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NEUROPSYCHOLOGICAL FUNCTIONING AND BRAIN CONNECTIVITY IN AUTISM SPECTRUM DISORDER (ASD): UNDERSTANDING COGNITIVE, SOCIAL, AND BEHAVIORAL DIFFICULTIES

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Abstract
Autism spectrum disorder (ASD) is a lifelong neurodevelopmental condition marked by differences in social communication together with restricted and repetitive patterns of behavior, interests or activities. Behind these visible features lies a distinctive way in which the autistic brain takes in, links and acts upon information. This review brings together evidence from neuropsychology and neuroimaging to explain how the cognitive, social and behavioral difficulties seen in ASD relate to the organisation of brain networks. Three classic cognitive accounts, namely theory of mind, executive dysfunction and weak central coherence, are examined alongside later views based on social motivation and predictive processing. Findings from structural, diffusion and functional imaging are then traced, from early brain overgrowth and altered white matter development to the pattern of reduced long-range and increased local connectivity first proposed in the underconnectivity models and later refined by large data-sharing projects. The review shows that social difficulties are linked to atypical activity and coupling in the "social brain" network, including the fusiform face area, amygdala, superior temporal sulcus and medial prefrontal cortex; that problems with planning, flexibility and inhibition reflect weaker integration between frontal and posterior regions; and that repetitive behavior and sensory differences relate to frontostriatal circuits and an altered balance of excitation and inhibition. Connectivity findings vary with age, sex, intellectual ability and method, which argues against a single explanation and in favour of a developmental, multi-level view. The implications for early identification, assessment and individualised intervention are discussed.

Keywords: autism spectrum disorder; neuropsychology; brain connectivity; theory of mind; executive function; central coherence; social brain

1. Introduction

Few conditions have changed in public understanding as much as autism over the last eighty years. When Kanner (1943) described eleven children who preferred sameness and seemed to live in a world of their own, autism was thought to be rare and was often blamed on cold parenting. A year later Asperger (1944) described boys with fluent speech, intense interests and social awkwardness. Wing and Gould (1979) later showed, through a population study in London, that social, communicative and imaginative difficulties tended to occur together across a wide range of ability, and this "triad" paved the way for the idea of a spectrum.

The current diagnostic system, the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders, brought earlier categories such as autistic disorder and Asperger's disorder under a single label of autism spectrum disorder, defined by persistent difficulties in social communication and interaction and by restricted, repetitive patterns of behavior, including sensory differences (American Psychiatric Association, 2013). Recorded prevalence has risen steadily. Zeidan et al. (2022) estimated a global median of about one in a hundred children, and surveillance in the United States identified about one in 36 children aged eight years in 2020 (Maenner et al., 2023). Much of this rise reflects broader criteria and better awareness rather than a true increase, yet it has placed autism at the centre of child health and education

services worldwide.

Autism is now understood as a condition of brain development with strong genetic roots (Lai et al., 2014). The observable features, however, do not map neatly onto single brain regions. A child may struggle to read a friend's expression, become distressed when a routine changes and notice small visual details that others miss, all at once. Neuropsychology studies these patterns at the level of mental functions such as attention, memory, planning and social understanding, while connectivity research asks how brain regions communicate with one another. Bringing the two together offers the most complete account of why autistic people think, feel and behave as they do. The present review attempts this synthesis and considers what it means for assessment and support.

2. Objectives of the Review

1. To describe the main neuropsychological profiles reported in ASD across social cognition, executive function, perception, language and memory.
2. To summarise structural and functional brain connectivity findings in ASD and the theories built on them.
3. To relate cognitive, social and behavioral difficulties to specific brain networks.
4. To discuss the implications of these findings for assessment, intervention and future research.

3. Method of Review

A narrative review approach was used. Peer-reviewed studies, meta-analyses, theoretical articles and authoritative reviews in neuropsychology, developmental psychology and neuroimaging were identified through PubMed, PsycINFO and Google Scholar using combinations of the terms autism, neuropsychology, executive function, theory of mind, central coherence, connectivity, diffusion tensor imaging and resting-state fMRI. Classic works that shaped the field were included alongside recent large-sample studies. Evidence was grouped by domain of functioning and then linked to the connectivity literature.

4. Review of Literature

4.1 Cognitive theories

Baron-Cohen et al. (1985) used the Sally-Anne false-belief task and found that most autistic children failed to predict where a doll would look for a marble that had been moved in her absence, whereas most children with Down syndrome of lower mental age passed. They proposed that autism involved a specific difficulty in attributing mental states to others, termed a theory of mind deficit.

