WHAT PARIETAL APRAXIA REVEALS ABOUT THE BRAIN'S TWO ACTION SYSTEMS

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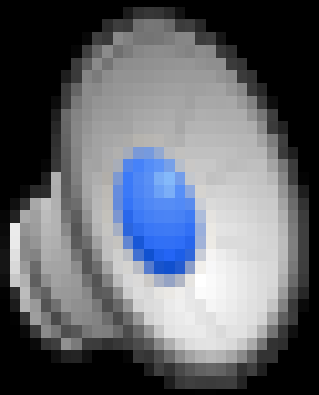
LIMB APRAXIA

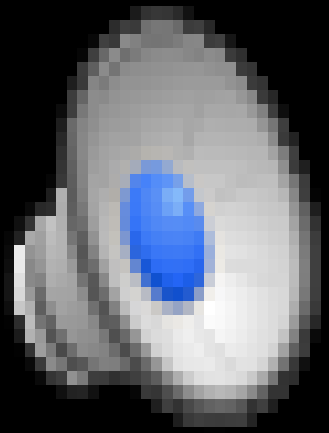
- **A cluster of deficits in skilled action not attributable to weakness or incoordination**
- **Occurs in ≈ 50% of left hemisphere stroke**
- **Deficits in pantomime of tool actions, imitation of meaningful and meaningless actions (bilaterally), and/or action recognition**
- **Historical and current confusion about terminology and characteristics (e.g., ideomotor vs. ideational).**
- **Obfuscation drives researchers away from studying the disorder.**

Our approach (cognitive neuropsychology/cognitive neuroscience):

1) Develop a componential cognitive neuroanatomical model of the brain regions subserving different aspects of action production and recognition.

2) Understand the computational mechanisms that underlie these components.

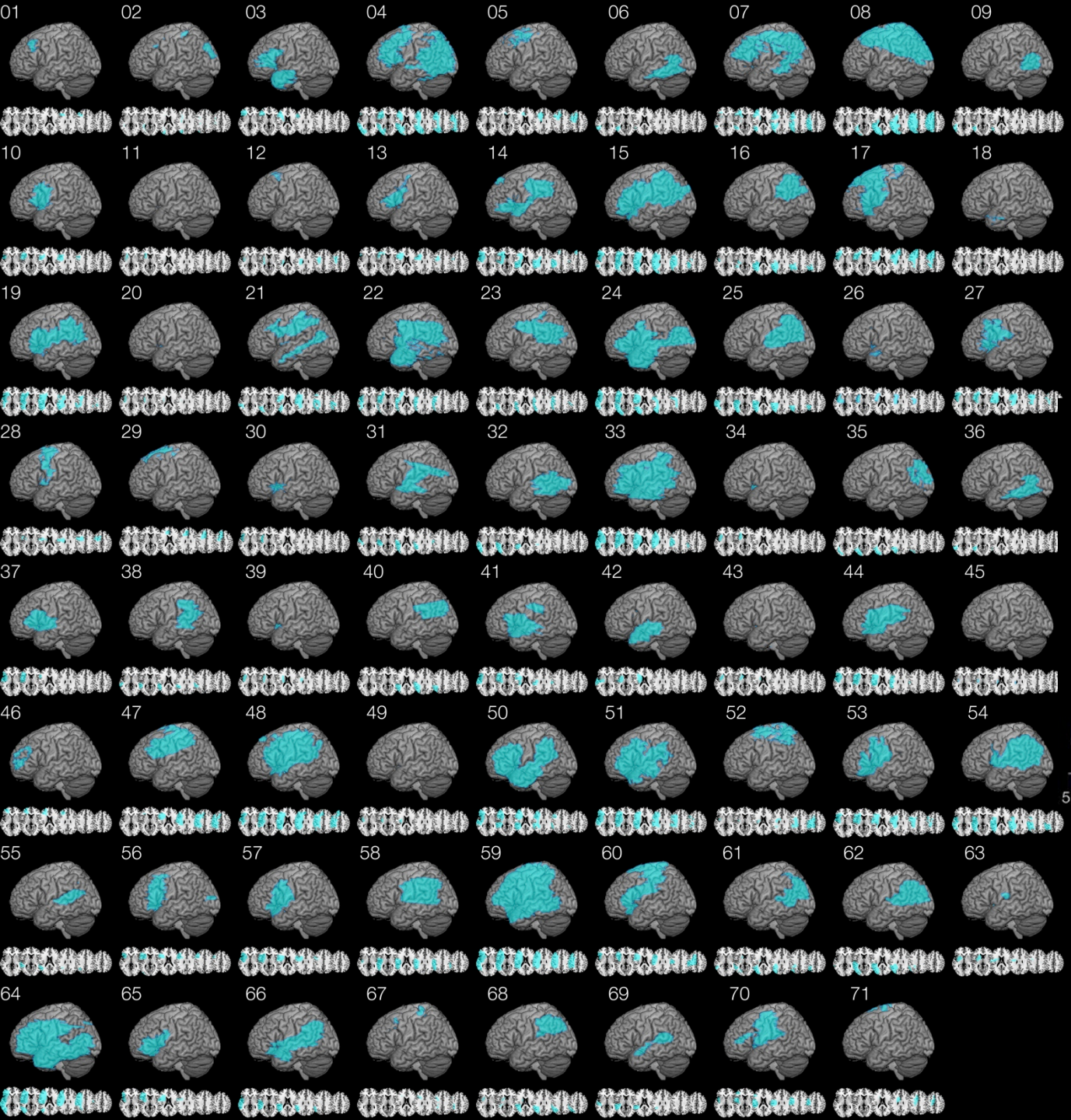


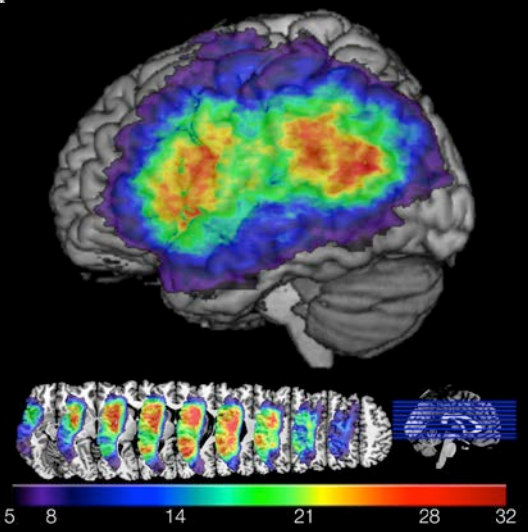


A

B

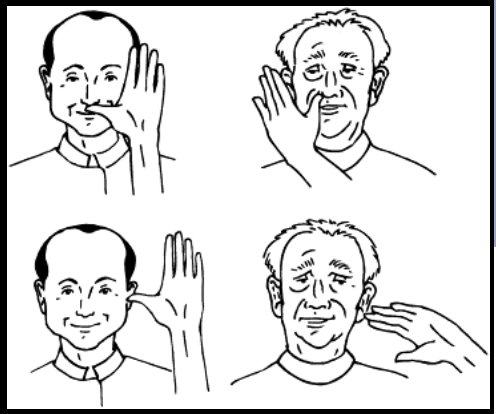
PART 1: WHICH BRAIN REGIONS ARE CRITICAL FOR WHICH *COMPONENTS* OF SKILLED ACTION?

