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NEUROIMAGING DIFFERENCES BETWEEN AUTISTIC AND NEUROTYPICAL BRAINS:IMPLICATIONS FOR SPEECH, LANGUAGE, AND SOCIAL COMMUNICATION—A SYSTEMATIC REVIEW

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Abstract

Autism Spectrum Disorder (ASD) is associated with differences in speech, language, and social communication. This systematic review synthesised neuroimaging evidence published between 2020 and 2026 comparing autistic and neurotypical brains. A systematic search of nine databases identified 832 records, of which 30 peer-reviewed studies met the inclusion criteria. Findings showed atypical organisation in language-related cortical regions, white matter pathways such as the arcuate and uncinate fasciculi, functional networks including the default mode and salience networks, auditory electrophysiological processing, and self-related brain networks. Overall, the evidence suggests that communication differences in autism arise from distributed neural network organisation rather than isolated abnormalities in a single brain region. These findings have implications for speech-language pathology assessment, early intervention, and individualised support planning. Future research should include longitudinal designs, larger diverse samples, and stronger links between neuroimaging findings and communication outcomes.

Keywords: *autism spectrum disorder; neuroimaging; speech-language pathology; social communication; fMRI; DTI; EEG; functional connectivity; white matter; language networks.*

INTRODUCTION

Autism Spectrum Disorder (ASD) is a common neurodevelopmental disorder in the 21st century, with an estimated prevalence rate of 1 in 36 children in the United States (Maenner et al., 2023) and approximately 1 in 100 worldwide (World Health Organization, 2023). ASD is a very heterogeneous and variable clinical condition that involves difficulties in social communication, language *development, and adaptive functioning.*

Among the most clinically relevant features of ASD and primary areas of concern in speech-language pathology practice (SLP) are deviations in speech, language, and social communication. For years, researchers have been investigating the neural underpinnings of communicative differences in autism. But, with the development of advanced neuroimaging techniques, it has been possible to map the structure of the autistic brain in vivo and systematically compare it with its neurotypical counterpart.

Neuroimaging techniques, including structural MRI, functional MRI (fMRI), DTI, MEG, EEG, fNIRS, and PET, have each contributed unique insights into the structural, functional, and metabolic organization of the autistic brain. Most importantly, there is converging evidence from all modalities that autism is not a localized dysfunction in any single brain region, but rather differences in the organization of the neural networks.

The language and communication problems are very diverse in ASD. In some autistic children, speech is delayed, in others, expressive language is limited, echolalia is present, and in others, speech is fluent, but pragmatic language, conversational reciprocity, prosodic regulation, and social inference are impaired (Jouravlev et al. 2020; Larson et al. 2023). This is because the neural systems involved in communication are heterogeneous and comprise not only prefrontal, temporal, parietal, cerebellar, subcortical, and limbic regions, but also their interactions.

This period is especially remarkable for the neuroimaging research in autism, becoming more abundant due to the large multi-site datasets (Autism Brain Imaging Data Exchange—ABIDE; Latham et al. 2019; Di Martino et al. 2014), the growing awareness of neurodiversity, and the rapid publication of important longitudinal studies (EU-AIMS Longitudinal European Autism Project—Loth et al. 2022; Di Martino et al. 2014). Self-related brain network research has been an important development during this time, and now it has been incorporated into autism neuroscience. In their review of the neuroimaging literature, Zhou et al. (2026) showed that the atypicalities at each of these three hierarchical levels of self-processing – interoceptive, exteroceptive, and mental make systematic, additive contributions to the social communication deficits that define ASD. This hierarchical organization that groups neural signatures around the insula and thalamus (interoceptive self), temporoparietal junction (TPJ), and medial prefrontal cortex (mPFC) (exteroceptive self), and around the anterior and posterior cingulate cortices (mental self) has direct implications for understanding communicative phenotypes and provides a unifying neurobiological account.

Speech-language pathologists are increasingly using subtle knowledge of neuroimaging findings. Neuroimaging evidence can be used in differential diagnosis, to inform the selection of evidence-based interventions, and to account for the differential efficacy of therapeutic interventions for some individuals with autism but not others. The aim of this systematic review is therefore to collate the evidence published in neuroimaging studies between 2020 and 2026, with a particular focus on brain regions and networks linked to speech, language, and social communication, and to arrive at a clinically actionable integrative account.

AIM AND RESEARCH QUESTIONS

This systematic review examined recent neuroimaging evidence comparing autistic and neurotypical brains, with particular emphasis on the neural underpinnings of speech, language, and *social communication, and aimed to identify implications for clinical speech-language pathology practice. The review was guided by the following research questions:*

RQ1. What structural and functional neuroimaging differences are consistently reported between autistic and neurotypical brains in regions relevant to communication?

RQ2. How do white matter connectivity differences in autism relate to speech, language, and social communication outcomes?

RQ3. What electrophysiological evidence exists regarding atypical speech and language processing in autism?

RQ4. How do neurobiological findings, including self-related network disruptions, account for heterogeneous communicative phenotypes across the autism spectrum?

RQ5. What are the clinical implications of neuroimaging findings for speech-language pathology assessment and intervention?

RQ6. What gaps exist in the current neuroimaging literature regarding autism, speech, language, and social communication?

