Effect of familiarity on reward anticipation in children with and without autism spectrum disorders

Developmental Electrophysiology Laboratory
Yale Child Study Center

Yale Child Study Center SINCE 1911

Katherine K.M. Stavropoulos[1,2] & Leslie J. Carver[1]

1. Developmental Neuroscience Lab
University of California, San Diego
2. McPartland Lab
Yale Child Study Center, New Haven, CT

Developmental Neuroscience Lab university of california, san diego

BACKGROUND

- Autism spectrum disorder (ASD) is estimated to effect up to 1:68 children in the US (Centers for Disease Control and Prevention [CDC], 2014) .
- Documented difficulties in social communication, and presence of repetitive and restricted behavior and interests.
- Social motivation hypothesis states that individuals with ASD are have social-communicative impairments due to lack of motivation to engage in social interactions (Dawson, 2008).
- Previous work provides support for the social motivation hypothesis (Stavropoulos & Carver, 2014) using electrophysiology.
- However, it is unclear if social reward is mediated by familiarity in ASD.
- Do children with ASD have increased reward activity when viewing a familiar face?
- Mixed results in previous literature (Pierce & Redcay, 2008; Webb et al., 2010).
- Current study designed to to investigate whether familiar faces increase reward anticipation in children with ASD vs. their TD peers.

METHODS & PARTICIPANTS

SPN

- The stimulus preceding negativity (SPN) is a slow negative waveform occurring before participants receive feedback about their performance.
- The SPN is larger when feedback is informative (Chwilla & Brunia, 1991), and when participants feel control over the outcome of a task (Masaki, Yamazaki, & Hackley, 2010).
- The SPN reflects expectation of reward, and activity of the dopaminergic reward system (Van Boxtel & Bocker, 2004).
- Individuals with damage to the dopaminergic system (e.g. Parkinsons) show reduced SPN amplitudes (Mattox et al., 2006).

Present Study

- The present study was designed to understand the neural response to feedback anticipation when feedback was accompanied by either a familiar (caregiver's) face or an arrow picture.
- We controlled for rewards between face and non-face blocks.
- We made the face and arrow incidental to the task (e.g. participants did not rely on the picture for feedback).
- We controlled for visual stimulus differences by using scrambled faces in the arrow condition.

Participants

- 28 children (14 ASD, 11F, 3M ; 14 TD, 11F, 3M)
- ASD: mean age = 8.85 yrs, SE = .39
- TD: mean age = 7.94 yrs, SE = .57
- Participants were recruited through postings online and flyers.
- Exclusionary criteria for children in the ASD group included: Genetic causes of ASD (e.g. Fragile X), history of seizures, brain injury, neurological disorders, or any concurrent psychiatric condition (other than ASD).
- Exclusionary criteria for TD participants included all of the above plus an immediate family history of ASD.

Recording

- Neuroelectric data were collected using a 32 channel electro cap (Electro-cap international), which was placed according to the international 10-20 system.
- Electrodes were referenced to Cz and re-referenced offline to linked mastoids. Electrodes were also placed above and below the left eye and at the outer canthi of each eye to record electro-ocular activity (EOG).
- Impedances were kept below 10 kΩ before testing began, and were verified after testing.
- The data were digitized at 250 Hz for 2300 ms, a 200 ms pre-response baseline was included, the 60 Hz notch filter engaged, and filtered using a 30 Hz low pass filter (6 dB/octave), and a .1 Hz high pass filter.
- Averages were obtained from participants with at least 10 artifact-free trials for each condition.

Stimuli and Procedure

- 240 trials were presented in four separate blocks (60 familiar face trials, 60 "familiar" scrambled arrow trials, 60 unfamiliar face trials, 60 "unfamiliar" scrambled arrow trials).
- Participants were instructed to guess whether the left or right side was "correct" with a button pad.
- Participants choice (left or right) was indicated for 2000 ms before feedback was presented.
- Participants were told that they could earn a goldfish cracker for each correct answer (alternate snacks were available if children did not like goldfish).
- Importantly, trials were pseudo-randomly pre-programed as correct or incorrect by the computer in a 50/50 distribution.
- *Figure 1* shows a schematic of our stimuli and timing of the task.

