PERSPECTIVE

Impaired Face Perception in Individuals with Autism Spectrum Disorder: Insights on Diagnosis and Treatment

Taiyong Bi[1] · Fang Fang[2]

Received: 28 August 2017 / Accepted: 9 October 2017 / Published online: 9 November 2017

Autism spectrum disorder (ASD) is a neurodevelopment disorder characterized by impaired social interaction and communication along with restricted and repetitive behavior. For a long period of time, ASD was considered to be a rare mental disorder, with a prevalence of less than 1/100,000. However, the prevalence of diagnosed ASD

presented. Observers are then instructed to indicate whether the face stimulus is novel or not. This task has been shown to be very reliable and sensitive in identifying individuals with selective impairments in face processing and thus might be a promising test in ASD diagnosis [10].

Our neural system has specific circuitries to process face stimuli. For example, the circuitry used to process face identity includes the lateral occipital cortex, fusiform area, and anterior temporal cortex. The emotional information of the face may be processed by the superior temporal cortex, amygdala, and insula. The normal functioning of each region and interregional connection forms the basis of face perception. Given that face perception is selectively impaired in ASD, it follows that neurophysiological studies have found corresponding dysfunctions in the human visual system. Recently, a functional magnetic imaging (fMRI) study investigated this issue using the paradigm of repetition suppression (RS) [11]. RS is the effect that arises when the response of the human brain to repetitively presented stimuli is weaker than its response to unrepeated stimuli. RS is often used to measure the response selectivity of human visual areas [12]. Ewbank *et al*. [11] found that in the fusiform gyrus region, the RS effect of face stimuli was much weaker in the ASD group than in the control group, showing a selective impairment of face processing in this area. Similarly, Kleinhans *et al*. [13] investigated the RS effect to fearful faces and found reduced RS effects in the fusiform area and amygdala. Meta-analysis studies have shown that the function of the left fusiform area is most consistently found to be atypical in the face identity processing of ASD individuals [14] and that the function of subcortical structures, such as the amygdala, hypothalamus, and basal ganglia, is usually abnormal in facial emotion processing [15].

The question remains whether we can discriminate ASD individuals from others based on these neurophysiological abnormalities. Recent studies have made preliminary efforts on this issue. As previously mentioned, Kleinhans *et al*. [13] found a reduced RS effect in the amygdala and fusiform gyrus. They then tried to discriminate ASD individuals from typically developing controls based on the RS effects. The response in the left amygdala showed the strongest discriminability, with an accuracy of 71%. From a more data-driven aspect, Chanel *et al*. [16] measured the activation pattern of the whole brain to face and body stimuli and used machine learning techniques to classify the ASD and control groups. The overall accuracy of classification was 69% based on the response to static faces and 92% based on the response to dynamic bodies. Although the discrimination accuracies are far from applicable in the clinical diagnosis of ASD, these preliminary results have shed light on a possible way of diagnosing ASD effectively and efficiently. Furthermore, searching for effective biomarkers is important and challenging in the field of ASD research [17]. These results also indicate candidate biomarkers in ASD. Further studies may examine different tasks and analyses to improve discrimination performance.

Given that face perception is the core feature of interpersonal interaction, it is important to find a way to improve the impaired functioning in this skill among ASD individuals. Indeed, it is possible to improve the ability to recognize faces with training. One of the most effective ways of training is perceptual learning. Perceptual learning is the phenomenon that training can improve the discrimination and recognition of visual features or objects. For example, Bi *et al*. [18] asked healthy participants to discriminate the viewpoint of faces. Every participant was trained to perform this task one thousand times each day for a total of eight days. With such intensive training, they found that their ability to discriminate face viewpoints increased by $\sim$ 40% relative to their performance before training. Similar results have been obtained in face recognition tasks [19], face detection tasks [20], and facial expression discrimination tasks [21]. Importantly, the behavioral improvement in face discrimination was shown to be accompanied by improvement in the functioning of the human fusiform area [22]. Thus, this might be a reliable method to improve both behavioral performance and brain functions. Future studies should investigate how to apply this approach to ASD groups.

In conclusion, face perception is impaired in individuals with ASD. Neurophysiological evidence shows a selective dysfunction in the neural circuitry that processes face information. Current studies on impaired face perception indicate several possible ways to recognize and treat ASD individuals. However, these findings are far from serving as clinical diagnosis and treatment. Further research is needed on these topics.

