Gender Differences in Brain Networks Supporting Empathy

BY
MARTIN SCHULTE-RUTHER

COGS 171
DR. PINEDA

JONAS VILLADSEN, EMMA ANDERS, JASMIN TABATABAEE,
SARAH TANNEHILL, SHELBY COHANTZ

Previous Studies

- Females score higher on psychological tests (Hall, J.A. 2000. Gender differences in the nonverbal communication of emotion).
- Females show superior expression of emotion (Dimberg and Lundquist, 1990)

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- Females show superior expression of emotion (Dimberg and Lundquist, 1990)
- Differences from a neurological viewpoint – fMRI

Previous Studies

- Brain scanning data on emotion, *not* empathy
  - Lateralization, though inconsistent
  - Different strategies

- Reaction to observation of painful stimulus of others (Singer et al. 2006)

Two distinct components of empathy

Cognitive component

- Perspective taking and self-other distinction
  - Theory of Mind abilities (ToM)

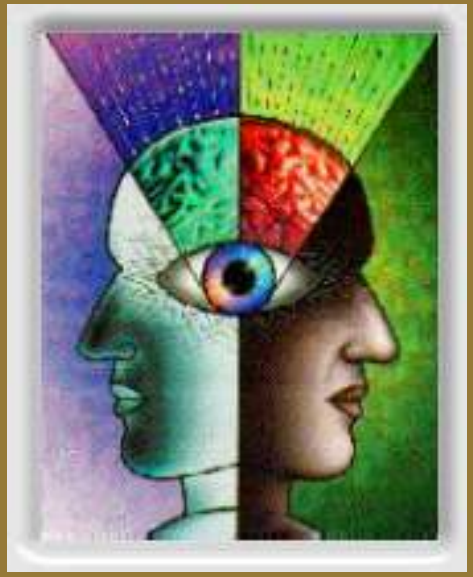
Emotional component

- Resonance with the emotions of other and the generation of an appropriate emotional response
  - hMNS

Experimental Procedure

Hypothesis:

- Genders use different strategies to access empathy
  - Shown by differential activation in various areas
  - Activity correlated with self-report ratings



Experimental Design, Schulte-Ruther 2007

Participants

- 26 right handed; 12 male, 14 female
- 24 years +/- 3

Screening

- Healthy
  - Neuropsychological testing: IQ, working memory, attention capabilities
  - Alexithymia (ability to verbalize mental states)
  - BEES test
- German speakers

Experimental Paradigm

- Cue question, view face (stimulus), presented list of emotional word phrases, choose appropriate answer
- BASELINE task
- SELF task
- OTHER task

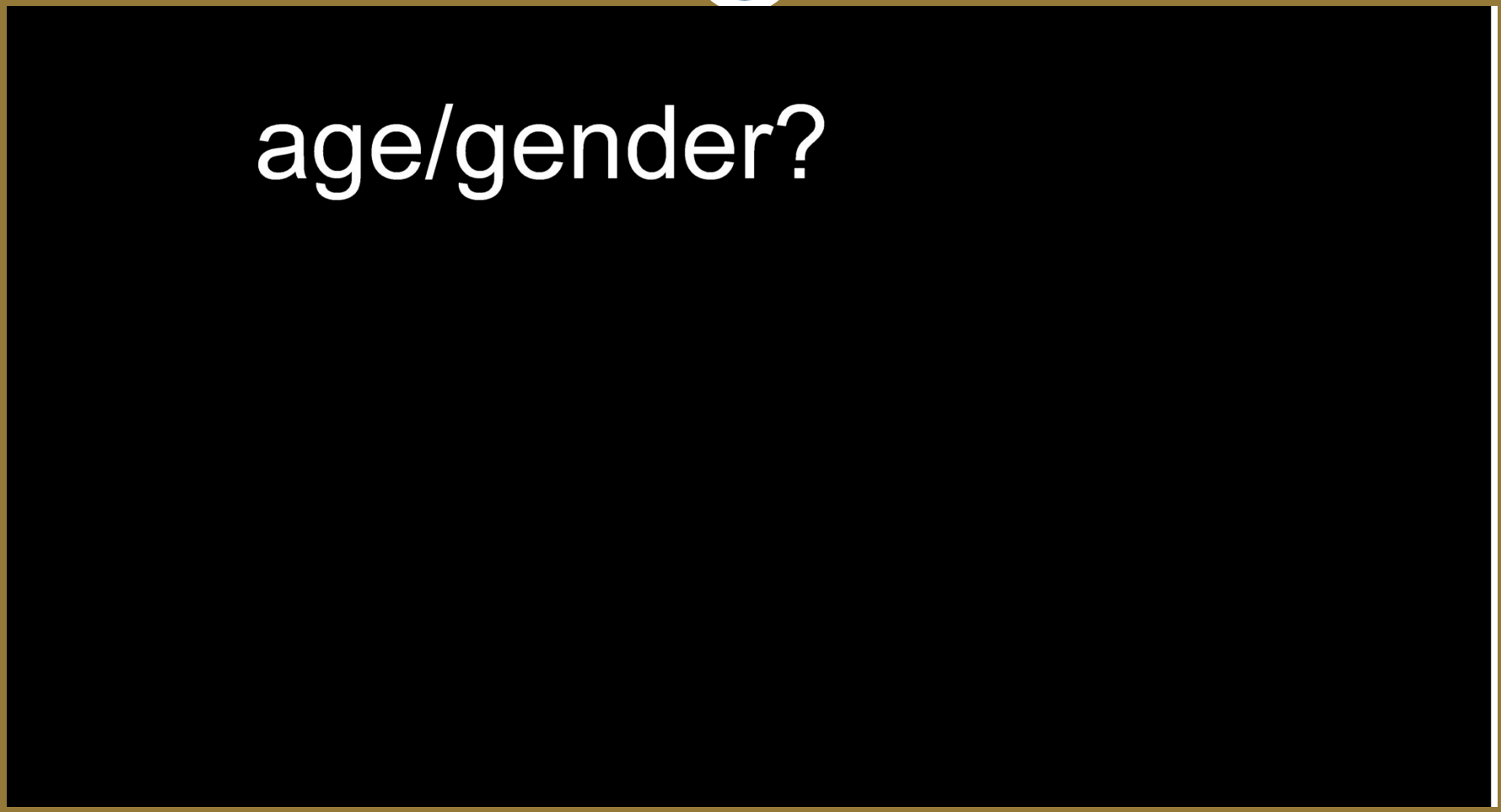
Tasks

- BASELINE
  - Age/gender; neutral faces
- Age
  - a. older
  - b. younger
- Gender
  - a. male
  - b. female