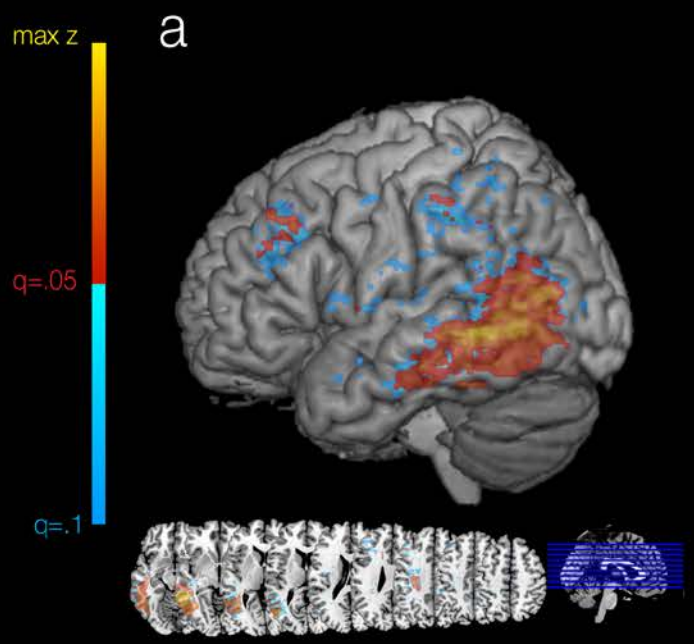




Buxbaum, Shapiro, & Coslett, *Brain* 2014

(patient image removed)

