

A sagittal MRI scan of a human brain, showing the internal structures of the brain in shades of blue and purple. The image is used as a background for the text.

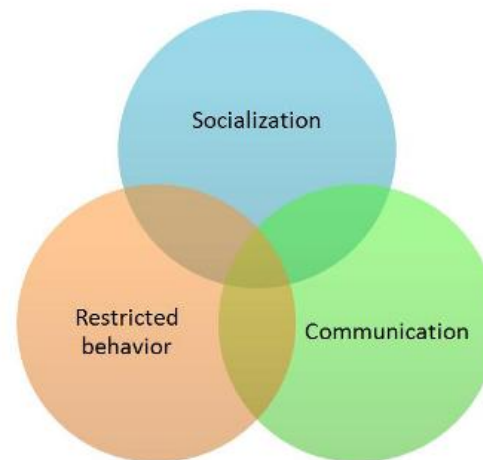
EEG evidence for mirror neuron dysfunction in autism spectrum disorders

Oberman, Hubbard, McCleery, Altschuler,
Ramachandran, Pineda

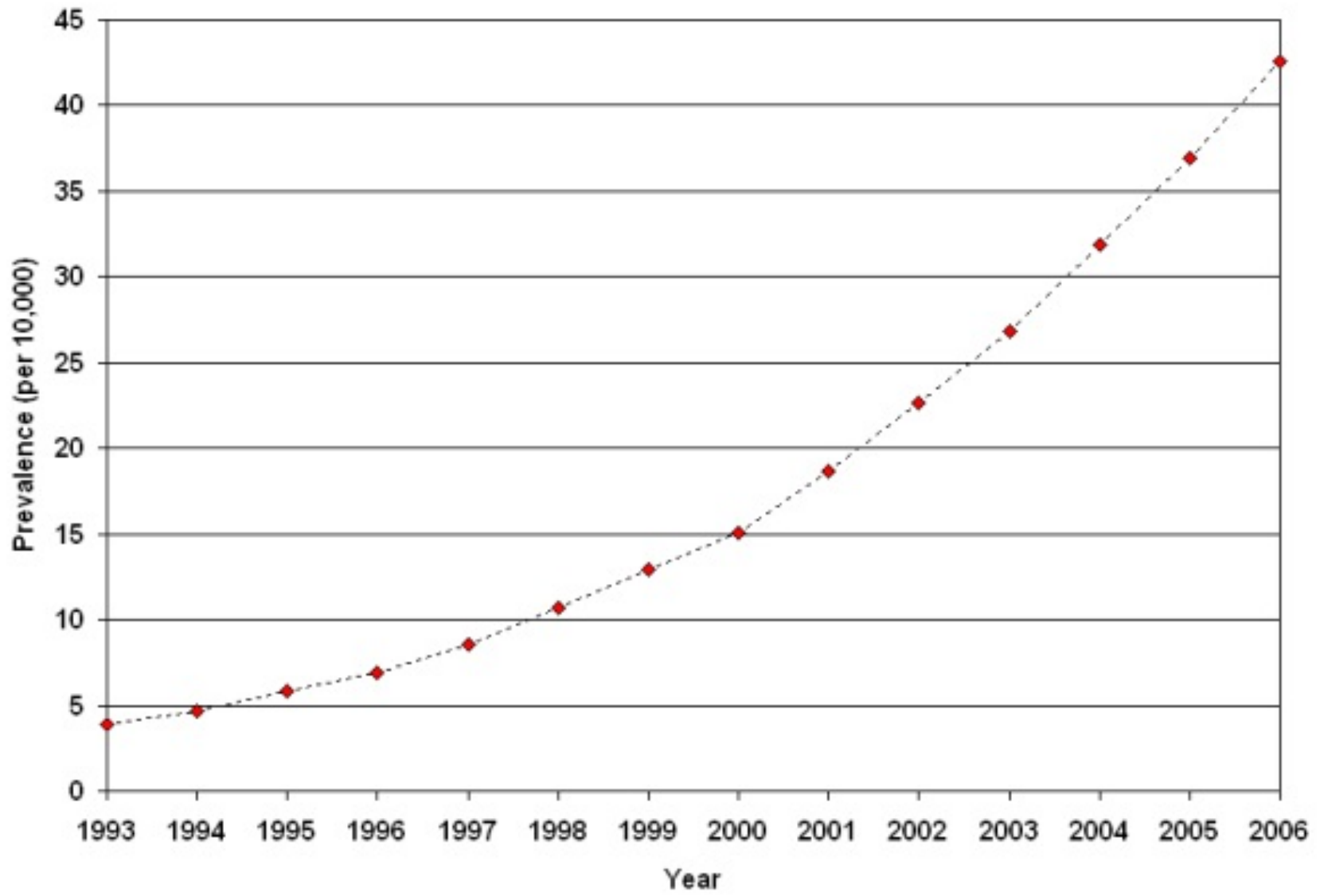
Autism Spectrum Disorders

- Characterized by deficits in social and communicative skills, such as
 - Imitation
 - Pragmatic language
 - Theory of Mind
 - Empathy

The Three Areas of Deficit in Autism
According to the DSM-IV



Autism Prevalence (Ages 6 - 17)
(from USDE data)



Lack of Specificity

- Severity
 - High functioning v. low
- Expression
 - autistic disorder
 - Asperger's disorder
 - pervasive developmental disorder- not otherwise specified

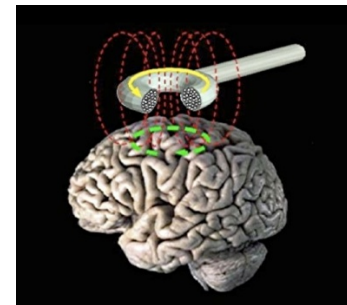
Monkey MNS Background

- Rizzolatti
 - Single-unit study of mirror neurons in area F5 of the premotor cortex of macaques
 - Observation/execution matching system
