



Brain activity during transitive and social action observation in adults and adolescents

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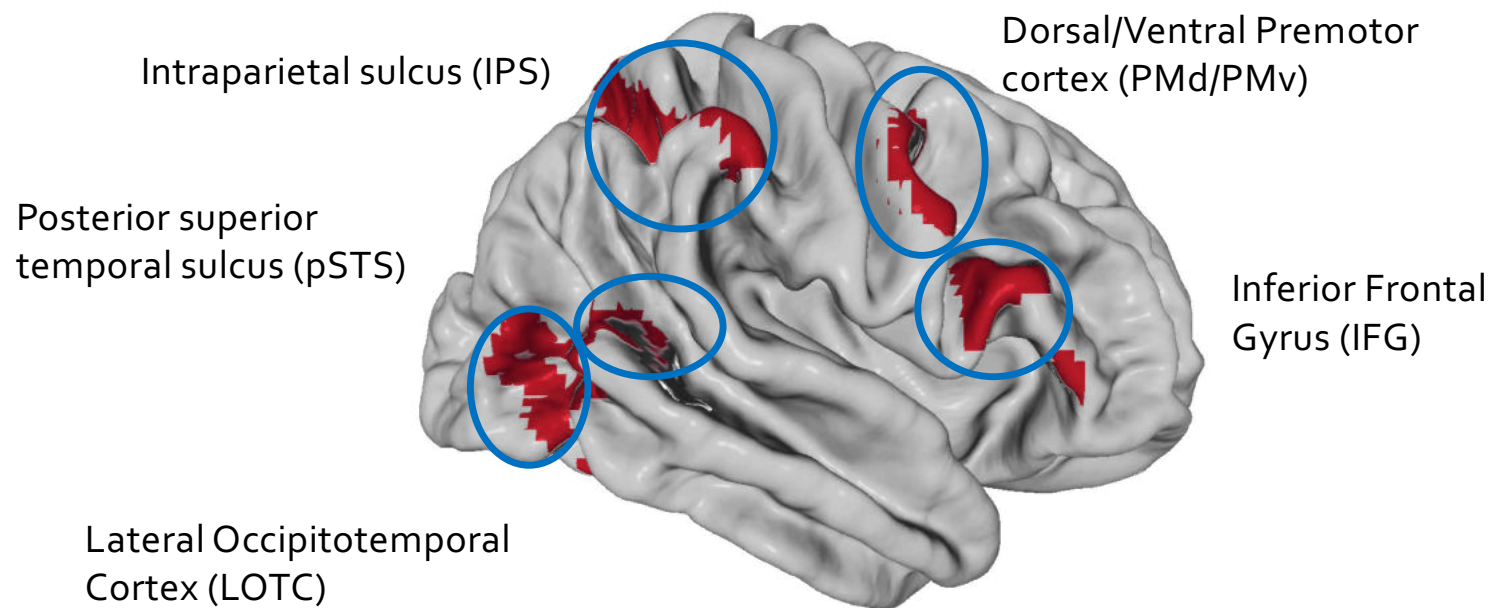
³ Univ. Grenoble Alpes, TIMC-IMAG, Grenoble, France

⁴ INT Institut des Neurosciences de la Timone, UMR 7289, Centre IRM Fonctionnelle Cérébrale, Marseille, France



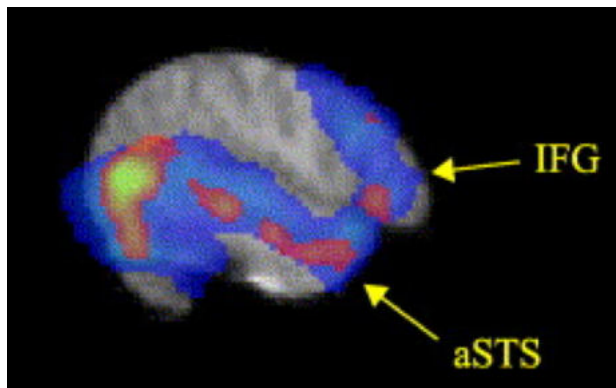
Background and rationale

- Action Observation Network (AON) = set of bilateral brain areas consistently engaged during observation of others' action

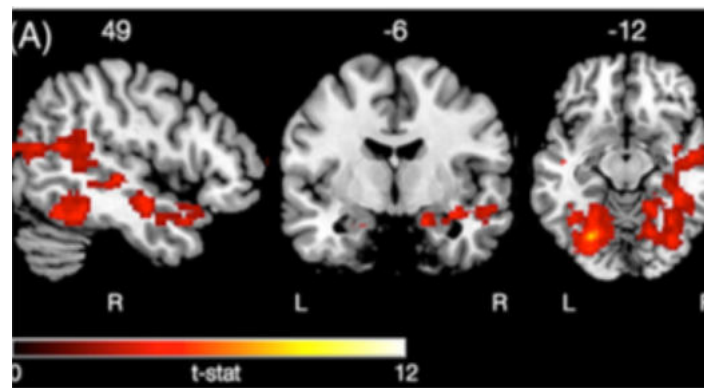


Grosbras et al., Human Brain Mapping 2012

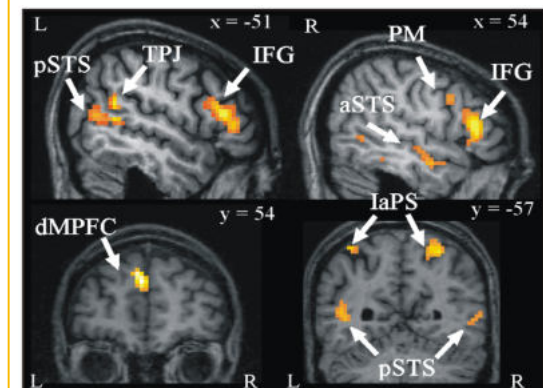
Modulation of AON by the content of action



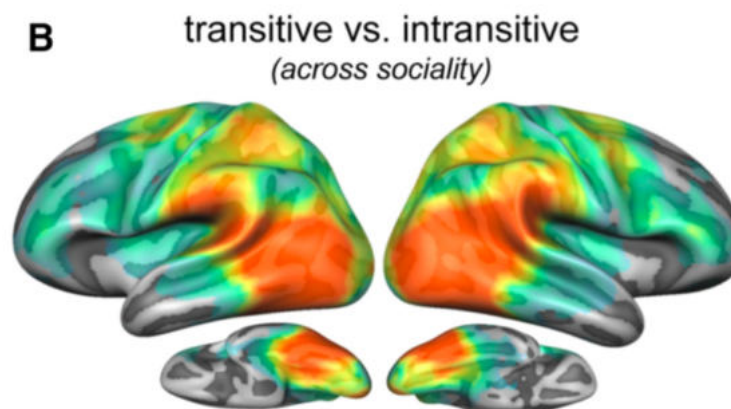
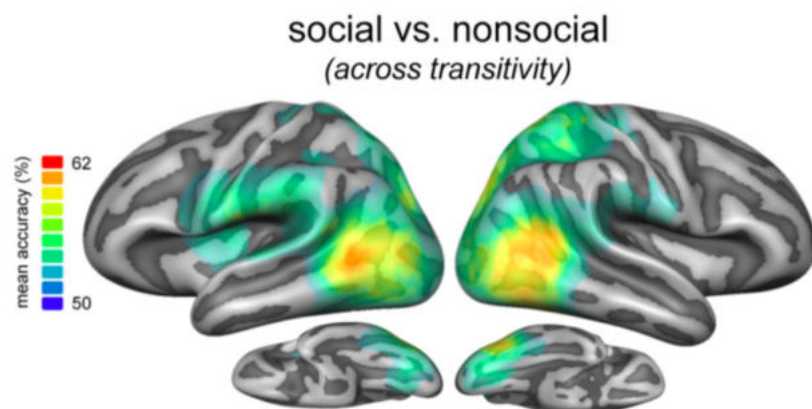
Iacoboni et al., 2004
Social vs individual interactions



Saggar et al., 2014
Social vs Non-social gestures



Centelles et al., 2011
Interacting vs isolated mvts



Wurm et al., 2017
MVPA
Decoding social vs non social action

Development of the AON

- Core nodes of AON are present in children and adolescents (Ohnishi 2004)
 - Strength and extent of activity increase with age (Shaw 2011, 2012; Biagi 2016)
 - From bilateral to more lateralized network (Biagi 2015)
- Occipitotemporal representation become more specific (Scherf 2007; Ross 2014; Peelen 2009; Pelphrey 2009)
- Structural changes in AON regions throughout adolescence (Gotgay 2010, Mills 2012)
- Improvement of social skills (Burnett 2011, Dumontheil 2012)
 - Inferring intentions of others
 - adapting actions to social context, recognizing emotions...