MATERIALS AND METHODS

A systematic search was conducted in the nine academic databases: PubMed, Scopus, Web of Science, PsycINFO, ScienceDirect, SpringerLink, Wiley Online Library, Google Scholar, and PMC. The search was restricted to peer-reviewed publications from January 2020 to April 2026. Search terms were combined in the following combinations: autism spectrum disorder, autistic brain, neurotypical brain, neuroimaging, MRI, fMRI, DTI, EEG, MEG, PET, fNIRS, functional connectivity, structural connectivity, white matter, language network, speech processing, pragmatic language, social communication, social cognition, social brain network, and self-related brain network. Hand searching of the reference lists of included articles was performed for additional relevant articles. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) were followed with a search strategy.

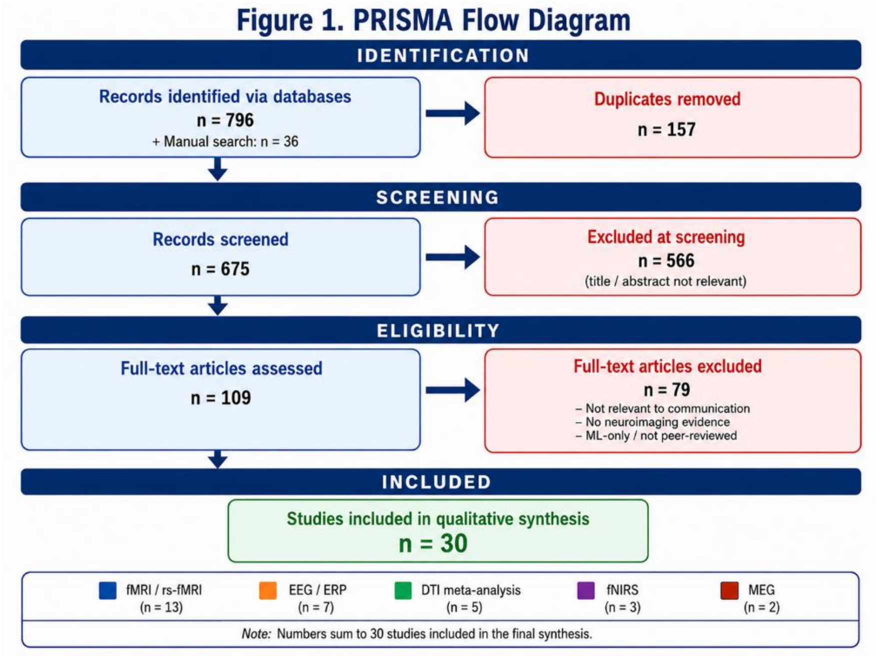
INCLUSION CRITERIA

Studies were included if they met the following criteria: (1) published from January 2020 to April 2026 in peer-reviewed journals, (2) focused on individuals with a diagnosis of ASD based on DSM-5 criteria, (3) included at least one neuroimaging measure (MRI, fMRI, DTI, EEG, MEG, PET, or fNIRS), or were a systematic review or a meta-analysis of such studies, (4) contained a neurotypical comparison group, (5) included findings relevant to brain structure, functional connectivity, white matter pathways, speech, language, pragmatic communication, social cognition, or self-related networks, and (6) written in English and published in journals with full-text availability.

EXCLUSION CRITERIA

Studies were excluded if they: (1) included only behavioural, educational, genetic or pharmacological data and lacked any neuroimaging data; (2) were case reports, commentaries, editorials, conference abstracts, dissertations, or book chapters; (3) did not report results in relation to speech, language, social cognition, or self-related brain networks; or (4) were duplicate publications (the most comprehensive publication was included).

STUDY FLOW (PRISMA)



INCLUDED STUDIES

The total number of records found by database searching was 796 and 36 were found by manual reference searching, for a total of 832 records. 157 duplicate records were removed, and 675 records were left for screening of titles and abstracts. Of this number, 566 documents were eliminated because of the eligibility requirements. Of the 109 full-text articles reviewed for eligibility, 79 were excluded due to lack of relevance to communication, no neuroimaging studies reported, and/or failure to be peer-reviewed empirical or review articles. Finally, 30 studies were included in the qualitative synthesis and are presented in Table 1.

Table 1. Peer-Reviewed Neuroimaging Studies Included in this Systematic Review (2020–2026)

No.	Author (Year)	Article Title	Location	Modality	Key Finding
1	Jouravlev et al. (2020)	Reduced Language Lateralization in Autism and the Broader Autism Phenotype	USA	fMRI	Autistic individuals showed reduced language lateralization during language comprehension tasks.
2	Roberts et al. (2020)	A Multimodal Study of Conduction Velocity and Auditory Evoked Response: Anomalies in ASD	USA	MEG/MRI	Auditory neural timing differences linked with conduction velocity abnormalities in ASD.
3	Federici et al. (2020)	Biological Motion Perception in ASD: A Meta-Analysis	Italy	Neuroimaging/behavioral	Biological motion processing differences linked with social communication difficulties in ASD.
4	Lombardo et al. (2021)	Atypical Genomic Cortical	USA/UK	fMRI + genomics	Atypical cortical patterning