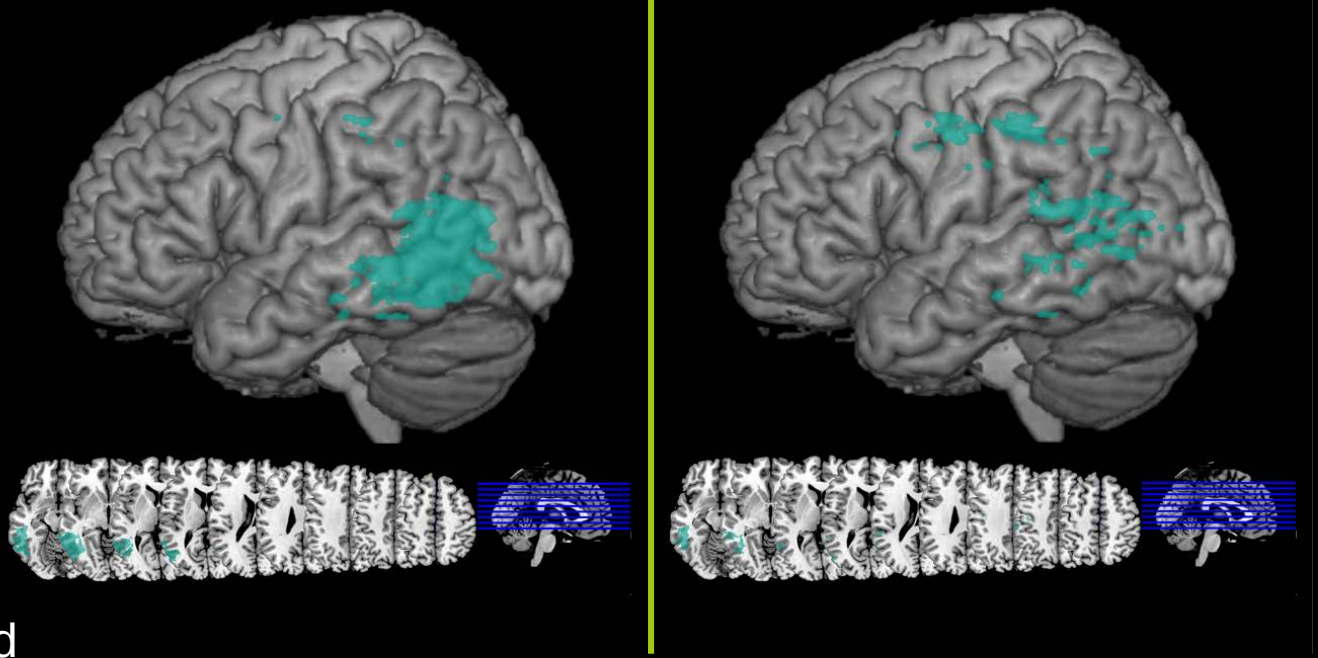




Buxbaum, Shapiro, & Coslett, *Brain* 2014

a

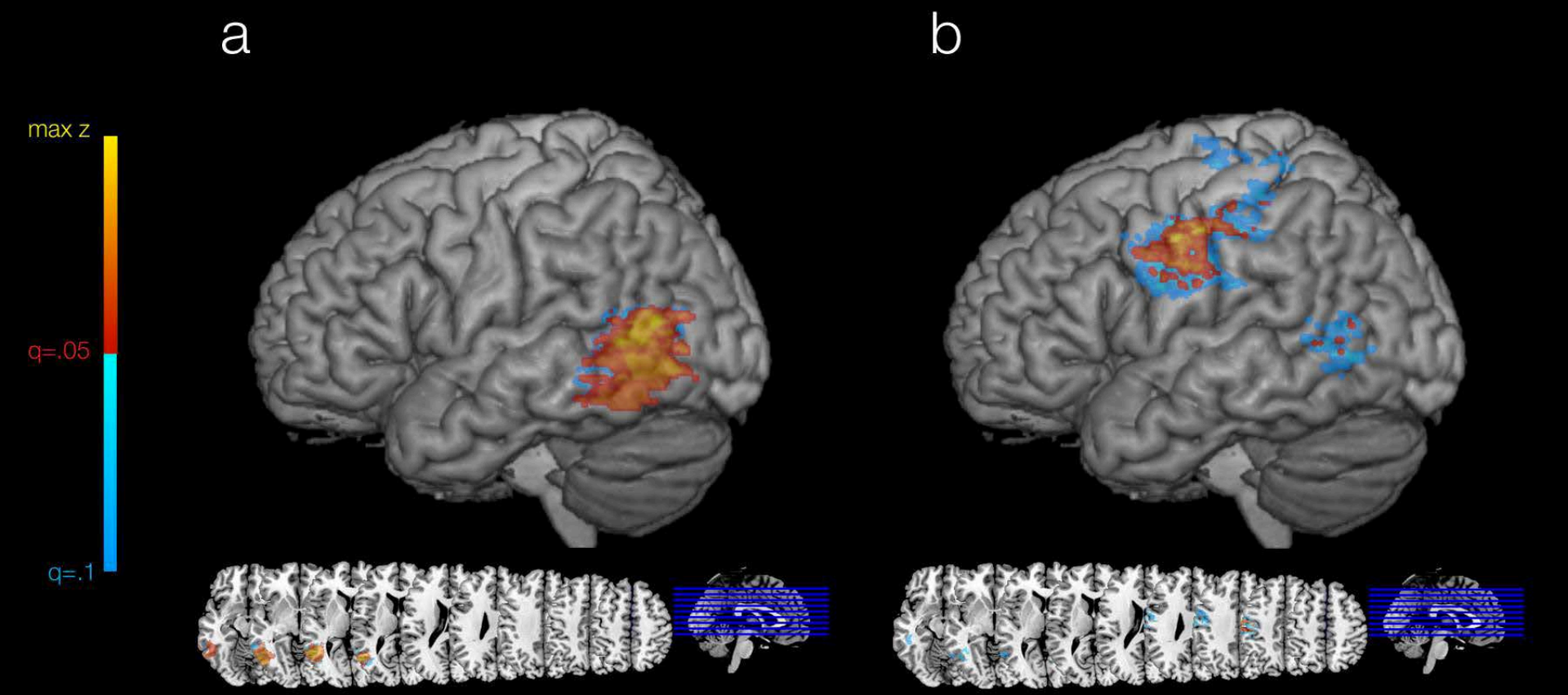
b



tool-related action

Imitation

Regions critical for postural and kinematic components of imitation of tool-related movements



Posture
(*tool-specific hand + arm shape/orientation/movement*)

Scale and timing
(adjusted *on-line*)

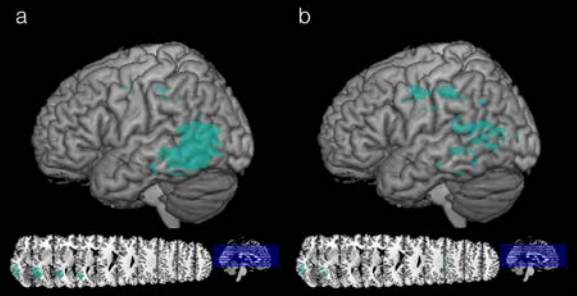
SUMMARY OF PART 1:

-**posterior temporal lobe/temporo-parietal junction:** **tool-specific representations of body to tool postures and movements, possibly in a visuo-kinesthetic format (transformation from visual to kinesthetic representation**

-**supramarginal gyrus/S1/M1:** **positioning of body in space over time**

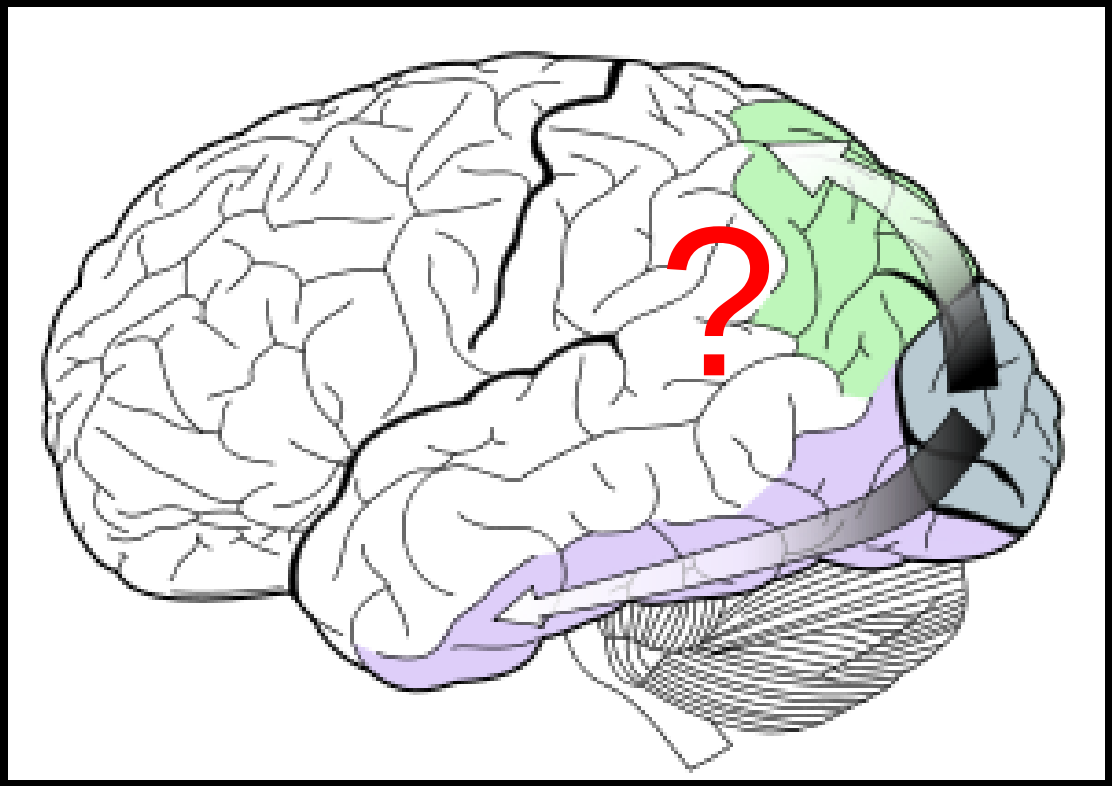
-Relative damage to each of these regions gives flavor of "ideational" and "ideomotor" apraxia, and given many MCA strokes, explains why they often co-exist