Questions

- Does the representation of action categories in the AON change during adolescence ?
 - Differential activation for different categories of action (object-related; socially-oriented)
 - Fine-grain representation of action categories (coding of social or transitive dimensions)
- More drastic developmental changes in the representation of the « social » dimension

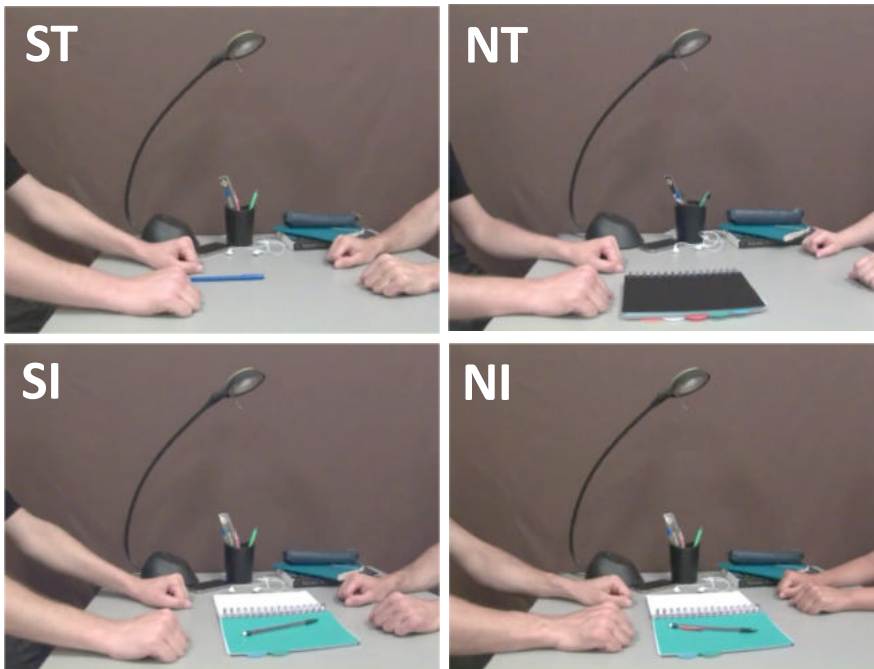
Material and Method

Stimuli

Sociality

Social

Non-Social

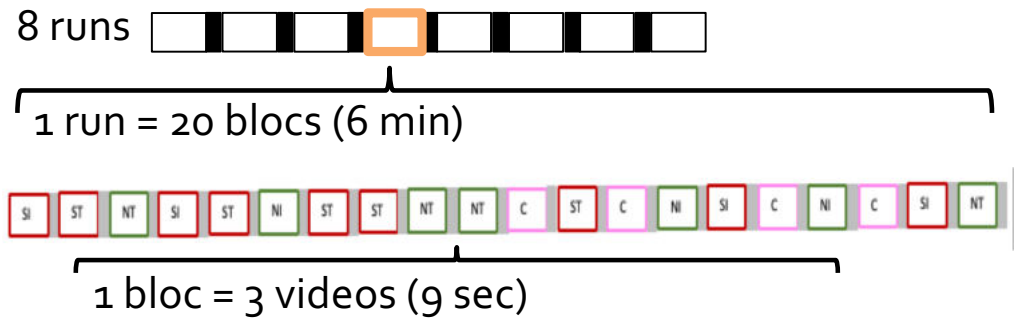


Participants

27 **Adolescents** aged 13-17 (15.0 ± 1.2), 13f

24 **Adults** aged 24-33 (26.6 ± 2.1), 13f

Procedure



Transitivity

Transitive

Intransitive

Data analysis I: Univariate analysis

Preprocessing of fMRI data

- Realignment (6-head motion correction)
- Co-registration
- Normalization to MNI space
- Smoothing (5 FWHM)
- Physiological noise (WM & CSF)
- Removal of non-corrected volumes exceeding $FD = 2\text{mm}$

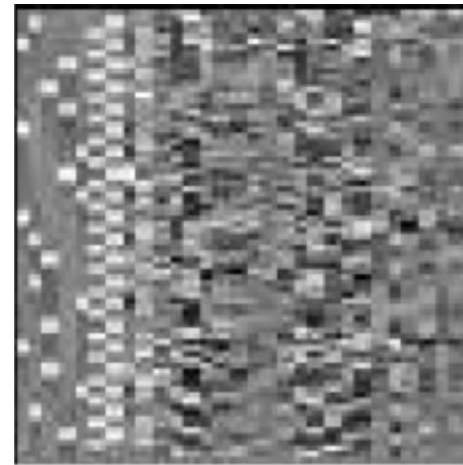
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GLM

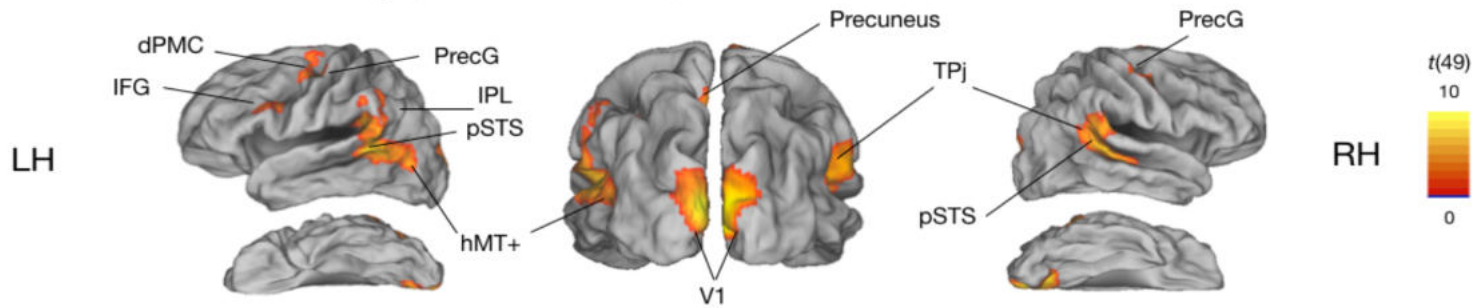
Design Matrix (e.g., 1 run)



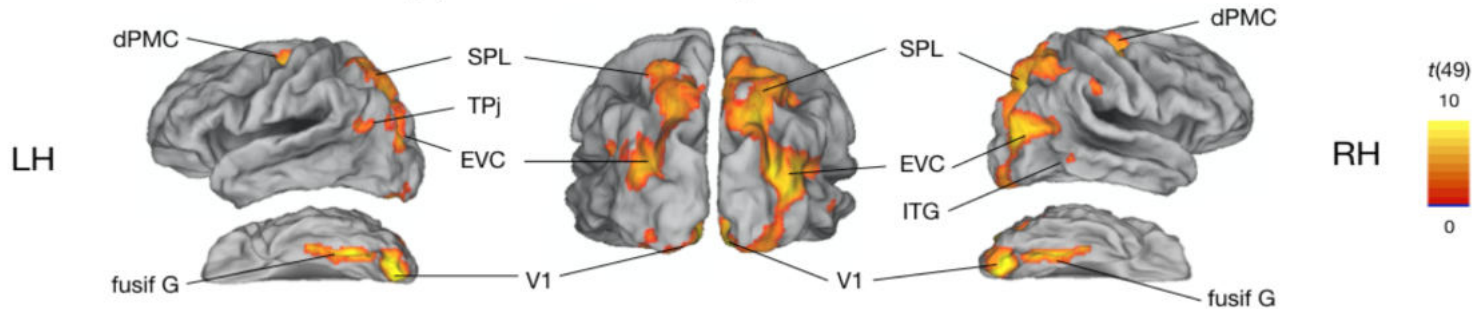
4 regressors (NI, NT, SI and ST)

Univariate fMRI results

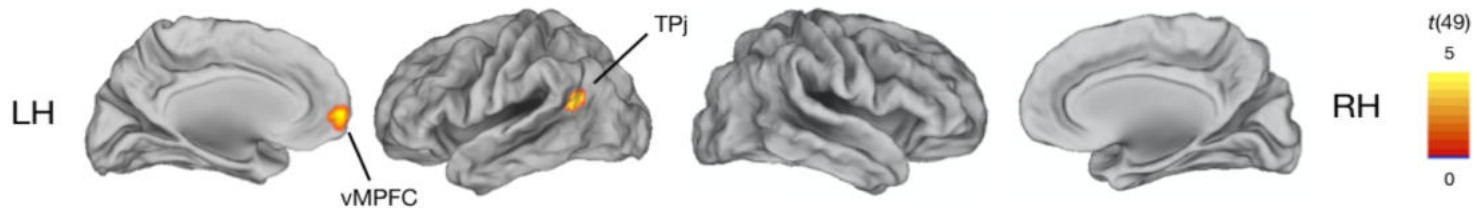
Main effect of Sociality (Social > Non-Social)



Main effect of Transitivity (Transitive > Intransitive)



Main effect of Group (Adolescents > Adults)



Data analysis II: Multi-voxel Pattern analysis (MVPA)

Preprocessing of fMRI data

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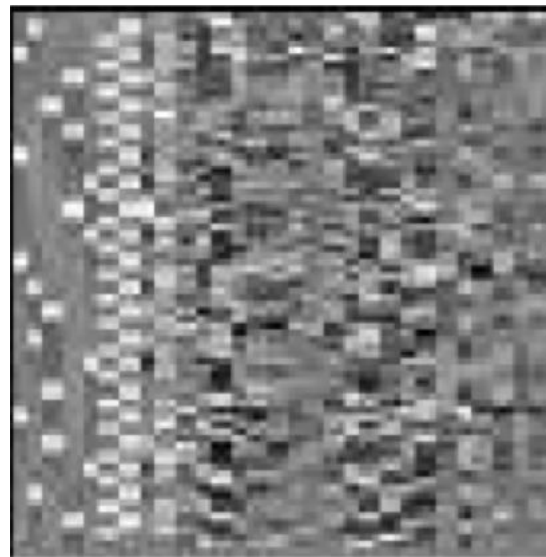
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GLM

univariate



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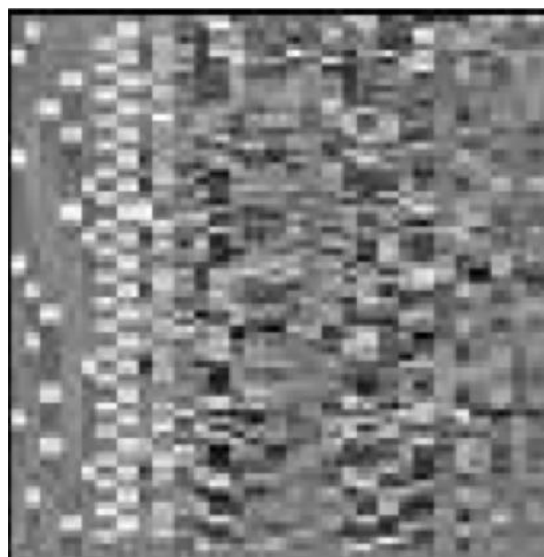
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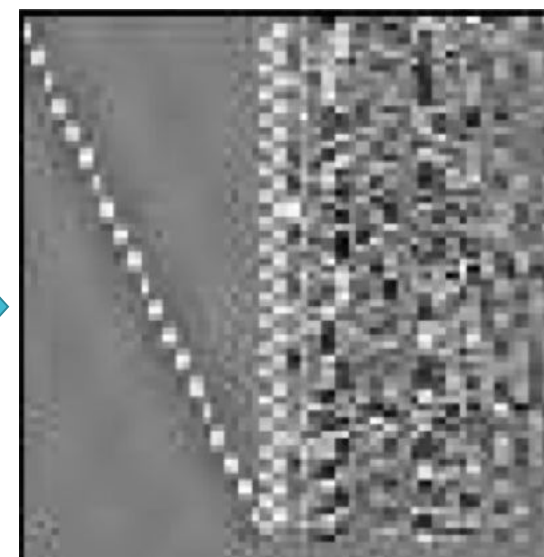
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GLM