No.	Author (Year)	Article Title	Location	Modality	Key Finding
		Patterning in Autism with Poor Early Language Outcome			associated with poor early language outcome in autistic toddlers.
5	Benkarim et al. (2021)	Connectivity Alterations in Autism Reflect Functional Idiosyncrasy	Canada	rs-fMRI	ASD showed increased individual variability in functional connectivity related to symptom severity.
6	Key & D'Ambrose Slaboch (2021)	Speech Processing in ASD: An Integrative Review of Auditory Neurophysiology Findings	USA	EEG/ERP review	Atypical auditory neurophysiology linked with speech and language processing differences in ASD.
7	Hiremath et al. (2021)	Early Behavioral and Neuroimaging Biomarkers in ASD	India	MRI/fMRI/DTI review	Early neuroimaging markers linked with later ASD-related communication outcomes.
8	Cermak et al. (2022)	Brain and Language Associations in ASD: A Scoping Review	Canada	Neuroimaging review	Brain regions associated with language performance were identified across ASD subgroups.
9	Larson et al. (2022)	Structural Language Impairment in ASD Versus Loss of Autism Diagnosis	USA	MRI/fMRI	Structural language impairment in ASD showed distinct neural and behavioral profiles.
10	Xiao et al. (2022)	Neural Responses to Affective Speech Including Motherese in Toddlers with ASD	USA	fMRI	Reduced neural response to affective speech was linked with social attention profiles.
11	Li et al. (2022)	Atypical Structural Connectivity of Language Networks in ASD: A DTI Meta-Analysis	China	DTI meta-analysis	ASD showed atypical white-matter connectivity in language-related tracts.
12	Chan et al. (2022)	Aberrant Prefrontal Connectivity During Verbal Fluency Test in ASD	China/Hong Kong	fNIRS	Prefrontal connectivity during verbal fluency was associated with reading comprehension deficits.

No.	Author (Year)	Article Title	Location	Modality	Key Finding
13	Knight et al. (2022)	Social Attention Influences Neural Processing of Biological Motion in ASD	USA	fMRI	Social attention altered neural processing of biological motion in ASD.
14	Larson et al. (2023)	Language Networks in ASD: A Systematic Review of Connectivity-Based fMRI Studies	USA	fMRI systematic review	ASD showed atypical language-network connectivity across fMRI studies.
15	Márquez-García et al. (2023)	Atypical Associations Between Functional Connectivity During Pragmatic and Semantic Language Processing in ASD	Canada	fMRI	Children with ASD showed distinct functional connectivity during pragmatic and semantic language processing.
16	da Silva Mayerle et al. (2023)	Mismatch Negativity in Children and Adolescents with ASD: Systematic Review and Meta-Analysis	Brazil	EEG/MMN meta-analysis	MMN differences reflected atypical auditory and speech-related processing in ASD.
17	Dunham et al. (2023)	Neural Correlates of Audiovisual Speech Processing in Autistic and Non-Autistic Youth	USA	fMRI	Autistic youth showed differences in neural mechanisms of audiovisual speech processing.
18	Dunham-Carr et al. (2023)	The Processing of Audiovisual Speech Is Linked with Vocabulary in Autistic and Non-autistic Children	USA	ERP	Audiovisual speech processing was associated with vocabulary and communication skills.
19	Hua et al. (2024)	Auditory Language Comprehension Among Children and Adolescents with ASD: An ALE Meta-Analysis	China	fMRI ALE meta-analysis	ASD showed atypical activation in auditory-language comprehension regions.
20	Márquez-García et al. (2024)	Atypical Brain Connectivity During Pragmatic and Semantic Language Processing in Children with Autism	Canada	fMRI	Autistic children showed altered connectivity in pragmatic and semantic language networks.
21	Patil (2024)	Neuroimaging Insights into ASD:	India	MRI/fMRI/DTI review	Reviewed structural and functional

No.	Author (Year)	Article Title	Location	Modality	Key Finding
		Structural and Functional Brain Differences			brain differences relevant to ASD communication profiles.
22	Lai et al. (2024)	Atypical Brain Lateralization for Speech Processing in Autistic Children	China	fNIRS	Autistic children showed atypical lateralization during speech processing.
23	Ross et al. (2024)	Neural Correlates of Audiovisual Narrative Speech Perception in Children and Adults on the Autism Spectrum	USA	fMRI	Autistic individuals showed reduced audiovisual speech benefit during narrative speech processing.
24	Mukerji et al. (2025)	Resting Frontal Gamma Power and Expressive Language in Young Autistic and Neurotypical Children	USA	EEG	Resting frontal gamma power was associated with expressive language ability.
25	Yu et al. (2025)	Acoustic Exaggeration Enhances Speech Discrimination in Young Autistic Children	China	EEG	Acoustic exaggeration improved speech discrimination responses in young autistic children.
26	Li et al. (2025)	Auditory and Semantic Processing of Speech-in-Noise in Autism: A Behavioral and EEG Study	UK/China	EEG	Autistic adults showed differences in auditory and semantic processing of speech in noise.
27	Pecukonis et al. (2025)	The Neural Bases of Language Processing During Social and Non-Social Contexts: A fNIRS Study	USA	fNIRS	Neurotypical and autistic preschoolers differed in language processing across social and non-social contexts.
28	Valles-Capetillo et al. (2025)	The Role of the Brain's Pragmatic Language Network in Reading Comprehension in Autistic Children	Canada/USA	fMRI	Pragmatic language network activity was linked with reading comprehension in autistic children.
29	Zhou et al. (2026)	Alterations in Self-Related Brain Networks in ASD: A	China	fMRI/sMRI systematic review	Atypical self-related network organisation across

No.	Author (Year)	Article Title	Location	Modality	Key Finding
		Systematic Review of fMRI and sMRI Studies			interoceptive, exteroceptive, and mental levels in ASD.
30	Witt et al. (2026)	Neurobiology of Language in Autism: A Systematic Review of Pediatric Studies	USA	Neuroimaging systematic review	Reviewed pediatric neuroimaging evidence on language processing in autism.

Table 1 lists all 30 included studies in chronological order. Modality abbreviations: fMRI = functional magnetic resonance imaging; DTI = diffusion tensor imaging; EEG = electroencephalography; MEG = magnetoencephalography; fNIRS = functional near-infrared spectroscopy; ERP = event-related potential; rs-fMRI = resting-state fMRI.