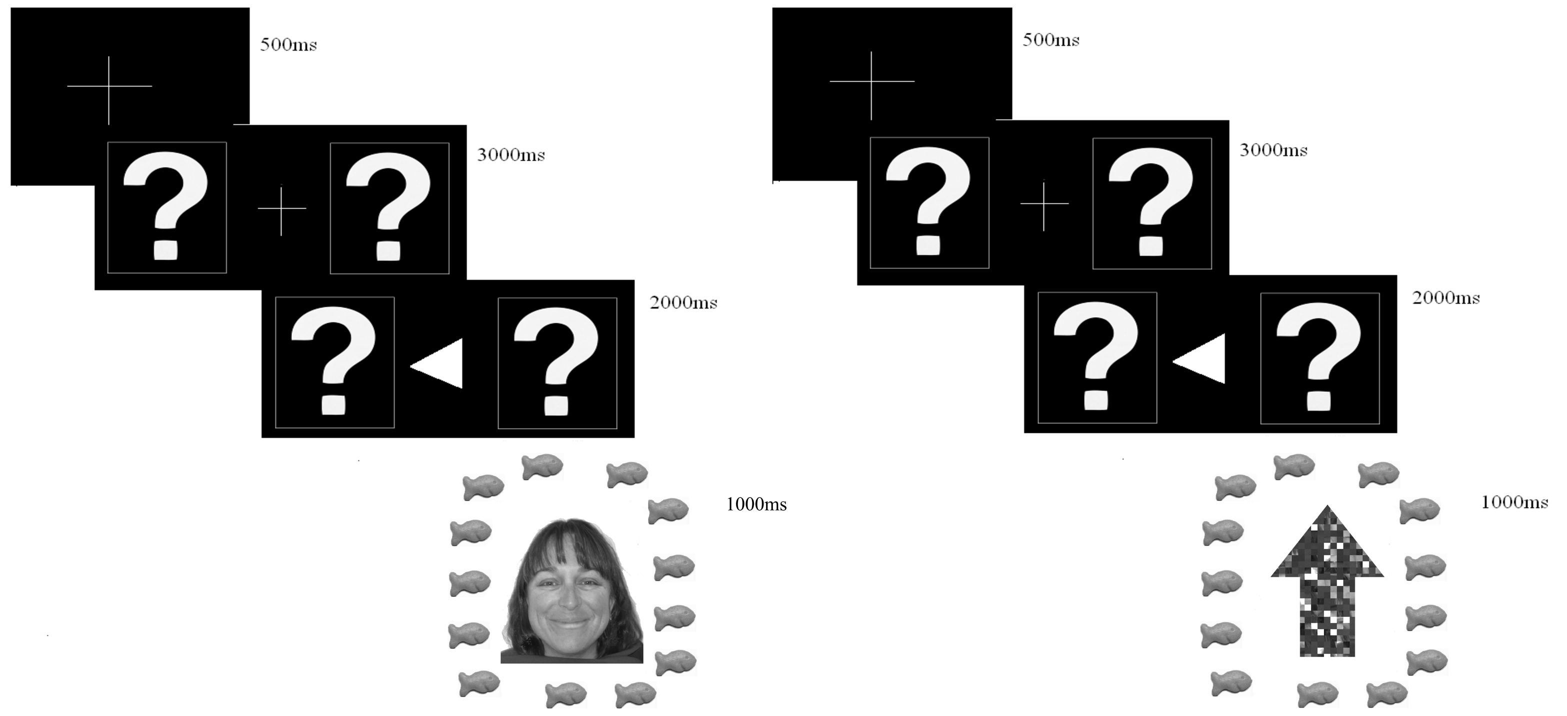

Figure 1. Schematic of the stimuli and task in the familiar face condition with a correct response (left), and familiar non-face (arrow) condition with a correct response (right). Incorrect responses were identical in structure, with the goldfish crossed out and a frowning face in the face condition, and the goldfish crossed out and a downwards facing arrow in the non-face condition.