Stored, tool-specific



on-line body positioning

PART TWO: THE BRAIN'S TWO CORTICAL ACTION SYSTEMS



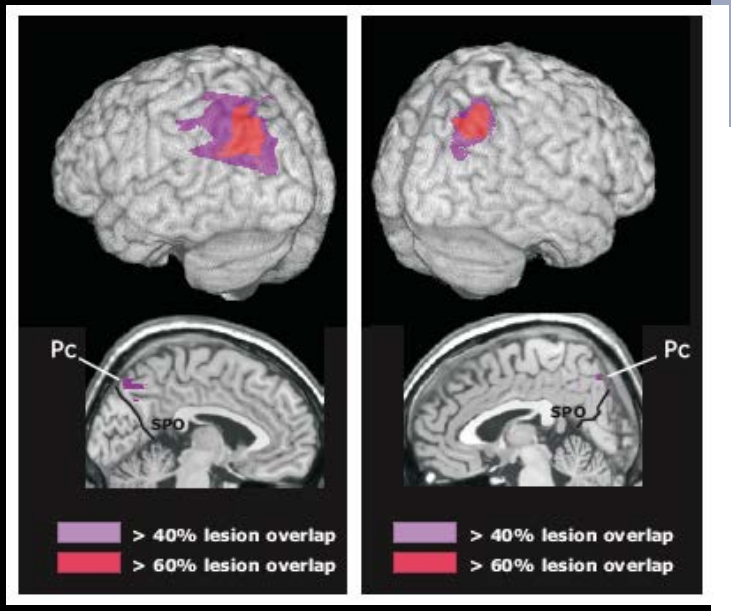
Dorsal Stream: Reaching, grasping, and eye movements to visual targets
Ventral Stream: Object recognition, Semantic knowledge

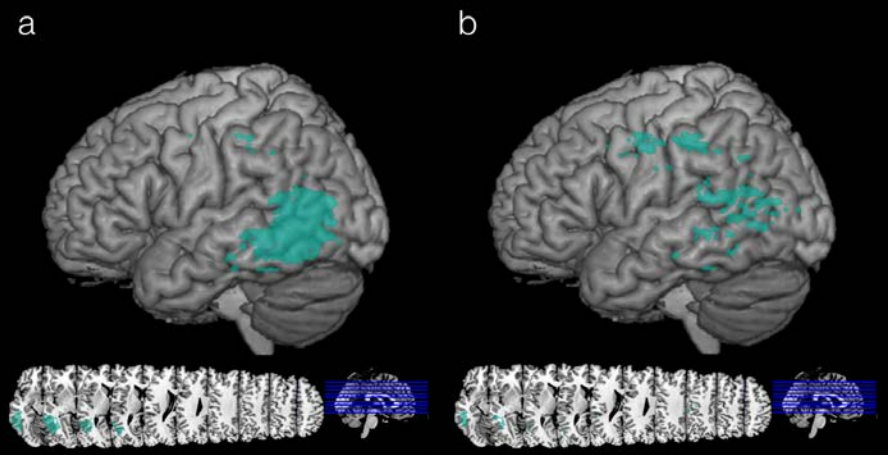
(Patient images removed)

Evidence for Segregation of Function: Optic Ataxia vs. Limb Apraxia

(patient image removed)

Karnath & Perenin, 2005



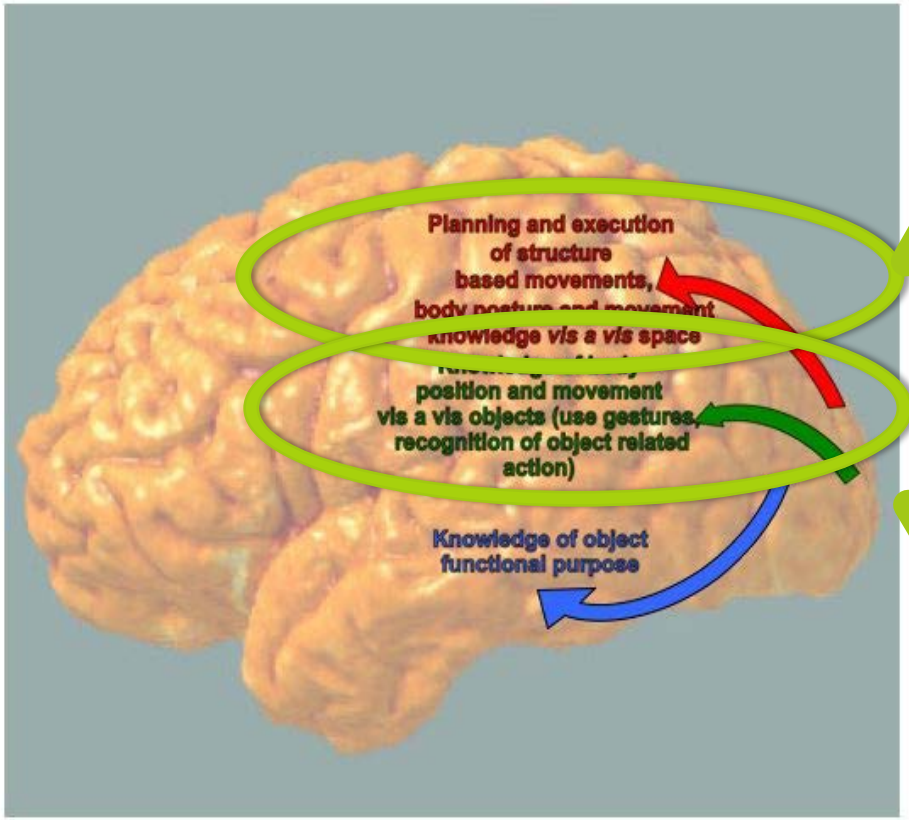


Impaired **Less Impaired**

Object-related Pantomime…… Actual object use

Memory-dependent actions …… Visually-guided actions

Object-specific hand postures …… Prehension



Two Action Systems:

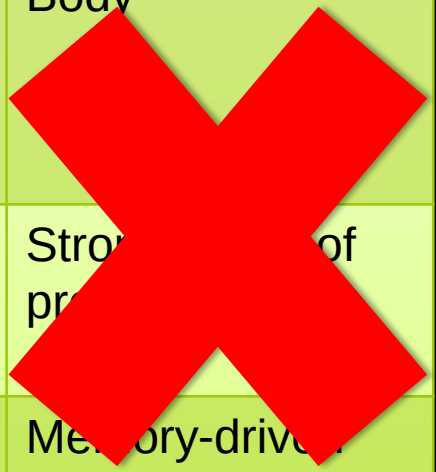
Move System = *bilateral* dorso-dorsal stream: action in response to current visual input
Use System = *left hemisphere* ventral-dorsal stream: action understanding, skilled object use

Gradient: current vision-based → retrieval-based

Buxbaum & Kalenine, *Ann. NY Acad Sci.*, 2012

TESTING THE MODEL

	Dorso-Dorsal (Move)	Dorso-Ventral (Use)
Coordinate frame (movements vis a vis the body or objects)	Objects	Body
Visual dependence	Stronger role of current visual guidance	Stro of pr
Dependence on structural "affordances"	Affordance-driven	Me ory-drive

