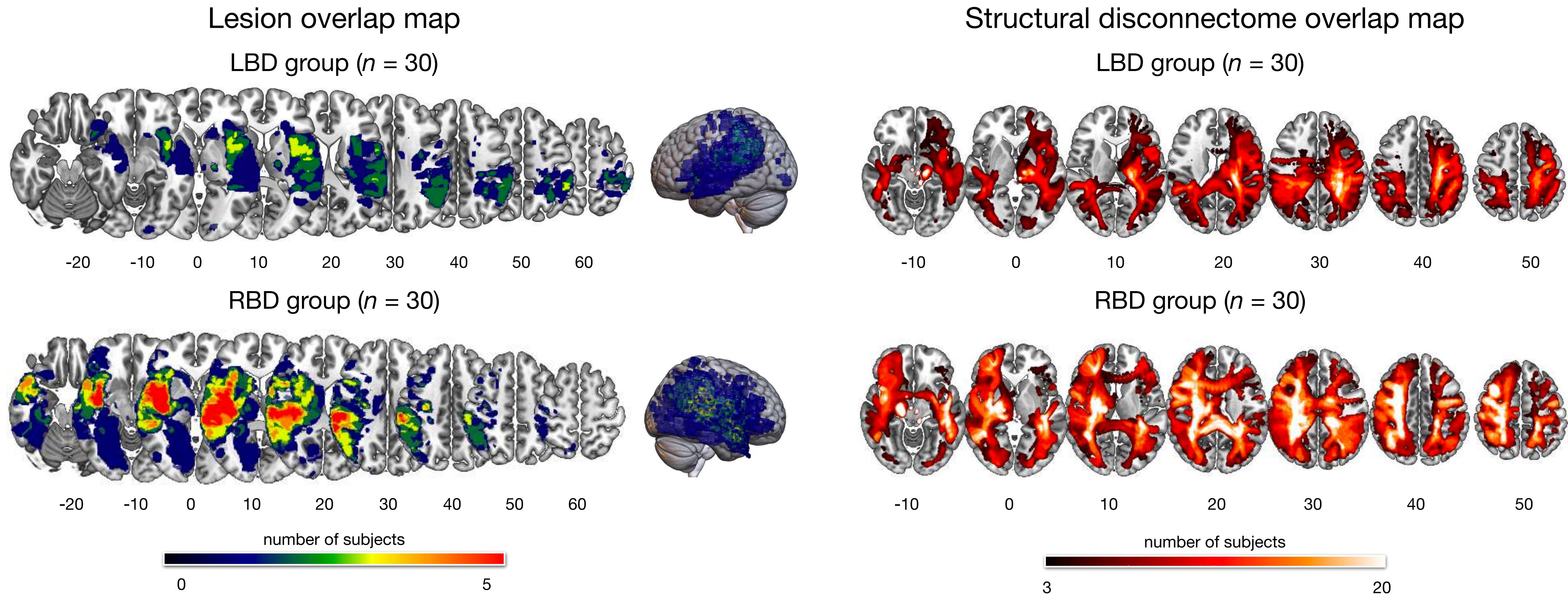
^a MOCA scores were not available for one patient

^b Interval lesion onset days were not available for two patients

Exploring the effect of brain lesions in action and semantic tool representations

Method and design

Participants



Exploring the effect of brain lesions in action and semantic tool representations