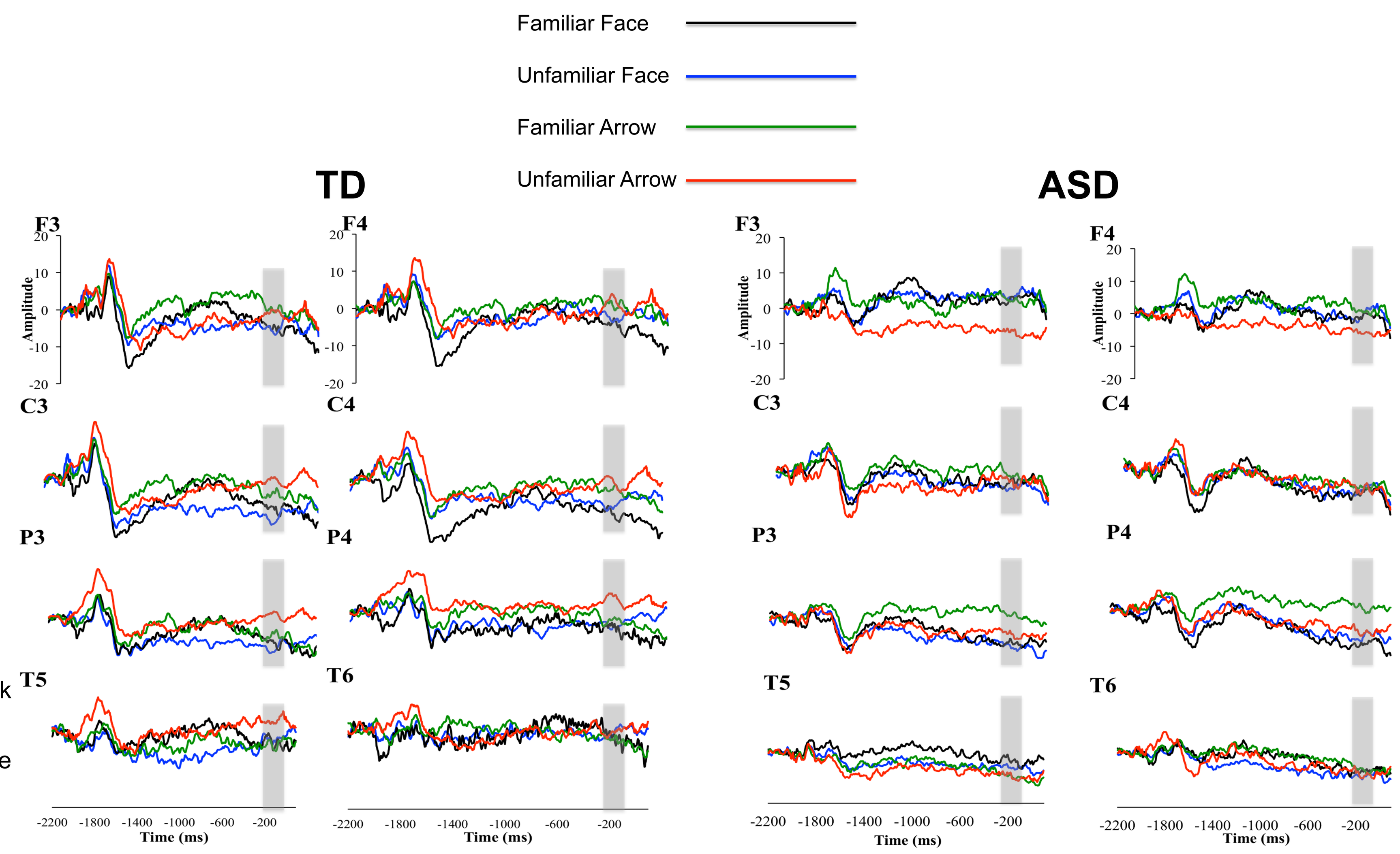

Figure 2. (Left) Grand averaged waveforms for TD children from the Stimulus Preceding Negativity (SPN) prior to familiar faces, unfamiliar faces, familiar arrows, and unfamiliar arrows. (Right) Grand averaged waveforms for children with ASD from the Stimulus Preceding Negativity (SPN) in anticipation of familiar faces, unfamiliar faces, familiar arrows, and unfamiliar arrows. The area between -210 and -10 ms, used for statistical analysis, is highlighted with a grey box.