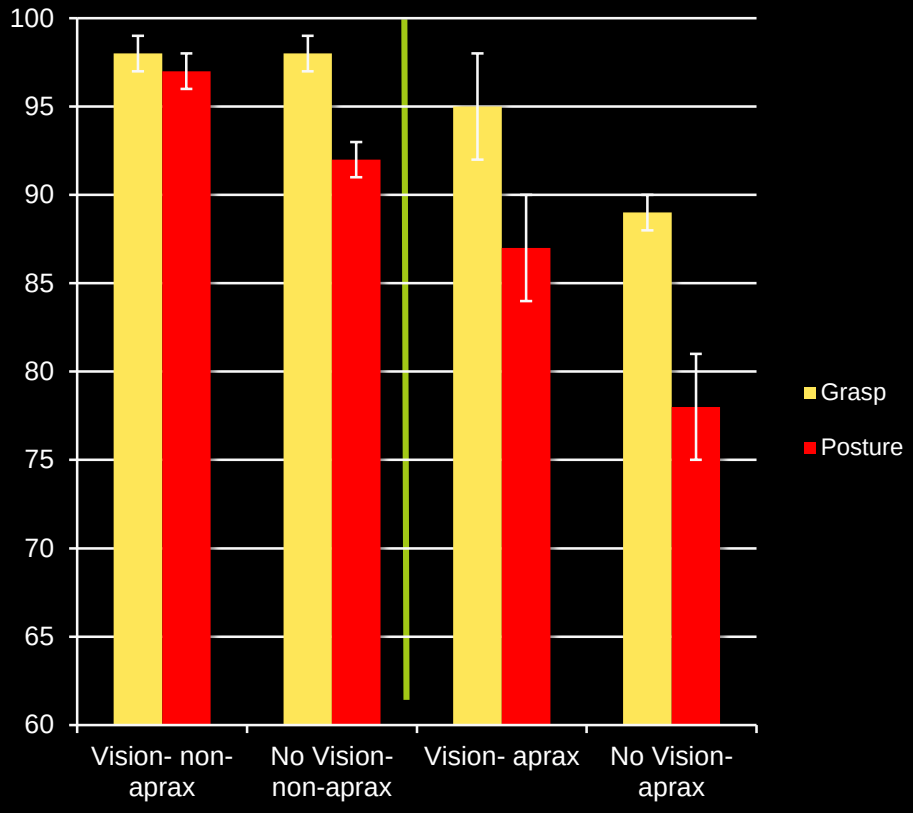


And: partial segregation of function predicts COMPETITION

Coordinate frame and availability of visual feedback

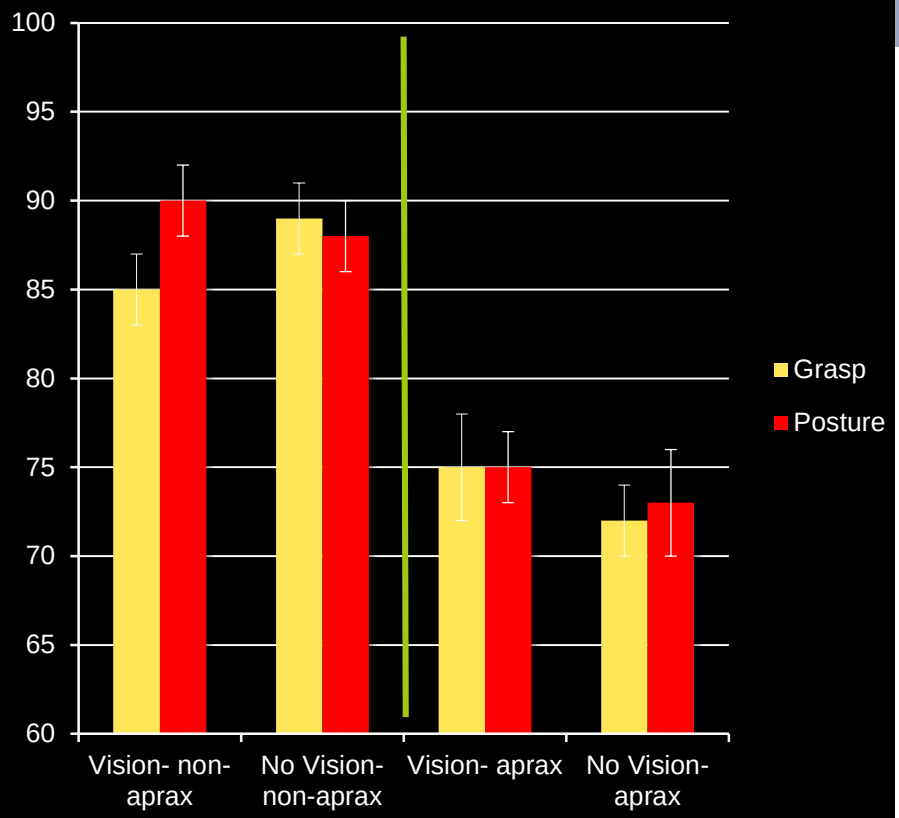
Deficits in Body-Relative Coding and Abnormal Reliance on Visual Feedback (Jax, Buxbaum, & Moll, JOCN, 2006)