Ozonoff et al. (1991) compared high-functioning autistic individuals with matched controls and found that difficulties on executive tasks such as the Wisconsin Card Sorting Test and the Tower of Hanoi were more widespread and better at separating the groups than theory of mind measures, which suggested that executive dysfunction might be a core feature.

Frith and Happé (1994) argued that theory of mind could not explain the non-social strengths of autistic people, such as superior performance on the Embedded Figures Test and block design, and proposed that a weak drive for central coherence led to processing of parts rather than wholes.

Hill (2004) reviewed the executive function literature and concluded that planning and cognitive flexibility were most consistently affected, while findings on inhibition and working memory were more mixed and depended on the task used.

Happé and Frith (2006) revisited the weak coherence account and reframed it as a detail-focused cognitive style rather than a deficit, noting that local processing could coexist with intact global processing when people were explicitly asked to attend to the whole.

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Chevallier et al. (2012) proposed the social motivation theory, arguing that reduced reward value of social stimuli such as faces and voices led autistic children to attend less to people, which in turn limited the social learning on which later social skills depended.

Pellicano and Burr (2012) offered a Bayesian account of autistic perception, suggesting that weaker use of prior expectations made the world appear "too real", which could explain both sensory overload and sharper perception of detail.

Demetriou et al. (2018) carried out a meta-analysis of 235 studies and found a moderate overall executive function difficulty in ASD that was present across age groups and domains, while no single executive domain clearly separated ASD from other conditions.

4.2 Brain structure and connectivity

Courchesne et al. (2003) used head circumference records and found that autistic infants showed a period of accelerated brain growth in the first year of life after a normal or small size at birth, suggesting that early overgrowth disturbed the formation of neural circuits.

Just et al. (2004) studied sentence comprehension with fMRI and found lower functional connectivity between frontal and posterior language regions in high-functioning autistic adults, and proposed that cortical underconnectivity limited the integration of information across the brain.

Belmonte et al. (2004) brought together physiological and anatomical evidence and suggested that autism involved high local connectivity alongside low long-range connectivity, which could reduce the brain's ability to separate signal from noise.

Courchesne and Pierce (2005) argued that frontal cortex in autism showed local over-connectivity but long-distance disconnection, so that it might be "talking only to itself", and linked this pattern to early overgrowth.

Geschwind and Levitt (2007) described autism as a developmental disconnection syndrome in which genetic influences on synapse formation and neuronal migration led to altered connectivity between higher-order association areas.

Wolff et al. (2012) followed infants at high familial risk with diffusion tensor imaging and found that those later diagnosed with autism showed differences in white matter fiber tract development from six months of age, with higher fractional anisotropy early and slower change thereafter.

Uddin et al. (2013) reconciled conflicting reports by proposing a developmental view in which children with autism showed functional hyperconnectivity, while adolescents and adults more often showed hypoconnectivity.

Di Martino et al. (2014) analysed more than a thousand resting-state scans from the Autism Brain Imaging Data Exchange and found both reduced and increased connectivity, with the most consistent reductions in cortico-cortical and interhemispheric links and increases in subcortical-cortical connections.

These studies showed that no single cognitive account fully explained autism, and that connectivity differences were real but varied with age and method. Fewer studies linked specific neuropsychological profiles to particular network patterns within one framework, a gap the following discussion attempts to address.

5. Neuropsychological Functioning in ASD

Table 1 summarises the main domains of functioning, the typical neuropsychological findings, common assessment tools and the brain networks most often implicated.

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Table 1. Domains of neuropsychological functioning in ASD and associated brain networks

Domain	Typical findings in ASD	Common measures	Networks most implicated
Social cognition	Difficulty inferring beliefs and intentions; atypical face and emotion processing; reduced attention to eyes	False-belief tasks, Reading the Mind in the Eyes, eye tracking	Medial prefrontal cortex, temporoparietal junction, superior temporal sulcus, fusiform gyrus, amygdala
Executive function	Weaker planning and cognitive flexibility; variable inhibition and working memory	Wisconsin Card Sorting Test, Tower of London, BRIEF	Dorsolateral prefrontal cortex, anterior cingulate, fronto-parietal network
Perception and attention	Detail-focused processing; strengths in visual search; sensory over- or under-responsiveness	Embedded Figures Test, block design, sensory profiles	Primary sensory cortices, thalamocortical circuits
Language and communication	Delayed or atypical language; difficulty with pragmatics and figurative meaning	CELF, pragmatic language scales	Inferior frontal and superior temporal language regions and their links
Memory	Good rote and cued memory; weaker free recall of complex or meaningful material	Story recall, list learning tasks	Hippocampus and its frontal connections
Repetitive behavior	Motor stereotypies, insistence on sameness, restricted interests	Repetitive Behavior Scale-Revised, ADI-R	Frontostriatal and cortico-basal ganglia loops