 - May allow for offline simulation of observed action



Human MNS Background: TMS

- Fadiga et al.
 - Motor evoked potentials in response to transcortical magnetic stimulation over motor cortex are stronger when watching another human perform an action than when watching that same action without an agent
 - Conclusion: “this enhancement was a result of activity of mirror neurons in the prefrontal cortex influencing the motor response”



Human MNS Background: PET

- Parsons et al.
 - Using PET found that frontal, parietal, and cerebellar regions were active during movement, imagined movement and observed movement
 - Found MNs in the inferior premotor cortex (Brodmann's area 44)

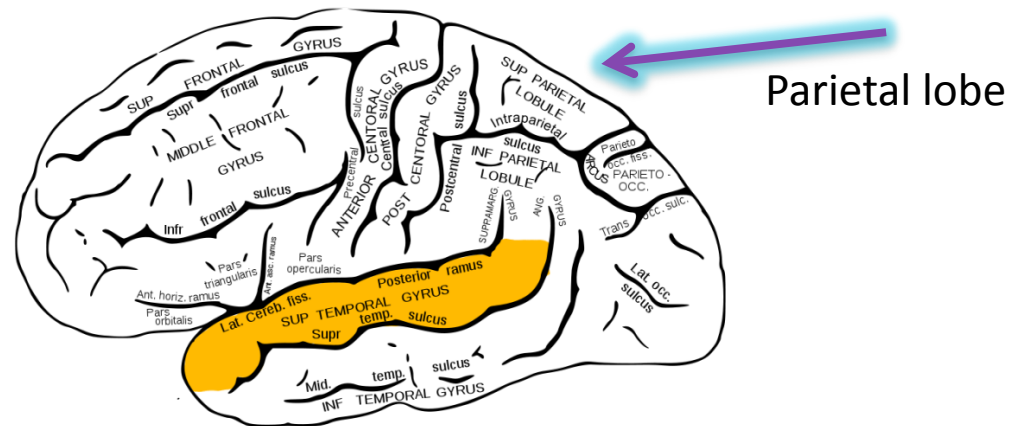


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Human MNS Background: fMRI

- Iacoboni et al.
 - Found, using fMRI, increased blood flow in Brodmann's Area 44 during both execution and observation of actions
 - More recent studies have found similar results in the parietal cortex and the superior temporal sulcus