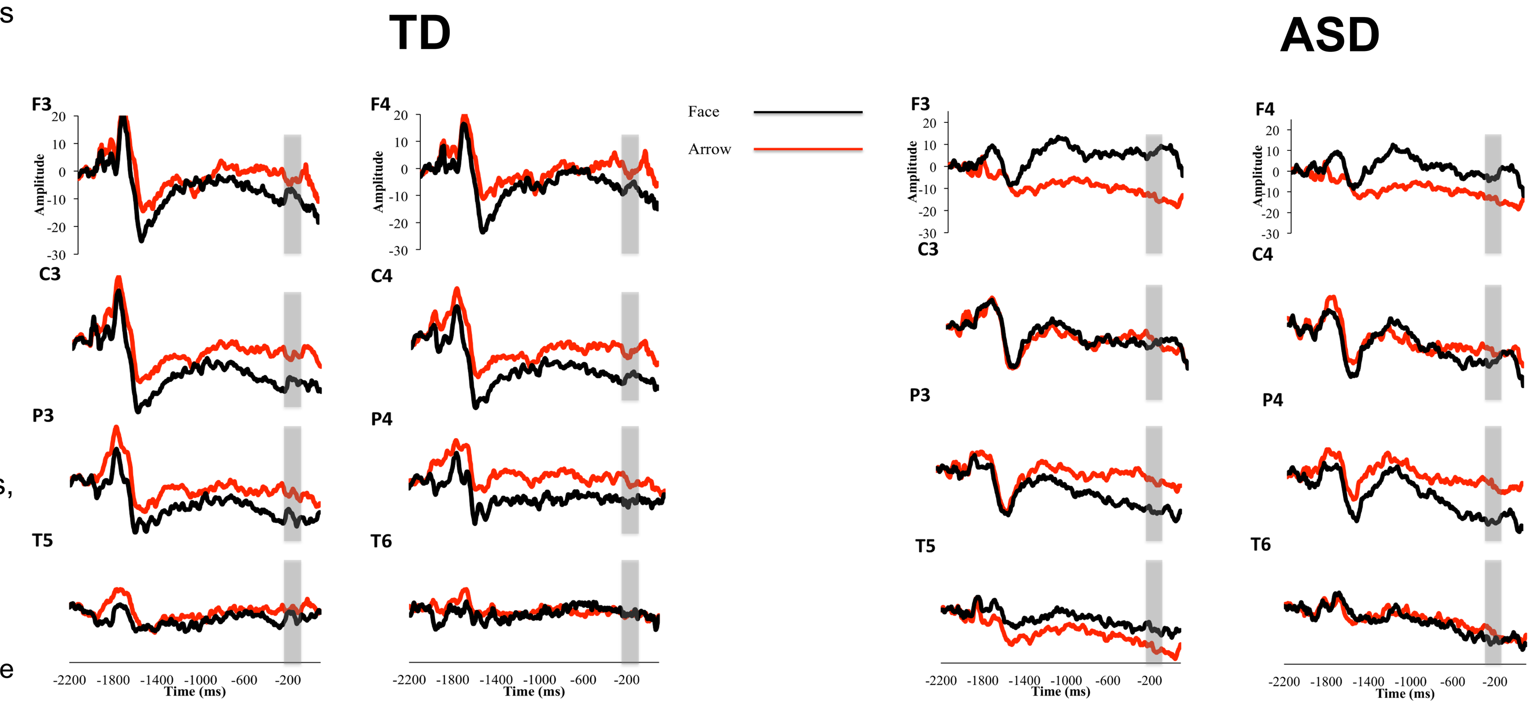

Figure 3. (Left) Grand averaged waveforms for TD children from the Stimulus Preceding Negativity (SPN) prior to faces and arrows (collapsed across familiarity). The area between -210 and -10ms, used for statistical analysis, is highlighted with a grey box. (Right) Grand averaged waveforms for children with ASD from the Stimulus Preceding Negativity (SPN) prior to faces and arrows (collapsed across familiarity). The area between -210 and -10ms, used for statistical analysis, is highlighted with a grey box.

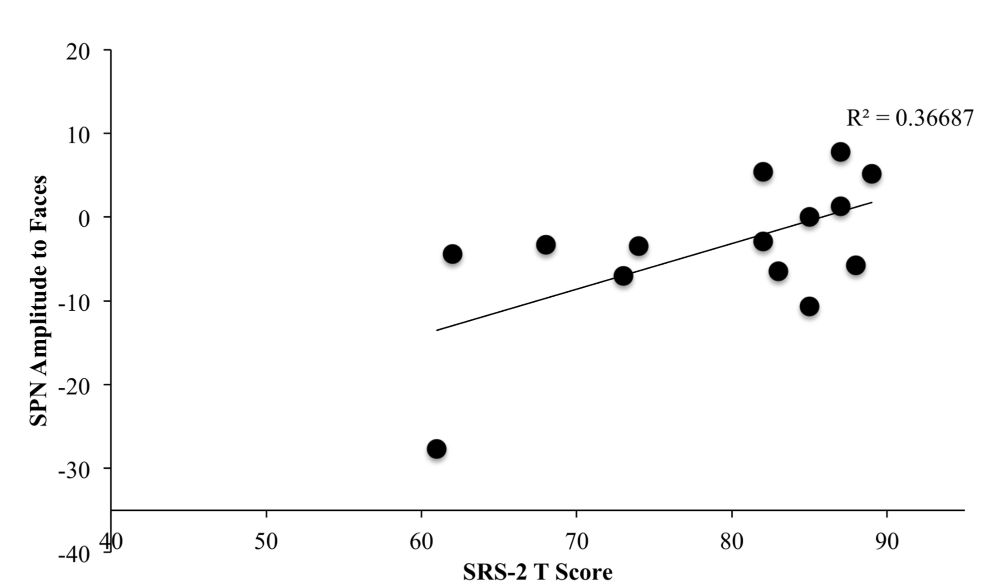

Figure 4. Scatter plot of SPN amplitude to faces (collapsed across familiarity) by SRS-2 T-score for children with ASD. Higher SRS-2 T-scores indicate more severe social impairments. As the SPN is a negative ERP component, more negative values indicate a larger response.

RESULTS

ERP Results: SPN

- Mean amplitude of the SPN was measured between -210 and -10ms prior to feedback onset at bilateral frontal, central, parietal, and temporal electrode sites.
- 2(Group) * 2(Condition) * 2(Familiarity) *4(Electrode location) ANOVA was conducted. No significant effect of familiarity.
- A 4(Condition) * 4(Electrode location) ANOVA was conducted on TD and ASD groups separately.
- **TD group:** main effect of condition such that the familiar and unfamiliar face conditions elicited a larger response vs. familiar and unfamiliar arrow conditions $F(3, 37.55) = 2.76$, $p = .055$. Pairwise comparisons revealed that this difference was largely driven by the familiar face condition versus the familiar arrow condition ($p = .02$), and unfamiliar arrow ($p = .018$) conditions.
- **ASD group:** No significant effects were observed between conditions.
- A 2(Group) *2(Condition) *4(Electrode location) ANOVA was conducted (collapsed across familiarity).
- Significant interaction of Group * Condition $F(1,26.03) = 5.97$, $p = .021$ such that for TD children, faces elicited a significantly larger SPN vs. arrows ($p > .01$), but no significant effect of condition for children with ASD.