Method and design

Task

Manipulation



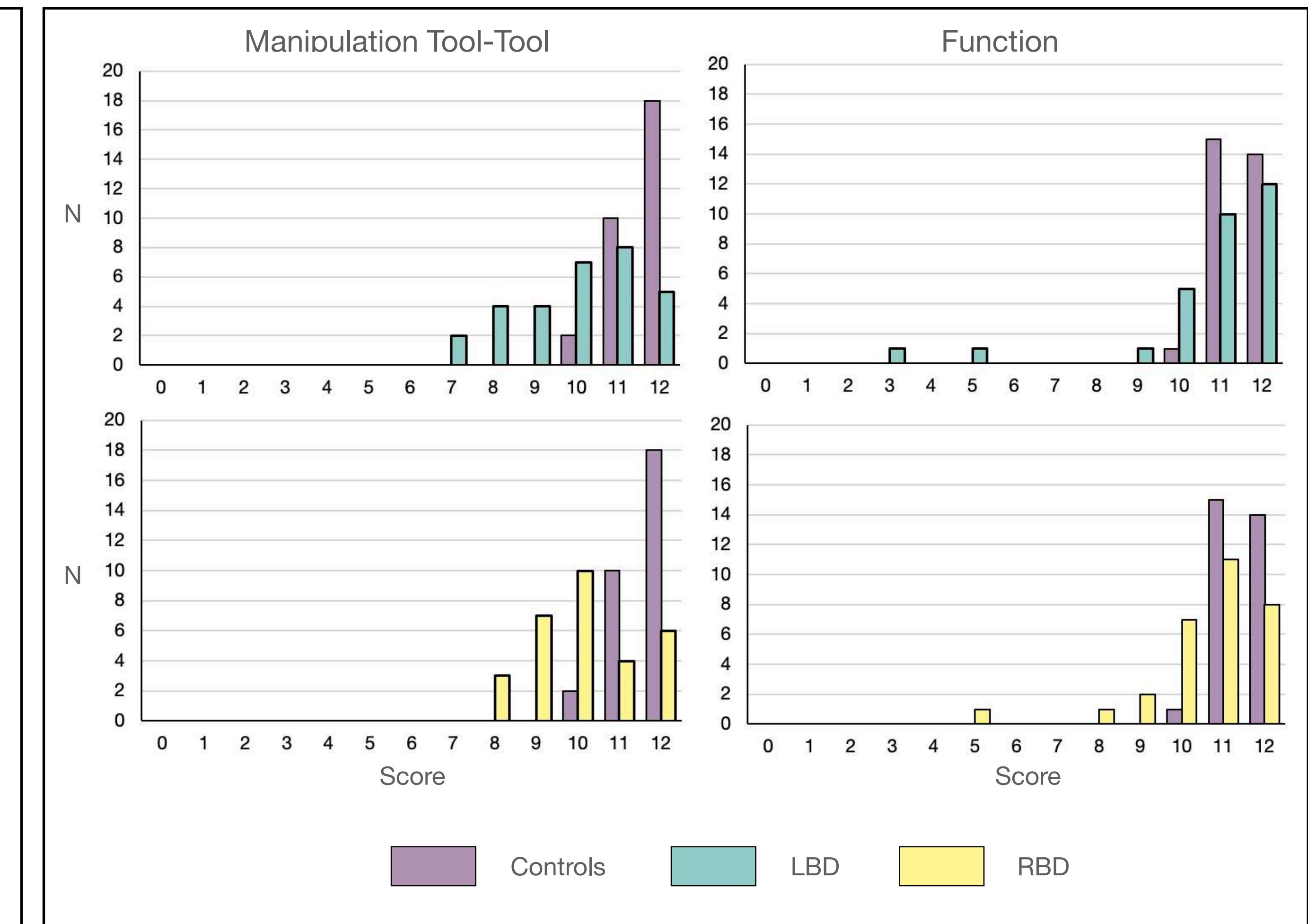
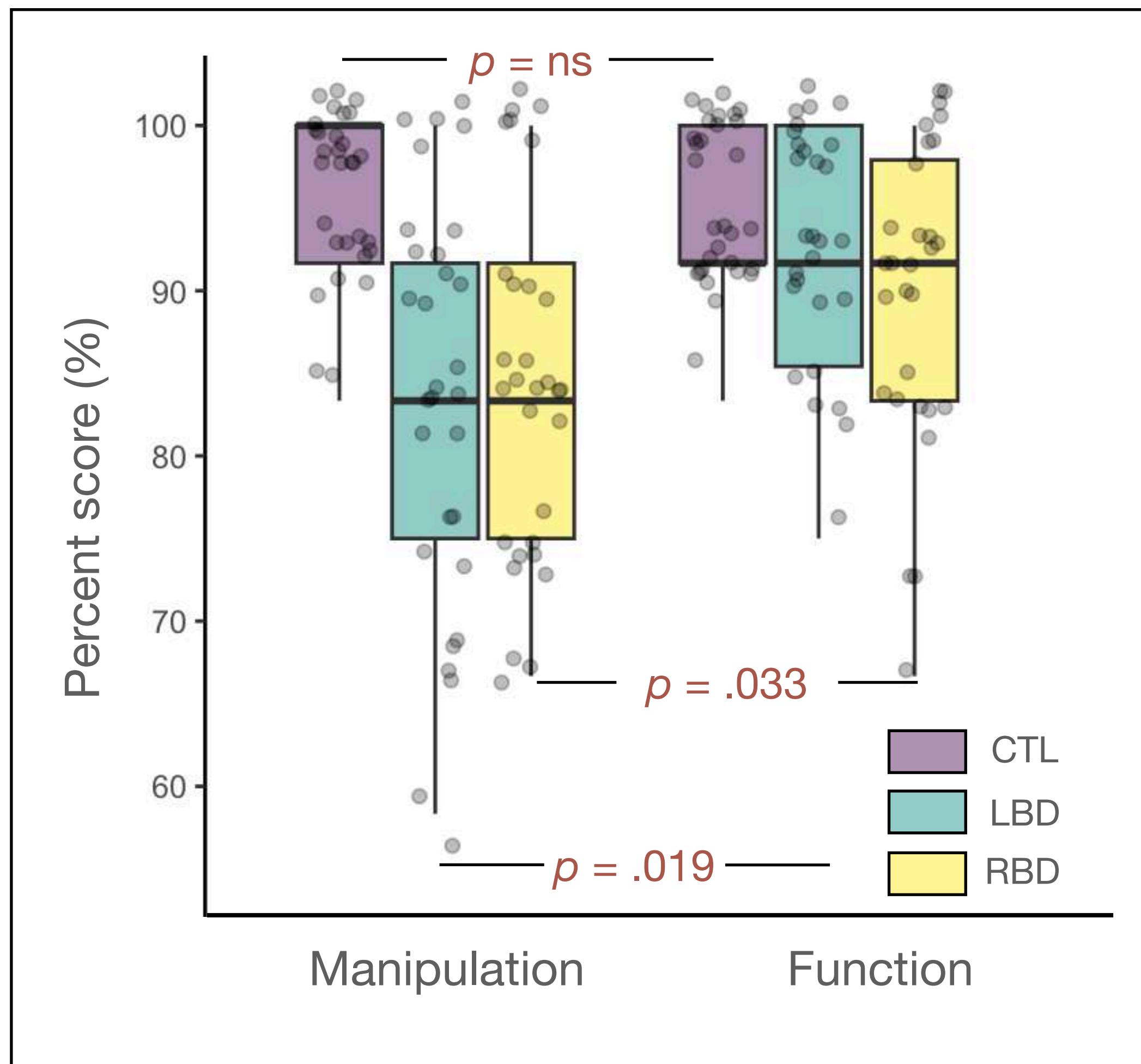
Function



Exploring the effect of brain lesions in action and semantic tool representations