BASELINE - permutations

- a.a. <older male>
- a.b. <older female>
- b.a. <younger male>
- b.b. <younger female>

BASELINE trial-cue

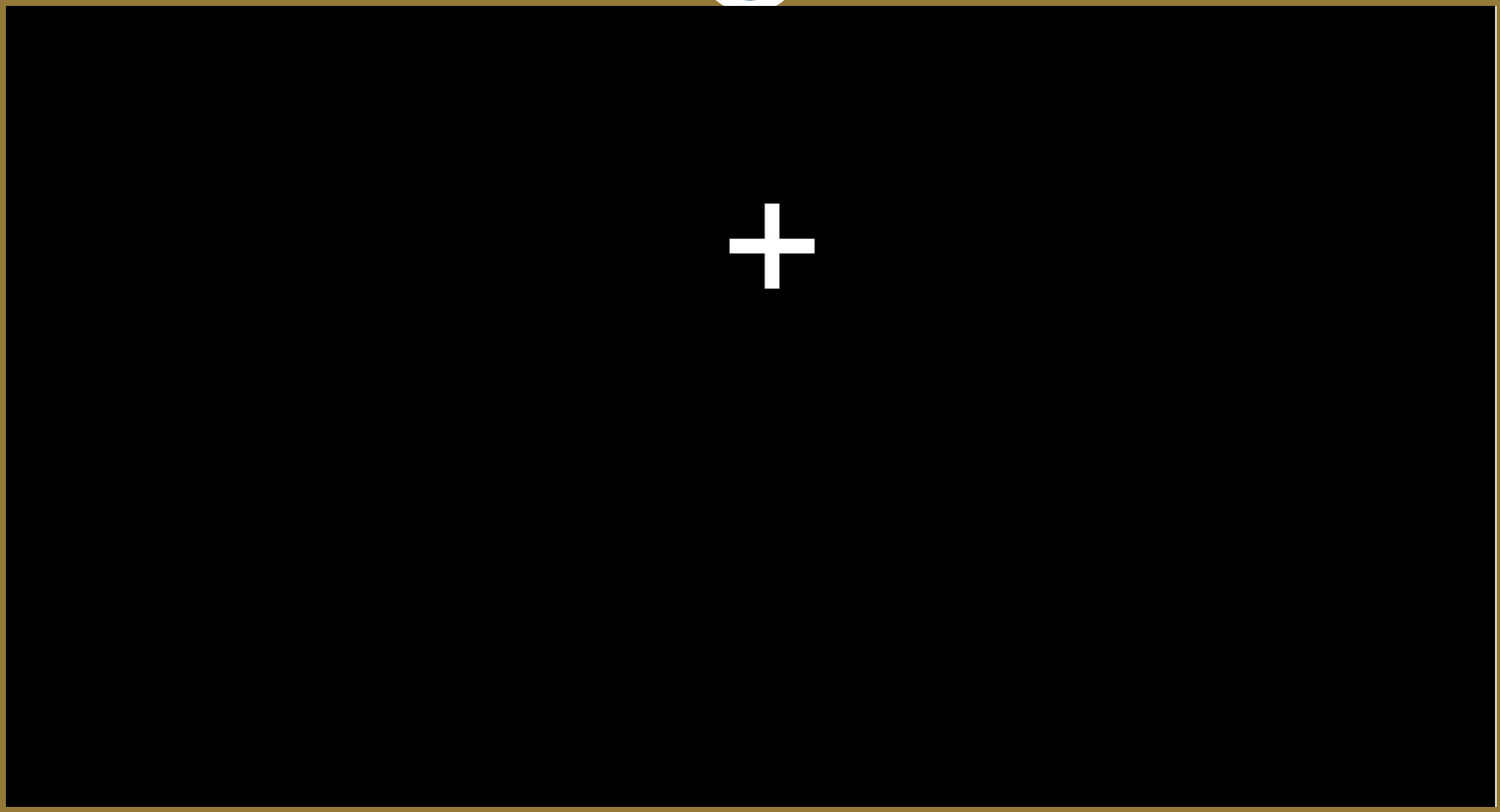


BASELINE trial-face

BASELINE trial-choice

older male
younger female
younger male
older female

BASELINE trial-cross



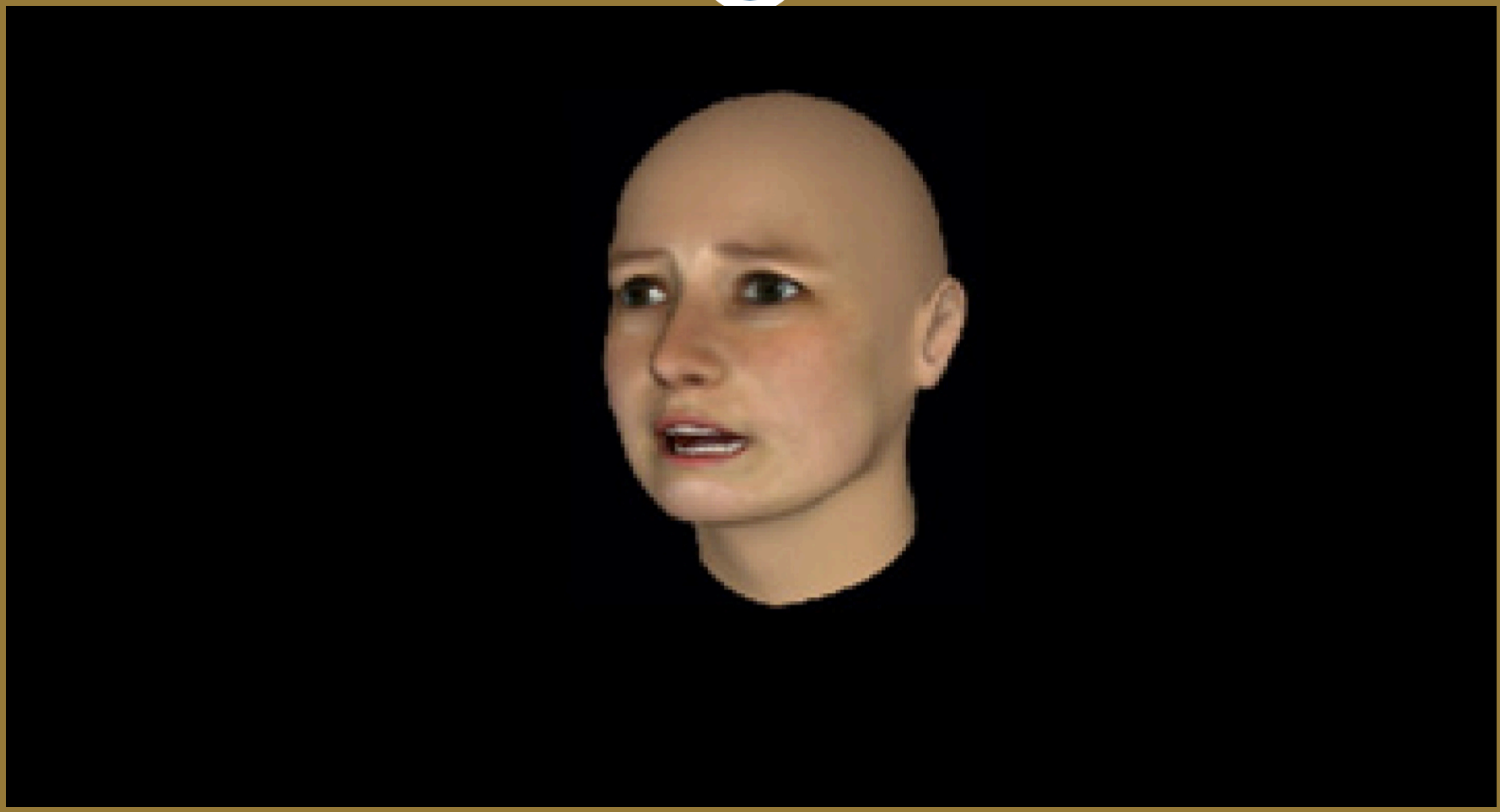
Tasks

- SELF
  - Subject judges own feelings in response to stimulus face
  - Prompted with “How do you feel?”
- Emotion