Object-relative



non-apraxic apraxic

Body-relative



non-apraxic apraxic

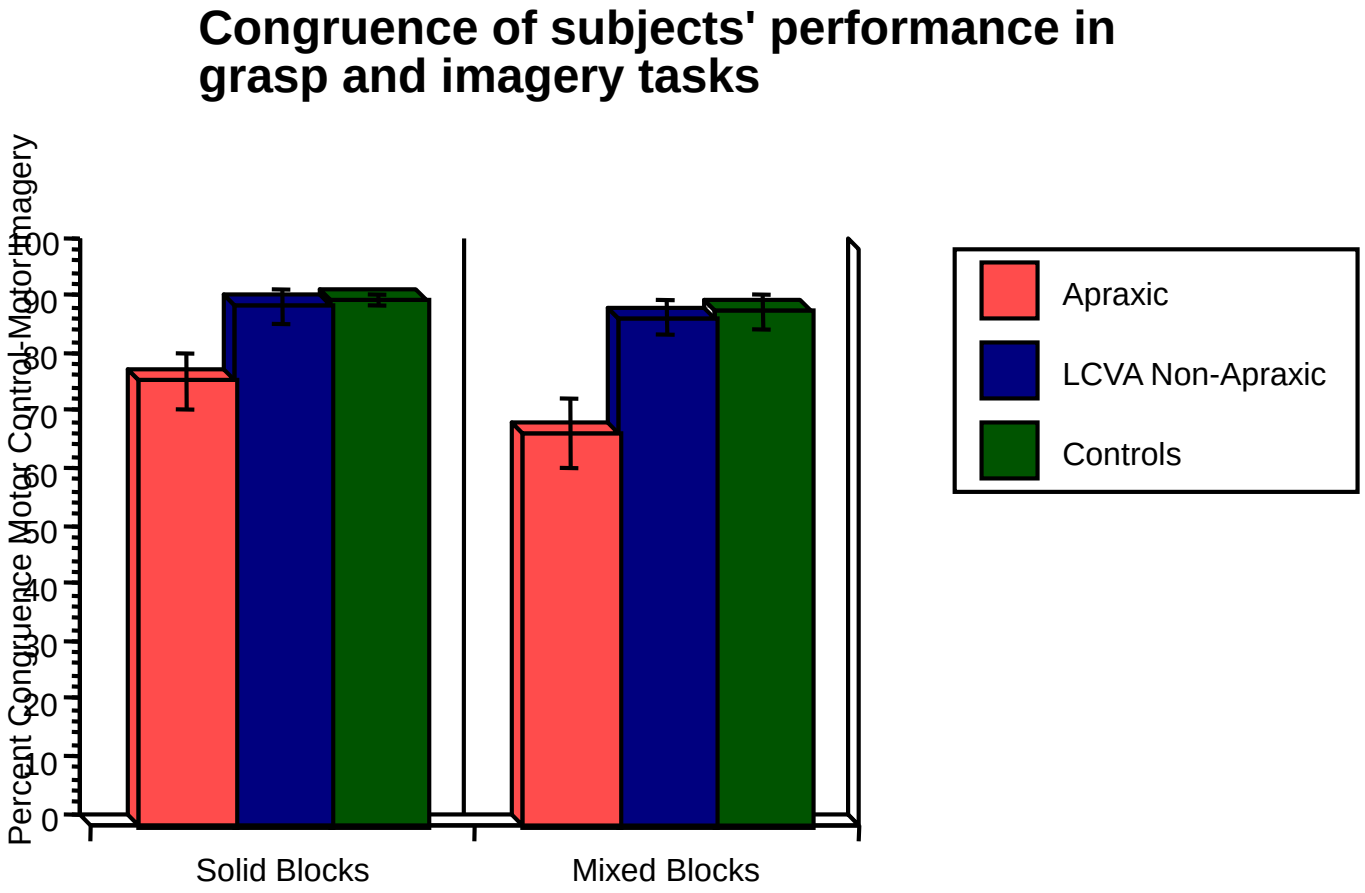
Requirement to imagine/predict movement

Motor control condition: Actual prehension of dowels and widgets presented in 6 orientations

Motor imagery condition: planned prehension (with no feedback from target objects)

(Both in non-mixed and mixed blocks)

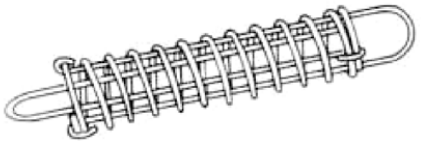
Buxbaum, Johnson-Frey, & Bartlett-Williams, Neuropsychologia, 2005


Congruence of subjects' performance in grasp and imagery tasks
Percent Congruence Motor Control-Motor Imagery
100
90
80
70
60
50
40
30
20
10
0
Solid Blocks
Mixed Blocks
Apraxic
LCVA Non-Apraxic
Controls

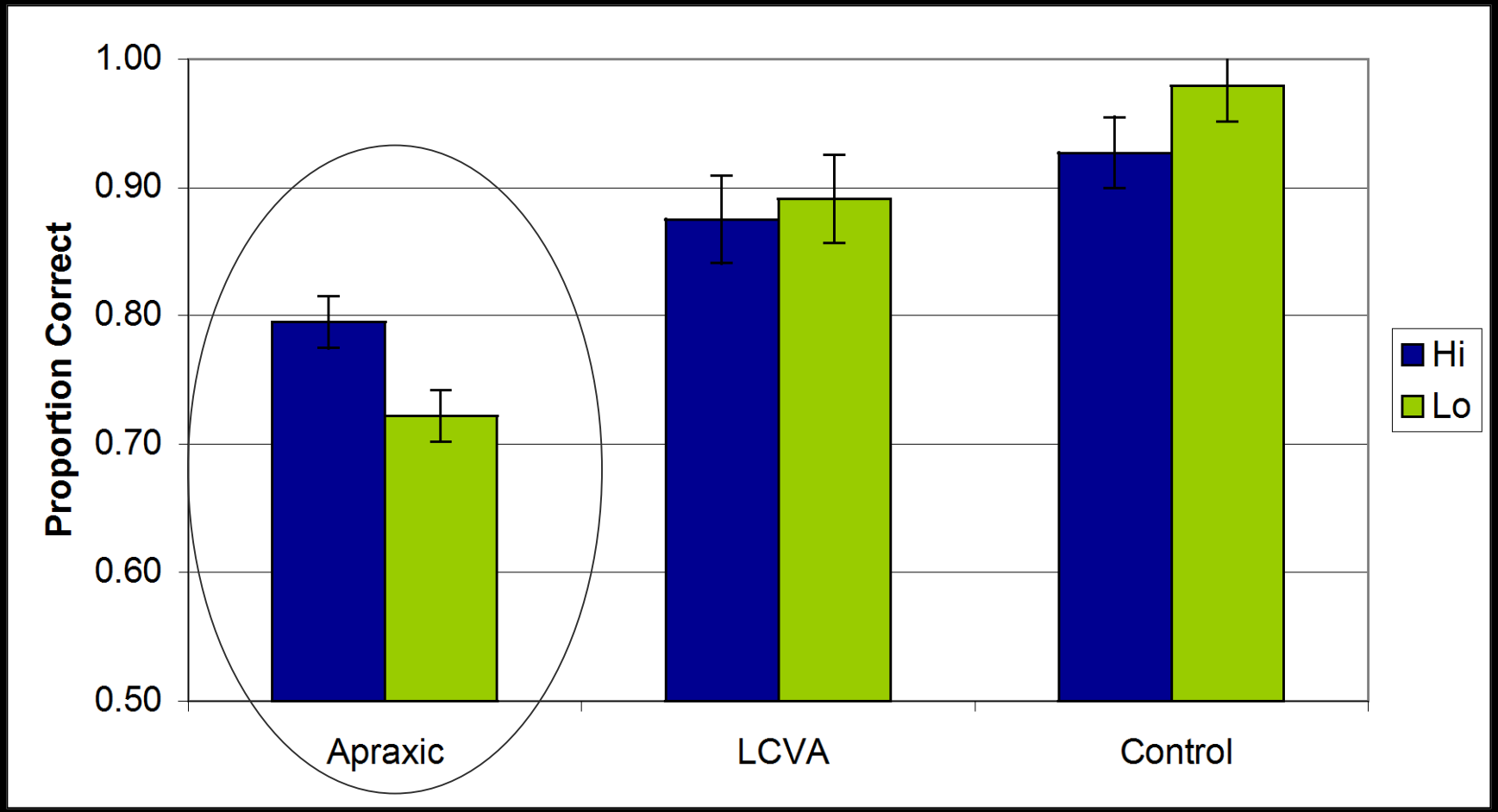
Dependence on structural “affordances”