Results

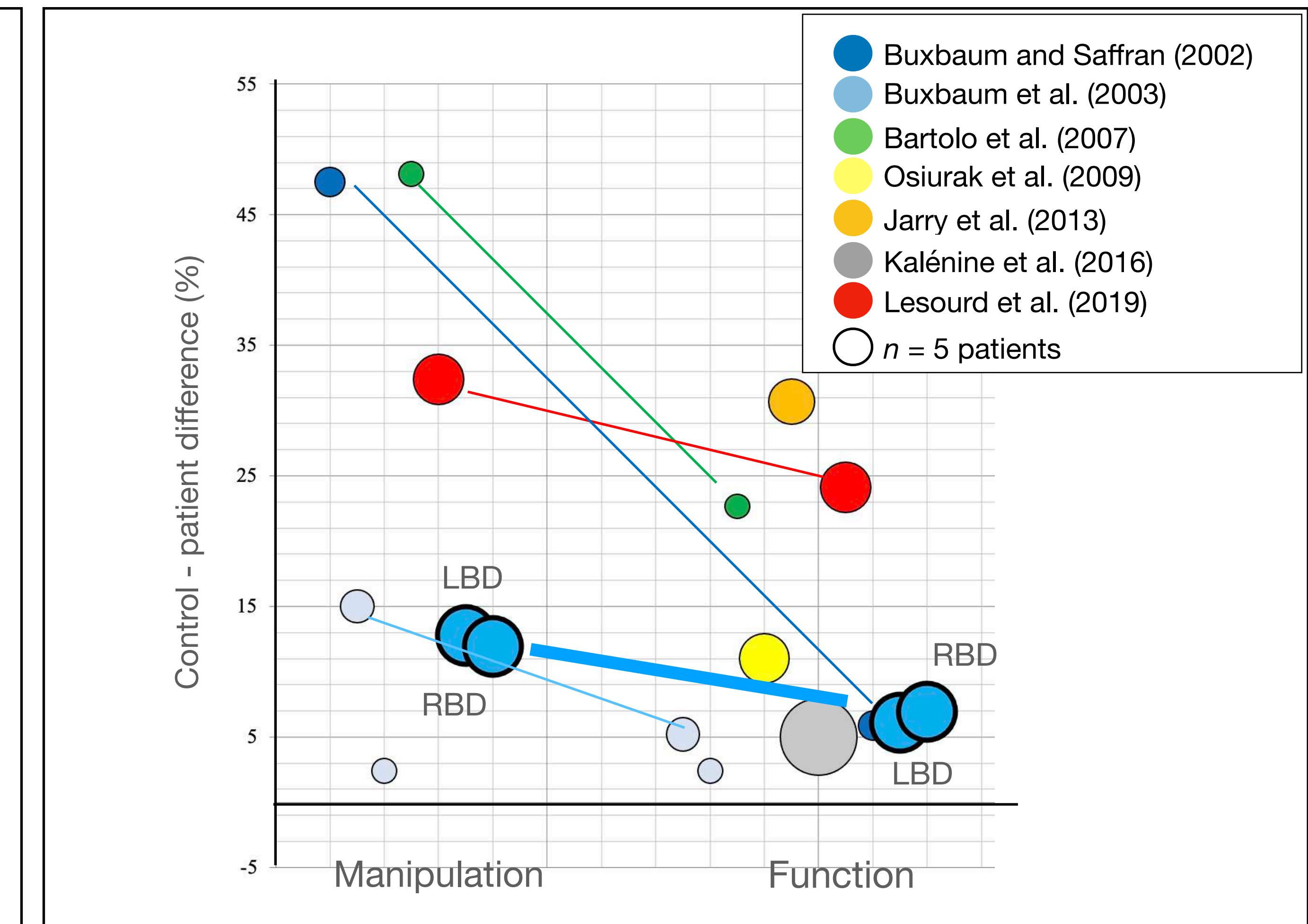
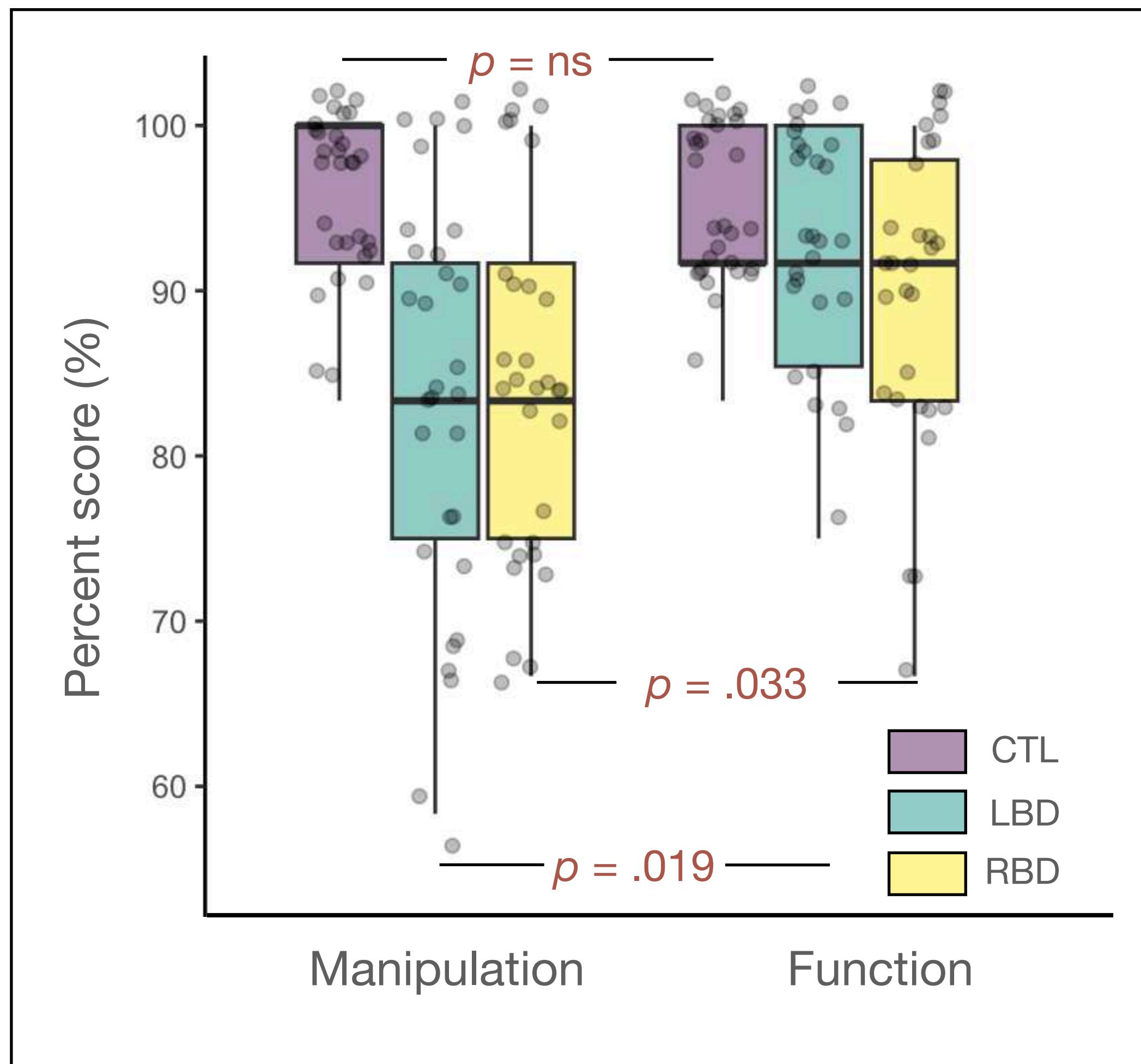
Group analysis



