

Neuromagnetic Measurements of Emotional Face Processing in Children With Autism Spectrum Disorder

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Autism spectrum disorder (ASD) is a neurodevelopmental condition associated with difficulties with social interaction and communication, along with restricted and repetitive behavior. It affects more than 1% of the population and impacts the way a person perceives and socializes with others. Many behavioral studies have reported deficits in face processing in individuals with ASD. From an early age, children with ASD show less attention to faces and eyes than their typically developing peers. They also have difficulty understanding the emotional expressions of others.

The development of and increasing use of neuroimaging techniques allowed the investigation of neural responses to emotional faces in ASD, providing an insight into the underlying mechanisms of the deficit in processing emotional expressions. Numerous functional magnetic resonance imaging (fMRI) studies on emotional processing in ASD reported atypical activation of the brain regions involved in face processing, such as the fusiform gyrus, the superior temporal sulcus, and the amygdala [see Nomi and Uddin (1) for a review]. Whereas fMRI measures the hemodynamic neurovascular response, providing excellent spatial resolution, electroencephalography (EEG) and magnetoencephalography (MEG) directly measure neural response with high temporal resolution. Although early EEG studies found reduced or delayed responses to various sensory stimuli in individuals with ASD, MEG has increasingly been used to investigate sensory processing in ASD because of its superior ability to localize measured neuronal activity. In addition to the methodological advantages, MEG is particularly suitable for developmental studies with children with ASD because it is quiet (as opposed to fMRI) and comfortable because electrodes do not need to be placed on the scalp as in EEG.

Despite the increased use of MEG in ASD research, studies on emotional processing in ASD are rather scarce. In the current issue of *Biological Psychiatry: Cognitive Neuroscience and Neuroimaging*, Leung *et al.* (2) examined spatiotemporal patterns of MEG responses to emotional faces in children with ASD and typically developing control children (ages 7–10). The children performed an implicit emotional face processing task; the emotional faces were irrelevant to the task because they had to indicate the location of the nonface target. Beamforming techniques were used to assess differences between happy and angry face processing in children with and without ASD.

Typically developing children showed greater activity to happy faces than to angry faces in the right temporal areas in the 300- to 400-ms time window. Quite the opposite, children

with ASD had the greater activity to happy faces than to angry faces in several frontal and temporal areas in various parts of the time interval between 250 ms and 500 ms. The between-group comparison revealed late reduced activity (425–500 ms) in the thalamus and posterior cingulate cortex to both angry and happy faces in children with ASD compared with control children. These results indicate the atypical processing of happy and angry faces in young children with ASD.

The authors discuss late atypical recruitment of the posterior cingulate cortex and the thalamus in children with ASD, suggesting poor modulation of toggling between the default mode network and task-based processing. Late activation of the posterior cingulate cortex in typically developing children indicates activation of the default mode network after emotional face processing, whereas it seems that children with ASD lack this deactivation phase, i.e., a return to the default mode network. Furthermore, reduced activity to angry faces compared with happy faces in children with ASD is opposite to the increased activity to angry faces in typically developing children. One possible explanation suggested by the authors is that a preference for happy faces in children with ASD indicates less mature emotional processing because happy faces are more easily recognized by young children. Another possible explanation is that children with ASD did not perceive angry faces as emotional, so activation in areas related to emotional face processing was not pronounced. However, the results indicate impaired processing of angry faces in children with ASD.

The current study makes a significant contribution to the existing literature on impaired emotional face processing in individuals with ASD. Previous studies from the same research group showed the spatiotemporal patterns of atypical emotional face processing in adolescents and young adults with ASD (3,4). To investigate the developmental trajectory of emotional face processing in ASD, Leung *et al.* (2) extended their previous studies to younger children, thus covering the whole age range from early childhood to young adulthood. This allows the comparison of spatiotemporal properties of emotional face processing in individuals with ASD across different age groups.