LITERATURE REVIEW FINDINGS

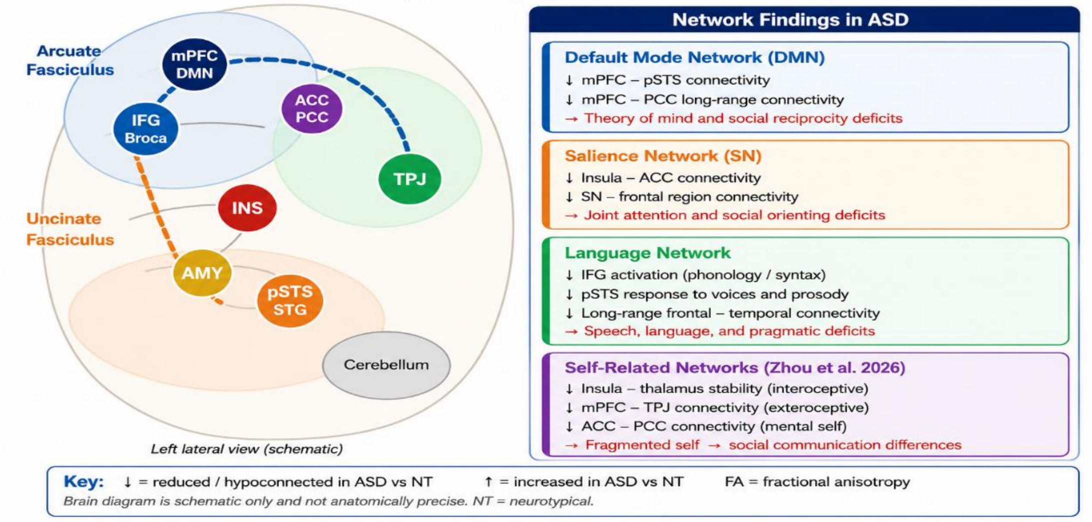
Thirty studies were included with different types of neuroimaging/neurophysiological methods used: task-based and resting state fMRI (n = 13), DTI/tractography meta-analyses (n = 2), EEG/ERP studies (n = 7), MEG studies (n = 1), fNIRS studies (n = 2), and multimodal or systematic review designs (n = 5). The results have been sorted into five thematic areas: (1) structural brain differences; (2) white matter microstructure; (3) functional connectivity differences; (4) speech and language networks; and (5) social communication and self-related networks.

STRUCTURAL BRAIN DIFFERENCES

The structural MRI results from the studies included suggest that autistic individuals might have an atypical organization of brain areas related to language, social cognition, and self-related processing. Some differences are reported in the superior temporal gyrus (STG), inferior frontal gyrus (IFG), temporoparietal junction (TPJ), posterior superior temporal sulcus (pSTS), insula, thalamus, and cingulate regions. They are sensitive to speech perception, language comprehension, pragmatic communication, social inference, and self–other processing. Lombardo et al. (2021) demonstrated that early language outcome was related to atypical cortical patterning in autistic toddlers, indicating that structural and genomic brain differences in early childhood may be linked to language functioning in later development. Likewise, Patil (2024) summarized structural and functional alterations in the brain in ASD and pointed out that these alterations are not confined to classical language areas but also extend to broader language-related networks that facilitate social communication. Recent findings concerning self-related brain networks further confirm this general reading. Zhou et al. (2026) identified structural and functional abnormalities in interoceptive, exteroceptive, and mental-self networks, such as changes in grey matter density in the insula and thalamus, and disrupted cingulum-related connectivity. The results indicate that structural differences in the brain in autism might be affecting communication beyond the language-specific brain regions, and even across larger systems that play roles in body awareness, social understanding, emotional meaning, and the self–other distinction.

Figure 2. Key Brain Regions and Networks Showing Atypical Organisation in ASD

(Relevant to Speech, Language, and Social Communication)



Schematic representation of brain regions and networks that have been reported as being atypically organized in ASD and are involved in speech, language and social communication. The left panel shows a schematic lateral brain view, the right panel summarizes network-level findings. The inferior frontal gyrus (IFG), medial prefrontal cortex (mPFC), posterior superior temporal sulcus (pSTS), temporoparietal junction (TPJ), anterior cingulate cortex (ACC), insula (INS) and amygdala (AMY). The diagram is schematic and not intended to be anatomically precise.

WHITE MATTER MICROSTRUCTURE: DIFFUSION TENSOR IMAGING FINDINGS

White matter microstructure research, most often conducted with diffusion tensor imaging (DTI), offers valuable evidence for structural connectivity abnormalities in ASD. Li et al. (2022) carried out a meta-analysis of DTI studies and found that structural connectivity of language-related networks is abnormal in individuals with autism. The results indicate that variability in expressive language, receptive language, phonological processing, and communication outcomes is associated with variation in white matter organization. Of special interest for speech-language function is the arcuate fasciculus (AF), which is a large fronto-temporal white matter bundle that plays a role in language processing. Distinctive features in AF microstructure can impact on repetition, phonological processing, verbal learning, and expressive language development. Neuroimaging data is not sufficient to make clinical decisions, but evidence related to AF can clarify why sometimes autistic people perform very differently when asked to perform non-verbal tasks versus utter words.