5.1 Social cognition

Difficulty understanding what others think, feel and intend is the most widely recognised feature of autism. Many autistic children pass simple false-belief tasks later than their peers, and even adults who pass them may find it hard to apply such understanding quickly in real conversation. Face processing also differs. Klin et al. (2002) recorded eye movements while autistic adolescents and adults watched film scenes and found that they looked more at mouths and objects and less at eyes, and that greater fixation on mouths was linked to better social adjustment while greater fixation on objects predicted poorer adjustment. Dawson et al. (2005) reviewed behavioral and electrophysiological evidence and concluded that slower and less specialised face processing appeared early in development and might reflect reduced social attention from infancy.

5.2 Executive function

Executive functions allow a person to hold goals in mind, shift between tasks, stop unwanted responses and plan a sequence of actions. In daily life, difficulties in these skills appear as trouble adjusting to unexpected changes, organising homework, starting tasks or moving from one activity to another. Laboratory tasks show the greatest difficulties in flexibility and planning, but performance depends heavily on how structured the task is. Autistic individuals often perform better when rules are explicit and worse when they must generate their own strategies, which helps explain why problems in everyday settings can be larger than test scores suggest.

5.3 Perception, attention and sensory processing

Many autistic people notice small details, find patterns quickly and perform well on visual search and

embedded figures tasks. At the same time, sensory experiences can be overwhelming. Robertson and Baron-Cohen (2017) reviewed evidence that sensory differences occurred in a large majority of autistic individuals, were present early in life and were linked to changes in early sensory cortices and in neural inhibition. Such sensitivities to noise, light, touch or textures often lie behind avoidance, distress and meltdowns that are wrongly taken as behavioral problems.

5.4 Language and memory

Language in ASD ranges from the absence of speech to fluent and sophisticated vocabulary. Across this range, the use of language in social contexts, such as taking turns, understanding sarcasm or adjusting speech to the listener, is usually the area of greatest difficulty (Tager-Flusberg et al., 2005). Memory shows an uneven profile, with good recall of facts and rote material but weaker recall of complex stories or events that require organising information around meaning.

5.5 Restricted and repetitive behavior

Repetitive behaviors include simple motor movements, rigid routines, insistence on sameness and highly focused interests. Langen et al. (2011) reviewed animal and human studies and linked such behaviors to altered function of the circuits connecting the frontal cortex with the striatum. Repetitive routines may also serve a regulating purpose, reducing anxiety in an unpredictable world, which is why abrupt attempts to stop them often increase distress.

6. Brain Connectivity in ASD

6.1 Early brain development and structure

Brain imaging and head growth studies point to atypical growth in early childhood, followed by a slowing of growth in later years. Changes in the cortex, cerebellum, amygdala and corpus callosum have all been reported, though findings vary between samples. Such developmental timing matters because the first years are when long-range connections are being refined through experience.

6.2 White matter organisation

Diffusion tensor imaging measures the integrity and direction of white matter tracts. Travers et al. (2012) reviewed this literature and found that reduced fractional anisotropy and increased mean diffusivity were most often reported in the corpus callosum, cingulum and tracts of the temporal lobe, all of which support communication between distant regions involved in social and language processing.

6.3 Functional connectivity

Functional connectivity refers to the correlation of activity between brain regions over time. Early task studies mainly reported underconnectivity between frontal and posterior regions. Kana et al. (2011) reviewed the evidence and described a disrupted cortical connectivity model in which weaker coordination among distant regions limited complex tasks that required integrating information. Resting-state studies later found a more mixed picture. Hull et al. (2017) reviewed resting-state work and noted that both hypo- and hyperconnectivity were reported, depending on the age of participants, the regions studied and the analysis choices, such as handling of head motion and global signal.