Exploring the effect of brain lesions in action and semantic tool representations

Results

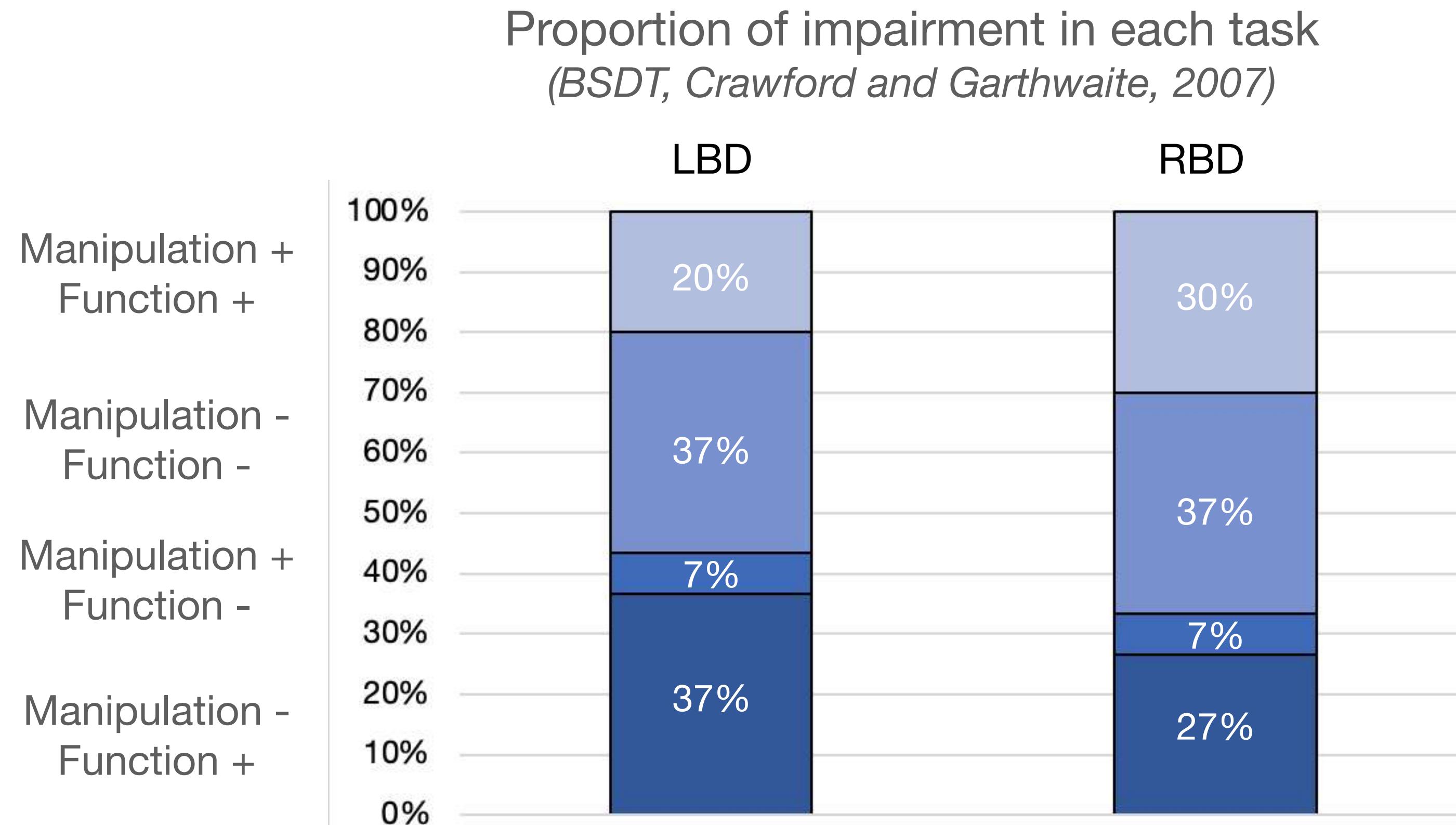
Group analysis



Exploring the effect of brain lesions in action and semantic tool representations

Results

Neuropsychological dissociations



Exploring the effect of brain lesions in action and semantic tool representations

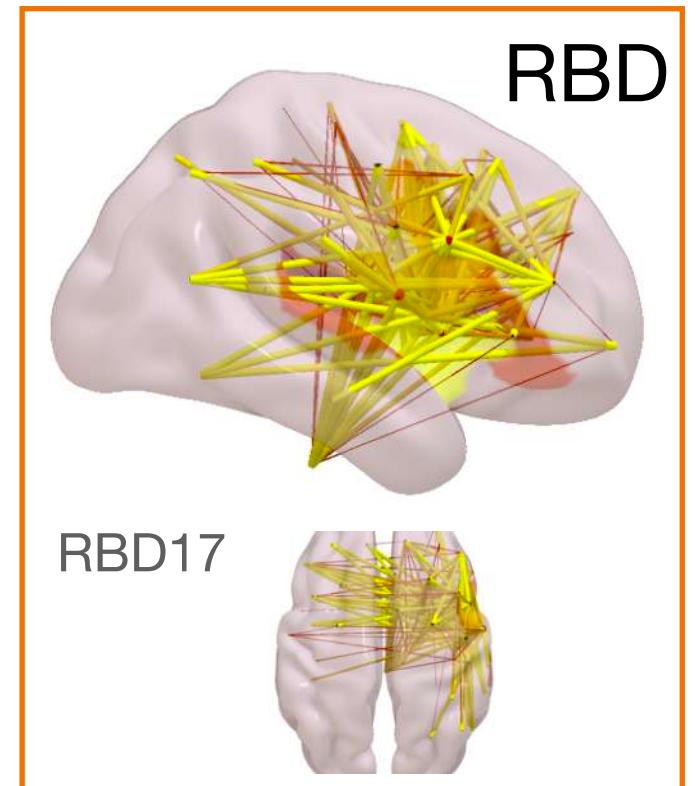
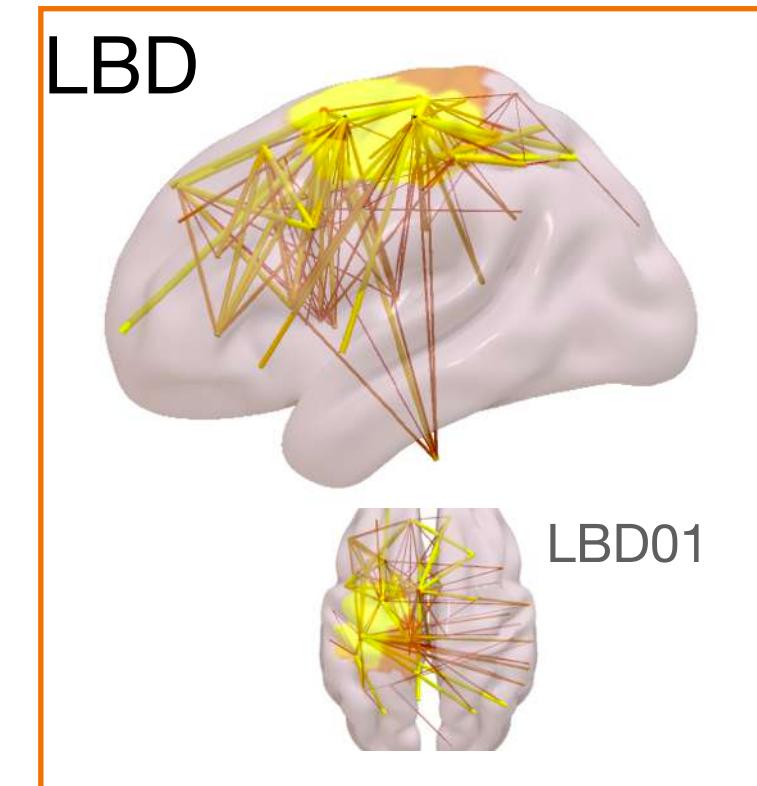
Results