In previous work on the emotional face processing in adolescents with ASD, Leung *et al.* (3) identified several brain regions with distinct activation to angry and happy faces in the ASD group compared with control subjects. These differences appeared in various parts of the analyzed time interval (50–400 ms). Adolescents with ASD showed a complex pattern of reduced and increased activations in orbitofrontal, temporal, and limbic areas that indicated their impairment in integrating

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these areas in the emotional face processing network. In the corresponding study with young adults with ASD, Leung *et al.* (4) reported increased activation for the ASD group in traditional emotional face processing areas (such as the anterior insula, fusiform gyrus, inferior temporal gyrus, anterior cingulate cortex, and amygdala) and reduced activation in occipital and parietal areas (such as the cuneus, precuneus, middle occipital gyrus, postcentral/supramarginal gyrus caudate, and, again, anterior cingulate cortex). Similar to the findings of the study with adolescents with ASD, the differences between young adults with and without ASD were found during the whole analyzed time interval (100–500 ms).

The apparent difference between the current study by Leung *et al.* (2) and their previous studies with adolescents and young adults (3,4) is the lack of discrepancies in neural activity during the early stages of visual processing of emotional faces between individuals with ASD and those without ASD. A possible conclusion could be that the early processing of emotional faces is similar in younger children with ASD and their typically developing peers and that the differences appear later in development. However, this conclusion would not concur with numerous behavioral, eye-tracking, and EEG studies [see (5,6) for review]. P100 and N170 were the most commonly explored event-related potentials, and most studies reported slower latencies and smaller amplitudes of N170 in children with ASD. Some studies found a modulation of P100 in children with ASD, but the results were not consistent across all studies (6). The inconsistencies in finding discrepancies in neural activity during the early processing of emotional faces between children with ASD and typically developing children might be caused by the heterogeneity of ASD. ASD etiologies and developmental trajectories are highly variable across individuals, as are brain structural and functional correlates of ASD.

Electrophysiological and neuroimaging studies are usually designed to identify common features among individuals with ASD and compare them with the typically developing population. However, more recently some studies tried to address variation within ASD by comparing the subgroups within ASD and by using a dimensional approach to examine the relationship between neuroimaging data and clinical features (7). Using this approach is demanding because it requires the recruitment of a large sample of participants with ASD, and it is especially challenging to conduct large-scale studies with children with ASD.

Furthermore, recent fMRI studies are going beyond the traditional model of atypical activation of particular brain areas during emotional face processing in individuals with ASD to emphasize the distinctive features of emotional face processing brain networks [see (1) for review]. Correspondingly, an increasing number of MEG and EEG studies report patterns of functional brain connectivity in ASD [see (8) for review]. Despite diverse methods and the results of studies exploring brain electrophysiological connectivity, it seems that they bring converging evidence for long-range functional underconnectivity in ASD, whereas the hypothesis of short-range overconnectivity should be further evaluated. However, there is a lack of developmental studies on the evolution of functional brain connectivity in children and adolescents with ASD.

Two recent MEG studies examined functional connectivity during emotional face processing in children with ASD (9,10).

Mamashli *et al.* (9) did not find any difference between children with ASD and their typically developing peers in either local functional connectivity in the fusiform face area or long-range functional connectivity between the fusiform face area and the anterior cingulate cortex, inferior frontal gyrus, and precuneus. However, when they included adolescents and young adults, they found that both local and long-range functional connectivity measures were negatively correlated with age in individuals with ASD, whereas they were positively correlated in the control subjects. Besides, local functional connectivity was correlated with ASD severity, measured by the Autism Diagnostic Observation Schedule, but only in the older group of adolescents and young adults. These findings, together with results by Leung *et al.* (2–4), suggest that adolescence is a particularly vulnerable period for ASD individuals and could be one of the critical time windows for interventions that might improve emotion-processing abilities.

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Article Information

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