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Review Article

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Study of Dysfunction in the Neural Systems in Autism Spectrum Disorders: A Review Article

Florica Voiţă-Mekereş[1,2], Larisa Bianca Galea-Holhoş[1], Gabriel Mihai Mekeres[2,3*], Razvan Parvan[1]

[1]*Department of Morphological Discipline, Faculty of Medicine and Pharmacy, University of Oradea, 410087 Oradea, Romania.*
[2]*County Clinical Emergency Hospital of Oradea, 410087 Oradea, Romania.*
[3]*Department of Medical Disciplines, Faculty of Medicine and Pharmacy, University of Oradea, 410087 Oradea, Romania.*

***Email:** mekeres_gabriel@yahoo.com*

ABSTRACT

One of the worst developmental abnormalities, autism spectrum disorder, is often identified before the age of three. All forms of autism impair people's capacity to communicate with others, despite the fact that each person's symptoms and degree of severity vary. Despite the fact that there is no known cure for autism, children who receive prompt and serious treatment see significant improvements in their quality of life. The deficiencies in social functioning seen in individuals with autism spectrum disorders may be brought on by diseases of the neurological systems responsible for processing social information, according to research in the field of social neuroscience. This study examined the available evidence on the neurological underpinnings of autism spectrum disorders. The outcomes demonstrated aberrant activity in sections of the mirror nerve system and its three interrelated regions that are engaged in social perception, areas related to action observation, and regions that are involved in theory of mind. These findings point to faulty social information processing in autism spectrum disorders, which are characterized by flaws in the neurological systems responsible for social perception, action comprehension, and theory of mind. These results emphasize the involvement of the posterior superior temporal sulcus as a common location in all three systems and offer a framework for understanding the brain processes underlying social deficiencies in autism spectrum disorders.

Key words: *Neural systems, Autism spectrum disorders, Social neuroscience, Developmental abnormalities*

INTRODUCTION

Autism spectrum disorder (ASD), which manifests as inadequate, delayed, or aberrant functioning in one of the domains of social interaction, language used in social communication, and creative or symbolic play. A child with autism spectrum disorder lives in his inner world, and since establishing appropriate social communication requires receiving and processing sensory information correctly and adopting appropriate behavior based on this information, his connection with the outside world is cut off, and the lack of receiving and understanding external sensory stimuli disrupts his learning process and appropriate social communication [1,2].

Cognitive neuroscience has begun the study of neural structures and circuits underlying the processing of social information and the social brain in humans. Particularly, the discipline of social neuroscience is expanding quickly, and its primary study subfields have aided in describing the distinct elements of both healthy and disordered social information processing [3,4]. Therefore, it seems necessary to describe the abnormal performance of the key systems of social information processing in autism spectrum disorders by reviewing the research that has examined the neural mechanisms of these systems.

The neural system of social perception

People are naturally sociable beings. Due to its efficiency and reflective character, social perception skill is described as the capacity to interpret the mental states of others based on fundamental behavioral cues [3,5]. This capacity is thought to be evolutionary advantageous. Numerous efficient and explicit mechanisms that develop later in the course of transformation require social awareness to function [6]. Research on primates is seen as a helpful model for understanding social perception in humans since similar social behaviors have been seen in monkeys [7,8]. For instance, chimpanzees are able to comprehend what their peers are aware of in the context of competition for food. They can assist their fellow humans by using their knowledge of others' motivations [9,10]. According to research, Rhesus monkeys may estimate what other people are thinking based on what they hear and observe [11,12]. The fusiform gyrus (FFG), amygdala (AMY), orbitofrontal cortex (OFC), and posterior superior temporal sulcus (PSTS) all need to be active for dynamic social perception. In both humans and monkeys, these regions are selectively responsive to social cues and are linked in the primate brain [13,14].

In the network of social perception, PSTS is crucial. This region is directly connected to the major visual and auditory centers in both monkeys and humans, and it participates in the representation of information in both areas [15,16]. PSTS selectively activates against static social stimuli (such as faces) and dynamic and complex social information (such as changes in gaze direction or facial emotions) [16,17]. PSTS is sensitive to social stimuli that people interpret as deliberate [16] and is activated against static social stimuli (such as faces).

In comparison to non-target acts, PSTS exhibits more discriminating behavior toward intentional human behaviors that have social significance. The processing of emotional speech via PSTS is crucial in the auditory domain.

The FFG is comprised of a number of different but connected areas that are engaged in the visual facets of social perception along the ventral-temporal cortex. They include the fusiform face area (FFA), which responds to facial cues, and the fusiform body area (FBA), which only responds to physical stimuli. The FFA is sensitive to distinct fixation patterns and simple eye movements during implicit face processing [18]. In addition, FFA in facial identity recognition and goal-directed actions is involved [19]. AMY encodes the emotional significance of social information, especially when such information requires rapid and reflexive processing [20]. For example, the amygdala enhances gaze orientation toward facial features that contain socially relevant information, such as eyes, especially when facial expressions are associated with fear [21]. The OFC is related to the reward encoding of environmental sensory cues, which is a fundamental aspect of behavioral planning in humans as well as in primates [22]. Paying attention to socially rewarding stimuli, determining personal interest in social interactions, and responding to social cues [23] requires the activity of this area due to its central role in value-based decision-making.