Additional cases analyses (Metzgar et al., 2022)

- Patients selected based on low lesion volume (within-group mean-split)
- Manipulation regressed by function and *vice versa*
- Studentized residuals to identify participants performing worse than expected either in manipulation or in function, $t(29) = -1.70$, $p < .05$

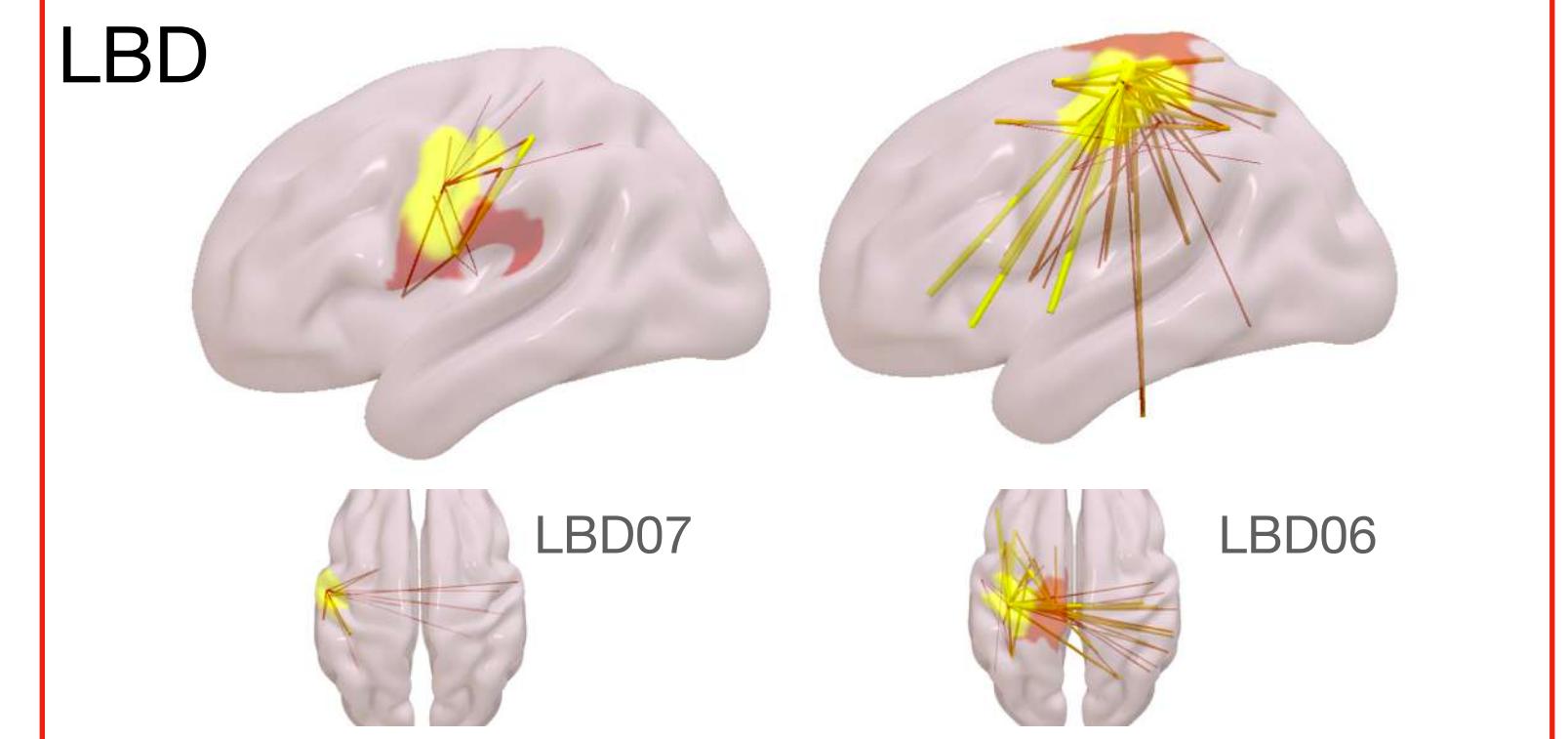
- Function < Manipulation

Manipulation **impaired** Function **impaired**



- Manipulation < Function