  - a. angry
  - b. fearful
- Head Direction
  - a. direct
  - b. averted* (45 degree)
- *gaze direction vs. levels of activation

SELF trail-cue

How do you feel?

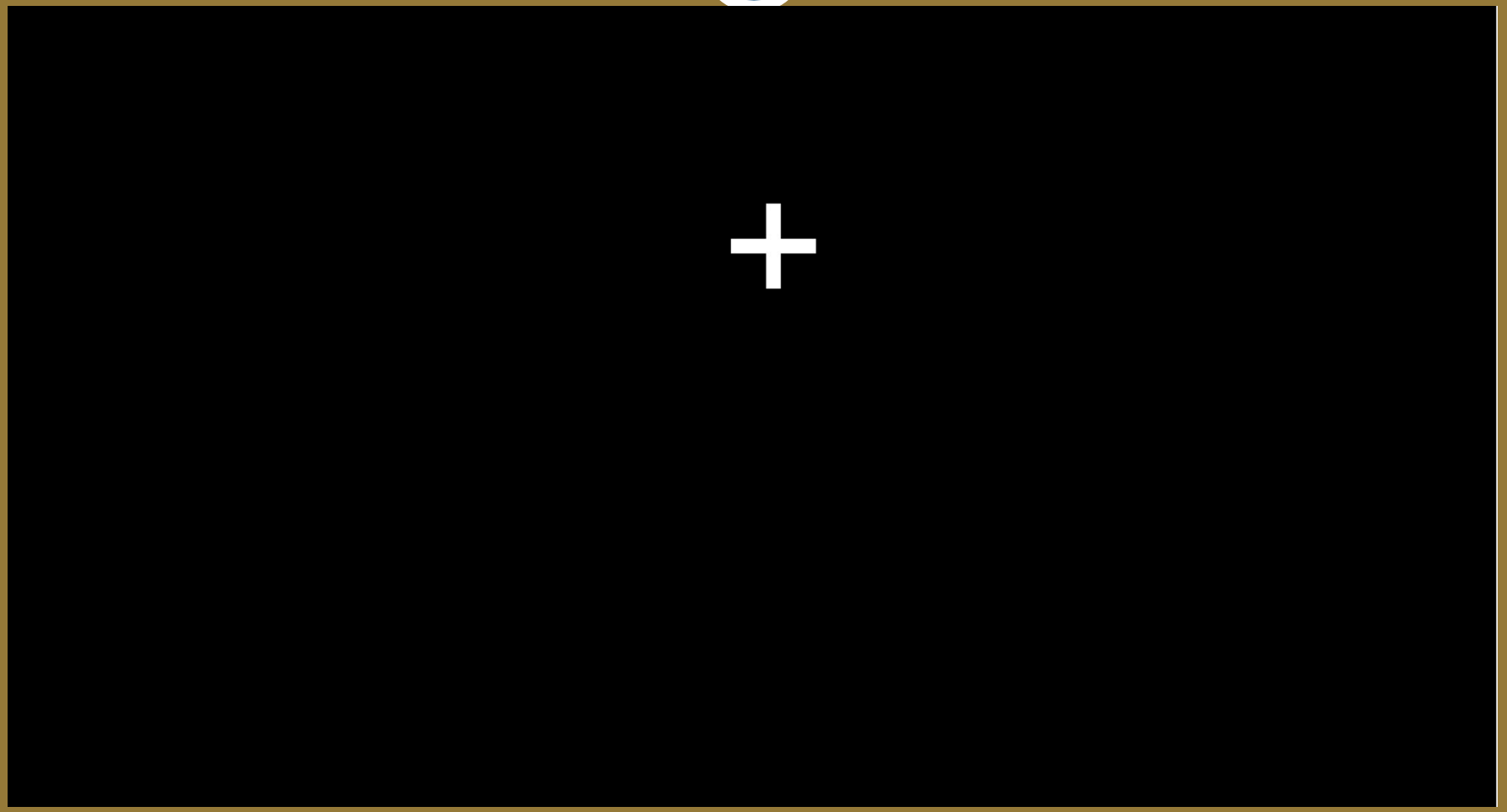
SELF trial-face



SELF trial-choice

tense
cowed
frightened
insecure

SELF trial-cross



Tasks

- OTHER
  - Subjects judge the emotion of stimulus face
- Emotion
  - a. angry
  - b. fearful
- Head Direction
  - a. direct
  - b. averted (45 degree)

