

Abnormal Magnocellular Pathway Visual Processing in Infants at Risk for Autism

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Background: A wealth of data has documented impairments in face processing in individuals with autism spectrum disorders (ASD). Recently, the suggestion has been made that these impairments may arise from abnormal development of a subcortical system involved in face processing that originates in the magnocellular pathway of the primate visual system.

Methods: To test this developmental hypothesis, we obtained visual perceptual data from 6-month-old infants who were at risk for ASD because they had an older sibling diagnosed with the disorder ("high-risk infants"). To measure sensitivity of the magnocellular (M) pathway and, for comparison, of the parvocellular (P) visual pathway, we employed visual stimuli designed to selectively stimulate the two. Sensitivity data from high-risk infants ($n = 13$) were compared with data from matched control infants (i.e., "low-risk" infants with no family history of ASD, $n = 26$).

Results: On the P pathway stimulus, high-risk infants exhibited sensitivities that were identical to those of control infants. By contrast, on the M pathway stimulus, high-risk infants exhibited sensitivities nearly twofold greater than those of control infants.

Conclusions: Given that ASD and its symptoms are known to run in families, these preliminary results suggest that ASD may be associated with abnormal M pathway function early in infancy, which may aid in early diagnosis of the disorder.

Key Words: Autism spectrum disorders, face processing, infancy, magnocellular, parvocellular, visual system

Autism spectrum disorders (ASD) are pervasive developmental disorders characterized by deficits in a variety of social, communicative, and emotional behaviors (1–3). In addition to these well-known higher level deficits in ASD, there also exists substantial evidence for atypicalities in lower level visual (4–6) and auditory (7,8) perception. Most notably, in the visual domain, it is well documented that individuals with ASD exhibit impairments in face processing (9,10). Given that face processing is a socially relevant aspect of visual perception and that social deficits are a core component of ASD, several researchers have suggested that face-processing deficits and the neural systems that underlie them may play an important role in the development of ASD (11–14).

There are several models of what leads to the face-processing impairment in ASD (see 12 for review). Most relevant to the current study, it has recently been posited that the impairment may arise from abnormal development of a subcortical face-processing system (11). This subcortical system originates in the magnocellular (M) visual pathway and projects to the amygdala (see Discussion for details). The M pathway is one of the three pathways from the eye to the brain, the other two being the parvocellular (P) and koniocellular (K) pathways.¹ The amygdala is a limbic system structure involved in processing emotion, including facial expressions of emotion (e.g., 15,16). It has been suggested (11) that abnormalities of the amygdala (known to exist in individuals with ASD, 17,18) are likely to be responsible

for developmental abnormalities of the subcortical face-processing system. However, it is also possible that the problem originates in the M pathway, which provides the input to the amygdala. This is especially true given that the M pathway develops very early (19,20), and thus early abnormalities in this pathway hold the potential to create a cascade of abnormalities in later developing brain regions downstream, including (but perhaps not limited to) those involved in face processing. In the current study, we tested this "abnormal M pathway" developmental hypothesis by studying M pathway functioning in 6-month-old infants at risk for ASD. The logic behind this approach is described below.

Because ASD cannot currently be diagnosed reliably before 24 months of age (21), a recent way investigators have been studying early stages of development of the disorder has been to track the development of infant siblings of children diagnosed with ASD (22,23). These infants are referred to as "high-risk infants" because their likelihood of developing ASD, ~9% (24), is roughly tenfold to twentyfold higher than that seen in the general population, .2% to .6% (25,26), suggesting a strong genetic component in ASD (27,28). (Note that there are also retrospective approaches to studying early development of ASD [e.g., 29–34]; however, they are potentially limited by parental bias and/or lack of experimental control). One type of analysis performed in these prospective infant studies involves measuring a given behavior in high-risk infants early in development (typically within the first 18 months), waiting until each infant is old enough to be tested reliably for ASD (between 24 and 36 months), and then comparing the early data between infants who did versus who did not develop the disorder. To date, initial results from these analyses suggest that there are social, communicative, and language deficits in high-risk infants who go on to develop ASD, starting as early as 4 months of age (e.g., 35–38).

Another type of analysis from these prospective studies focuses on differences between high-risk infants and low-risk control infants (e.g., 37,39), the latter defined as infants without a family history of ASD. This approach capitalizes on what is referred to as the broader autism phenotype (BAP), i.e., behavioral markers of ASD, such as impairments on social, communi-

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¹Because relatively little is known about the K pathway (53,91), we restrict our discussion to that of the M and P pathways.