6.4 Excitation-inhibition balance

At the cellular level, Rubenstein and Merzenich (2003) proposed that some forms of autism arose from an increased ratio of excitation to inhibition in key neural systems, making circuits noisier and less stable. Such an imbalance would explain heightened sensory responses, a higher rate of epilepsy and difficulty filtering irrelevant input, and offers a bridge between genetic findings and network-level differences.

7. Linking Brain Connectivity to Difficulties

7.1 Cognitive difficulties

Tasks that require pulling together information from several sources, such as planning, switching strategy

or understanding the gist of a story, depend on smooth communication between frontal and posterior regions. Reduced long-range coordination therefore fits well with weaker executive control and a detail-focused style. Strong local processing, on the other hand, may underlie the islands of ability seen in many autistic individuals, including visual pattern detection, memory for facts and talents in music, mathematics or drawing.

7.2 Social difficulties

Social understanding depends on a network that links the fusiform face area, which identifies faces; the amygdala, which tags them for emotional importance; the superior temporal sulcus, which reads movement and gaze; and the medial prefrontal cortex and temporoparietal junction, which infer mental states. Schultz et al. (2000) found that autistic individuals showed less activation of the fusiform face area and more activity in object-processing regions when discriminating faces, suggesting that faces were processed more like objects. Weaker coupling among the nodes of this network means that cues from a face, a tone of voice and the context are not combined quickly enough to guide an appropriate response in real time.

7.3 Behavioral difficulties

Restricted and repetitive behaviors have been linked to frontostriatal circuits that help shift attention and stop habitual actions. When these circuits are less flexible, routines become harder to break. Sensory differences, related to altered excitation and inhibition in sensory cortices, add to the picture: a crowded classroom can become a source of real discomfort, leading to withdrawal, repetitive movements that calm the body, or outbursts. Seen through this lens, many behaviors that appear challenging are understandable responses of a brain that processes the world differently.

7.4 Heterogeneity across the spectrum

No two autistic people are alike. Lord et al. (2018) stressed that intellectual ability, language level, co-occurring conditions such as ADHD, anxiety and epilepsy, sex and age all shape both the clinical picture and the research findings. Connectivity differences that appear in one subgroup may be absent in another. This variation means that brain-based findings describe groups rather than individuals and cannot yet be used as diagnostic tests.

8. Implications for Assessment and Intervention

- **Comprehensive assessment:** Neuropsychological evaluation should cover social cognition, executive function, language, memory and sensory processing, so that strengths are identified alongside difficulties.
- **Early identification:** Since brain differences emerge in the first years of life, screening during infancy and toddlerhood offers the best chance to support development while circuits are still highly plastic.
- **Early intervention:** Dawson et al. (2010) found that toddlers who received the Early Start Denver Model for two years showed greater gains in IQ, language and adaptive behavior than those receiving community services, which shows the value of intervening during sensitive periods.
- **Executive function support:** Visual schedules, clear routines, advance notice of change and step-by-step task breakdowns reduce the load on planning and flexibility.
- **Social skills and communication:** Interventions that use structured practice, peer involvement and explicit teaching of social rules help bridge differences in social understanding.
- **Sensory-friendly environments:** Quiet spaces, reduced clutter, noise control and sensory breaks in classrooms and workplaces lower distress and improve learning.
- **Family and teacher training:** Parents and teachers who understand the neuropsychological basis of autistic behavior respond with support rather than punishment.

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9. Limitations of Current Evidence and Future Directions

Much of the research has studied verbal autistic males with average or above-average intelligence, leaving autistic girls, minimally verbal individuals and people with intellectual disability under-represented. Imaging results also depend on small samples, head motion and analysis choices, which have contributed to conflicting connectivity findings. Few studies follow the same individuals from infancy to adulthood, so developmental changes in connectivity are inferred from cross-sectional comparisons. Future work should combine cognitive testing, imaging and genetics within large, diverse and longitudinal samples, and should involve autistic people themselves in setting research priorities. Research in countries such as India, where diagnostic and support services are still expanding, is particularly needed.

10. Conclusion

Autism is best understood as a different pattern of brain organisation rather than a collection of isolated deficits. Difficulties in understanding others, adapting to change and coping with sensory input share a common thread in how brain networks develop and communicate, with weaker long-range integration and stronger local processing appearing in many, though not all, autistic people. The same features that create challenges also give rise to genuine strengths, such as attention to detail and deep focus. Neuropsychological assessment that maps both strengths and needs, early support while the brain is most adaptable, and environments that respect sensory and cognitive differences offer the most practical way to translate this knowledge into better lives for autistic individuals and their families.

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