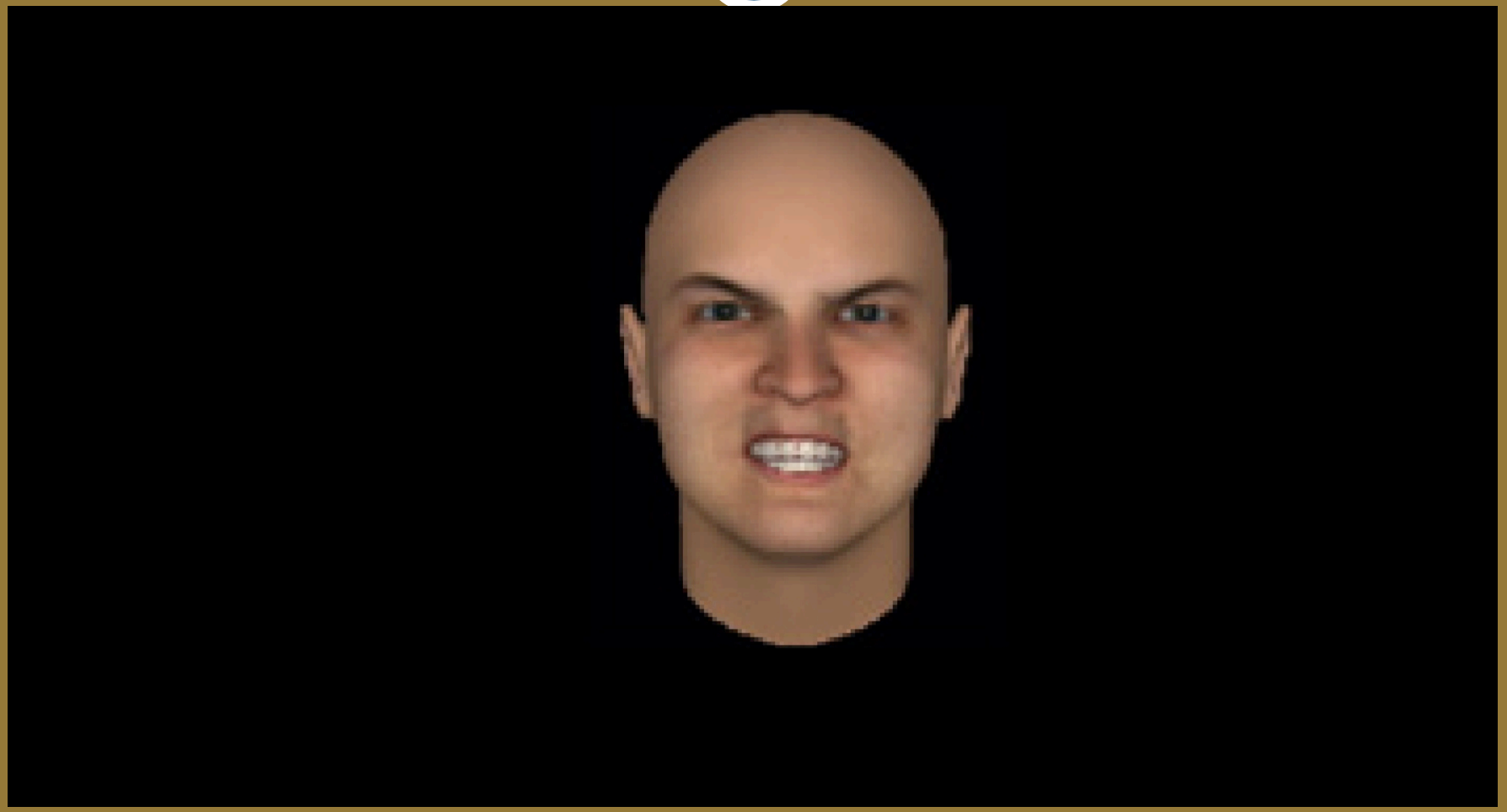
OTHER - permutations

- a.a. <angry direct>
- a.b. <angry averted>
- b.a. <fearful direct>
- b.b. <fearful averted>

OTHER trial-cue

How does he/she feel?