Other fiber tracts are important to communication as well: the uncinate fasciculus and the corpus callosum. The uncinated fasciculus links anterior temporal and frontal areas and may play a role in semantic processing, emotional meaning and social-pragmatic language. The corpus callosum provides interhemispheric communication and may have an impact on phonological awareness, language coordination, and literacy-related skills. In conclusion, DTI results suggest that communication impairments associated with ASD are not only tied to the structural integrity of language regions of the cortex but also to the structural integrity of the pathways linking language regions with social communication regions of the cortex.

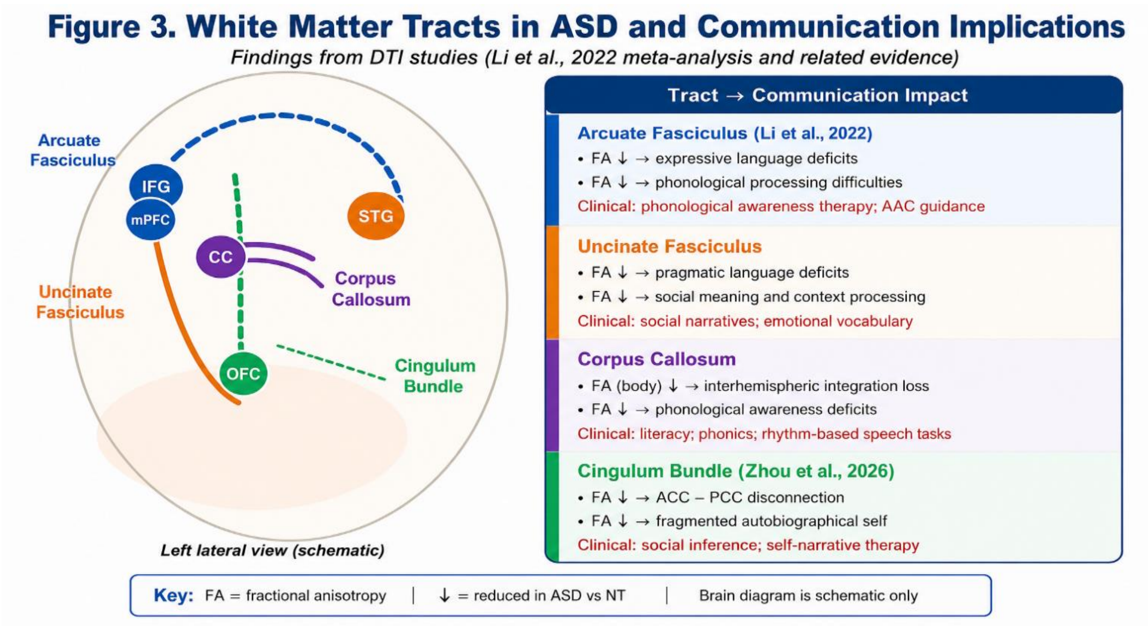


Figure 3. White Matter Tracts in ASD and Communication Implications
Findings from DTI studies (Li et al., 2022 meta-analysis and related evidence)

Schematic illustration of key white matter tracts showing atypical microstructure in ASD and their possible communication implications. The left panel presents a schematic lateral brain view, while the right panel summarises related speech, language, and social communication outcomes. FA = fractional anisotropy; ↓ = reduced in ASD relative to neurotypical controls. Based mainly on Li et al. (2022) and related DTI evidence.

FUNCTIONAL CONNECTIVITY DIFFERENCES

One of the most consistent observations from the reviewed fMRI studies was functional connectivity, or coordinated activity of spatially distributed brain regions. Several long-distance brain networks were found to have altered connectivity, such as the default mode network (DMN), salience network (SN), executive control network (ECN), and language network. All these networks work together to facilitate social cognition, language processing, attention, and communicative behaviour. The DMN, which includes the medial prefrontal cortex (mPFC), posterior cingulate cortex (PCC), and temporoparietal junction (TPJ) is implicated in self-referential processing, social cognition, and theory of mind. The analyzed studies found atypical connectivity within the DMN and abnormal interaction between various DMN and other large-scale networks in autistic people. These disparities are believed to account for differences in social communication, conversational reciprocity and pragmatic language skills.

The salience network (consisting of the anterior insula and anterior cingulate cortex (ACC)) is involved in identifying behaviorally relevant social and emotional information and in switching between internally and externally directed attention. Multiple studies have found decreased functional connectivity in the salience network and between the salience network and the frontal language network; abnormal integration of networks may play a role in the variance in joint attention, social engagement, and communicative interaction. Further, Benkarim et al. (2021) showed that functional connectivity patterns in autism are very individualized. Although ASD was a heterogeneous condition, individual autistic participants did not display a uniform pattern of network disruption in resting state.

