

Abstract

Our study investigated the Pupillary Light Reflex (PLR) in younger ASD and TD children than have been studied previously, using a simplified paradigm. The goal of our study was to examine differences in the PLR between groups of children with ASD ($n=45$) and TD ($n=54$) between the ages of 3 and 10 years, and to develop a simple testing procedure that could be used for young, minimally verbal children. Children were asked to watch black and white circles alternating every second on a standard computer monitor, while an eye-tracker measured their pupil size. A larger baseline pupil size and a delayed PLR latency were observed in children with ASD. Our results suggest that the differences in some of the conventional PLR measures may be extended to younger ages and serve as a potential early biomarker for ASD.

Background

Previous studies have found differences in autonomic nervous system (ANS) functioning between children with ASD and typically developing (TD) children. A larger baseline pupil size, shorter dilation time, slower constriction speed, delayed Pupillary Light Reflex (PLR) latency, reduced constriction amplitude, and faster heart rate have been reported in ASD samples between 6 to 20 years compared to TD samples (Anderson & Colombo, 2009; Bal et al., 2010; Daluwatte et al., 2013; Fan et al., 2009; Kootz & Cohen, 1981; Ming et al., 2005; Rubin, 1961). Although one recent study examined pupillary responses in 10-month-old infants at risk for ASD (Nystrom et al., 2015), patterns of pupillary responses have not yet been examined in children with ASD under 6 years of age.

Study Aims

To compare PLR measures of latency, constriction time, constriction amplitude, baseline pupil size, and rate of dilation recovery in children with ASD and typical development from 3 to 10 years old.

Participants

Method

	ASD group*	TD group
Gender	$n=45$ (M=36, F=9)	$n=54$ (M=34, F=20)
Age (in years)	M= 6.13, SD= 2.37	M= 5.82, SD= 2.33
Exclusion criteria	Use of medication (i.e. stimulants), history of seizures or head injury, genetic disorders	Cognitive or developmental delay, learning problems, family history of ASD, genetic disorders

*Diagnosis was based on the ADOS, a parent interview, and a clinical diagnosis using DSM-5 criteria

Procedure

PLR measures were collected using the Tobii X120 system, an infrared-based eye tracker. Participants watched black and white circles, alternating every second, on a standard LCD monitor screen (Vizio SV420M). The monitor was calibrated with a spectroradiometer, PR 650.

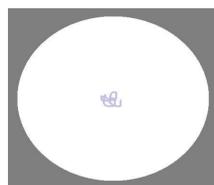
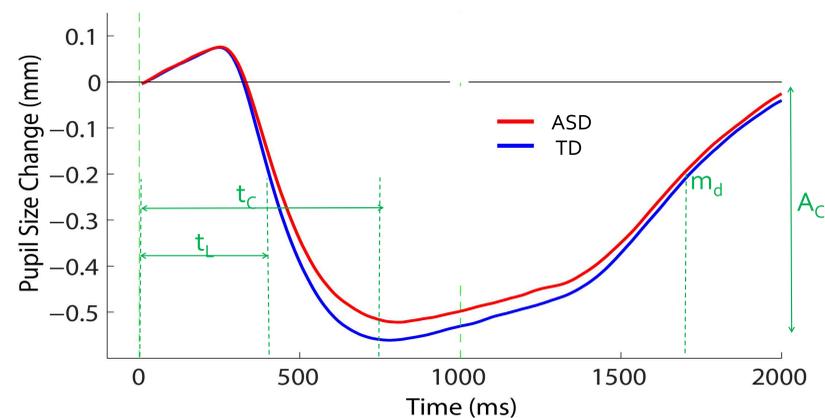