Manipulation **impaired** Function **spared**

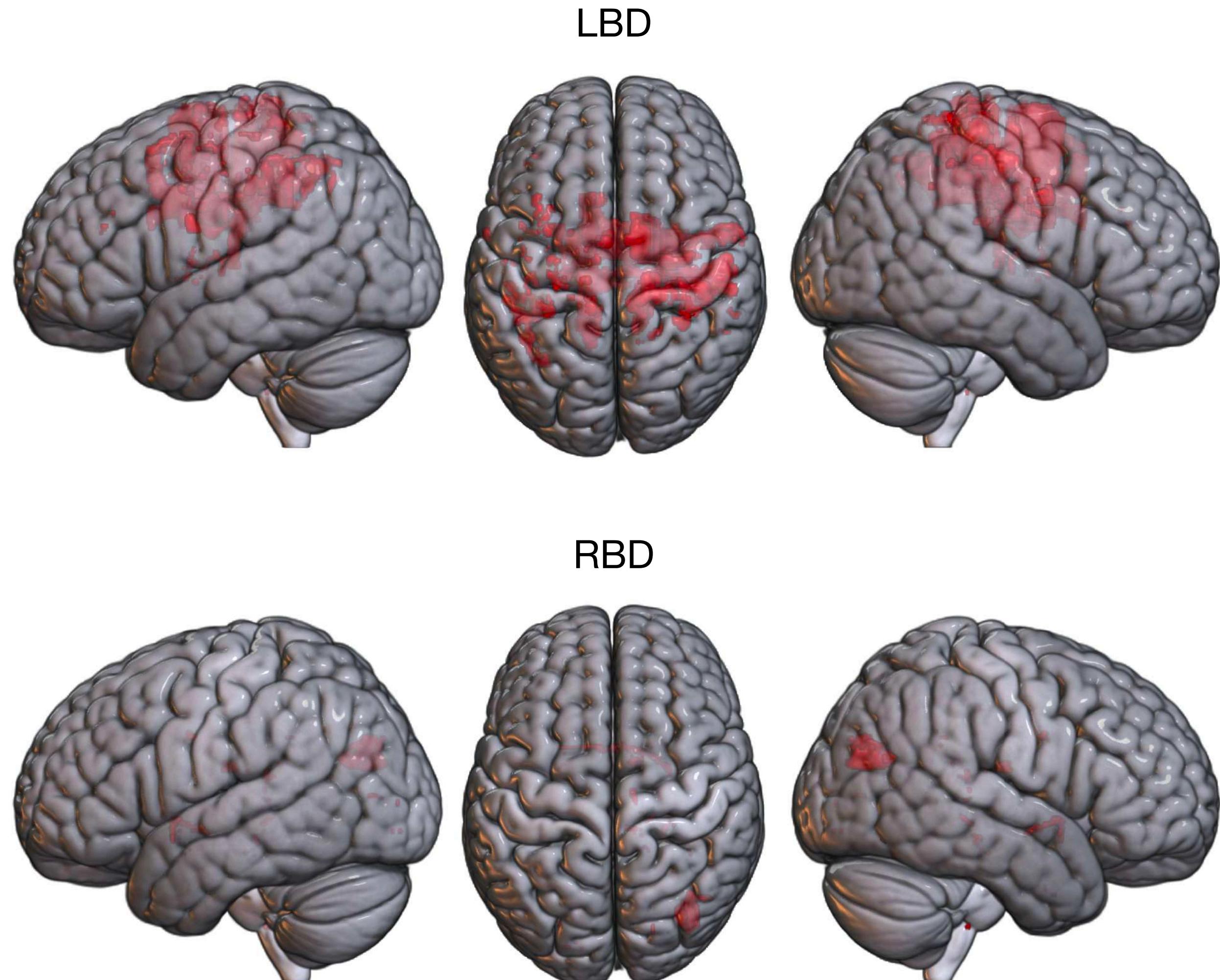


Exploring the effect of brain lesions in action and semantic tool representations

Results (preliminary)

SVR-DSM for *manipulation* scores

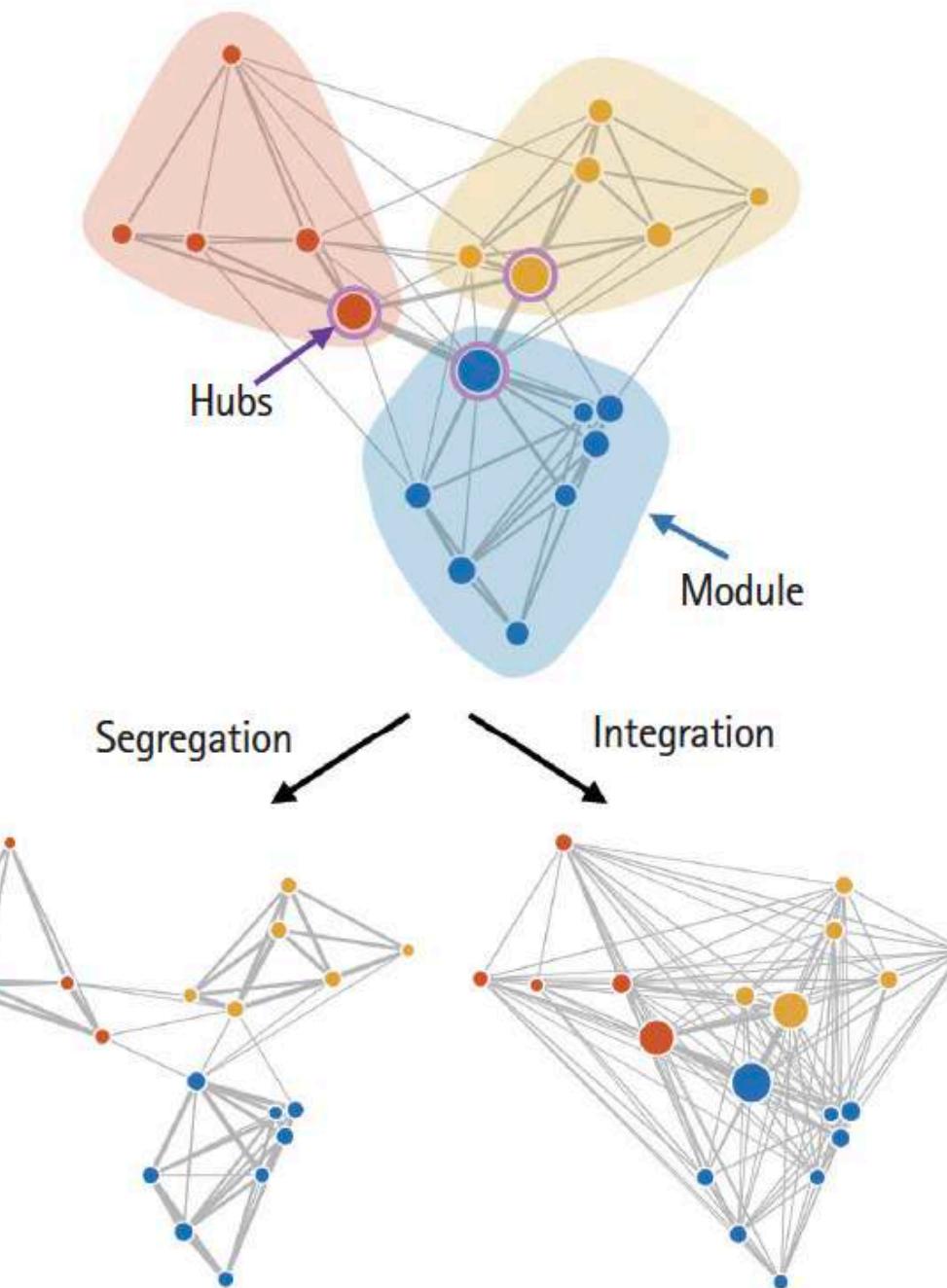
- Disconnectome maps entered in SVR-DSM analysis (DeMarco & Turkeltaub, 2018)
- Volume lesions regressed from both behavioral and lesions data
- Voxelwise thresholded at $p<0.01$ after 5000 permutations