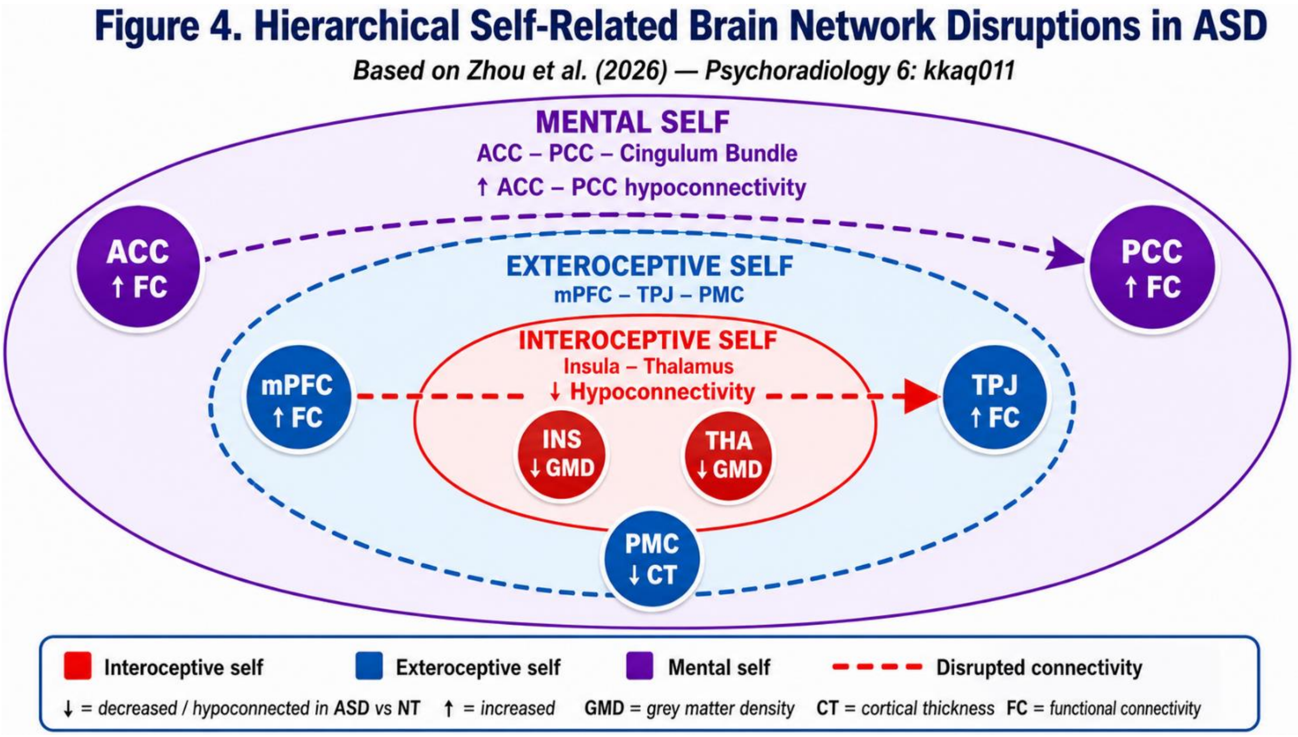
The results of this study emphasize the need for person-specific assessment and intervention in speech-language pathology and for individual-level neuroimaging approaches. 4.4 Speech and Language Networks

SPEECH AND LANGUAGE NETWORKS

Task-based neuroimaging research suggests atypical activation and connectivity in brain areas related to speech perception, language comprehension, and pragmatic communication. The inferior frontal gyrus (IFG), superior temporal regions, posterior superior temporal sulcus (pSTS), and temporoparietal regions seem to play a special role: they are involved in phonological processing, sentence comprehension, narrative understanding, and conveyance of social meaning in communication. A robust individual-subject fMRI analysis was used to show reduced language lateralisation in autism and the broader autism phenotype by Jouravlev et al., (2020). This discovery indicates that atypical hemispheric specialization could be an important neural trait in language organization in ASD. Likewise, Larson et al. (2023) conducted a systematic review of connectivity-based fMRI studies and found atypical connectivity of language networks in ASD, particularly frontal and temporal language areas. In addition, Márquez-García et al. (2023, 2024) demonstrated that autistic children had different functional connectivity during pragmatic and semantic language processing. The present findings are clinically meaningful as they offer a neural basis for problems with figurative language, making inferences, finding the meaning in context, and comprehending pragmatics even in children with autism who have good basic vocabulary or decode language. The differences in the timing and efficiency of speech and language processing are revealed by electrophysiological studies, which supplement the fMRI findings. Key and D'Ambrose Slaboch (2021) summarized the findings of EEG/ERP studies in relation to atypical responses to auditory processing at various levels of speech-processing complexity in ASD. The same applies to da Silva Mayerle et al. (2023), who identified differences in mismatch negativity (MMN) indicating atypical automatic auditory change detection and phonological discrimination in autistic children and adolescents. EEG and MEG studies in recent years have helped to clarify this picture. Roberts et al., 2020, obtained multimodal MEG/ MRI recordings of atypical auditory neuromagnetic responses in autism, which were related to differences in neural conduction velocity. In young autistic children, Mukerji et al. (2025) reported that expressive language and non-verbal cognitive ability were related to resting frontal gamma power. In their study, Li et al. (2025) found that autistic adults process auditory and semantic stimuli differently during speech-in-noise tasks, indicating that they engage with speech in noisy situations in a different way.

SOCIAL COMMUNICATION AND SELF-RELATED BRAIN NETWORKS

Social communication is a combination of verbal language, non-verbal cues, emotional meaning, and social context. Neuroimaging evidence suggests a distributed network of regions that underlie these processes: the amygdala, fusiform face area (FFA), superior temporal sulcus (STS), temporoparietal junction (TPJ), anterior cingulate cortex (ACC), medial prefrontal cortex (mPFC) and insula. In the literature reviewed, there is a pattern of atypical activation and connectivity in these regions that is associated with variations in facial emotion processing, biological motion perception, perspective-taking, self–other distinction, and pragmatic communication in ASD. Zhou et al. (2026) gave us a *helpful framework for understanding social communication differences in terms of a disruption of the brain networks associated with self. They conducted a systematic review of fMRI and structural MRI studies, identifying atypicalities on three hierarchical levels of self-processing: interoceptive, exteroceptive, mental self-processing. The differences between the insula and thalamus could impact on self-awareness at the interoceptive level and emotional regulation. The exteroceptive level of altered connectivity between the mPFC and TPJ may impact self–other distinction and perspective-taking. At the mental-self level, differences related to the ACC, PCC, and cingulum-related pathways could be related to autobiographical memory, self-representation and social meaning making. The self-related network findings can be useful for the understanding of social communication in autism. Interoceptive, exteroceptive, and mental-self systems may be atypically integrated to account for challenges with conversational reciprocity, emotional interpretation, perspective-taking, and contextual understanding. This framework proposes that social communication in ASD could be influenced by social communication differences within a wider, more general context of ways in which the brain integrates information from the body, from others, and from the self.*