Image 1:
Example of the visual stimulus



Image 2:
A participant during data collection

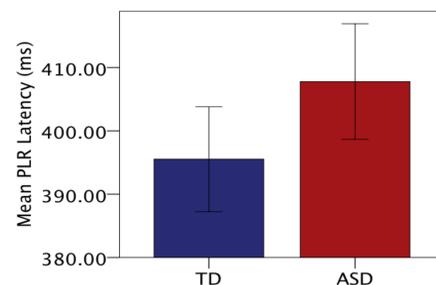
Pupil Traces & PLR Parameters



- **PLR Latency (t_l):** time elapsed between stimulus onset and the maximum rate of change in the pupil diameter, in milliseconds
- **Constriction Time (t_c):** time elapsed between stimulus onset and when pupil reached minimal diameter, in milliseconds
- **Constriction Amplitude (A_c):** how much pupil constricted from baseline, in millimeters
- **Baseline Pupil Size (A_b):** average pupil diameter before stimulus onset, in millimeters (not shown in figure)
- **Dilation Recovery Slope (m_d):** the rate of recovery after pupil constriction, calculated over the period from 1750 to 1920 ms.

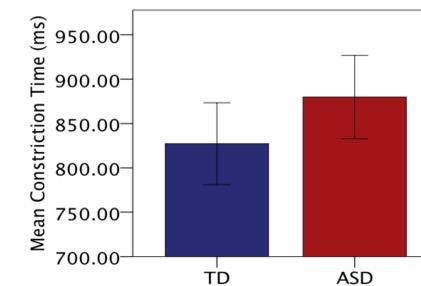
Results

PLR Latency



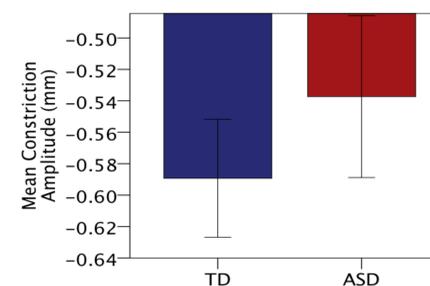
The ASD group (M=407.78, SD=30.38) had a significantly delayed PLR latency compared to the TD group (M=395.52, SD=30.36), $t(97)=-2.00$, $p=.048$.

Constriction Time



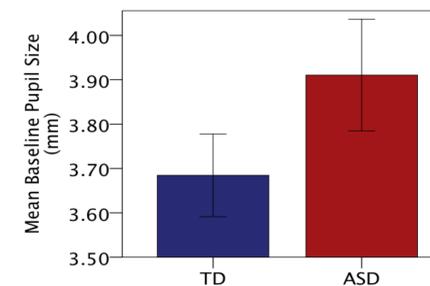
There was a trend for the ASD group (M=879.82, SD=156.30) to have a delayed constriction time compared to the TD group (M=827.16, SD=169.36), $t(97)=-1.60$, $p=.11$.

Constriction Amplitude



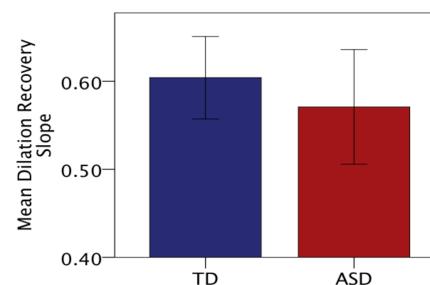
There was a trend for the ASD group (M=-.54, SD=.17) to have a reduced constriction amplitude compared to the TD group (M=-.59, SD=.14), $t(97)=-1.67$, $p=.098$.

Baseline Pupil Size



The ASD group (M=3.91, SD=.42) had a significantly larger baseline pupil size compared to the TD group (M=3.68, SD=.34), $t(97)=-2.96$, $p=.004$.

Dilation Recovery Slope



There was no significant difference in the recovery slope between the ASD group (M=.57, SD=.22) and the TD group (M=.60, SD=.17), $t(97)=.85$, $p=.40$.

Conclusions

Before the onset of the light stimulus, a larger pupil size was observed in 3 to 10 year-old children with ASD compared to TD children of the same age. When the light stimulus was presented, children with ASD had delayed constriction times relative to the TD children. After the light onset, children with ASD tended to have an overall smaller constriction amplitude compared to TD children, but the difference did not reach statistical significance. These findings are consistent with previous research examining children aged 6 years and older. The rate of dilation recovery time did not differ between children with ASD and the TD children, and this finding was not consistent with previous research. Our results suggest that the differences in PLR in response to the light stimulus extend to younger ages and that the PLR in response to the light stimulus may serve as an early biomarker for ASD.