Acknowledgements This perspective review was supported by the National Natural Science Foundation of China (31400960).

Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

References

1. Ratto AB, Mesibov GB. Autism spectrum disorders in adolescence and adulthood: Long-term outcomes and relevant issues for treatment and research. Sci China Life Sci 2015, 58: 1010–1015.
2. Masi A, DeMayo MM, Glozier N, Guastella AJ. An overview of autism spectrum disorder, heterogeneity and treatment options. Neurosci Bull 2017, 33: 183–193.

3. Bailey A, Le Couteur A, Gottesman I, Bolton P, Simonoff E, Yuzda E*, et al.* Autism as a strongly genetic disorder: evidence from a British twin study. Psychol Med 1995, 25: 63–77.
4. Shen DN, Zhang LH, Wei EQ, Yang Y. Autophagy in synaptic development, function, and pathology. Neurosci Bull 2015, 31: 416–426.
5. Hua R, Wei M, Zhang C. The complex genetics in autism spectrum disorders. Sci China Life Sci 2015, 58: 933–945.
6. Zhang HF, Dai YC, Wu J, Jia MX, Zhang JS, Shou XJ*, et al.* Plasma oxytocin and arginine-vasopressin levels in children with autism spectrum disorder in China: associations with symptoms. Neurosci Bull 2016, 32: 423–432.
7. Mosconi MW, Sweeney JA. Sensorimotor dysfunctions as primary features of autism spectrum disorders. Sci China Life Sci 2015, 58: 1016–1023.
8. Tager-Flusberg H. Defining language impairments in a subgroup of children with autism spectrum disorder. Sci China Life Sci 2015, 58: 1044–1052.
9. Nomi JS, Uddin LQ. Face processing in autism spectrum disorders: From brain regions to brain networks. Neuropsychologia 2015, 71: 201–216.
10. Wang R, Liu L, Liu J. A new approach to the diagnosis of deficits in processing faces: Potential application in autism research. Sci China Life Sci 2015, 58: 1024–1035.
11. Ewbank MP, Pell PJ, Powell TE, von dem Hagen EA, Baron-Cohen S, Calder AJ. Repetition suppression and memory for faces is reduced in adults with autism spectrum conditions. Cereb Cortex 2017, 27: 92–103.
12. Grill-Spector K, Henson R, Martin A. Repetition and the brain: neural models of stimulus-specific effects. Trends Cogn Sci 2006, 10: 14–23.
13. Kleinhans NM, Richards T, Greenson J, Dawson G, Aylward E. Altered dynamics of the fMRI response to faces in individuals with autism. J Autism Dev Disord 2016, 46: 232–241.
14. Nickl-Jockschat T, Rottschy C, Thommes J, Schneider F, Laird AR, Fox PT*, et al.* Neural networks related to dysfunctional face processing in autism spectrum disorder. Brain Struct Funct 2015, 220: 2355–2371.
15. Aoki Y, Cortese S, Tansella M. Neural bases of atypical emotional face processing in autism: A meta-analysis of fMRI studies. World J Biol Psychiatry 2015, 16: 291–300.
16. Chanel G, Pichon S, Conty L, Berthoz S, Chevallier C, Grezes J. Classification of autistic individuals and controls using cross-task characterization of fMRI activity. Neuroimage Clin 2016, 10: 78–88.
17. Li D, Karnath HO, Xu X. Candidate biomarkers in Children with autism spectrum disorder: a review of MRI studies. Neurosci Bull 2017, 33: 219–237.
18. Bi T, Chen N, Weng Q, He D, Fang F. Learning to discriminate face views. J Neurophysiol 2010, 104: 3305–3311.
19. Hussain Z, Sekuler AB, Bennett PJ. Perceptual learning modifies inversion effects for faces and textures. Vision Res 2009, 49: 2273–2284.
20. Gold J, Bennett PJ, Sekuler AB. Signal but not noise changes with perceptual learning. Nature 1999, 402: 176–178.
21. Du Y, Zhang F, Wang Y, Bi T, Qiu J. Perceptual learning of facial expressions. Vision Res 2016, 128: 19–29.
22. Bi T, Chen J, Zhou T, He Y, Fang F. Function and structure of human left fusiform cortex are closely associated with perceptual learning of faces. Curr Biol 2014, 24: 222–227.