Our knowledge of the social development and social deficiencies of people with autism spectrum disorders has been improved by studies that look at social perception in these diseases. Compared to normal children, children with autism spectrum disorders pay less attention to social cues such as voices and faces [24]. Children with autism spectrum disorders tend to place more emphasis on physical and non-social relationships than their typical classmates do at this age, failing to recognize the social significance of biological functions [25].

Social difficulties seen in autistic spectrum diseases in young children continue throughout adulthood. Autistic adults with high activity have difficulty inferring the mental states of others, vocalization, and emotional facial expressions [26]. According to these results, there is compelling evidence of aberrant cortical and subcortical social perception processing for somatosensory, auditory, and visual inputs. The AMY FFC and PSTS brain regions, which are involved in social perception, are less active in autistic children than in their non-autistic siblings when they are seen making displays or motions, according to studies in the domain of visual signals [27]. In particular, it appears that autism spectrum disorders show less selective PSTS area performance in social perception. Compared to normal people, the function of this area in people with autism spectrum disorders is less specific to evaluate the inconsistency of the actions of the characters in a show with their displayed preferences at the beginning. In the auditory domain, those with autism spectrum disorders have the same pattern of activity as the control group for non-vocal sounds, but the sound selection regions in PSTS become inactive in response to vocal sounds. In terms of somatosensory signals, individuals with high levels of autism features had decreased activity in the OFC and PSTS regions in response to a light touch of the arm [28,29].

The nervous system of action observation

While social perception is concerned with comprehending and interpreting the outward behaviors of others in order to infer their underlying intentions, the function of the perceiver is not entirely obvious. Another process that significantly depends on the perceiver himself is active when individuals react to the behaviors of others. An individual who is observing the behaviors of others may be attempting to comprehend what such actions would entail if he were to carry them out himself. Therefore, the role of a self-perceiver is important, and understanding the actions of others is to some extent self-based. This is the mechanism of the nervous system of perception or action observation. Perceivers must go beyond simple decoding in order to correctly match their behaviors with those that are being watched [30]. The perceiver must first see another person's activity in order to grasp it, and only then can they mentally mimic it. As a result, imitation and action perception are strongly connected. Mirror neurons, a subclass of visuomotor neurons first identified in the prefrontal cortex of monkeys, have received the majority of attention in studies investigating the neurological basis of action perception and observation. Mirror neurons have been identified in humans and monkeys in response to action observation and execution. Three interconnected brain regions make up the mirror nerve system in humans [31,32]: the parietal mirror neuron region, which contains the front section of the inferior parietal lobule (IPL) and offers low-level motor description of other people's movements; the PSTS area, which serves as an intra-visual area of the dynamics of other people's actions; High-level motor plans are created in the frontal mirror neuron area, which comprises the ventral premotor cortex (PMC) and posterior inferior frontal gyrus (IFG). The process of action perception in the mirror nervous system is a crossroads process [31].

The IPL and the IFG receive the data encrypted in the PSTS. The data is subsequently sent via the IFG to the IPL and PSTS. As a result, PSTS functions as both an input and an output area in the mirror nervous system, enabling comparison between seen activities and those that have been carried out. The study of action observation is still relatively new but is expanding quickly. While some studies have found that autistic children perform poorly in imitation activities or exhibit delayed development when compared to their typical counterparts, the question of whether there is a problem in the imitation process in autism is still up for dispute [33]. Other studies have reported the same performance in the field of imitation both in autistic children and in the control group [34, 35].

The mirror neuron system in autism disorder has been the subject of several neuroimaging investigations, with varying degrees of success. On the one hand, the outcomes of functional magnetic resonance imaging (MRI) studies suggest that kids with autism spectrum disorders display aberrant activity in particular areas of the mirror nerve system, such as TFG and IPL, when watching facial expressions or hand motions [36]. According to the electroencephalography (EEG) results, mu rhythm attenuation is typically observed in people going through normal neurodevelopment during observation and execution of hand movements. People with autism spectrum disorders do not exhibit mu rhythm suppression when watching an action. The neural activity of regions of the brain related to the mirror nervous system in persons with autism spectrum disorders and those in the control group, on the other hand, has not been observed to vary in other investigations [37,38]. It is interesting to note that research showing aberrant neural activity of the mirror nervous system typically employ emotional stimuli, whereas studies showing normal activity of the mirror nervous system typically utilize non-emotional stimuli [39]. There is a developing tendency in the research of the mirror nervous system, and work is still being done to rectify the way that the distinct roles played by the mirror nervous system's various brain regions are recognized.

