

Brain Function in Autism Spectrum Disorder

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Cardinal Features of ASD

1. Social communication deficits
2. Restricted repetitive stereotyped behavior



Cognitive Psychopathology of ASD

“Theory of Mind”

- Theory of Mind refers to the ability to represent the **mental states** of others
- Theory of Mind allows the attribution of mental states to **self** and **others** to explain and **predict** behavior.

Theory of Mind

- The person with autism spectrum disorder may not recognize the cues that indicate the **intentions** or **feelings** of the other persons or know how to respond.
- This has been described as '**mind blindness**'

Joint Attention

- Infants achieve considerable skill at following another's **direction of gaze**, thereby focusing on the other person's object of attention (Adamson 1985).
- Children with ASD have some problem in following **others' gaze**

Face Processing

- Faces are remarkably homogenous and share a highly similar structure:
- Consisting of the same **parts** (eyes, nose)
- In the same basic **configuration** (nose below the eyes).

Face Processing

- Development brings an increasing ability to process faces **configurally** rather than in a **piecemeal** fashion (Gauthier 2000).

Face Processing

- **Inattention to face** is a developmentally primary symptom of **autism** that is apparent in infancy (Osterling 2002).
- Individuals with autism are impaired in **holistic face recognition** processes,
- and instead rely on **feature-or part-based** face recognition strategies.

Face Processing

- **Individuals with autism pay particular attention to the **mouth** instead of the **eye region** of faces (Klin, 2002).**

Face Processing

- It has also been shown that they are less able to **read the meaning** in the eyes than control subjects (Baron –Cohen, Jolliffe 1997; Baron – Cohen, et al. 2001).

Facial Expression

- Children as young as a few months old have been shown to be able to discriminate happy and sad faces from surprised faces

Facial Expression

- In normal children, **emotion decoding** improves throughout much of childhood (Vicari et al. 2000)
- and into adolescence (Thomas et al. 2007).

Facial Expression

- Facial emotion recognition (FER) **improves less** over time in children with **ASD** than in typically developing children.
- In one study of young children, **FER performance** was correlated with **age in the TD**, but not the ASD group (Gepner et al. **2001**).

Facial Expression

- Many studies find **reduced accuracy** in identifying **emotions** in individuals with ASD, especially for negative emotions (Ashwin et al. 2006; Bal et al. 2010).

Neural systems Impaired in ASD

Neural systems Impaired in ASD

- Brain network involving :
 - occipitotemporal cortex,
 - superior temporal regions,
 - amygdala,
 - frontal cortex,
 - and somatosensory cortex
- are involved in processing social information, in particular emotions and direction of eye gaze, from the face.

Neural systems Impaired in ASD

- we reviewed 292 task-based fMRI studies on ASD individuals.
- We observed that face perception, language, attention, and social processing tasks were mostly studied in ASD.

Neural systems Impaired in ASD

- In addition, 73 brain regions, estimated as about **83% of brain grey** matter, showed an altered activation between the ASD and normal individuals during these four tasks, either a lower or a higher activation (*Batouli et al 2023*)

Social Stimuli

- In this systematic review (*Batouli et al 2023*):
- Thirty brain areas showed a different activation between cases and controls during the processing of **social stimuli and tasks**;
- 21 of them only showed **lower activation** in patients,
- 1 had a **higher activation**,
- and 8 areas had both lower and higher reports.

Social Stimuli

- The most brain areas with a lower activation in patients were **temporoparietal junction**,
- **inferior frontal gyrus**,
- **superior temporal gyrus**,
- **medial prefrontal**,
- **anterior cingulate cortex**, posterior cingulate cortex,
- **inferior parietal lobule**,
- **ant. insula**, caudate

Social Stimuli

- while doing **theory of mind** task (**Eyes Task**),
- reduced activity in **medial prefrontal** cortex
- Decreased activity in left **inferior prefrontal** gyrus,
- orbitofrontal cortex,
- **temporopolar** and
- middle temporal gyrus

Social Stimuli

- during the attentional orienting triggered by **eye gaze**:
- Amygdala showed a **lower** activation (Klapwijk, E. T. *et al* 2016)
- The decline of activation in the **hippocampus** also suggests problems in integrating emotional information with declarative memory (Klapwijk, E. T. *et al* 2016)

Social Stimuli

- Superior temporal gyrus is active in tasks involving the attribution of intentions to moving geometric figures, as well as in social dysfunction in autism (*Pelphrey, K. A. 2007*)

Face Processing

- In **facial identity** processing and FER in ASD,
- **decreased fusiform gyrus** (FG) activation is a common finding (Hubl et al. 2003).
- **Reduced amygdala** activity is a common finding on both **neutral face processing** (Hadjikhani et al. 2007)
- and **FER** (Ashwin et al. 2007;) in ASD.