Three-level hierarchical model of self-related brain network disruptions in ASD, adapted from Zhou et al. (2026). The interoceptive aspects of the self (insula and thalamus) are depicted in the inner ellipse, the exteroceptive aspects of the self (medial prefrontal cortex [mPFC], temporoparietal junction [TPJ] and premotor cortex [PMC] are represented in the middle and the mental aspects of the self (anterior cingulate cortex [ACC] and posterior cingulate cortex [PCC]) are depicted in the outer ellipse. Reduced functional connectivity (hypoconnectivity) has been reported in ASD and is shown by dashed lines. INS = insula, THA = thalamus, ACC = anterior cingulate cortex, PCC = posterior cingulate cortex, GMD = grey matter density, FC = functional connectivity. This is a *conceptual figure and not anatomically correct.*

In addition, Valles-Capetillo et al. (2025) found that the pragmatic language network, encompassing right-hemisphere inferior frontal and temporal-parietal regions, is linked to reading comprehension and higher-order language processing in autistic children. Even children with good word decoding abilities may struggle with inference, figurative language and context in this network, which might help to account for some of the problems seen among autistic children.Some of the problems seen even among autistic children with good word decoding abilities may be due to reduced activation and connectivity within this network, which affect their ability to understand inferences, figurative language or context. This discovery indicates that pragmatic communication deficits in autism are related to specialised neural networks, and cannot be accounted for solely on the basis of attentional or motivational factors.

Social communication networks also play an important role in the domain of audiovisual speech integration. Dunham et al. (2023) and Ross et al. (2024) found that autistic people have atypical neural responses when processing audiovisual speech, especially in areas involved in multisensory integration and social communication. Dunham-Carr et al. (2023) also reported an association between neural integration efficiency (as indexed by ERP) and vocabulary outcomes in autistic and non-autistic children, which indicated a relationship between neural integration efficiency and communicative competence.

DISCUSSION

The 30 studies synthesised in this review provide converging evidence that autism is associated with distributed differences in neural network organisation rather than dysfunction in a single isolated brain region. The communication differences in autism are found to be related to atypical organisation of the interconnected frontal, temporal, parietal, subcortical, cerebellar and limbic systems that work together to support speech, language and social communication, rather than to Broca or Wernicke's areas alone (Larson et al. 2023).

One of the main findings of this review is that the self-related brain network approach can be used as a framework to understand communicative heterogeneity in autism. Zhou et al. (2026) propose that atypical integration between the interoceptive, exteroceptive, and mental–self systems may play a role in interoceptive/exteroceptive or mental–self self–other distinction, perspective–taking, emotional interpretation, and contextual understanding. This framework does not pathologise autism, but emphasizes that there are differences in neural organisation that can influence various communication practices and needs.

The importance of the white matter findings in clinical practice for speech language pathologists is discussed, especially with regard to the arcuate fasciculus (AF) and the uncinate fasciculus (UF). Variability in these pathways may account for differences in expressive language, receptive language, phonological processing, semantic integration and pragmatic communication. In specialised diagnostic or research contexts, neuroimaging data may be included in the broader clinical formulation, but should not be relied on as the sole basis for making a prognosis or determining AAC candidacy.

Results of functional connectivity analyses of the default mode network, salience network, and *language network highlight a relationship between social communication differences in autism and atypical functional connectivity of large-scale neural systems. They are congruent with intervention strategies which focus on joint attention, social interaction, language and naturalistic communication in integrated contexts. Neuroimaging results should be used as an adjunct, and should not be interpreted as a proof of the effectiveness of a particular intervention model.*

EEG and MEG studies suggest that measures of neural timing and neural processing of auditory speech could be useful objective measures of language processing and response to language intervention. Results from MMN responses, frontal gamma power, speech-in-noise processing and auditory neuromagnetic responses indicate potential biomarker measures to monitor auditory and language development, especially among those for whom behavioural assessment is poor.

Gender differences in neural organisation is an emerging consideration. Current findings are generalisable to autistic females, non-binary individuals, minimally verbal individuals and culturally diverse populations, but this needs to be investigated further.

It's important to view these findings in the context of a neurodiversity affirming lens. The neural differences reviewed here should not be viewed solely as a deficit that needs to be eradicated. Instead, they propose that individuals with autism use alternative neural pathways and have alternate efficiencies for the processing of communicative information. Clinical intervention should thus work towards communicative competence, autonomy, and participation, and take into account individual neural and behavioural diversity.

CLINICAL IMPLICATIONS FOR SPEECH-LANGUAGE PATHOLOGY

The neuroimaging findings synthesised in this review have several potential implications for speech-language pathology practice, summarised in Table 2.