Brain-Behavior Correlations

- In children with ASD, a significant correlation was found between SRS-2 T-scores and SPN magnitude in the face condition, $F(1,12) = 6.95$, $p = .021$. *(Figure 4).*

CONCLUSIONS

SPN

- Findings suggest that for 6-11 year old children with and without ASD, there is no effect of familiarity on the SPN component.
- However, for TD children, familiar faces elicited a larger SPN compared to either of the arrow conditions, whereas unfamiliar faces were numerically larger than the arrow conditions (but this difference did not reach statistical significance).
- Replicated previous findings that for TD children, faces elicit a larger SPN component versus arrows (and suggests that TD children find familiar faces especially rewarding).
- Children with ASD, on the other hand, do not have differences between conditions.
- Our findings differ from some previous investigations of familiar versus unfamiliar faces in ASD (Pierce & Redcay, 2008), but are in accordance with others (Webb et al., 2010).
- Differences in methods may explain these discrepancies (e.g. Pierce & Redcay, 2008 utilized multiple exemplars of familiar and unfamiliar faces in order to maximize FFA activation).

Brain-Behavior Correlations

- In individuals with ASD, SRS-2 scores were significantly correlated with SPN magnitude in the face condition.
    - Participants with higher levels of social impairment (reflected by higher SRS-2 scores), evidenced a decreased SPN when anticipating faces compared to individuals with lower levels of social impairment (reflected by lower SRS-2 scores).

IMPLICATIONS

- The current study replicates our previous findings that TD children evidence a larger SPN component when anticipating faces versus objects (Stavropoulos & Carver, 2013), but that children with ASD do not show this effect (Stavropoulos & Carver, 2014).
- The current study suggests that older children (both TD and ASD) do not anticipate upcoming familiar faces more than unfamiliar faces (although for TD children, familiar faces elicited a numerically larger SPN component vs. other pictures).
- Future studies should extend this work by utilizing multiple exemplars of both familiar and unfamiliar faces in order to maximize FFA activity.
- Correlations between SPN amplitude and SRS scores suggest that individuals with higher levels of social impairment have smaller reward anticipation to faces.
- In order to make the current paradigm applicable to lower functioning and younger children, we are adapting the paradigm in order to make overt responses unnecessary.

REFERENCES

- Boxtel GJM Van, Böcker KBE (2004) Cortical Measures of Anticipation. J Psychophysiol 18: 61–76. doi:10.1027/0269-8803.18.2.
- Chwilla, D. J., & Brunia, C. H. M. (1991). Event-related potentials to different feedback stimuli, *Psychophysiology, 28*, 123-132.
- Dawson G (2008) Early behavioral intervention, brain plasticity, and the prevention of autism spectrum disorder. Dev Psychopathol 20: 775–803.
- Masaki, H., Yamazaki, K., & Hackley, S. H. (2010). Stimulus-preceding negativity is modulated by action-outcome contingency. *Neuroreport, 21*, 277–81.
- Mattox, S. T., Valle-Inclan, F., & Hackley, S. A. (2006). Psychophysiological evidence for impaired reward anticipation in Parkinson's disease. *Clinical Neurophysiology, 117*, 2144–2153.
- Pierce K, Redcay E (2008) Fusiform function in children with an autism spectrum disorder is a matter of "who". Biol Psychiatry 64: 552–560.
- Stavropoulos KKM, Carver LJ (2014) Reward anticipation and processing of social versus nonsocial stimuli in children with and without autism spectrum disorders. J Child Psychol Psychiatry.
- Webb SJ, Jones EJH, Merkle K, Murias M, Greenson J, et al. (2010) Response to familiar faces, newly familiar faces, and novel faces as assessed by ERPs is intact in adults with autism spectrum disorders. Int J Psychophysiol 77: 106–117.

Funding Sources

Autism Speaks Weatherstone Predoctoral Fellowship (KKMS)
Autism Science Foundation Postdoctoral Fellowship (KKMS)
RO1 MH100173-01A1 (McPartland)