High-Afforded

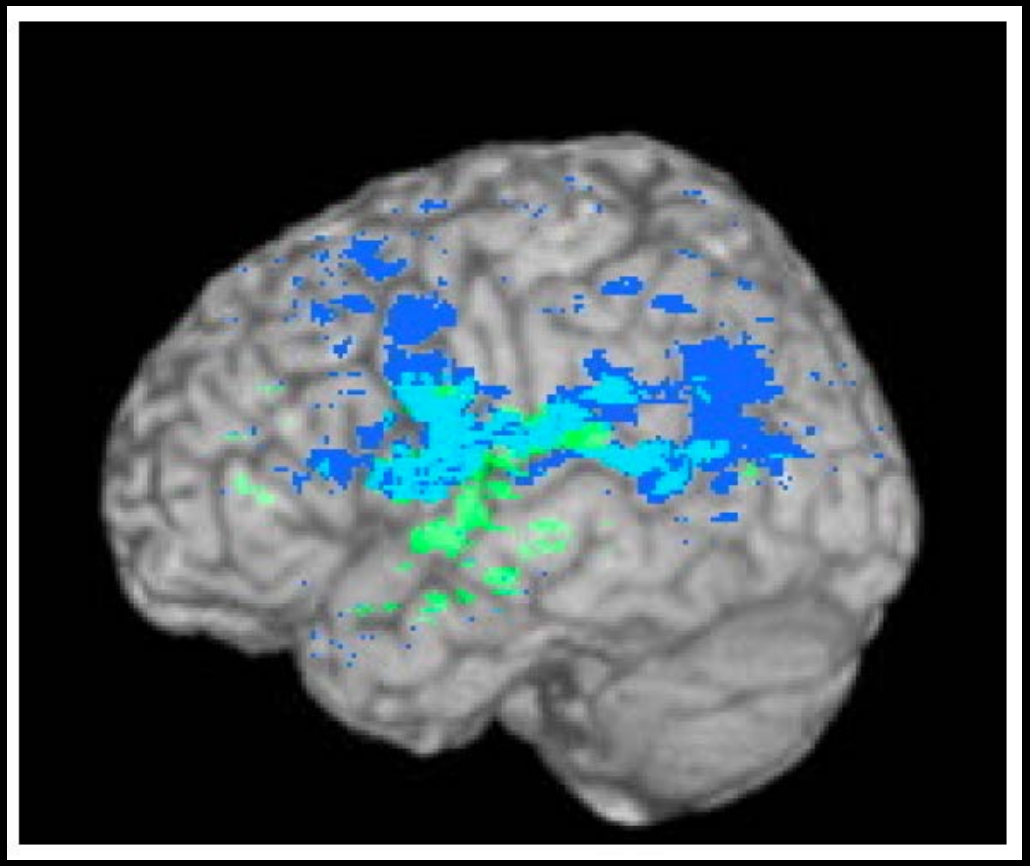
Low-Afforded



Barde, Buxbaum, & Moll, JINS, 2007



Affordance x Group Intxn - $F(2,18) = 7.40$, $p = .005$



Apraxia -Medium blue

Benefit of Structure Information -Green

Intersection - Light blue

Competition between Move and Use Actions

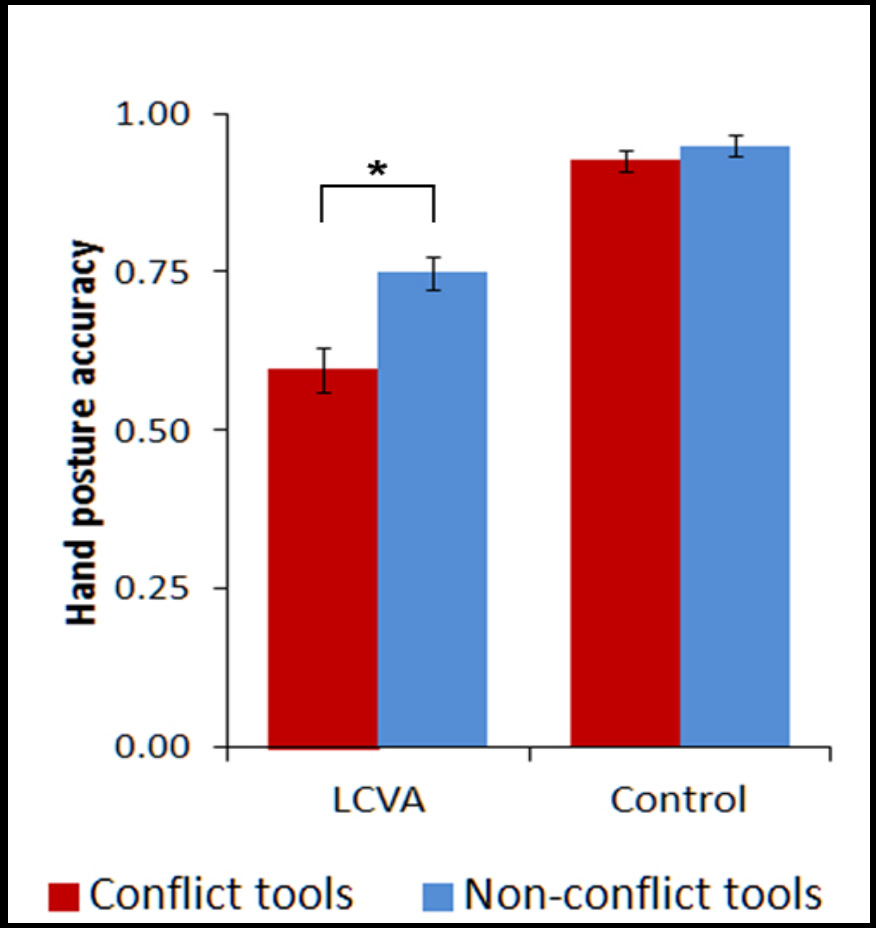
Conflict

No conflict

Move: faster, shorter-lasting
Use: slower, longer-lasting

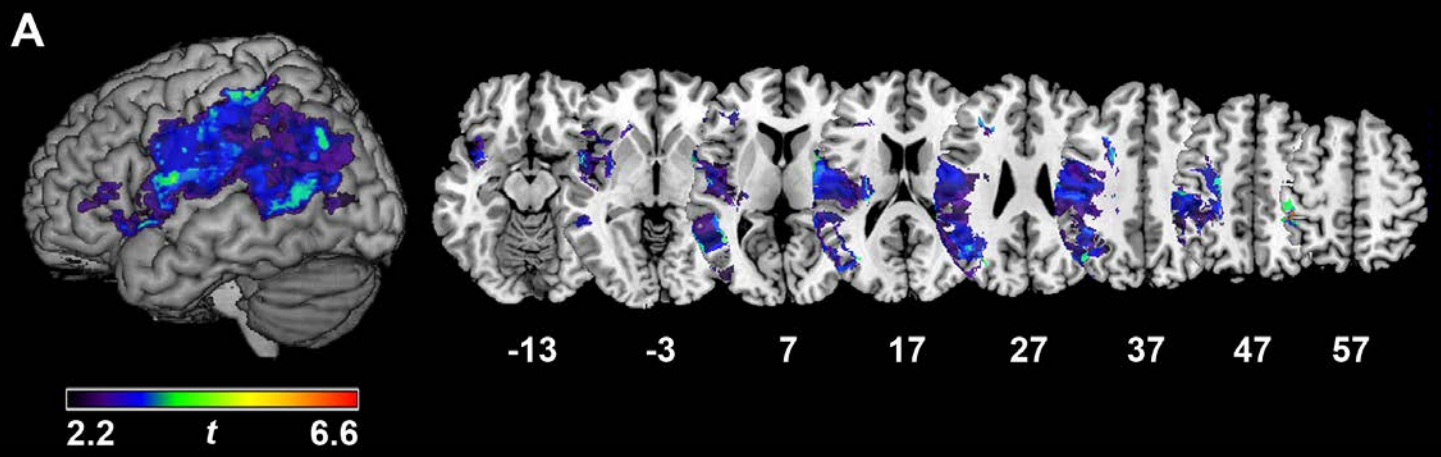
Jax & Buxbaum, *Cognition,* 2010.

The Neuroanatomic Substrates of Competition between Move and use Actions



Watson & Buxbaum, *Cortex,* 2015

Total pantomime scores



Disrupted connectivity between nodes in the Use System network (Resting Functional Connectivity)