Table 2. Clinical Implications of Neuroimaging Findings for Speech-Language Pathology

Neuroimaging Region / Network	***Possible Communication Impact***	***Speech-Language Pathology Implication***
Inferior frontal gyrus (Broca's area)	*Difficulty with speech planning, expressive language, and sentence organisation*	*Structured expressive language tasks, verbal planning support, sentence-building activities, visual supports, and AAC*
Superior temporal gyrus / pSTS	*Difficulty processing speech sounds and multimodal social cues; reduced voice processing*	*Auditory processing activities, receptive language therapy, prosodic awareness, and narrative comprehension support*
Arcuate fasciculus	*Weakness in repetition, phonological processing, and language learning; possible association with reduced verbal output*	*Repetition-based language tasks, phonological awareness, graded verbal learning; AF-related findings may support broader AAC planning*
Uncinate fasciculus	*Difficulty linking emotion, memory, and social meaning to language*	*Emotional vocabulary, narrative context, social interpretation tasks, and pragmatic language therapy in natural contexts*
Amygdala / fusiform face area	*Difficulty recognising facial emotions and interpreting social cues*	*Emotion recognition activities, face-reading, social-cue interpretation, video modelling, and social stories*
Default mode network / mPFC–pSTS	*Difficulty with perspective-taking, social reciprocity, and self–other processing*	*Perspective-taking tasks, conversational turn-taking, role play, and naturalistic communication intervention*
Salience network (insula–ACC)	*Difficulty with joint attention, social orienting, and detecting communicative bids*	*Pre-linguistic social-orienting routines, joint-attention training, and early intervention targeting social engagement*
Corpus callosum	*Reduced interhemispheric integration affecting phonological awareness and language coordination*	*Phonological awareness tasks, rhythm-based speech activities, and literacy intervention grounded in phonics*
Cerebellum / basal	*Atypical timing, rhythm, speech motor*	*Prosody practice, rhythm-based speech therapy, and*

Neuroimaging Region / Network	*Possible Communication Impact*	*Speech-Language Pathology Implication*
ganglia	*control, and prosody*	*speech motor coordination activities*
Insula / thalamus (self-related networks)	*Difficulty integrating bodily self-signals; possible effect on social communication and emotional regulation*	*Interoceptive awareness activities, sensory self-regulation support, and mindfulness-based approaches where appropriate*

Table 2 maps neuroimaging regions and networks to possible communication impacts and corresponding SLP intervention targets.

Assessment of communication in autism should include pragmatic language, prosodic processing, conversational reciprocity, social inference, and sensory/self-regulation features. These domains relate more closely to differences in the distributed neural networks rather than to any single classical language region dysfunction. The integrated contexts of naturalistic intervention strategies outlined in this review align with the neural architecture of communicative differences found in this review, which include interventions to focus on joint attention, social orienting, language use, and self-regulation. Lastly, neurobiological heterogeneity shows that there is no one-to-one correspondence between a behavioural profile and a specific underlying neural architecture, thus one-size-fits-all intervention strategies are not enough. Thus, neuroimaging-informed frameworks could potentially help to facilitate more individualised and precision-based methods in speech and language pathology.

GAPS IN THE LITERATURE

There are a number of significant gaps in the literature regarding neuroimaging in relation to autism, speech and language, social communication. Firstly, the current literature is predominantly composed of verbally fluent school-age autistic males from high income, English speaking countries. Therefore, the results of the present study might not be applicable to those with little verbal communication, to autistic females, to individuals from low- and middle-income countries, or to linguistically and culturally diverse populations. Second, there are few studies that used longitudinal neuroimaging designs that tracked the development of the neural systems from infancy to adolescence, while also studying communication outcomes. Of the 30 studies in this review, only a few studies had longitudinal neuroimaging components. More and larger samples of individuals with autism and more diverse samples of individuals across the spectrum of developmental outcomes are needed in future multi-site, longitudinal studies to better describe developmental trajectories of brain organisation and communication across the autism spectrum. Third, despite the fact that there is a vast amount of literature on the topic, few studies have translated their neuroimaging results into practical applications for speech-language pathology assessment or intervention. Improving interdisciplinary communication among neuroscientists, speech-language pathologists, educators, autistic individuals and their families should be part of the solution to the gap between neuroscience and clinical practice. Moreover, there is significant methodological heterogeneity among studies, ranging from imaging hardware, acquisition protocols, preprocessing procedures, analytic methods, task paradigms, and statistical thresholds. More methodological standardization, open science practices and data sharing would enable more comprehensive comparisons between studies and improve future evidence from meta-analysis.

CONCLUSION

This systematic review aimed to present the evidence from 30 peer-reviewed neuroimaging studies that compared autistic and neurotypical brains, focusing on speech, language and social communication between 2020 and 2026. The evidence reviewed here suggests that there are distributed differences in neural network organization related to the communication differences of autism, rather than there being a dysfunction in a single brain region. The results reveal: atypical organization of language-relevant cortical regions across modalities, of white matter pathways like the arcuate fasciculus and uncinate fasciculus, large-scale functional networks like the default mode network and salience network, electrophysiological mechanisms in the processing of auditory speech, and self-related networks in the brain. A novel framework discussed by Zhou et al. (2026) is the self-related network framework which connects interoceptive, exteroceptive, and mental-self processing networks to social communication. This approach does not merely view communicative differences in autism as a lack of social motivation and theory of mind, but rather as communication that may also be influenced by more general differences in self–other processing, emotional integration, bodily awareness, and contextual meaning-making. This is in line with a view of autism that is neuro-diversity affirming and is more individualistic in the approach to assessment and intervention for autism. Longitudinal designs, larger, more diverse samples (including minimally verbal individuals and autistic females), methodological standardization across sites within the neuroimaging field, and direct correlations between brain-based measures and communication outcomes should be emphasized in future research. This work will contribute to the creation of an evidence base of culturally responsive, neurodiversity affirming communication supports for autistic people throughout the lifespan that are characterized by precision.

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