Unraveling the Dimensionality of Social Attention through Psychometric Optimization of an Eye-Tracking Battery: Results from the Autism Biomarkers Consortium for Clinical Trials (ABC-CT)

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Background

- There are currently multiple eye-tracking batteries that quantify attention to social information, e.g., faces.
- Traditional analyses have revealed large effect sizes (d = .78) between autistic and neurotypical children such that autistic children look less at social information [1].
- However, specific stimuli within and across studies are highly variable (e.g., dynamic videos, static photographs). It is unknown if or why these differences impact the measurement of social attention.
- Here we sought to address the following questions:
  - Do different stimuli measure social attention equivalently?
  - If stimuli are *not* equivalent, can we select and use the 'best' stimuli?
  - What aspects of stimuli are associated with better measurement?

Method

	ASD (n=280)	NT (n=119)
Age (in years)	M=8.55 (1.6)	M=8.51 (1.6)
Sex (male)	215 male	83 male
DAS-II GCA (Full Scale IQ)*	96.6 (18.1)	115.1 (12.6)
Verbal Cluster Standard Score*	96.4 (20.7)	116.3 (11.2)
Special Nonverbal Composite*	97.5 (16.9)	112.2 (14.0)

- Data were collected from 280 autistic (ASD) and 119 neurotypical (NT) children between the ages of 6 and 11 across five sites as part of the Autism Biomarkers Consortium for Clinical Trials (ABC-CT). Groups differed significantly on measures of cognitive ability.
- Data were collected across three time points: baseline, six weeks, and six months allowing us to quantify measurement stability.
- The eye-tracking battery included seventy stimuli (Figure 1) presented across two days.
  - •Dynamic social videos with speech (DVS)
  - •Dynamic social videos without speech (DVN)
  - •Static social scenes (SS)
  - •Biological and non-biological stimuli (BM)
- Item response theory (IRT) was used to address our objectives. IRT estimates how different stimuli, or items, may have more or less precision depending on the level of the trait they are measuring. In contrast, traditional analyses assume that all items are equally effective measures.
- Each stimulus, e.g., image or video, was defined as an item coded as a 0 or 1, with a 1 indicating that a participant had attended to the social aspects of the scene.
- Looking to social information more than 25% of the time was used as a threshold, based on inspection of trial level distributions, to determine whether someone had sufficiently attended to social information.
- IRT models these stimuli as if they were items on a test and determines
  - •How well items measure a central construct (item discrimination)
  - •What levels of the construct the items measure, e.g., are they easy or difficult? (item difficulty)

1. Shic, F., Naples, A. J., Barney, E. C., Chang, S. A., Li, B., McAllister, T., ... & McPartland, J. C. (2022). The autism biomarkers consortium for clinical trials: evaluation of a battery of candidate eye-tracking biomarkers for use in autism clinical trials. Molecular Autism, 13(1), 15.

Results: Item Characteristics

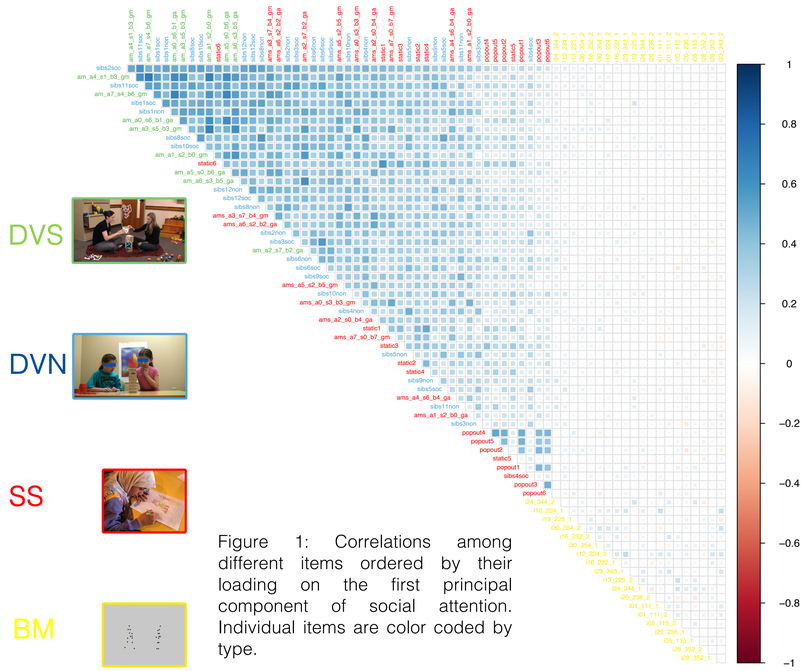


Figure 1: Correlations among different items ordered by their loading on the first principal component of social attention. Individual items are color coded by type.