univariate



multivariate

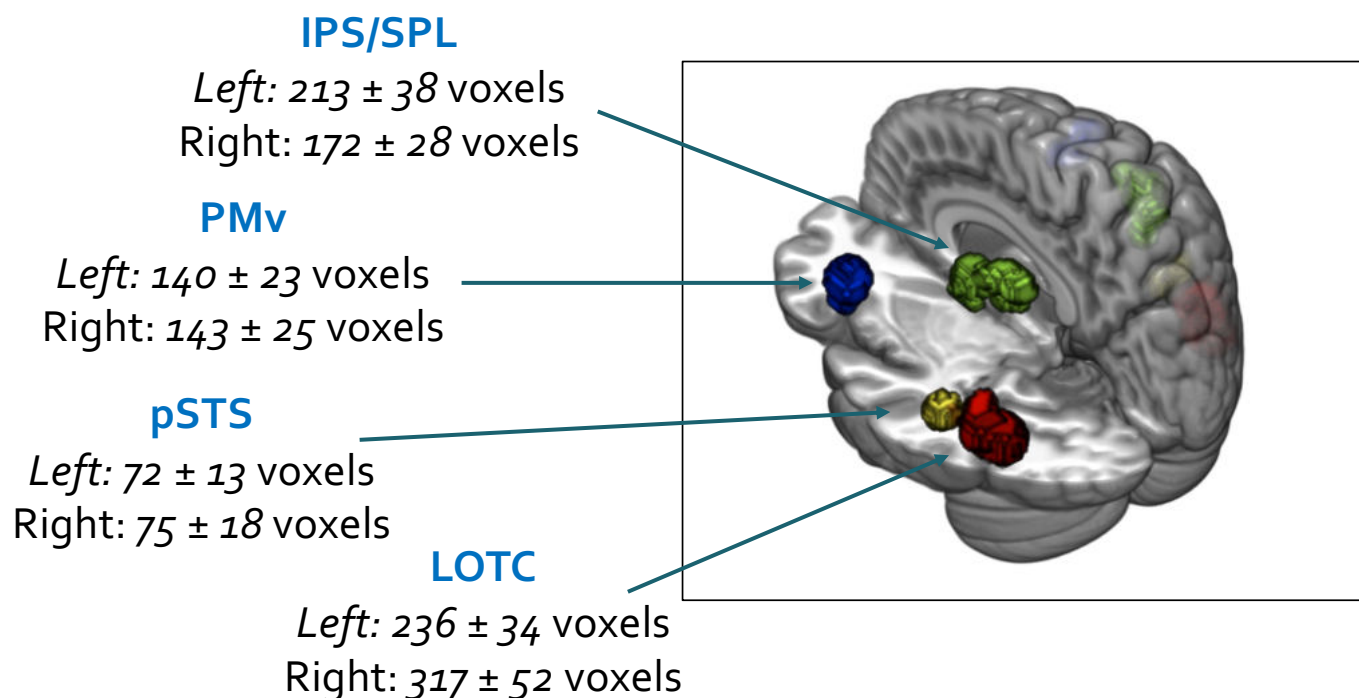


1 regressor for each trial (4 NI, 4 NT, 4 SI and 4 ST)

Data analysis II: Multi-voxel Pattern analysis (MVPA)

- Support Vector Machine (SVM) classifier

(1) **ROI-based**: Regions of the AON (Grosbras et al., 2012)



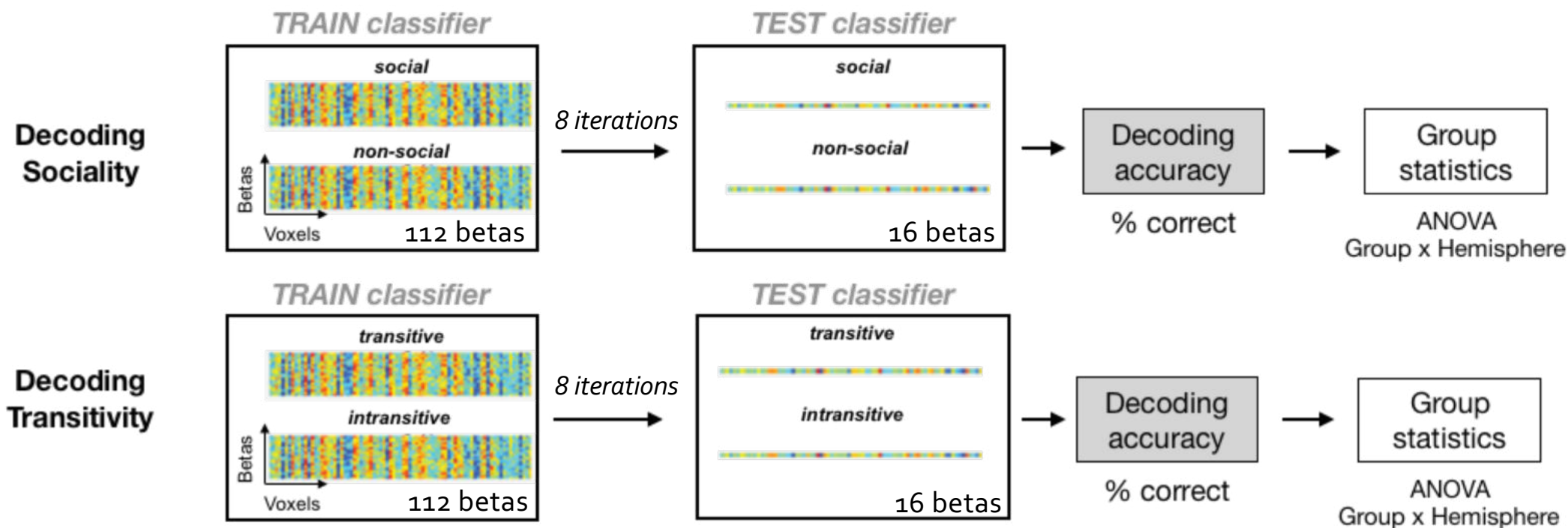
Feature selection (F-test)

IPS/SPL: 104 voxels
PMv: 96 voxels
pSTS: 47 voxels
LOTC: 174 voxels

(2) **Whole-brain**: Searchlight = 12mm radius sphere (Kriegskorte 2006)

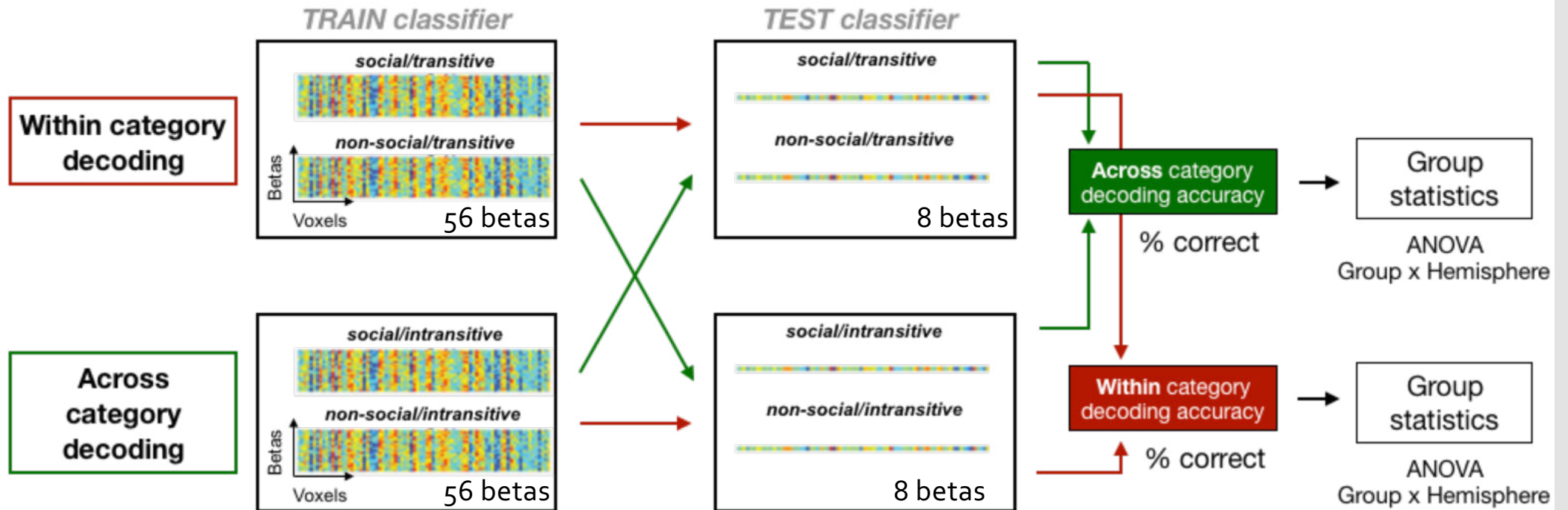
Data analysis II: Multi-voxel Pattern analysis (MVPA)