Human MNS Background: EEG

- Mu band (8 – 13 Hz) frequency is suppressed during execution of action, imagined action, and observation of action
- Also modulated by object-directed actions



Higher Level Processes

- Association of visual representation of observed action with motor representation of that action → imitative behavior/prediction of mental state (Theory of Mind)/empathy
- MNS may have played a prominent role in the evolution of language
 - Homolog of F5 is Broca's Area



Caveman Dictionaries

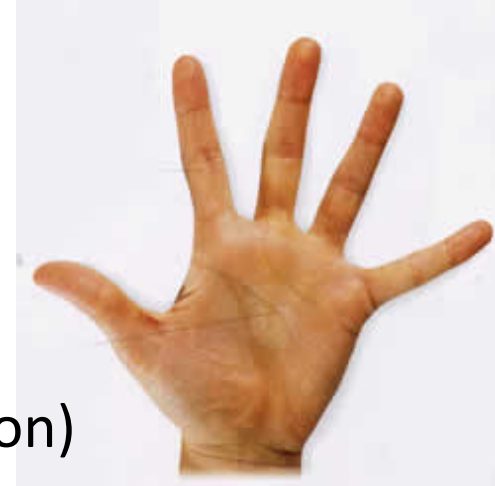
Subjects

- 10 ASD individuals
- 10 Controls
- All male
- Ages 6-47 (ASD: M=16.6, SD=13)
(Control: M=16.5, SD=13.6)
- ASD Subjects all clinically diagnosed
- ASD Subjects all considered high functioning

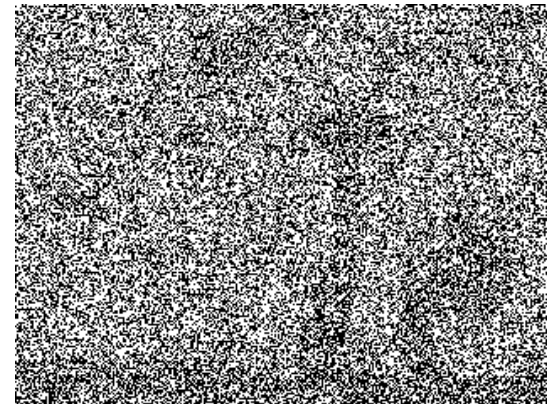
ASD Qualifications

- Diagnosed based off of DSM-IV criteria
 - qualitative impairment in social interaction
 - qualitative impairments in communication
 - restricted repetitive and stereotyped patterns of behavior, interests and activities
- Experimenters also noted:
 - “awkward use of pragmatics, intonation, and pitch in communication, lack of initiation of social interactions, and obsessive preoccupation with the order and specific details of the study.”

Procedure



- Four Conditions:
 - Moving own hand (self-initiated action)
 - Hand opening and closing at 1Hz
 - Watching moving hand (observed action)
 - Watch video of opening/closing hand
 - Watching two bouncing balls (non-biological)
 - Two gray balls moving vertically towards each other
 - Watching white noise (baseline)

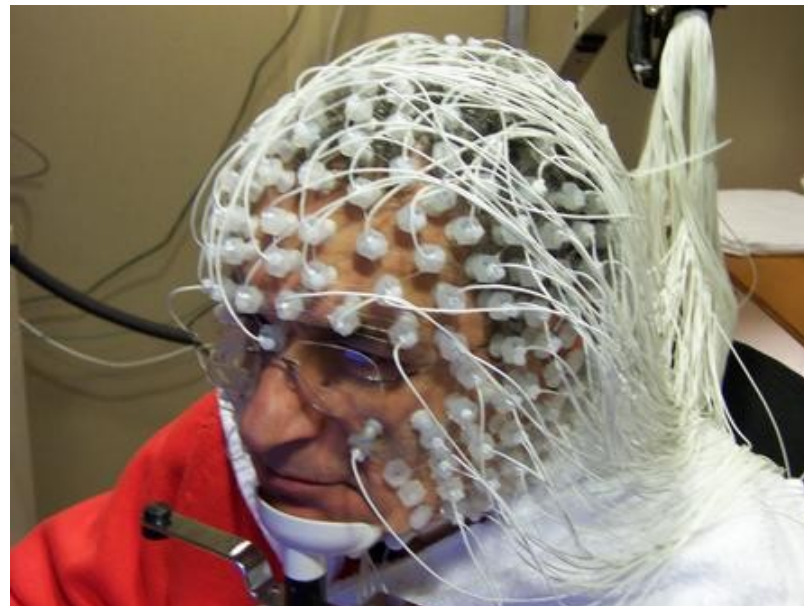


Procedure

- Videos were 80s long
- All conditions were presented twice
- Order of conditions was counterbalanced
- Task:
 - Attend to videos to look for frozen frame
 - Count the number of times that the video stops per block

