Toddlers with ASD are better at visual search without trying harder: a pupillometric study

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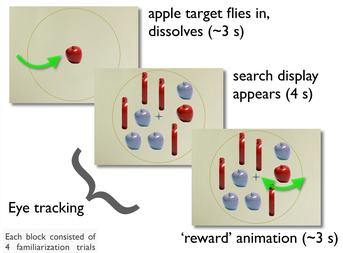
Motivation

We found that toddlers with Autism Spectrum Disorder are better at visual search than age-matched controls. The cause is mysterious: enhanced perception? faster search? more attentional resources? Greater 'focus'?

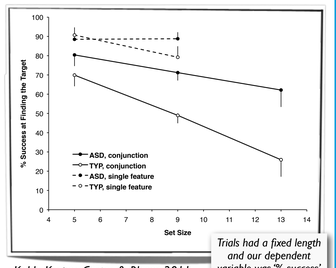
Goal

Use pupillometry to determine the attentional 'mode' of toddlers during visual search, to test the idea that toddlers with ASD do not search *better* than Typical toddlers, just *more often.*

Toddlers with ASD are better at visual search



Each block consisted of 4 familiarization trials and 13 test trials and lasted for approximately 4 minutes. The test trials consisted of 4 single feature trials (set size 5 or 9) and 9 feature conjunction trials (set size 5, 9 or 13).



Kaldy, Kraper, Carter, & Blaser, 2011

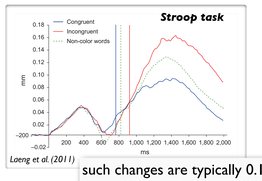
Trials had a fixed length and our dependent variable was '% success'

According to our *eye movement* data, the ASD group doesn't search faster, longer, or more dedicatedly than age-matched controls.

But *why* are toddlers with ASD better at visual search?

We can use pupillometry as a window into attentional 'mode'.

Task-evoked pupillary responses



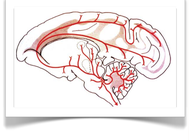
Laeng et al. (2011)

such changes are typically 0.1-0.5mm
Beatty & Lucero-Wagoner, 2000

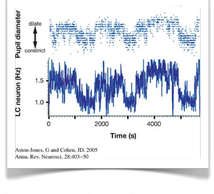
Measure of the "intensive aspect" or "load on attentional capacity"
Kahneman, 1973; Laeng, et al., 2012

This attentional mode and the pupil response is controlled by the *Locus Coeruleus.*

Pupillometry & Locus Coeruleus



Pupil changes due to mental activity are due to activity of the LC
Wilhelm, et al., 1999



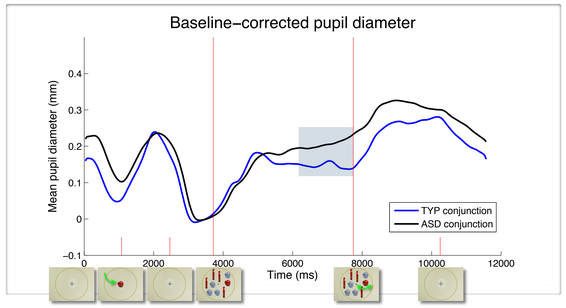
Firing rate of an LC neuron (in monkey) recorded simultaneously with the pupillary responses during a signal detection task.
(Aston-Jones & Cohen, 2005)

Phasic mode: *focused attention* on task-relevant stimuli (associated with better performance, e.g. on search tasks).
–>determines task-evoked pupil response
Aston-Jones, et al., 2007

Tonic mode: *diffuse attention* marked by broad sampling of stimuli in the environment.
–>determines baseline pupil level

We'll use pupil response to determine when LC is in phasic, 'focused' attention mode.
–>and look for differences between groups

