Naturalistic, Non-Invasive Method for Capturing Biometric Data during Autism Diagnostic Evaluations

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Introduction

- Computational approaches show promise in objectively capturing the complex repertoire of behaviors linked to Autism Spectrum Disorder (ASD).
- However, current tools are limited to specific environments and modalities, requiring participants to wear devices or restrict their movement by facing the camera.
- The work presented here focuses on **Neurora**, a model of computer vision and machine learning analyses with the capacity to capture and quantify domains of social, language, and early motor behaviors within the administration of the Autism Diagnostic Observation Schedule-Second Edition (ADOS-2).

Objectives

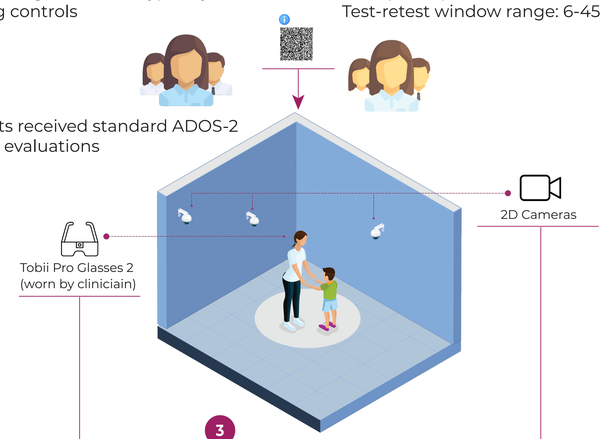
- Demonstrate technical validity by analyzing and appraising how our noninvasive methods (**Neurora**) detect and monitor social-communication behaviors within standard clinical contexts.
- Evaluate test-retest reliability and construct validity of biometrics captured through computational AI-based methods during ADOS-2 administrations.
- Establish the clinical association and validity between biometrics captured through these computational AI-based methods and their targeted clinical conditions.

Method

1. 60 participants were recruited, 47 with NDDs and 13 age-matched typically developing controls

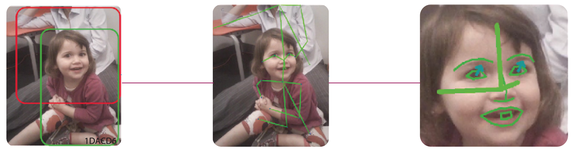
   For test-retest reliability, a separate 15 NDD participants underwent two visits. Test-retest window range: 6-45 days

2. Participants received standard ADOS-2 diagnostic evaluations



3. Collect ADOS-2 Footage

4. Analyze footage using computational Artificial Intelligence (AI) methods



Identify Subject | Gait Estmation | Facial Recognition

5. Capture Behavioral Domains

Gaze — e.g. Eye Contact, Gaze Response

Face — e.g. Action Units, Basic Emotion

Vocalization — e.g. Reciprocal Vocal Exchange

Gestures — e.g. Sensory Behaviors, Hand Contact

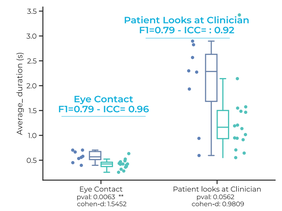
Quality Metrics and Data Analysis

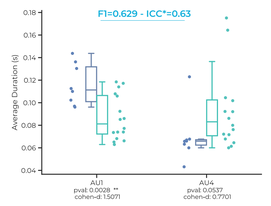
- F1 score: is a single number that tells you how good a machine learning model is at identifying things correctly. It combines two other numbers called precision and recall. The higher, the better.
- ICC, Intraclass Correlation Coefficient: a reliability index in test-retest analyses. The ICC value ranges from 0 to 1, where higher is better.
- A Welch's t-test was used to assess discriminative power and establish a clinical association.
- Normalized Count: Measures the frequency of behavioral events normalized by the session length (Vocalization Domain), patient's frontal face (Face Domain), or pose (Gesture Domain) presence on camera, expressed in seconds.
- 24 age-matched (NDD=16, TD=8) participants were selected for discriminative analysis. For the vocalization domain, only ADOS-2 Module 3 participants were selected.

Results

*Domain ICC represents the average ICC over the domain metrics

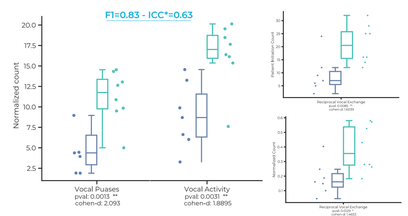
- Tobii Glasses 2 Pro were worn by the clinician and used to capture the clinician and child's gaze.
- Patients' gaze was estimated using machine learning techniques that track gaze direction in real-time.
- Results suggest Neurora differentiates eye contact (p=0.006) and patient-initiated gaze (p=0.056) between TD and NDD cohorts.

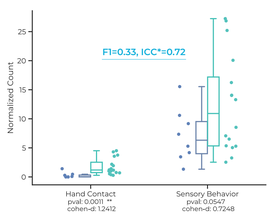




- AU1 corresponds to the inner brow raiser, typically associated with surprise, fear, and sadness, while AU4 corresponds to the brow lowerer, which may indicate negative emotions such as anger and frustration.
- Results suggest that Neurora significantly differentiated between AU1 and AU4 scores in the groups (AU1 p= 0.002; AU4 p= 0.053).

- Module 3 participants (NDD=8, TD=8) exhibited higher rates of vocalizations, including all vocal activity, pauses (300-5000 ms windows), and exchanges (3 speakers, 2-second intervals before and after reciprocal vocal exchange).
- TD patients' longer sustained conversations may lead to fewer breaks and a lower total number of conversations, despite conversing more.





- Hand Contact: Whenever a patient's hands come in contact with a clinician's hand.
- Sensory Behavior: An intense or prolonged (>500ms)tactile inspection, bringing an object/hand within close proximity of the head, including the neck.
- The results indicate higher counts of touching, including hand contact and sensory behavior, in the NDD cohort compared to the TD cohort.

Conclusion and Future Directions

- Results demonstrated the reliability and technical validity of captured nuanced metrics across behavioral domains including facial expressions, gaze, vocalization, and gestures.
- Clinical utility was demonstrated by assessing differences across captured behavioral domain metrics between participants with and without NDDs.
- Several biometric variables across domains show promise in differentiating NDD and TD populations, with some measures (Vocalizations) requiring further development to understand clinical correlates and clinical relevance.
- Future directions include evaluating clinical correlates of biometric measures and validation in larger ASD, NDD cohorts, and TD cohorts.

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Please note that additional information about the study is available via QR code scanning. Simply scan the code with your smartphone camera to access the relevant resources and learn more about our methods and findings.