Functional connectivity measures from patients:

- Can tell us how interactions between *intact* brain regions change after a lesion
- Help identify tissue behaving abnormally *beyond* areas obviously lesioned

(unpublished data removed from slide)

(unpublished theoretical model removed)

THANK YOU!

Cognition and Action Lab, Moss Rehabilitation Research Institute

Collaborators

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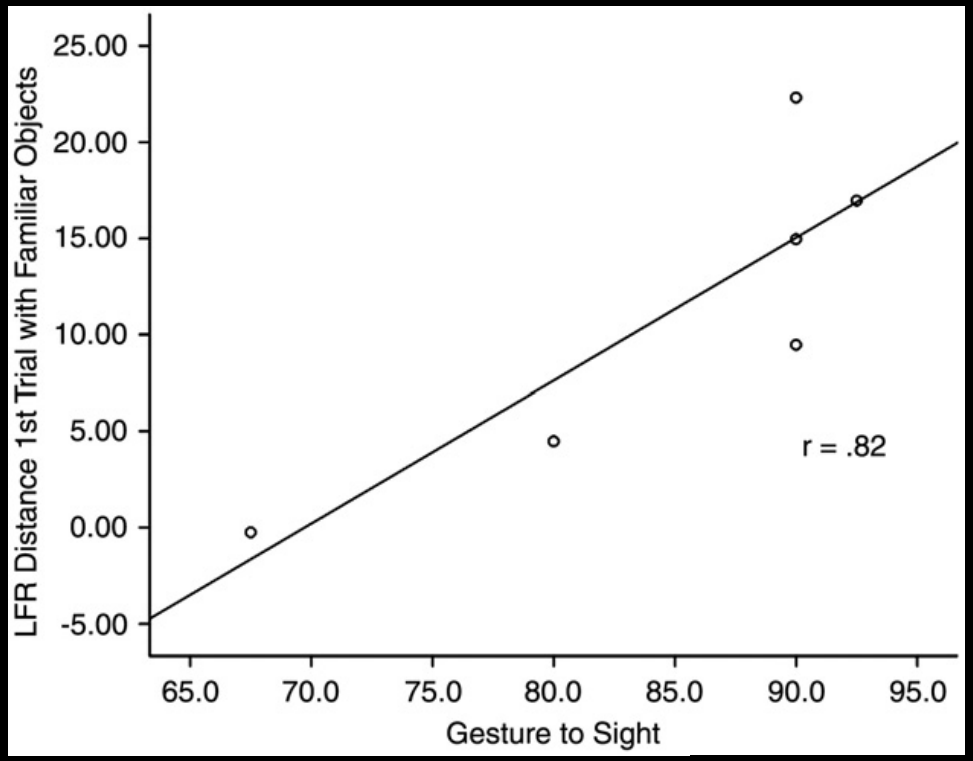
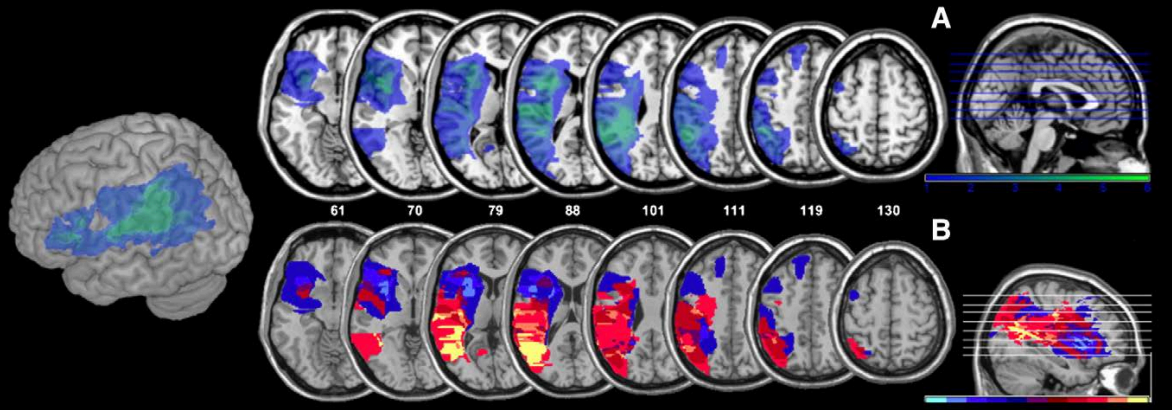
Anticipatory Force Control for Familiar Objects





Dawson, Buxbaum, & Duff, 2010 (and see Li Randerath, Goldenberg, Hermsdörfer, 2007).