- Cross-validation scheme with leave-One-Run-Out



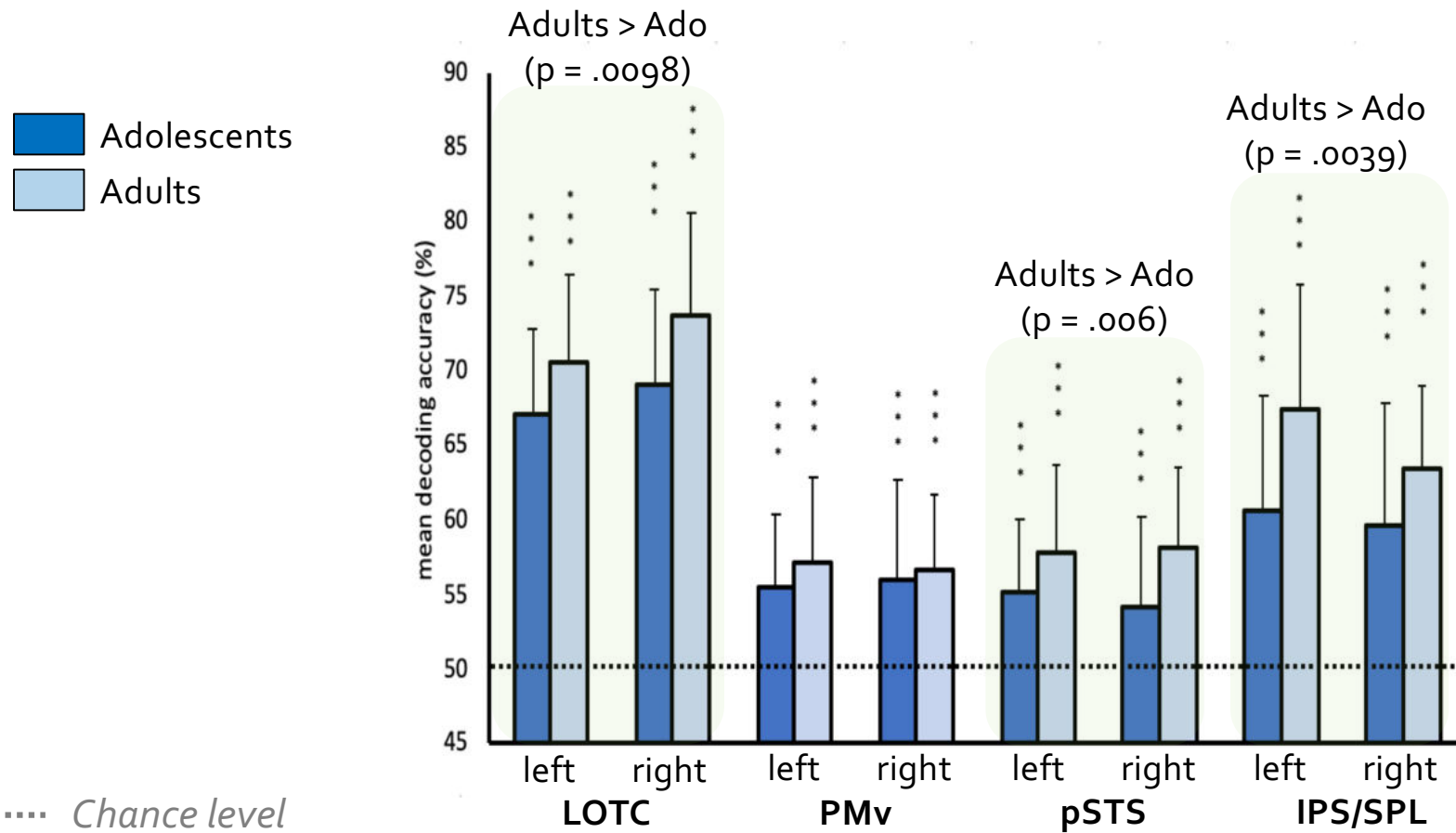
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MVPA: ROI-based decoding

Decoding Social vs Non-Social actions

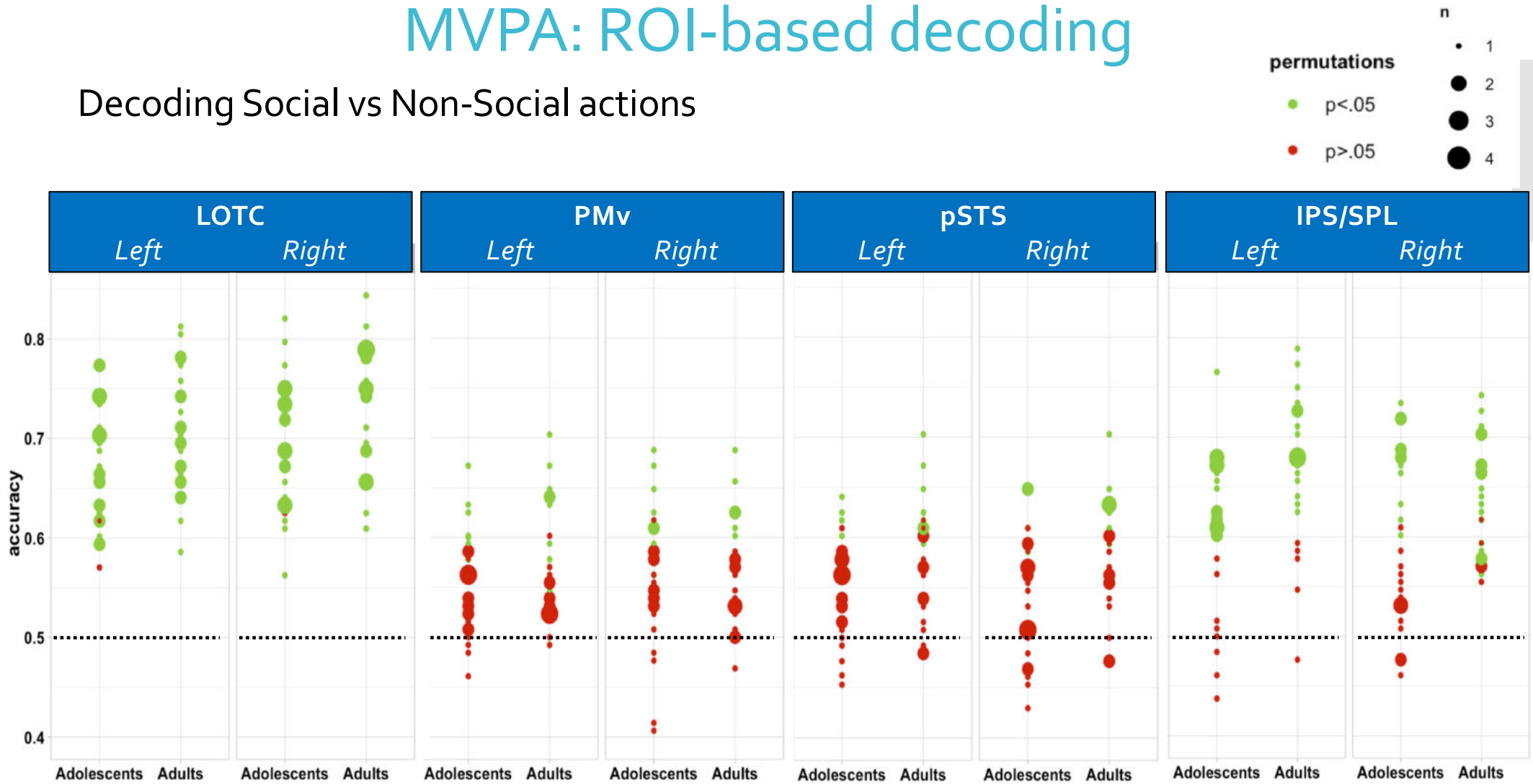


..... Chance level

*** $p < .001$ (FDR-corrected)

MVPA: ROI-based decoding

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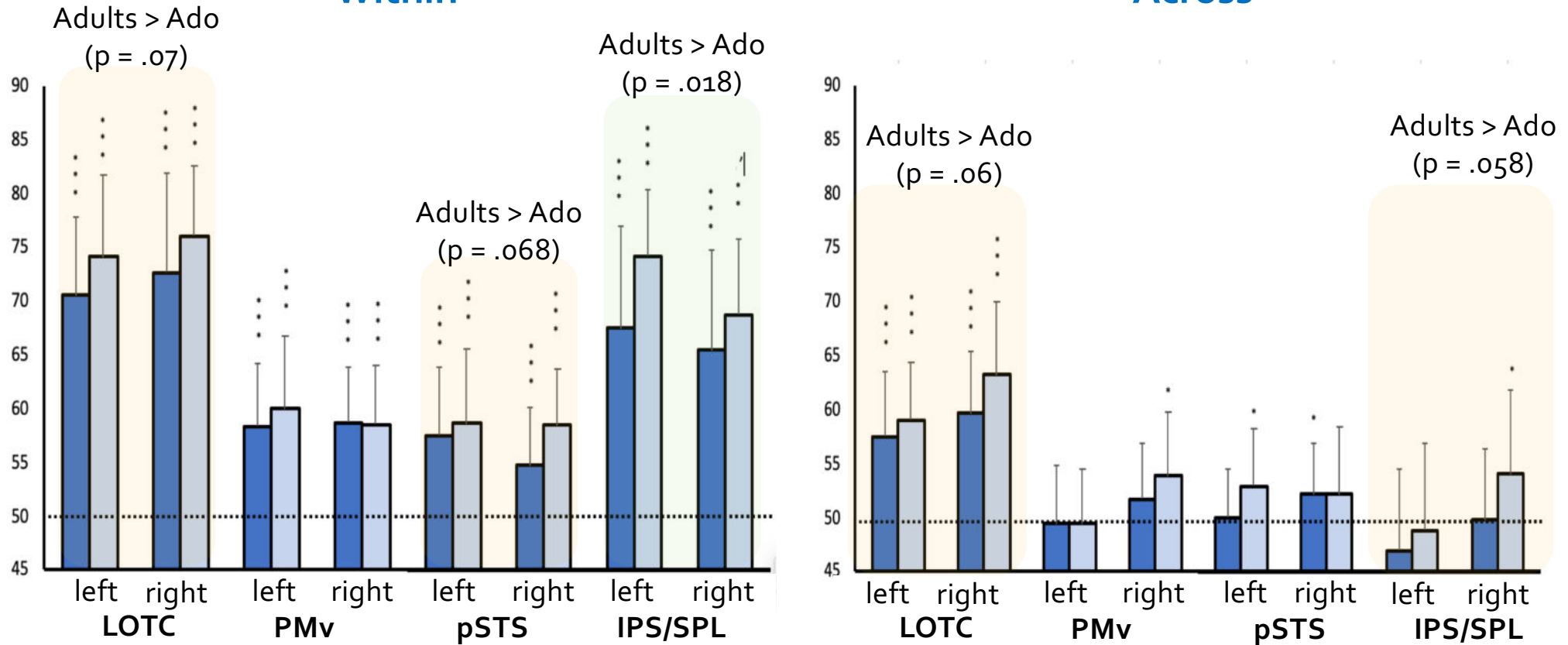
MVPA: ROI-based decoding