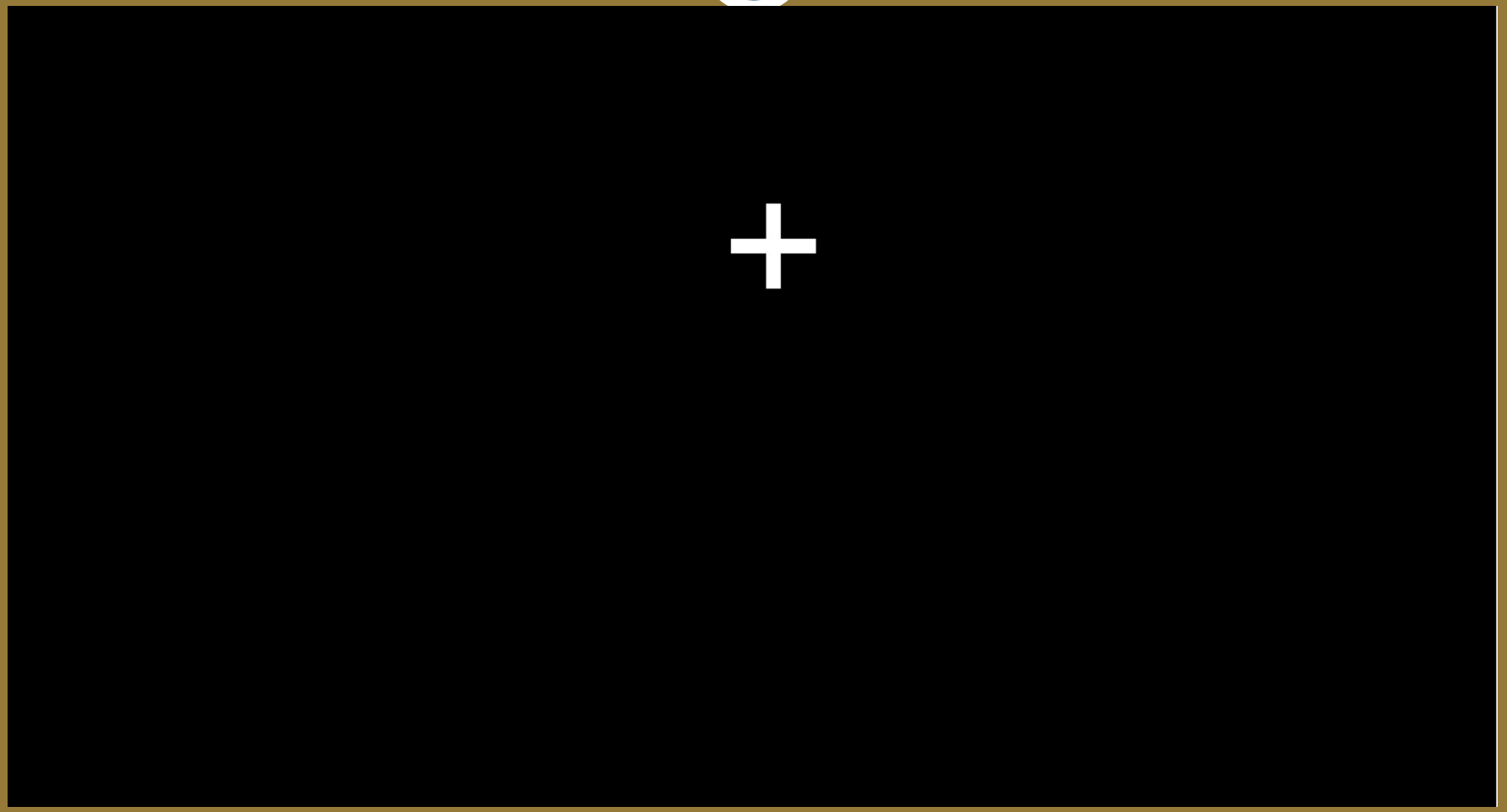
OTHER trial-face



OTHER trial-choice

cowed
furious
annoyed
frightened

OTHER trial-cross



Details of Experimental Variables

- Word choice
  - Complex emotional states
  - Evaluative
  - Require Theory of Mind reasoning; evoke more empathy
- Pilot study
  - Subjects generate words
  - Controlled for length, arousal, and positivity

Details of Experimental Variables (cont.)

- Selection
  - Right hand
  - Four button response device

Trials

- Blocks of four trials, then break
- Randomized orders

Methods for Analysis

- Same procedures as 2007
- Added second-level to account for gender differences
  - Within-group
  - Between-groups
- Common gender effects by simple effects of task
  - SELF vs. BASELINE
  - OTHER vs. BASELINE

Region of Interest Approach

- ROI to target a-priori hypothesized regions
  - Specific imaging maps
  - Superior Temporal Sulcus (STS)
  - Temporoparietal Junction (TPJ)

Pre- and Post- Scanning Procedures

- De-briefing questionnaire
  - Naturalness of stim faces
  - Intensity (evoked) in SELF
  - Intensity (observed) in OTHER
  - Levels of difficulty in BASELINE, SELF, and OTHER
  - 6 point scale

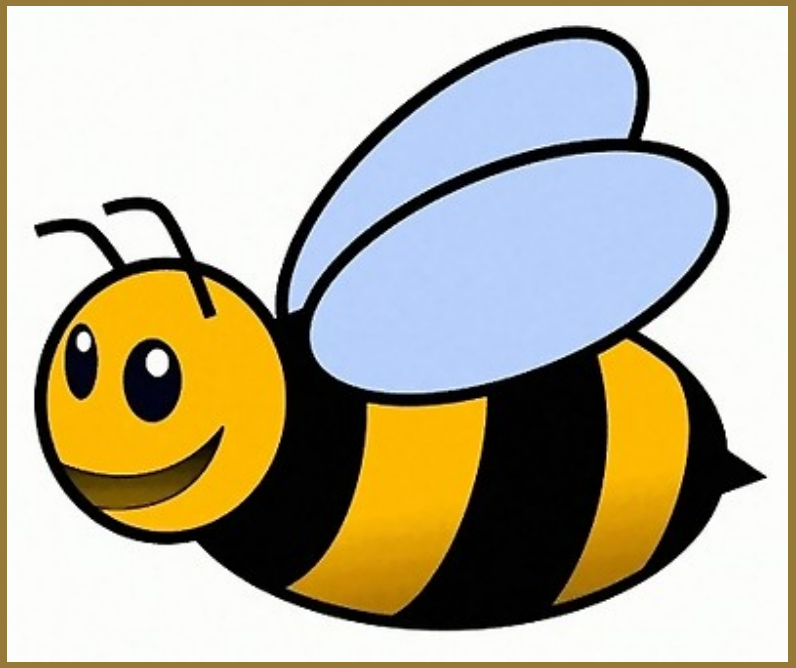
Pre- and Post- Scanning Procedures (cont.)

- Statistical Tests
  - Post-scanning data
  - Reaction times
  - Neuropsychological test scores (pre-scan)
  - Parametrics: t-test, ANOVA
- BEES
  - “to assess correlations between neural activation and individual empathetic abilities”

Experimental Results

Behavioral Data

- Found significant difference between sexes on the Balanced Emotional Empathy Scale (BEES)
  - Females scored higher than males



Stimulus Faces

- No gender differences in questionnaires on:
  - the naturalness of emotional or neutral faces
  - difficulty in SELF-task or OTHER-task or high-level baseline task.
- Females rated the intensity of their OWN emotions during the experiment significantly higher than males.
- Perceived emotion showed no between subject difference.

fMRI Data

Areas of significant differential activation in both SELF and OTHER task:

- STS
- Inferior Frontal Gyrus
- Temporal lobes in both hemispheres
- Left medial prefrontal cortex
- Middle frontal gyrus
- Pre-SMA
- Right cerebellum

SELF vs. high-level baseline:

- Bilateral TPJ activation
- Precuneus/posterior cingulate cortex
- MPFC

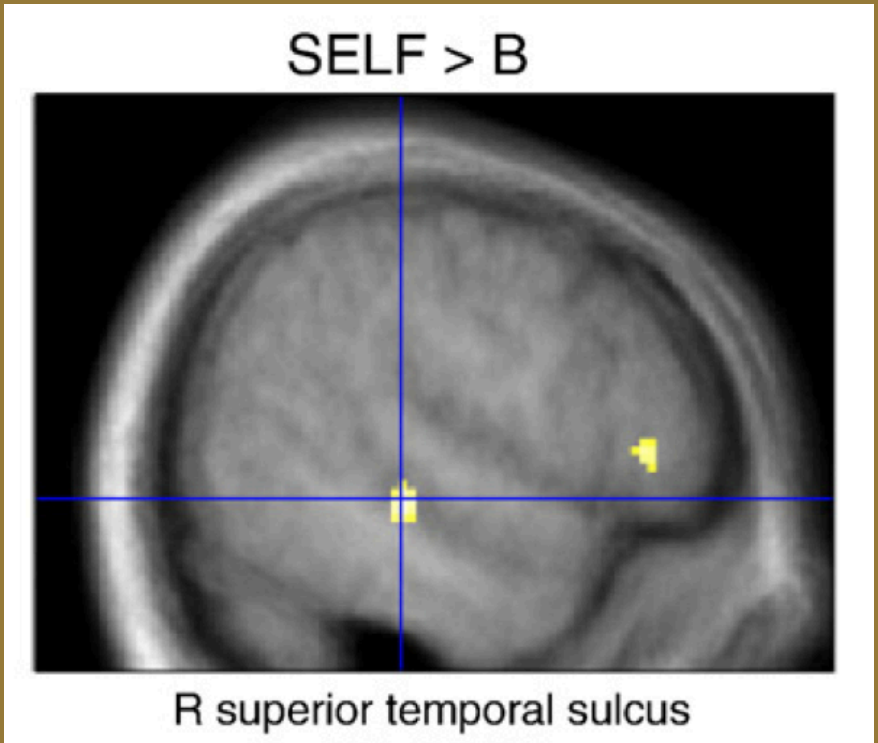
SELF vs. OTHER (in both sexes)