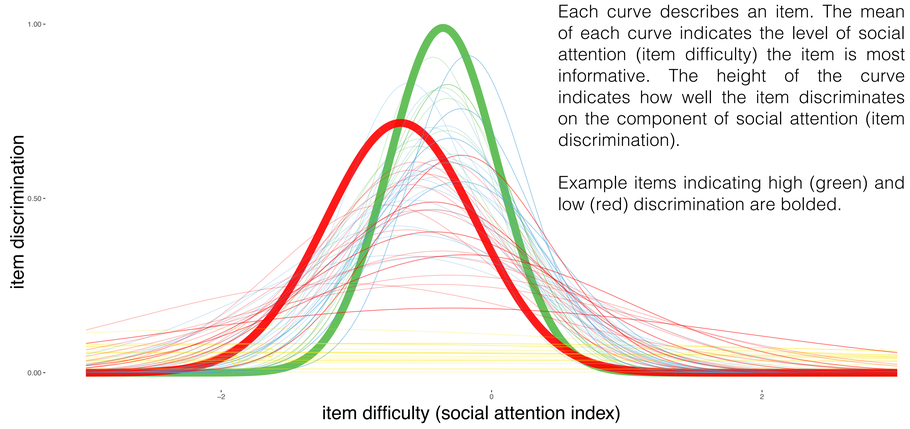


Figure 2: Item Information Curves (IICs). Each curve describes an item. The mean of each curve indicates the level of social attention (item difficulty) the item is most informative. The height of the curve indicates how well the item discriminates on the component of social attention (item discrimination).

Example items indicating high (green) and low (red) discrimination are bolded.

Results: optimized battery

- Dynamic movies and static social scenes associated strongly with social attention, while biological motion was virtually uncorrelated with social attention. (Figure 1)
- After excluding biological motion, a single component explained 46% of the variance in social attention indicating sufficient unidimensionality for IRT analyses.
- IRT analyses reveled that items captured a range of looking variability, with some items discriminating among lower (SS) and higher levels (DVS) of attention. (Figures 1 & 2)
- An optimized battery was constructed using the 10 best performing items, which captured 82% of the variance of all 70 items in the sample of 399 children.
- The IRT estimates discriminated groups with an effect size of d = 1.1. This is greater than the composite estimate (d = .78) and the largest single experiment effect size (d = 1.01) from traditional analyses in [1]. (Figure 4)
- The optimized battery scores correlated with social performance as measured by the ADOS Calibrated Severity Score (CSS) (r = -.2, p <.005) and face memory as measured by the NEPSY Memory for Faces (r = .34, p <.001). These relationships outperformed traditional analyses (r = .165 (CSS) r = .32 (NEPSY) in [1].
- Analyzing short-term stability of items across six weeks revealed that stability over time was associated with item discriminability (r = .66, p <.001). (Figure 4)

Figure 3: Group comparisons of social attention using the optimized battery.

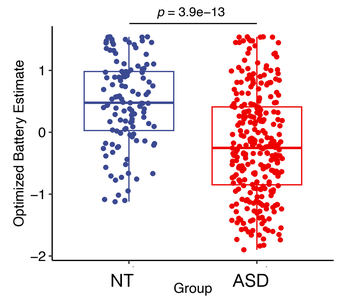
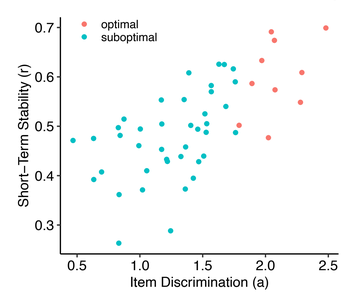


Figure 4: Correlation between Item discrimination and short-term stability



Conclusions

- We validated that social attention, as measured by the DVS, DVN, and SS, is unidimensional.
- Ongoing analyses are exploring whether attention to biological motion may index a unique marker of social attention as this measure has been effective in other modalities, e.g., fMRI.
- IRT measures of social attention in the optimized battery outperform traditional analyses in both discriminating groups and in identifying biomarker behavior relationships.
- Streamlining the battery using only high-performing items suggests that it is possible to dramatically reduce participant burden – from 70 to 10 items – without loss of information.

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