Decoding Social dimension across transitivity

■ Adolescents
■ Adults

Within

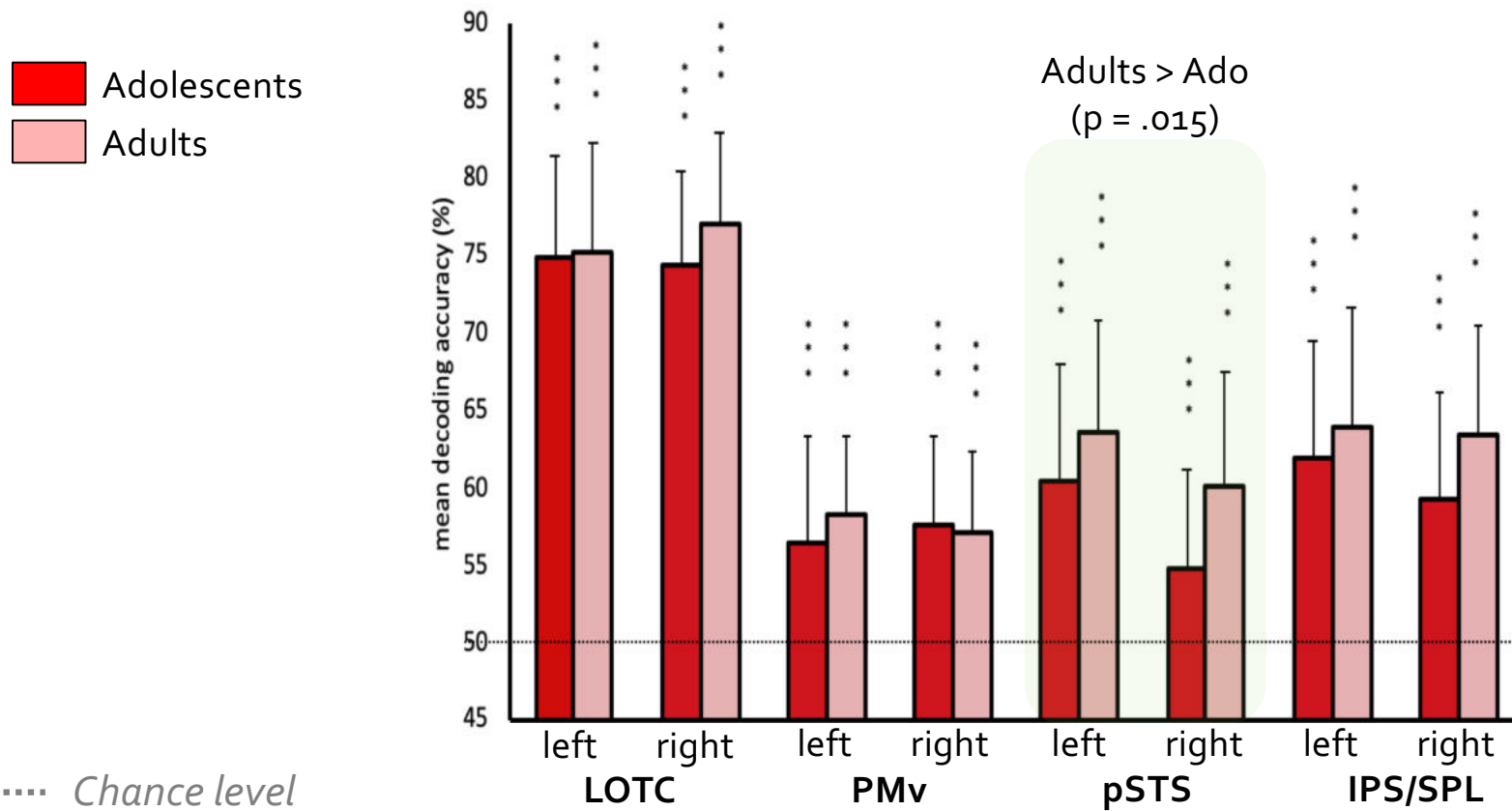
Across



..... Chance level * $p < .05$, *** $p < .001$ (FDR-corrected)