Conclusion

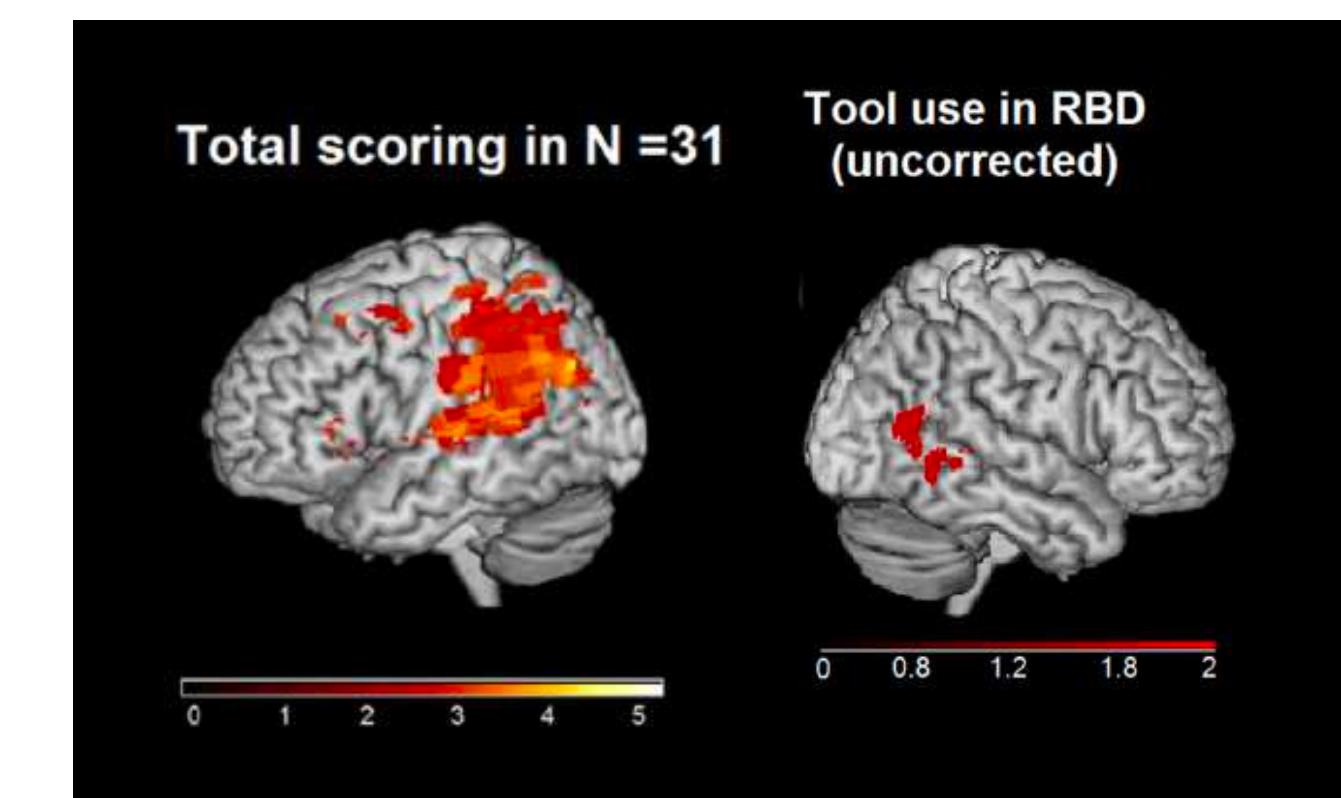
- Manipulation and function representations intrinsically related in the TPN with a particular organization

- Involvement of common and distinct brain regions
- Pattern of functional coupling
- Neuropsychological dissociations



Lim et al. (2021)

- Distinct contributions of left and right hemispheres?



Salazar-Lopez et al. (2016)

Perspectives

- What is the role of the right hemisphere following stroke in cognitive recovery?