Data Acquisition

- EEG
 - 13 electrode cap
 - Facial & mastoid electrodes
 - F3, Fz, F4, C3, Cz, C4, P3, Pz, P4, T5, T6, O1, O2



Data Analysis

- First and last 10 seconds of each block were eliminated to remove attentional changes
- Removed artifacts
- The remaining minute of each block was combined with the matching trial of the same condition
 - 2 minutes of data for each condition
- Calculated the power of the 8-13 Hz range using a FFT

Data Analysis

- Two measures of μ suppression:
 - 1) Ratio of power of observed and self hand movement relative to power during baseline
 - 2) Ratio of power of observed and self hand movement relative to power during ball
- Control Ratios:
 - Absolute power to control for individual variation
 - Ball condition ratio to control for the attention needed for counting and directional motion processing

Data Analysis

- Interpretation:
 - Suppression = log ratio of <0
 - No suppression = 0
 - Enhancement = log ratio >0



Behavioral Performance

- Subjects were asked to count the number of times the stimuli stopped moving during the hand and ball conditions
- All subjects had 100% accuracy on this task, confirming that they were attending to the stimuli
- Therefore, any differences found in mu suppression should not be due to differences in attention to stimuli

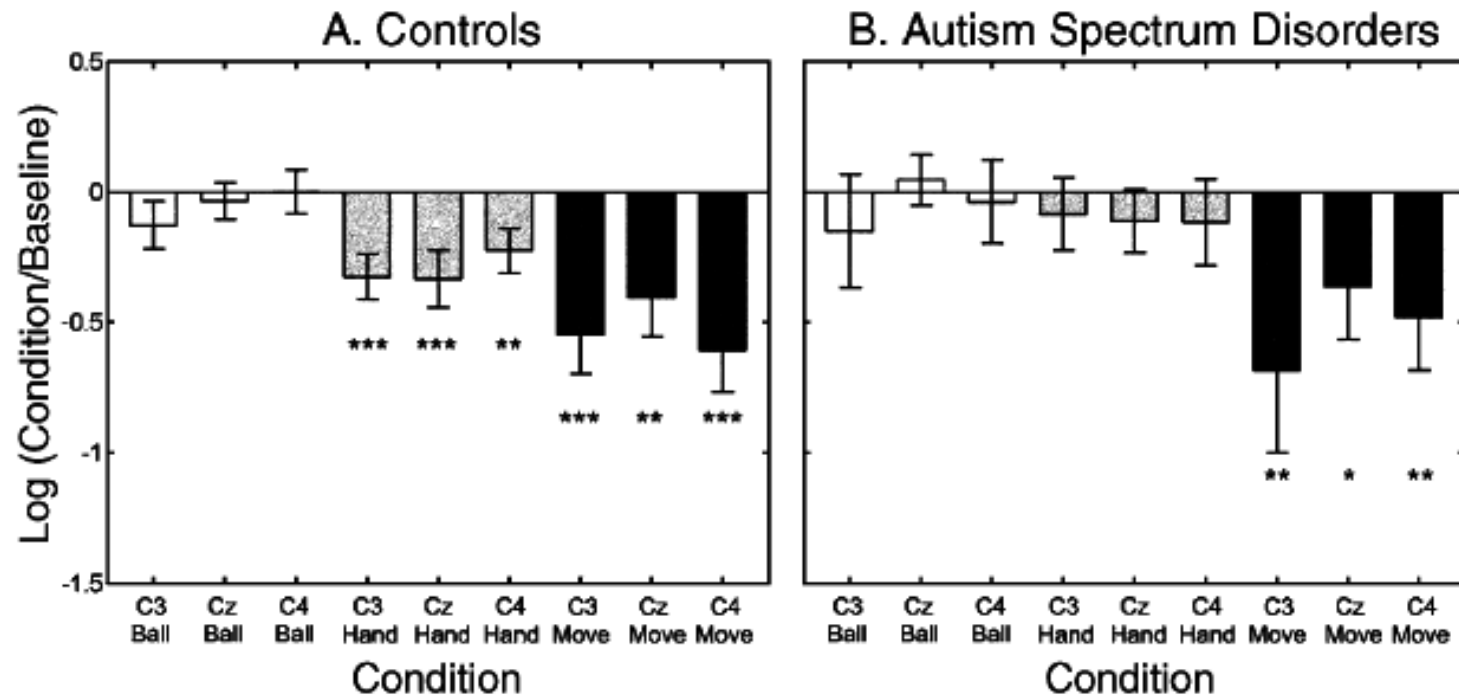
Mu Suppression

- Mu rhythm is defined as oscillations measured over sensorimotor cortex
- Only data from areas corresponding to sensorimotor cortex, C3, Cz, and C4 are presented in the article