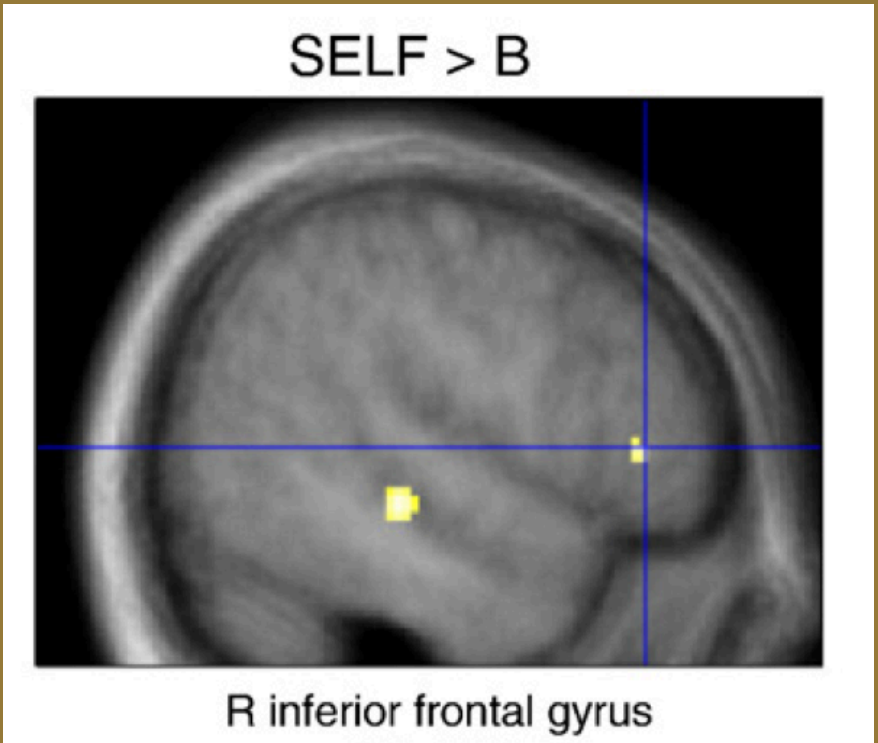
- TPJ
- MPFC
- Posterior cingulate cortex/precuneus
- Inferior frontal gyrus
- Pre-SMA bilaterally
- Left middle frontal gyrus
- Right cerebellum
- *The inverse contrast (OTHER vs. SELF) didn't show significant activation*

Gender effects on Brain Activations

SELF vs. High-level baseline task

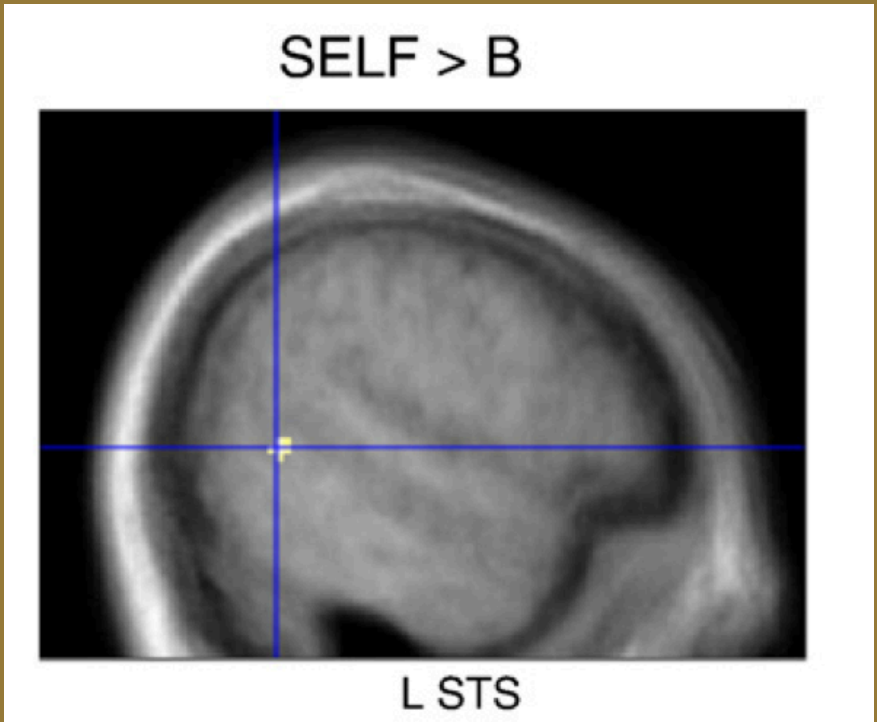
- Females showed stronger activation of the right inferior frontal cortex, right STS and right cerebellum

