Pathophysiology of sensory abnormality in Autism Spectrum Disorders

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Abstract

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder characterized by impaired social communication and limited interests and preoccupations. It is known that sensory abnormalities such as auditory and visual hypersensitivity are common symptoms in subjects with ASD. As sensory abnormalities are not objective, the behaviors to avoid sensory stimuli have long been regarded as "individual selfishness". In the questionnaire survey on sensory abnormalities in six senses (auditory, tactile, visual, oral, complex, and vestibular sensation), the rate of sensory abnormalities was significantly higher in children with ASD than in TD children. In addition, sensory abnormalities in children with ASD were characterized by multiple sensory modalities and are associated with obsessive-compulsive and aggressive behaviors. We attempted to evaluate sensory abnormalities objectively and to elucidate the pathophysiology of sensory abnormalities in children with ASD by measuring brain activity in response to sensory stimulation using magnetoencephalography magnetoencephalography (MEG). We found that ASD children with sensory abnormalities show enhanced and delayed responses in the primary sensory cortex to auditory and visual stimuli. We also observed brain activity in three types of stimuli: normal video, luminance-enhanced video, and luminance-enhanced video with sound stimuli, and hound differences in responses in the association cortex of the superior temporal sulcus, which is responsible for visual and auditory integration, and correlated them with the severity of sensory abnormalities.

Background & Results

Brain activity during sensory stimulation was evaluated by MEG. ASD children with sensory abnormalities showed enhanced and delayed responses in the primary sensory cortex to auditory and visual stimuli. In addition, we found that the prefrontal cortex, which is associated with attentional shift and inhibition, also showed a reduced response. Furthermore, the brain activity to the audiovisual stimuli revealed differences in the association cortex of the superior temporal sulcus, which is responsible for visual and auditory integration, and correlated with the severity of sensory abnormality.

Significance of the research and Future perspective

The present study demonstrated that sensory abnormalities in children with ASD can be assessed objectively. The pathophysiology related to sensory abnormalities in ASD involves cortical hypersensitivity in the primary somatosensory cortex related to sensory perception and association areas of sensory integration: changes in the balance of excitatory (E)/ inhibitory (I) systems, and abnormal attention/inhibition networks in the frontal lobe. In addition, it is speculated that thalamus-mediated regulatory mechanisms and insular cortical projections related to behavioral abnormalities are also involved. This study is expected to lead to objective diagnosis and the development of treatments for abnormal sensitivity.

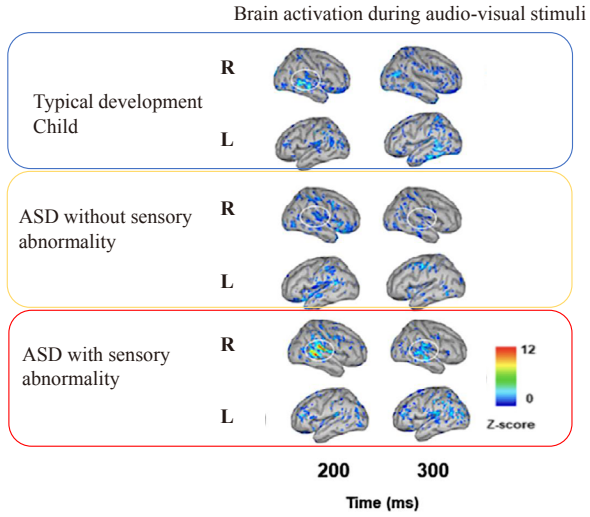


Figure 1: Comparison of brain activity during audio-visual stimulation.

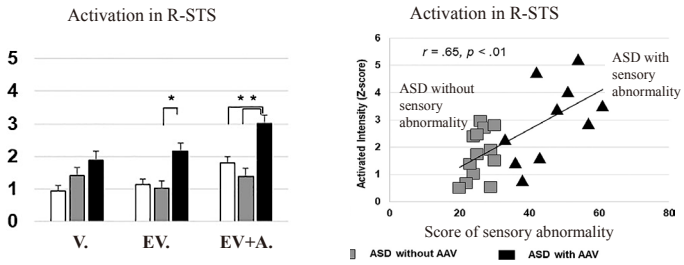
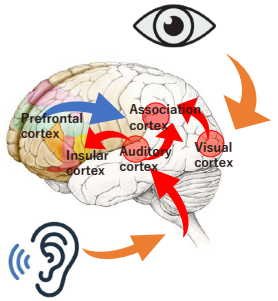


Figure 2. The right superior temporal sulcus (STS) and insular cortex show enhanced responses in children with ASD who are hypersensitive to sensory stimuli. Cortical responses in STS were most pronounced to the enhanced luminance movie with sound. The magnitude of cortical response in the right STS was correlated with the sensory hypersensitivity score. V: visual stimuli (silent movie), EV: enhanced luminance visual stimuli , EV+A: EV with auditory stimuli (sound).



- Primary somatosensory cortex: E/I balance changes
- Sensory integration (association cortex): E/I balance changes
- Dysfunction in attention/ inhibition network
- Change of projections to the insular cortex
- Altered gating mechanisms in the thalamus

Figure 3. Pathogenesis of sensory hypersensitivity. The cortical responses to visual and auditory sensory stimuli are delayed and prolonged in the primary sensory cortex, as well as enhanced in the superior temporal sulcus, which is involved in sensory integration. In addition, the networks of attention and inhibition from the prefrontal cortex are reduced, suggesting that these sensory-related broad networks are thought to be involved.

Patent

Treatise

Matsuzaki, Junko; Kagitani-Shimono, Kuriko; Taniike, Masako et al. Abnormal cortical responses elicited by audiovisual movies in patients with autism spectrum disorder with atypical sensory behavior: A magnetoencephalographic study. Brain & Development. 2022, 44, 81–94. doi: 10.1016/j.braindev.2021.08.007

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Keyword Autism Spectrum Disorder, sensory abnormality, MEG