Theory of mind and malfunction of neural systems

In the last two decades, theory of mind (also known as mentalizing or mental state reasoning) research has shed light on both typical and pathological social behavior. The capacity to anticipate connections between the internal states of the mind and the exterior conditions of circumstances is referred to as the theory of mind. To be able to do this, one must be able to distinguish their own reality from what others see [40]. Contrary to what is seen by others and what may be observed in the act of reasoning about mental states, it is thought to be a human-only ability that calls for significant cognitive resources and high levels of attention. People can successfully navigate the challenging social environment if they have the capacity to comprehend and forecast the mental states of others [41].

Wimmer and Perner conducted the famous Sally-Anne experiment on young toddlers in 1983 to test the theory of mind [42]. Children watch Sally and Anne, two dolls, as part of this exam. After placing the stone in her basket, Sally exits the room. She removes the stone from Sally's basket and places it in her box while she is not there. Participants in this test are required to respond to the following question : Where will Sally seek her stone when she enters the space again ? The children will answer that Sally will seek the rock in the basket that she placed it in if they are able to appreciate Sally's perspective, or, to put it another way, if they comprehend that Sally has a mistaken notion about the position of the rock. The clear grasp of another person's incorrect belief is a developmental milestone that children acquire around the age of four, according to developmental psychology experts who have used this test or variants of it. The second-level false belief tests are successfully completed by typical youngsters between the ages of 6-7 [43]. The development of more sophisticated mental-state reasoning, including moral judgment, occurs between puberty and maturity.

According to research, those who suffer from autism spectrum disorders exhibit deficiencies in their theory of mind. Even though they were approximately five years older than the other test subjects, children with autism spectrum disorders who completed Sally's task could not recognize Sally's incorrect notion [44]. According to the results of various studies that have compared mentalization skills in normal and abnormal children, failure to recognize false beliefs is considered a sign of more fundamental social deficiencies in autism spectrum disorders [45, 46]. Although those people with autism spectrum disorders who have medium or medium to high IQ learn to solve simple false belief tasks during the transformation, their performance in more advanced tests that are combined with complex social emotions and natural feelings shows that their shortcomings in the field of inferring mental states are stable in adulthood. Adults with high-functioning autism can understand false beliefs when tested, but they are not able to spontaneously predict false beliefs based on behavior [47]. An increase in knowledge about inferences about the mental states of both persons with these illnesses and healthy individuals has resulted from extensive study on the theory of mind in autism spectrum disorders utilizing a range of activities. Numerous neuroimaging studies have concentrated on the deficiencies in theory of mind in people with autism spectrum disorders. Studies that have investigated mentalization using static tasks have concluded that MPFC and TPI activity in people with autism spectrum disorders show a decrease compared to normal people, and the more severe the symptoms of these disorders are, the greater the decrease in the activity of these areas [48]. However, in another study, no difference was found between the neural activities during the story-oriented theory of mind task in these subjects compared to the subjects in the control group [49].

Overall, a vast number of recent studies suggest that individuals with autism spectrum disorders have atypical spatial activity patterns and lower activity of the fundamental mentalization regions, including TPJ and MPFC, while assuming the mental states of others.

CONCLUSION

The posterior superior temporal sulcus AMY, orbitofrontal cortex, and fusiform gyrus are among the brain regions involved in social perception. The results of studies that looked at the neural mechanisms of social information processing in the brains of people with autism spectrum disorders suggest that these individuals are in these regions as well. They exhibit decreased activity in the regions involved in action observation, such as the mirror nervous system and its three interconnected regions, the posterior cingulate cortex/pericaneus, inferior frontal gyrus, and inferior parietal lobule, as well as in the regions dedicated to theory of mind, such as the middle prefrontal cortex, temporal-parietal junction, PSTS, posterior cingulate cortex/pericaneus, and anterior temporal lobe. As a hub connecting these three systems, PSTS is particularly significant and plays a crucial part in the temporal integration of indicators of others' behavior from the senses of sight, sound, and touch, as well as intentional representation [50].

The capacity to create and integrate information throughout time into a cohesive whole in order to comprehend and predict when events will occur is known as temporal integration. This area must be active in order to forecast the temporal encoding of others' conduct [51], and improper activity in ASD makes it difficult to predict others' future behavior based on their past behavior, which is consistent with the recently proposed theory of poor temporal prediction in ASD [52]. Predictive impairment in autism (PIA) is a theory that claims ASD is linked to an erroneous state-by-state conditional probability estimate for an observed temporal sequence. The PIA hypothesis is significant because it offers a framework for comprehending some characteristics of ASD, such as sensory abnormalities, a preference for monotony, difficulties interacting with dynamic objects, difficulties with the theory of mind, and an aptitude for strictly rule-based disciplines like math, music, and computers. In light of this, it is intriguing to speculate that PSTS plays a role in the temporal integration of the essential components of the dynamic stimulus environment, particularly the integration of the visual and auditory systems. Future research should therefore focus on further examining PSTS's temporal integration and how it relates to the PIA hypothesis.

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