The Journal of Neuroscience, September 11, 2013 • 33(37):14631–14632 • 14631

Journal Club

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Enhanced Motion Perception as a Psychophysical Marker for Autism?

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Review of Foss-Feig et al.

In recent decades, the incidence of autism has reached epidemic proportions. The ever-mounting burden of disease from autism spectrum disorders highlights the urgency of developing effective treatment options. However, this remains a formidable task. Although autism is characterized by core symptoms, such as impaired communication, social interactions and stereotyped behaviors, it presents heterogeneously. This makes diagnostics challenging and might suggest diverse underlying pathologies. Fortunately, research is beginning to elucidate the neurophysiological basis of autism, namely, reduced neural inhibition, increasing the excitation/inhibition ratio (Rubenstein and Merzenich, 2003). In addition, individuals with autism exhibit an increased intertrial variability in response to sensory stimuli when probed with neuroimaging methods (Dinstein et al., 2012).

What are the perceptual consequences of such physiological effects in individuals with autism? Neural inhibition plays a fundamental role in cortical anatomy and physiology. Inhibitory connections are ubiquitous in sensory systems. Most receptive fields in the visual system have an inhibitory surround. It has now even been proposed that sensory responses are dominated by inhibition (Haider et al., 2013). Thus, one would expect widespread perceptual ramifications if the excitation/inhibition ratio was altered. Some phenomena, such as binocular rivalry, are hypothesized to crucially depend on the precise balance between excitation and inhibition. Yet, studies investigating this phenomenon in autistic and neurotypical populations show no difference in binocular rivalry (Said et al., 2013).

The initial motivation of Foss-Feig et al. (2013) was to track down the psychophysical signature of a possible underlying excitation/inhibition imbalance in autistic individuals. To do so, they investigated the well studied phenomenon of spatial suppression. Spatial suppression refers to the counterintuitive observation that larger stimuli are less readily perceived than smaller stimuli, particularly at high contrasts (Tadin et al., 2003). This is thought to occur because, relative to a small stimulus, a larger stimulus covers more of the inhibitory surround of a given neuron's receptive field, and therefore will produce greater inhibition of the cell. If neural inhibition is weakened, one would expect a diminished spatial suppression effect, rendering larger stimuli more visible than smaller ones. Such effects have been shown in patient populations with known GABAergic deficits, e.g., those suffering from major depression (Golomb et al., 2009).

To determine whether autistic individuals exhibit lower levels of spatial suppression, the authors recruited male children who had been diagnosed with autism, and a comparison group of age- and IQ-matched typically developing children. Both groups viewed slowly moving sinusoidal gratings of different sizes and contrasts. The task of the research participants was to judge whether these stimuli moved to the left or to the right. The authors measured how long the stimuli had to be presented for motion direction to be accurately discriminated (the "duration threshold").

Surprisingly, given the excitation/inhibition hypothesis, the authors did not find weaker spatial suppression in autistic individuals. Instead, they report several other effects. First, autistic individuals were much more sensitive in this task, as evinced by substantially lower duration thresholds, than neurotypicals. Across all stimulus sizes, typically developing children needed stimuli to be presented roughly twice as long as autistic children to accurately discriminate the motion direction. In addition, there was a profound effect of contrast: autistic children performed similarly to typically developing children at low contrasts, but for the smallest stimuli (which presumably are least affected by spatial suppression effects) an increase in contrast enhanced perception in autistic children much more than in typically developing children.

Finally, the authors did not find systematic correlations between perceptual performance in this task and the severity of clinical symptoms in the group of autistic children, as assessed by standard di-

Received July 10, 2013; revised Aug. 6, 2013; accepted Aug. 12, 2013.
A.M.B. was supported by National Institute of Mental Health Predoctoral Research Fellowship 1F31MH095501. We thank Michael Alexander Grubb and Zack Westrick for helpful discussions in preparation of this manuscript.
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DOI:10.1523/JNEUROSCI.2945-13.2013
 0270-6474/13/3314631-02$15.00/0

agnostic interviews. This is surprising, because strong correlations between spatial suppression strength and other metrics have been found for domains as diverse as length of depressive episodes (Golomb et al., 2009) and IQ (Melnick et al., 2013).