MVPA: ROI-based decoding

Decoding Transitive vs Intransitive actions

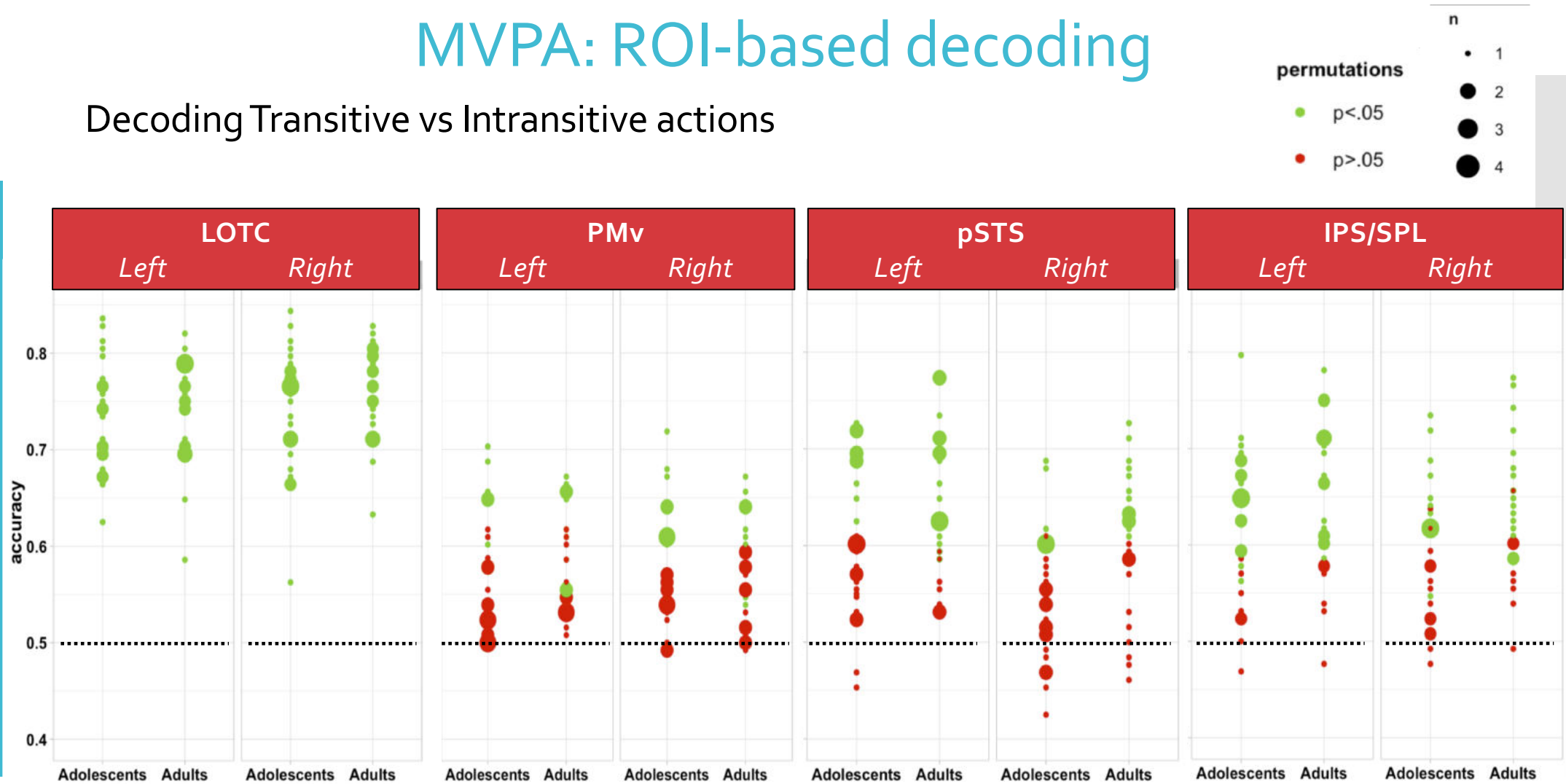


..... Chance level

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MVPA: ROI-based decoding

Decoding Transitive vs Intransitive actions



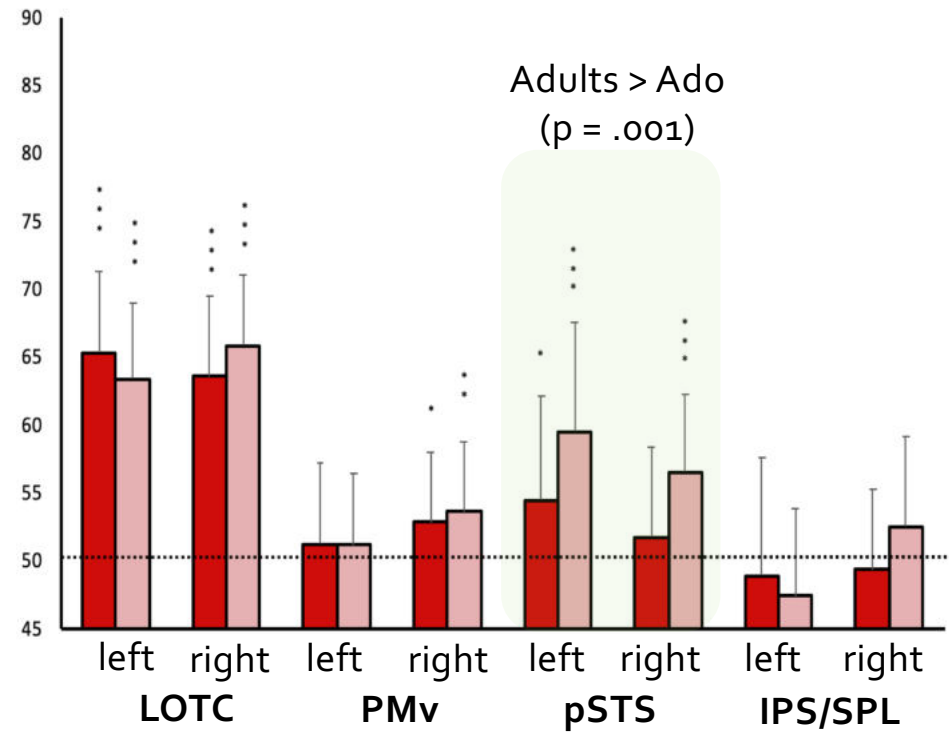
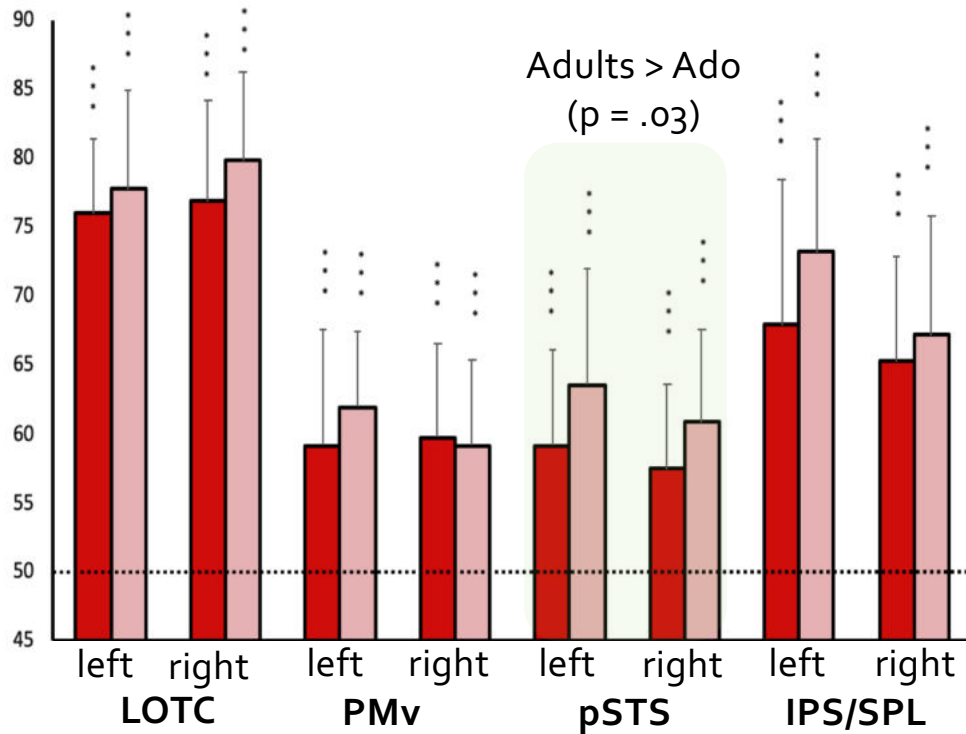
MVPA: ROI-based decoding

Decoding Transitive dimension across Sociality

Adolescents
Adults

Within

Across



..... Chance level

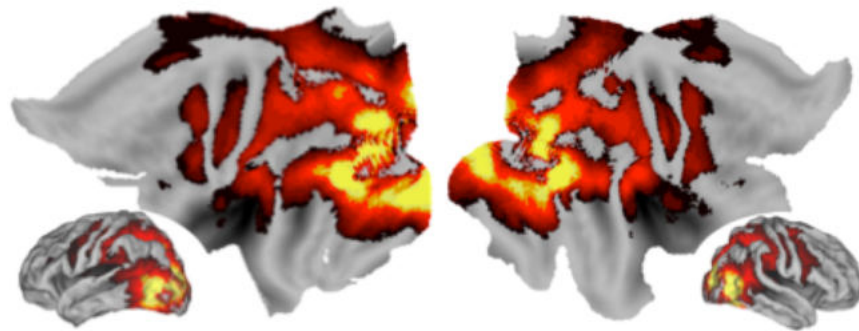
* $p < .05$, ** $p < .01$, *** $p < .001$ (FDR-corrected)

MVPA: Searchlight (whole-brain)

Sociality

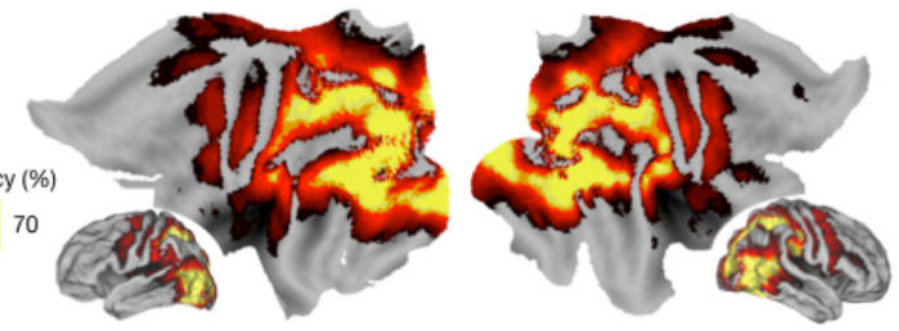
Adolescents

Adults



Mean accuracy (%)
55 70

t(26), $p < .05$ (FWE)
0 28



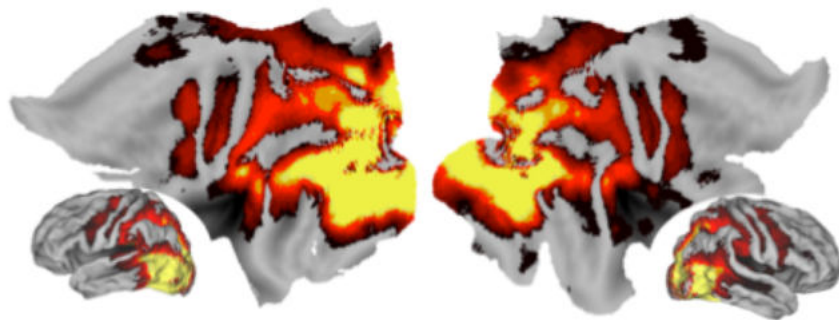
t(23), $p < .05$ (FWE)
0 28

MVPA: Searchlight (whole-brain)

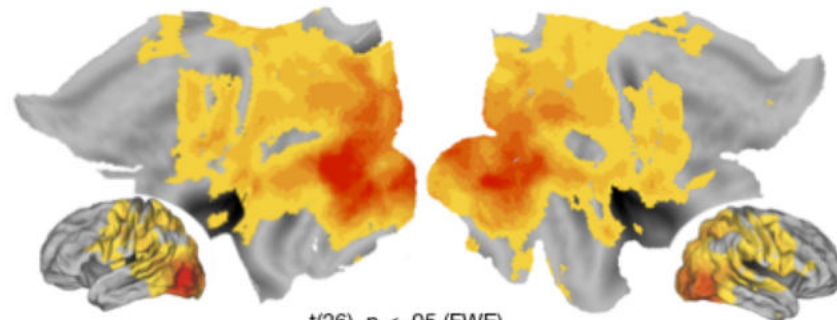
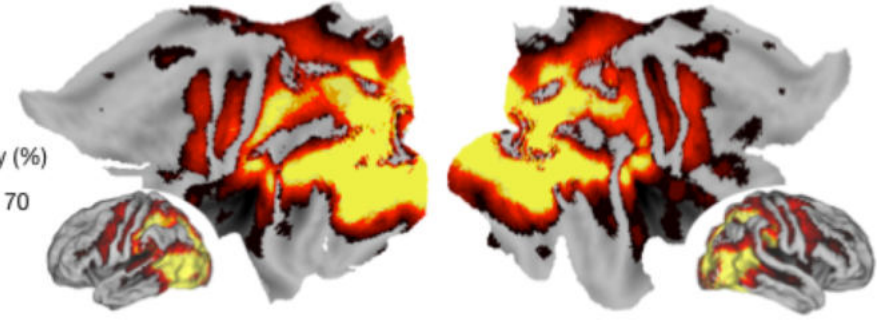
Transitivity