- Power in the mu frequency at these areas during the self-initiated and watching action conditions was compared to power during baseline (visual white noise), as well as to power during the ball condition

Results

- The control group showed significant μ suppression compared to baseline during both self-initiated and observed action conditions
- The ASD group showed significant μ suppression during the self-initiated action condition, but NOT during the observed action condition
- This result was not due to differences in baseline μ power

Results



By the numbers

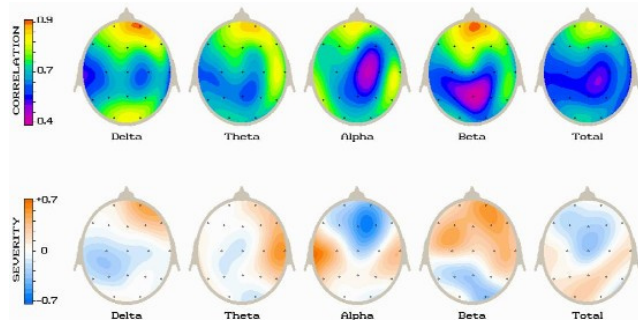
Control Group

- During self-initiated action condition:
 - C3 $t(9) = -3.97, P < 0.002$
 - Cz $t(9) = -2.85, P < 0.01$
 - C4 $t(9) = -4.00, P < 0.002$
- During watching action condition:
 - C3 $t(9) = -3.99, P < 0.002$
 - Cz $t(9) = -3.21, P < 0.005$
 - C4 $t(9) = -2.78, P < 0.01$

ASD Group

- During self-initiated action condition:
 - C3 $t(9) = -2.27, P < 0.03$
 - Cz $t(9) = -1.91, P < 0.05$
 - C4 $t(9) = -2.50, P < 0.02$
- During watching action condition:
 - C3 $t(9) = -0.64, P > 0.25$
 - Cz $t(9) = -0.98, P > 0.15$
 - C4 $t(9) = -0.74, P > 0.20$

- Ratios were also calculated comparing the power during the self-initiated and watching action conditions to the power during the ball condition
 - Results were consistent with baseline ratios
- The authors also ruled out influence from the large age range by calculating a Pearson r coefficient for both groups
 - Neither showed significant correlation during any condition or at any electrode site