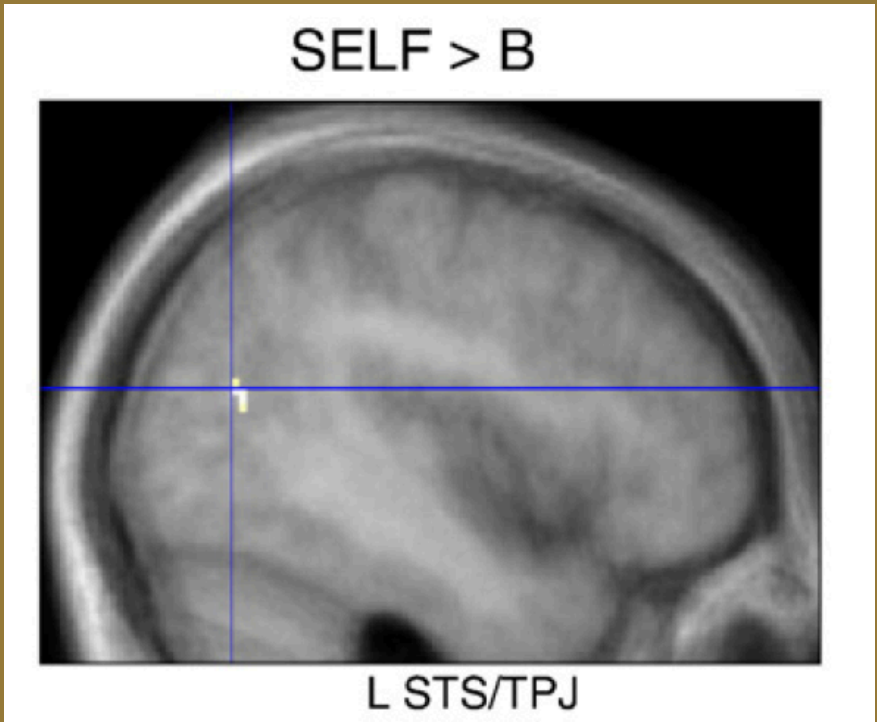




SELF vs. High-level baseline task

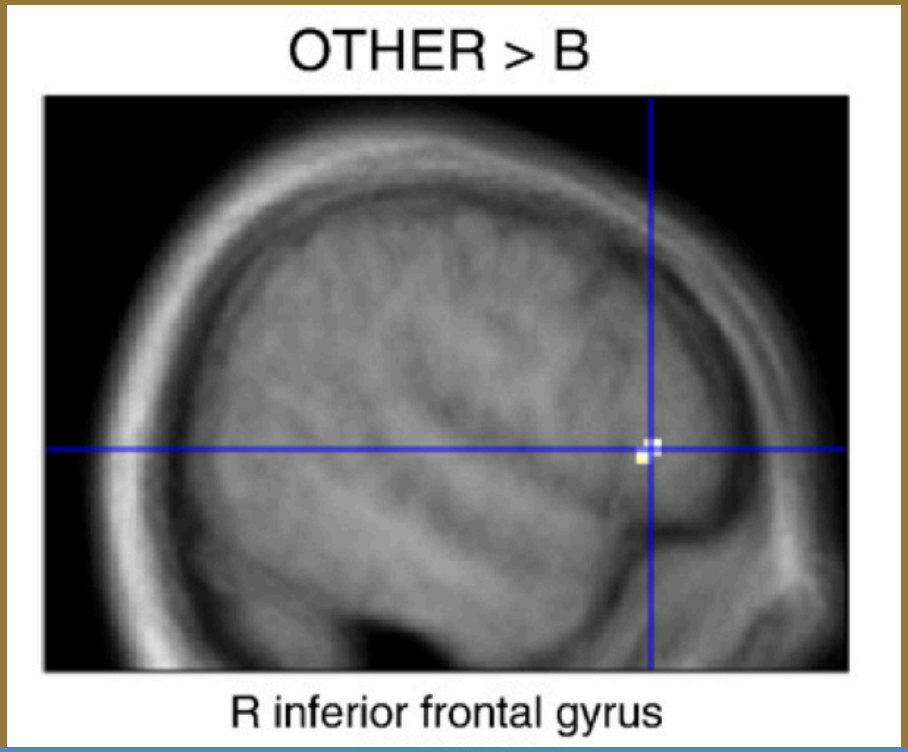
- Males showed stronger activation of left STS and TPJ





OTHER vs. High-level baseline

- Females showed stronger activation in the inferior frontal cortex
- No differential activation in males



Discussion

WHAT DOES ALL THIS MEAN?!

Results re-examined

- Found activation in regions involved in the hMNS during emotional perspective taking
  - Inferior frontal gyrus
  - BA 44/45
  - This occurs in both males and females

Activation differences between sexes

Females

- Activation is stronger in the right inferior frontal gyrus (IFG) and right Superior Temporal Sulcus (STS)
- Right hemisphere lateralization in females

Males

- Found increased activation during the attribution of emotion to themselves in TPJ (SELF-task)
- More of a logical analysis? (to be explained later)
- Left hemisphere lateralization in males

Human Mirror Neuron System

- Remember: During attribution of emotion to either oneself or a stimulus face, found significant activation in both sexes in the inferior frontal gyri bilaterally
- This includes Broca's area, BA 44/45 and it's homologue in the right hemisphere
  - The above have been previously implicated in the hMNS (Iacoboni, 1999)

hMNS continued

- Found a correlation between activation in these areas and self report of experienced emotion during the experiment
  - Suggests a relationship between the degree of interpersonal emotional involvement and mirror neuron activation

Theory of Mind

- Results from study may suggest that ToM abilities play an equally important role in interpersonal emotional perspective taking, from both the self and other perspective
- Increased activation of the TPJ in males relative to females, during the attribution of emotion to oneself may reflect a more cognitively driven access to one's own feelings in response to the emotions of other people

Theory of Mind

- TPJ has been found to mediate the inference of the belief of other people, and therefore plays a role in the distinction between self and other (Saxe and Kanswisher, 2003)
  - Could it be that men may have a tendency to show the sharing of emotions with others to a lesser degree than women?
- Although the coordinates of peak activation in the TPJ region and in the STS region for the comparison between males and females do not exactly line up with those found by Saxe and Kanwisher, other studies have shown similar coordinates during ToM reasoning or tasks requiring a self other distinction

What does Theory of Mind have to do with Empathy?

- Results suggest that distinct brain mechanisms related to ToM and to the hMNS may play an important role in empathic face-to-face situations

Implications and further discussion

Implications for behavioral gender differences in emotional processing and empathy

Empathizing-systemizing theory of psychological gender differences

Implications for autism

Behavioral gender differences in emotional processing and empathy

- Concerning the expressive component of emotion, findings are even more consistent across a large body of literature (e.g., Dimberg and Lundquist, 1990; Schwartz, 1980; see Brody and Hall, 2000)
  - EMG measures
  - ratings of communication accuracy
  - self-reports of expression
  - ratings of non-verbal behavior like smiling and gesturing
- Females show enhanced emotional expressivity and arousal in response to the emotions of other people in comparison to males

How does this relate to our article?

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- Schutle-Ruther behavioral data:
  - Females rated the intensity of their own experienced emotion during the experiment higher than males did

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- Schutle-Ruther behavioral data:
  - Females rated the intensity of their own experienced emotion during the experiment higher than males did

- The subjective increase of own emotional experience in females during the experiment could be related to:
  - a higher emotional arousal of women
  - enhanced emotional expressivity
  - or both

Keep in mind...

Keep in mind…

- No gender difference in the ratings of the emotional intensity of the observed facial expressions, suggesting:
  - The female emotional superiority exerted stronger influences on the SELF-task compared to the OTHER-task.
  - This finding also implies that an advantage of females in emotional behavior is more pronounced in the domain of emotional responsiveness than in that of emotion perception.

What about the hMNS?