NeuroImage: Clinical 21 (2019) 101526



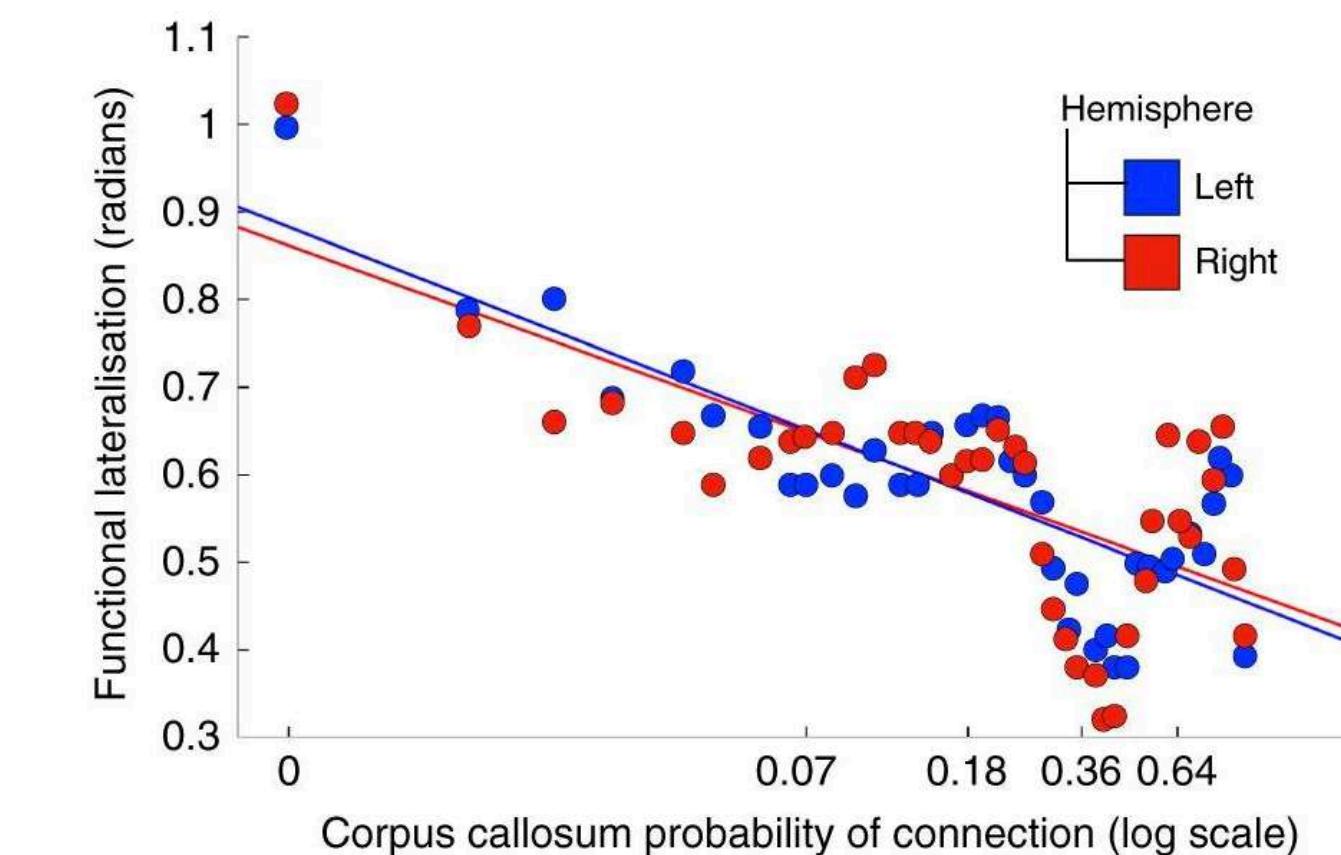
Bilateral functional connectivity at rest predicts apraxic symptoms after left hemisphere stroke

Christine E. Watson^{a,1}, Stephen J. Gotts^{b,1}, Alex Martin^b, Laurel J. Buxbaum^{a,*}

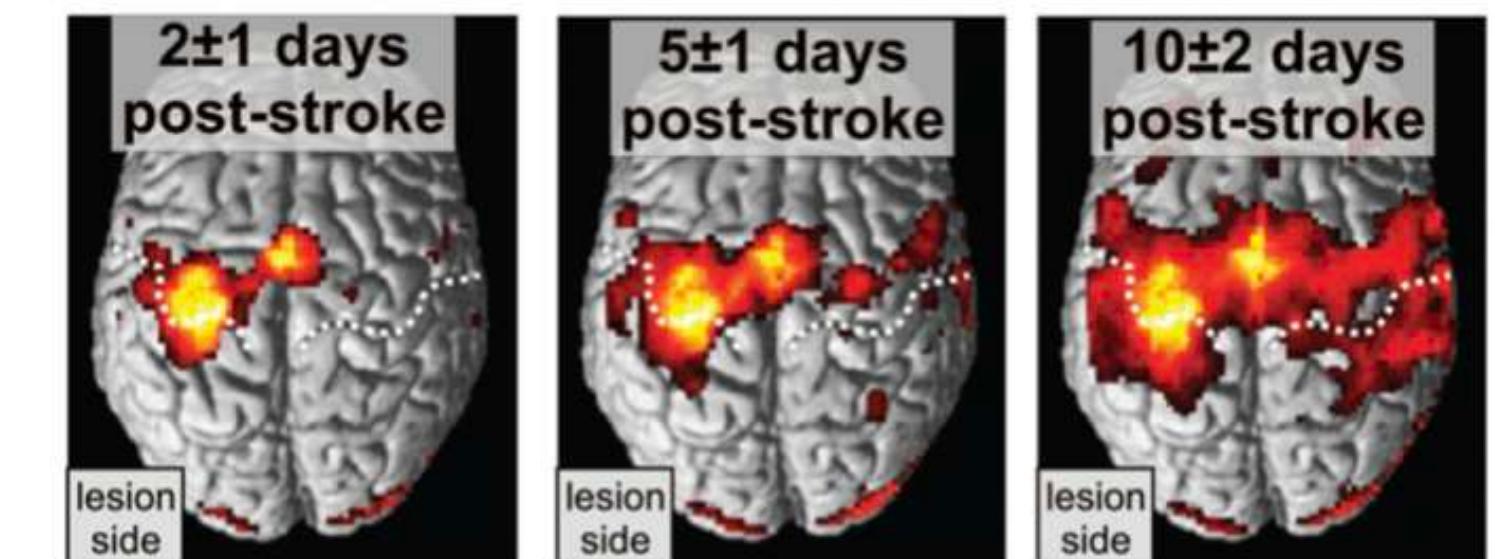
^a Moss Rehabilitation Research Institute, Elkins Park, PA 19027, USA

^b Laboratory of Brain and Cognition, National Institute of Mental Health, NIH, Bethesda, MD 20892, USA

- Unravelling the fine-grain representations of action semantics embedded in the right hemisphere (right LOTC) and its « potential » reorganization from acute to chronic stage post-stroke



Karolis et al. (2019)



Rehme et al. (2011)

Thanks for your attention!