Adolescents

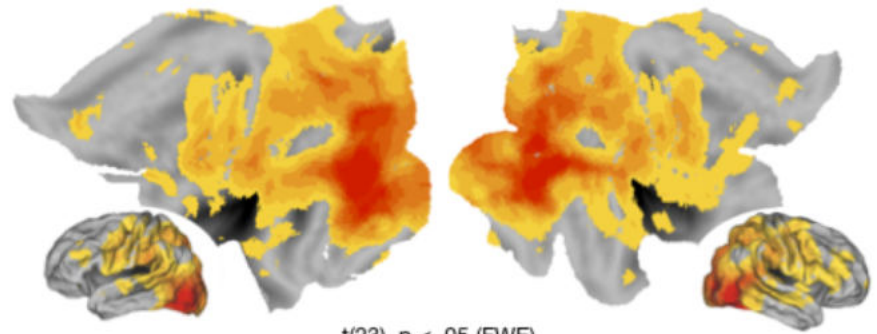
Adults



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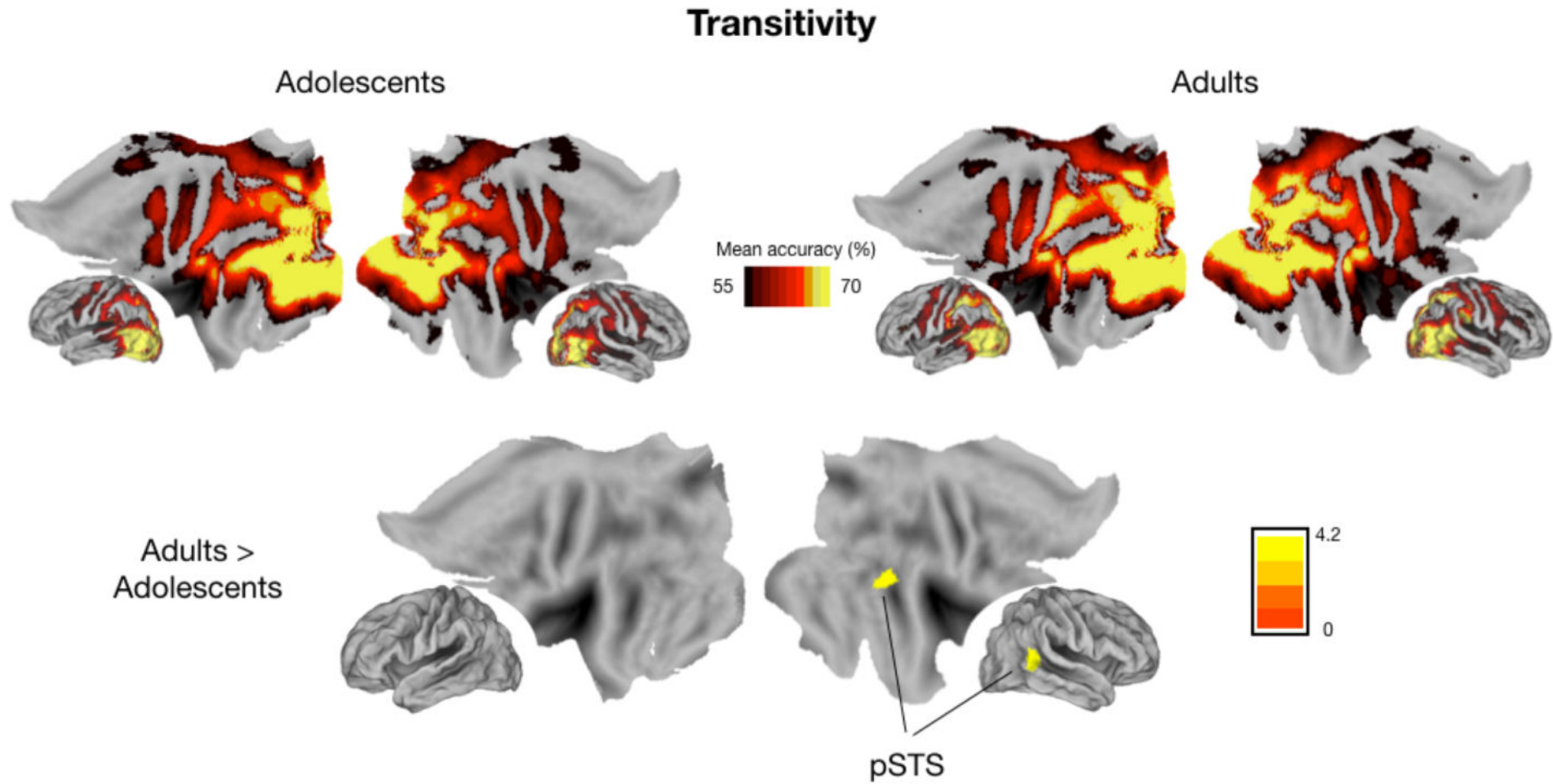


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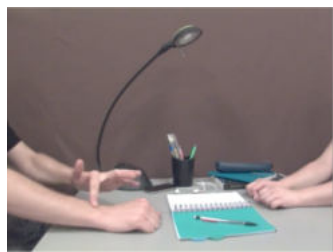
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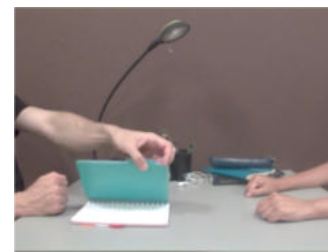
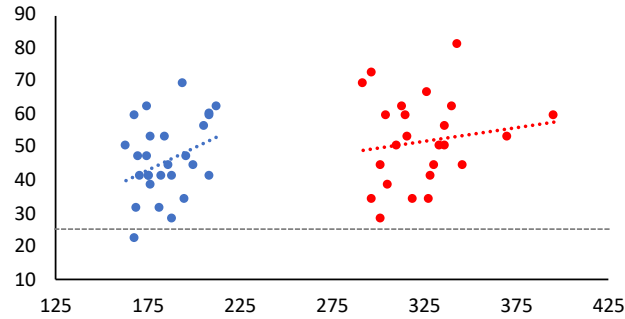
MVPA: Multiclass decoding and age effect

Left IPS/SPL

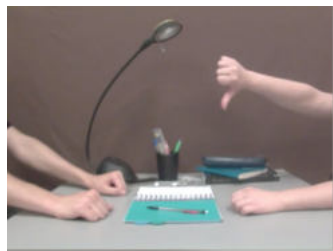
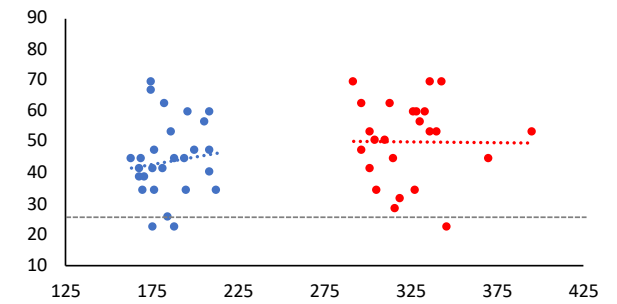
● Adolescents ● Adults



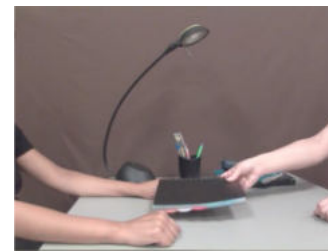
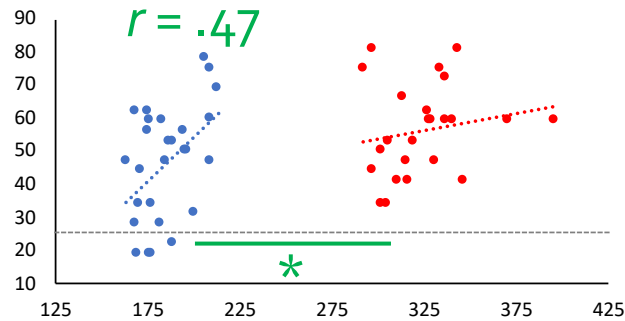
Non-Social Intransitive (NI)



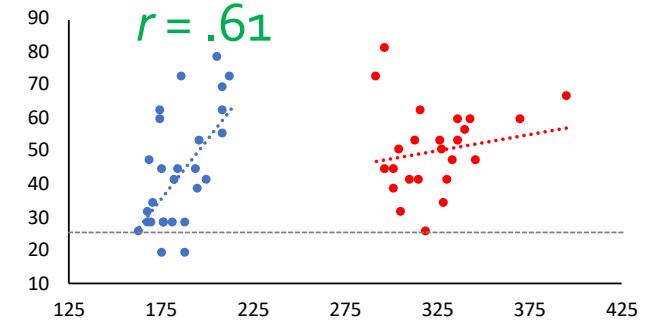
Non-Social Transitive (NT)



Social Intransitive (SI)



Social Transitive (ST)

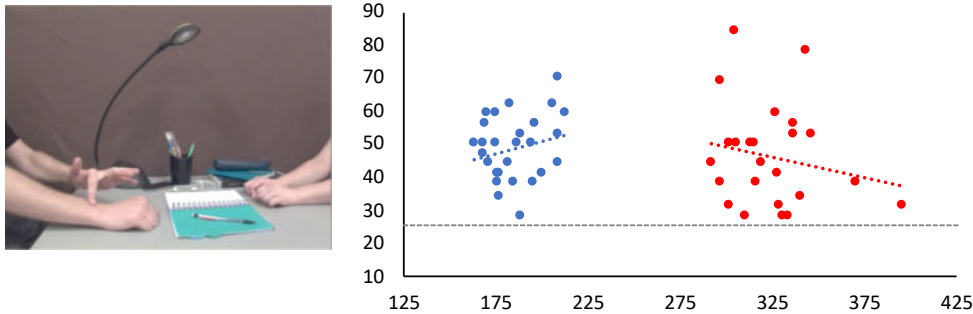


MVPA: Multiclass decoding and age effect

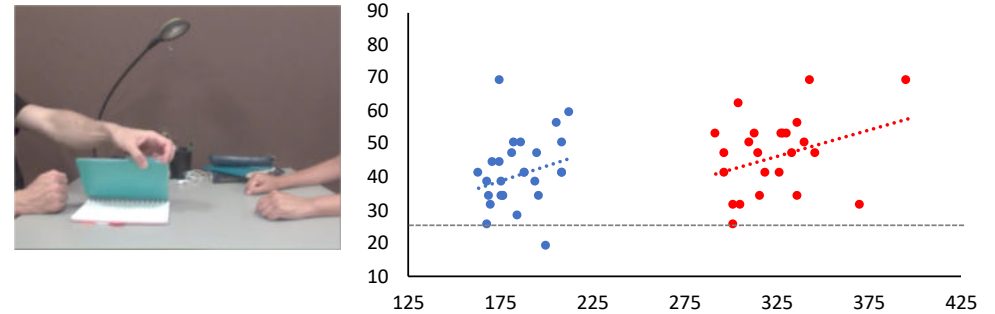
Right IPS/SPL

● Adolescents ● Adults

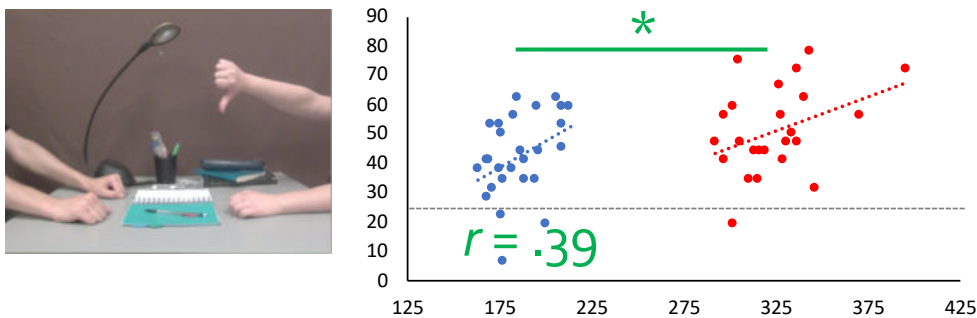
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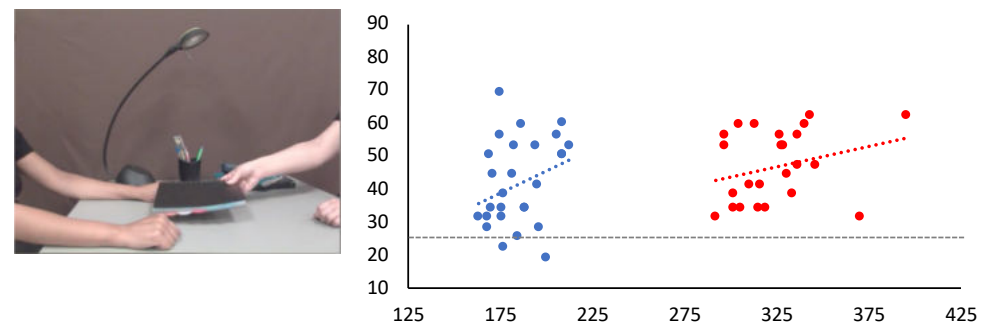
Non-Social Transitive (NT)