Face Processing

- when processing **faces**,
- forty brain regions showed a different activation between cases and controls.
- **Sixteen** areas only showed a **lower** activation,
- 7 areas only a **higher** activation,
- and **17 areas** showed both lower and higher activations (*Batouli et al 2023*).

Face Processing

- when processing faces,
- Fusiform gyrus, as well as the amygdala,
- superior temporal gyrus,
- ventromedial prefrontal cortex,
- occipital face area,
- inferior frontal gyrus,
- insula,, cuneus, hippocampus, and striatum,
- showed lower activation in the ASD group (*Batouli et al 2023*).

Face Processing

- It has been reported that **amygdala** has higher, lower, and no difference in activation between the ASD and healthy individuals in **face** processing.
- The reasons for the inconsistent findings could be due to the differences in **attention** to the faces
- or the type of **tasks** and stimuli.

Emotion Processing

- In **emotional face** processing while seeing **fearful** faces ,
- Reduced activity in **ventromedial prefrontal** cortex (vmPFC)
- decreased activity in right **superior temporal sulcus**,
- and right **inferior frontal gyrus**

Emotion Processing

- while processing **emotional** faces,
- Reduced activity in right **fusiform face area**,
- right **occipital face area** (OFA),
- left amygdala, **left putamen**,
- and the posterior **cingulate cortex** (PCC) **Increased activity in subcortical** face processing system (superior colliculus, pulvinar nucleus of the thalamus and amygdala)

Emotion Processing

- While viewing emotional faces,
- individuals with ASD also exhibit **decreased activation** in the **cerebellum** (Critchley et al. 2000),
- **medial-frontal** and **orbito-frontal** cortices (Loveland et al. 2008),
- and **inferior frontal gyrus** (IFG) (Greimel et al. 2010) compared to TD controls.

Emotion Processing

- in response to **dynamic** versus **static** facial expressions,
- reduced activation of several brain regions has been found in the ASD group compared with controls,
- including the **middle temporal gyrus** (MTG),
- **fusiform gyrus**,
- amygdala,
- **medial prefrontal cortex**, and inferior frontal gyrus (IFG)

(Wataru Sato 2012)

Connectivity

- researchers have reported altered **functional connectivity**, in certain regions in ASD when viewing emotional faces.
- Monk et al. (2010) found decreased functional connectivity between the medial **temporal gyrus** and right **amygdala** in ASD during the perception of emotional faces

Connectivity

- Decreased **effective connectivity** between some brain areas and **inferior frontal gyrus**
- There was a relationship between the **decreased connectivity** in **posterior cingulate** and impaired social functioning *(Batouli et al 2023)*

Connectivity

- Decreased functional connectivity in areas required for theory of mind processing
- Decreased functional connectivity between ventral premotor cortex and the ToM network
(Batouli et al. 2023)

Connectivity

- Decreased connectivity in **posterior limbic** and **sensorimotor**
- Decreased connectivity in areas of **default mode network**
- Reduced connectivity between amygdala and **cortical** areas
- **Increased** activity in **visual** cortex

Connectivity

- Impaired connectivity between the **cerebellum** and TPJ
- Decreased connectivity between **anterior** and posterior areas
- Reduced connectivity in areas related to **face processing**
- Impaired functional connectivity in areas of **social processing**

Connectivity

- Wicker et al. (2008) reported abnormal effective connectivity between pre-frontal and posterior temporal regions in ASD during an facial emotion recognition task

Connectivity

- bi-directional effective connectivity involving the **primary visual cortex**
- –**medial temporal gyrus**
- –**inferior frontal gyrus** circuit was **enhanced** in response to **dynamic** as compared with static facial expressions in the control group
- all these modulatory effects were **weaker** in the **ASD** group than in the control group (*Wataru Sato 2012*).

Connectivity

- **Overall**, brain regions with **reduced** activation,
- regions with **increased** activation,
- and abnormal **connectivity** between regions during social tasks in ASD suggest
- abnormality in the circuitry of the **social brain**



Thank You for Your Attention