- Schutle-Ruther neuroimaging results of the present study provide evidence that enhanced expressivity of emotion in females may be associated with a higher degree of hMNS activation

Presence of hMNS

- In females, however, the awareness of the feelings of others is accompanied by a stronger emotional resonance, while males may retain a more cognitively driven and distant approach to the emotional state of other persons (Hoffman, 1977)
- Neuroimaging results in the Schutle-Ruther present study provide evidence that enhanced expressivity of emotion in females may be associated with a higher degree of hMNS activation.

Empathy and the hMNS

- Empathy is not restricted to the sharing of the emotional state of another individual, but also requires the distinction between the self and the other (Decety and Jackson, 2004).
- Schutle-Ruther's previous neuroimaging data on common effects in both sexes as well as the present analysis of gender differences support the view that:
  - TPJ is involved in the maintenance of self–other separation (Decety and Sommerville, 2003).
  - TPJ activation was modulated by gender, with stronger TPJ recruitment in males compared to females.

What does all this imply?

- Attenuated TPJ activation might provide females with the better capability to temporarily suspend the boundaries between the SELF- and OTHER-perspective during face-to-face interactions (Hoffman, 1977).

Empathizing-systemizing theory of psychological gender differences

Empathizing vs. Systemizing Theory

- Baron-Cohen et al. (2005) suggested that psychological gender differences can be described by the relationship between:
  - The degree of empathizing (defined as the tendency to infer mental and emotional states of others and respond with appropriate emotional feelings and behavior) and
  - Systemizing abilities (defined as the tendency to analyze the rules of a system and predict its behavior).

Empathizing vs. Systemizing Theory

- According to this account, the “typical female” brain is characterized by a superiority of empathizing over systemizing capabilities while the “typical male” brain is supposed to show the reverse pattern.

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- According to this account, the "typical female" brain is characterized by a superiority of empathizing over systemizing capabilities while the "typical male" brain is supposed to show the reverse pattern.
- Although the Schutle-Ruther study does not make assumptions about gender differences in systemizing capabilities, their behavioral and neuroimaging data support the notion of a *general gender-related* difference in empathizing and provide evidence for an associated brain mechanism.

Implications for Autism

Extreme male brain theory

- The “extreme male brain theory” of autism is an extension of the previously mentioned “empathizing–systemizing theory” of typical cognitive and behavioral differences between sexes (Baron- Cohen et al., 2005).
-

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- The “extreme male brain theory” of autism is an extension of the previously mentioned “empathizing–systemizing theory” of typical cognitive and behavioral differences between sexes (Baron- Cohen et al., 2005).
- This suggests that individuals with autism are characterized by an extreme variant of a “typical male” brain.

Schutle-Ruther results and Autism

- The results are in accordance with both approaches.
- They demonstrate reduced activation of the hMNS in males (relative to females) during empathy-related emotional perspective taking in a face-to-face situation.

Other research on Autism

- Further support comes from a study of Dapretto et al. (2006) who observed reduced activation of inferior frontal areas in autistic individuals (relative to healthy control subjects) during the observation and imitation of facial emotions which was correlated with symptom severity

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- Further support comes from a study of Dapretto et al. (2006) who observed reduced activation of inferior frontal areas in autistic individuals (relative to healthy control subjects) during the observation and imitation of facial emotions which was correlated with symptom severity
- Moreover, automatic mimicry (McIntosh et al., 2006) and explicit imitation of facial expressions (Rogers et al., 2003) are impaired in autistic children.

Where does this leave the hMNS?

- Taken together, these results give rise to the assumption that a deficient mirror neuron system may play a role in autistic symptoms (Williams et al., 2001).
-
- However, evidence for a dysfunctional hMNS in autism is mixed. For example, it has been shown that the imitation and understanding of goal-directed hand actions is not impaired in autistic children (Hamilton et al., 2007).

Schutle-Ruther opinion on hMNS and Autism

- “Based on the results of our present study, we suggest that reduced activation of hMNS areas does not need to be an indicator of a basic deficiency of mirror neuron mechanisms. Rather, the degree of hMNS activation may reflect normal individual and, at least in part, gender-related differences in the tendency to recruit this brain system in emotional social interactions.”

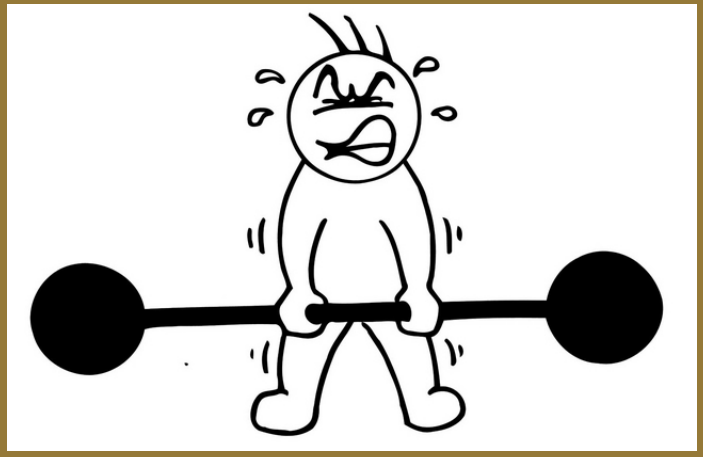
CONCLUSION/SUMMARY

- The Schutle-Ruther data provides novel evidence for:
  - The idea that the neural networks supporting empathy are differentially modulated by gender.
- Results suggest that:
  - Better empathic abilities of females are related to their:
    - Enhanced reliance on the hMNS when assessing the emotional states of other people
    - Their own emotional response to the feelings of others.
  - In contrast, males show stronger recruitment of ToM associated areas. They may thus rely on a more cognitive strategy, especially when determining their own emotional response to the feelings of others.

Issues with the article

Areas of Weakness

- Schulte-Ruther admits:
  - "a key aspect of empathy in interpersonal interactions is that it typically emerges in a dyadic social situation where the emotions of another person directly influence the perceiver's own emotional state."
  - Within a lab, have to somehow recreate this dual interaction



More weakness

- In regards to sex-specific lateralization, there are so many other factors that can contribute to this laterality,
  - Estrogen
  - “Estrogen is supposed to modulate this functional hemispheric lateralization, yielding both differences in neuropsychological task performance between males and females and variation in cognitive performance across the menstrual cycle in females” (Dietrich et al., 2001).

Still weakness

- This study is the first to demonstrate enhanced hMNS activation in emotional perspective taking in females compared to males
- "These differential activations in the hMNS cannot simply be explained as reflecting basic gender differences in emotional responsiveness, as they are still present when individual intensity of emotional experience is controlled for."
  - Telling us something else?
  - The inferior frontal cortex is also known to host functions of executive control (working memory, inhibitory control, rule application, or reversal learning)

Gender vs. Sex