The authors interpret their results to indicate that the excitation/inhibition imbalance underlying autism predominantly manifests as a lack of contrast response gain, not as a lack of spatial suppression. Moreover, the fact that perceptual sensitivity clearly distinguished autistic and neurotypical individuals without correlations to severity of autistic symptoms led the authors to suggest that the observed enhancement of motion could function as a categorical marker of autism.

Overall, the study was conducted in a technically rigorous and careful fashion. For instance, the sinewave gratings used in this study were windowed with smooth envelopes both spatially and temporally, thus avoiding potential edge artifacts that would have resulted from sharper windowing. Nonetheless, we would like to highlight a few points that could potentially weaken some of the conclusions in the paper.

A first concern is the choice of dependent measure, namely duration thresholds. This metric is pervasively used in the spatial suppression literature and it might have serendipitously revealed the differential gain control effect, something that may have been unlikely using contrast thresholds. However, we think it is important to link these results to the rest of the psychophysical literature, which rarely uses duration thresholds, for good reason: varying the exposure duration of a stimulus changes its power in the spatiotemporal frequency domain. At short exposure durations, the power distribution is smeared across the spectrum, which could have unforeseen consequences, especially when examining putative inhibitory mechanisms whose effectiveness can vary nonlinearly with time. This is a particular concern given that the stimulus was only shown for a few frames in some cases. Instead, one could easily use the same high contrast stimuli, but use a fine-discrimination task to establish direction discrimination thresholds (Purushothaman and Bradley, 2005).

The authors used two tasks, one low and one high contrast, to distinguish spatial suppression and summation effects. Yet, spatial suppression and summation are inherently confounded regardless of contrast, even though spatial suppression is presumably weaker at low contrast and summation weaker at high contrast. Indeed, there seems to be a hint of a spatial suppression effect in the low contrast condition for the typically developing group. One could avoid this confound by presenting a center stimulus of fixed size, while varying the size of an uninformative surround stimulus, thus independently modulating spatial suppression. A manipulation of this sort could provide valuable confirmatory evidence to observations in this paper, and perhaps elucidate the precise mechanism.

Finally, there is a less interesting interpretation of these results, namely a speed-accuracy tradeoff. It has been shown that autistic individuals sometimes exhibit longer reaction times (Inui et al., 1995) and that waiting for a while after a stimulus ends before responding can improve task performance (Vlassova and Pearson, 2013). Therefore, the reported higher sensitivity in autistic individuals could have simply resulted from the fact that they waited longer before responding. Although this explanation cannot account for the low-contrast results, this issue is left unaddressed by the authors, and could be resolved by measuring reaction times or by enforcing a sufficiently long wait period before all participants are allowed to respond.

Recording reaction times could also help to substantiate a parallel between the effect on motion perception of autism and that of IQ in neurotypicals. Specifically, Melnick et al. (2013) report that high IQ predicts reduced performance for large motion stimuli like those used in this study. IQ accounts for a substantial proportion of the variance of the reported perceptual performance effects in that study, as autism does in this. Is there a latent factor driving both correlations? While high IQ has not been linked to global inhibition levels, and a unifying biophysical explanation of complex phenomena such as IQ and autism seems ambitious at this stage, that these traits appear to share computational features suggests potentially fruitful model-based analyzes. In particular, the link between both effects could be substantiated by fitting reaction times with a drift-diffusion model, an approach recently applied to suggest that IQ modulates specific aspects of evidence accumulation during simple detection tasks (Ratcliff et al., 2008). A common effect of IQ and autism on perceptual processing, captured by models with well characterized parameter spaces, could open new research directions for psychophysical markers of autism.

Taken at face value, the results reported by Foss-Feig et al. (2013) are interesting and certainly deserving of further inquiry. Specifically, the possibility of diminished contrast gain control in autism is interesting, and could be investigated with an adaptation study: we would expect stronger adaptation effects for autistic individuals. It is also possible that autistics have an advantage at processing briefly presented stimuli per se. It would be straightforward to test this by using a variety of fixed stimulus durations and a diverse set of stimuli. Regardless of future studies to establish the validity and generality of the reported results, this is an intriguing study as it promises to allow a rapid and objective diagnosis of autistic individuals. As such, it is at the vanguard of an exciting development: bringing the hard-won knowledge of vision science to bear on disorders of the nervous system in general, and hopefully helping to alleviate the devastating suffering that they cause.

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