Pupillometry of toddlers

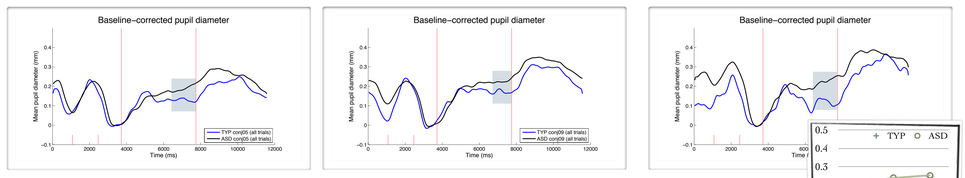


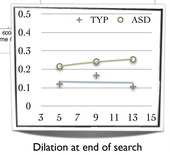
Missing data is replaced with other eye's data or interpolation.
Data are averaged across eyes.
Data are smoothed.
Baseline is set at 500 ms before onset.
Significant differences are highlighted.
Analysis is based on Sirois' Matlab scripts.

Jackson, I., & Sirois, S., 2009

The ASD group has greater *average* dilation during search.
This implies greater 'phasic' LC mode and greater focused attention.

We see the same trend when we look at the different set size conditions, *but...*





Dilation at end of search interval as a function of set size

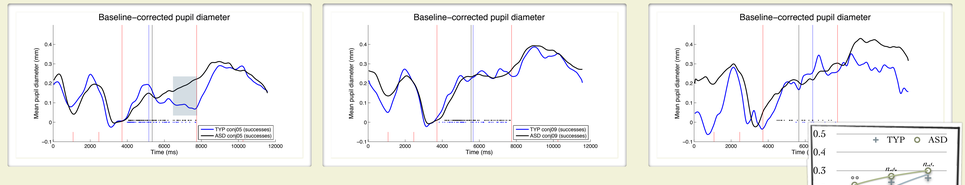
...is the ASD group devoting more attention to the task? Or just devoting attention more often?

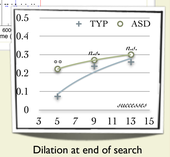
We can tease these possibilities apart by just looking at successful trials as set size increases.

Successes in high-set size conditions rarely happen by chance; only through focused attention. Looking at just successful trials as set size increases allows us to isolate 'best-case' focused attention (LC phasic) mode. Will it look the same in ASD and Typical groups?

If the ASD group always just devotes more attention than the Typical group, we should not see a set size effect, just ASD>Typical across set sizes.

But if the ASD and Typical groups are capable of devoting the same amount of attention (but the ASD group just does so more often) then the two groups should asymptote together.





Dilation at end of search interval as a function of set size

The ASD and Typical groups are already indistinguishable by set size 9.

Phasic, focused attention mode is the same in both groups; the ASD group is just in this mode more often.

Conclusions

Previously, we showed that 2.5-year-olds with ASD were more successful than age-matched controls at conjunction search.

Here we used pupillometry to gain insight into attentional 'mode'

Pupillometry reveals that the ASD group is in a 'focused attention' mode more often.

While the Typical group is in a diffuse, 'exploratory' attention mode more often.

The ASD group does not try harder, they just try more often

(Indeed, when 'best case' trials are isolated, pupil responses look identical between groups)

This explains the ASD advantage without invoking perceptual enhancement.

The Locus Coeruleus modulates phasic, 'focused' vs. tonic, 'exploratory' attention.
Is the LC implicated in ASD?

The Locus Coeruleus and ASD

Autism is thought to resemble a persistent, highly focused attentive state, with LC neurons in a persistent 'hyperphasic' mode.
Aston-Jones, et al., 2007

Febrile episodes normalize LC activity and mitigate ASD symptoms.
Mehler & Purpura, 2009

The LC hypothesis is supported by recent findings demonstrating that the NE reuptake inhibitor venlafaxine suppresses LC neuronal activity...
Beique, J., , et al.,2000

...and is also an effective treatment for attention-impairment symptoms associated with autism.
Hollander, E., et al., 2000

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Apparatus

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