Social Intransitive (SI)



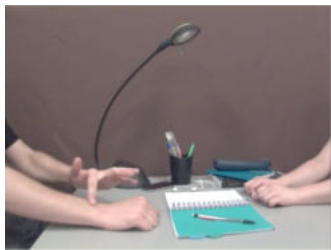
Social Transitive (ST)



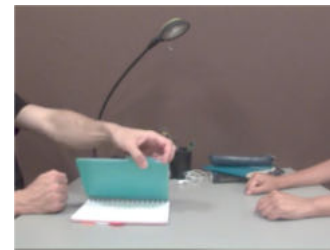
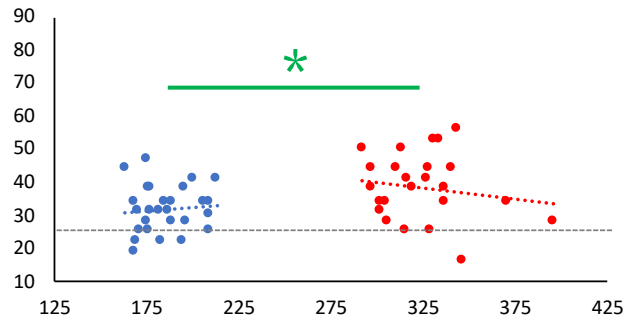
MVPA: Multiclass decoding and age effect

Right pSTS

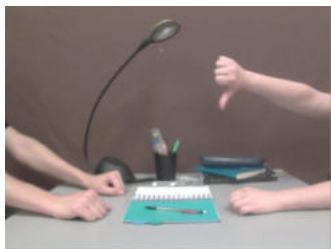
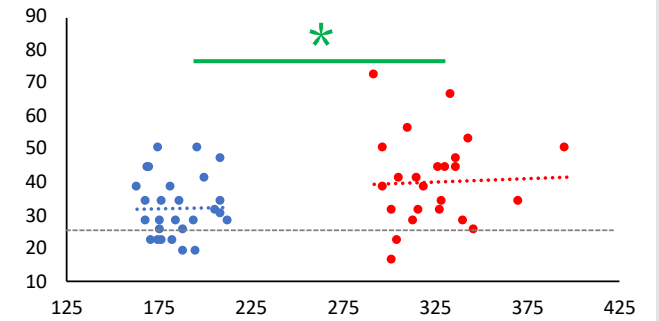
● Adolescents ● Adults



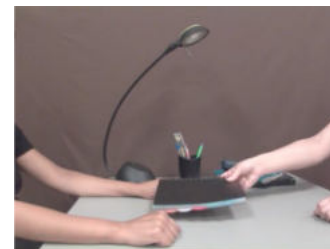
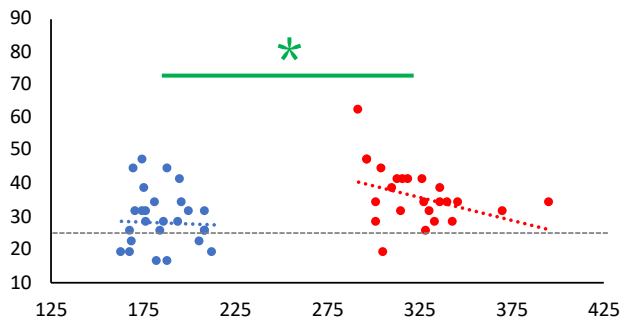
Non-Social Intransitive (NI)



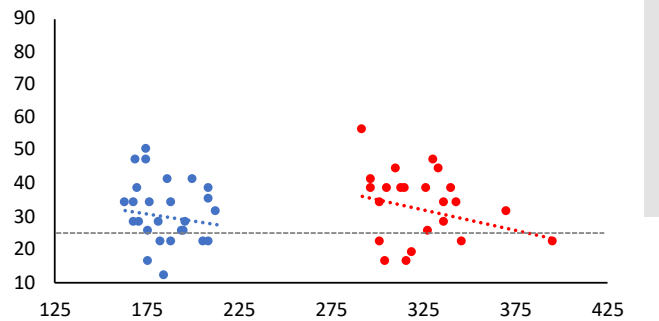
Non-Social Transitive (NT)



Social Intransitive (SI)



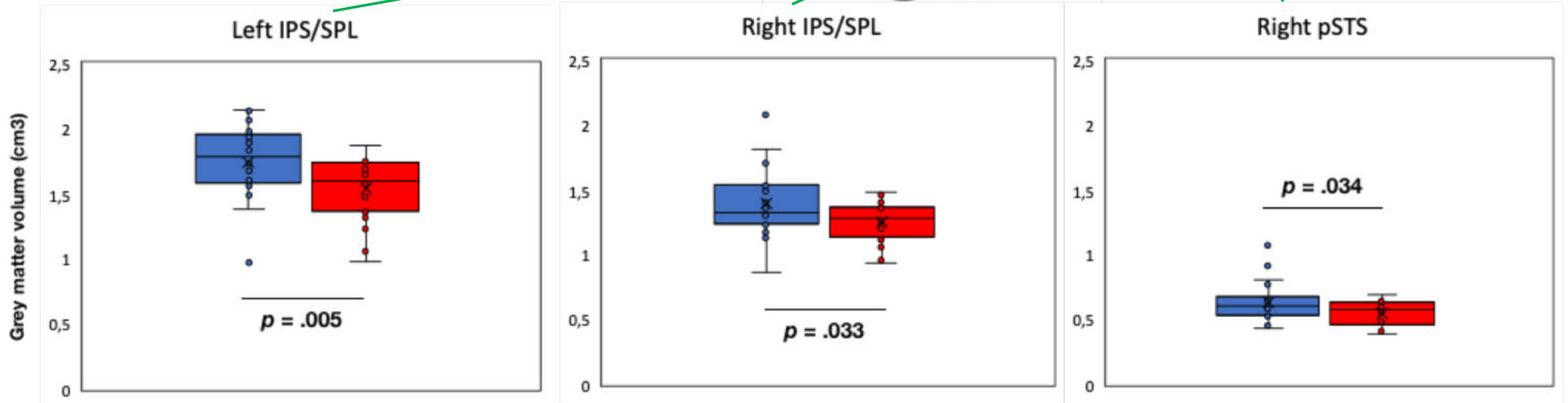
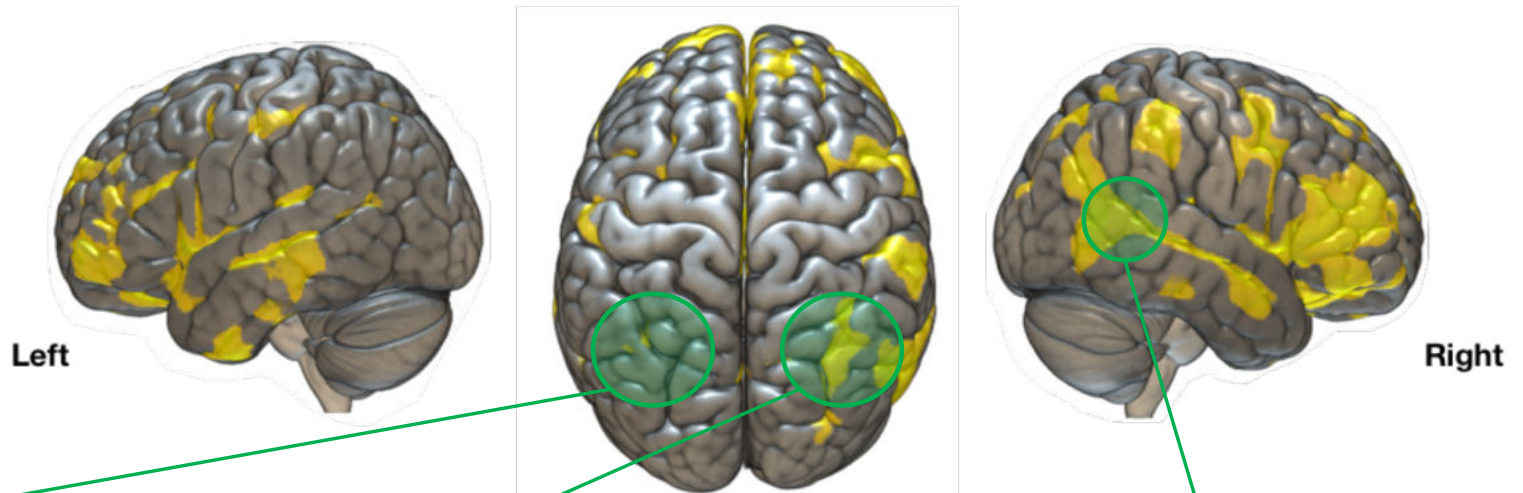
Social Transitive (ST)



Voxel-Based Morphometry analysis

Adolescents > Adults

Adolescents
Adults



Discussion

- AON is already present in adolescents
 - Sensitivity to the nature of action (sociality and transitivity)
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 - Fine-grain representations of action category
- Adolescents recruit more regions of social brain (mPFC and TPj)
- Differences within the AON
 - Less reliable representation of the content of the action (pSTS and IPS)
- IPS/SPL
 - **Age effect** for **social intransitive actions**
 - Complex goal oriented behavior and social interaction (Tunik 2007)
 - « Beyond grasping »
 - Structural difference not associated with age effect

Conclusion

« Social aspect of action representation is still maturing in adolescents, in bilateral IPS, a core node of the AON »

Thanks for your attention!