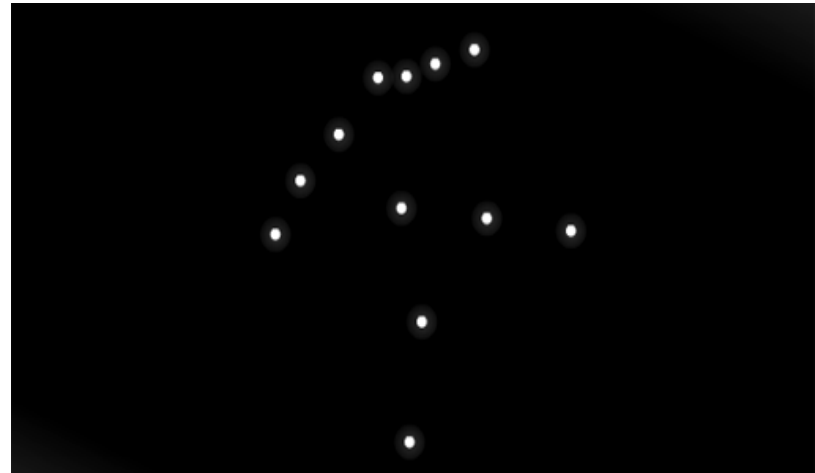
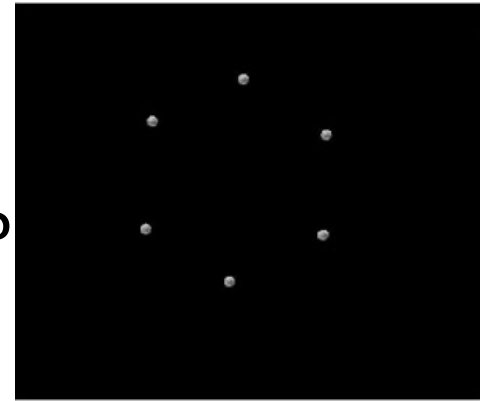
ASD Implications

- Possible dysfunction in mns that does not improve as we age
- IFL and PMC were weaker in ASD
- Supports theories regarding ASD in social situations
 - Removed
 - Failure to empathize
 - Failure to relate

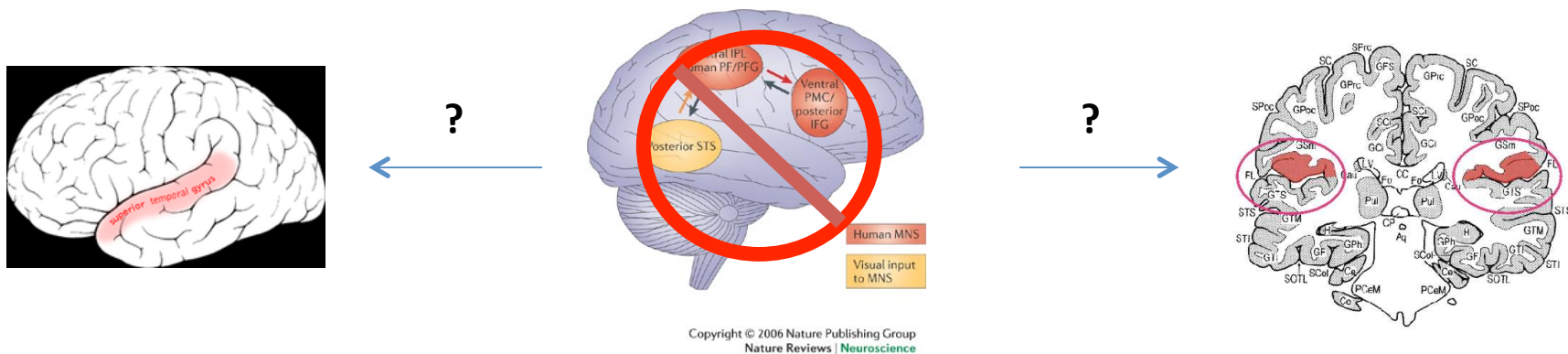


Possible Explanations for ASD Differences in Trial

- No study is perfect
- Counting task was %100
 - Mechanical, not biological tracking?
- Repetitive nature of task
 - No longer processing biological motion because they are losing focus
 - Not likely, but possible



(continued)...



- Poor spatial resolution of EEG doesn't account for activity from STS
 - Maybe ASD process info in different locations/maybe we are just looking in the wrong area
- Maybe ASD have impaired processing of biological motion

Why do ASD have this activity?

- Receive bad info from other parts of brain
 - Helpful in explaining why ASD have deficits in understanding metaphors/similes

- Connection malfunction in MNS



What do we have to say?

- Extensive amounts of evidence point to mns as involved in imitation, language, theory of mind, and empathy
- Social cognition



Thank you!

- Emma Bloom



- Katrin Porcella



- Jenny Lyons



- Tyler Nelson

