# Clinical Research Overview

## Multimodal Biometric Analysis of Social Communication During ADOS-2® Sessions

A Naturalistic, Non-Invasive Method for Capturing Biometric Data During Autism Evaluations

### WHAT WAS STUDIED

This study evaluated whether automated, multimodal analysis of audio, video, and gaze data captured during a routine ADOS-2® session can quantify social-communication behaviors and generate objective biometric measurements to complement expert clinical assessment of autism in children ages 2 to 12.

### WHY IT MATTERS



**The autism diagnosis crisis has a capacity and infrastructure problem.** Autism prevalence has reached 1 in 31 U.S. children and approximately 1 in 100 worldwide, yet median diagnostic wait times reach 525 days, with only 20% of assessments meeting recommended time targets. Demand structurally outpaces clinical capacity.

**Gold-standard tools are accurate but structurally constrained.** Existing clinical assessments are time-intensive, specialist-dependent, and culturally limited. False-negative rates as high as 39% have been reported when session video is reviewed without standardized coding, compounding the capacity problem.

**Most computational tools were not built for real-world clinical use.** The majority are restricted to a single modality, narrow age windows, fixed-position setups, or culturally homogeneous samples — limiting deployability outside controlled research settings and excluding the populations who need access most.

### WHAT NEURORA DOES

| Multimodal Behavior Capture | Clinical Workflow Compatibility | Objectively Measured, Not Missed |
|---|---|---|
| Every social-communication cue is also a measurable motor behavior.<br><br>Neurora captures vocalization, gaze, and facial movement directly from session video, preserving behavioral detail to support precise measurement and expert clinical judgment. | Clinician-worn video glasses and the Neurora app capture behaviors during a standard ADOS-2® session.<br><br>No restrictions, requirements, or wearables for the child. | Outputs include an Overall Score and per-domain sub-scores — *Vocal Activity, Pitch Patterns, Vocal Rhythm, Gaze Toward Clinician, Facial Movements and Smiling Patterns* — alongside a full transcript and timestamped recordings anchored to reported behaviors. |

## HOW THE STUDY WORKED

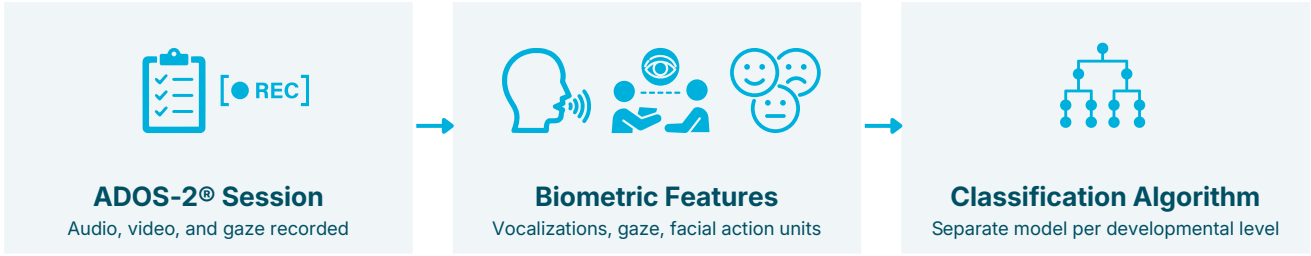
**Multicenter. Prospective. Clinicians blinded to Neurora outputs.**
Enrolled and evaluated across four clinical sites in the United States and Qatar — among the most diverse autism digital health datasets to date.

| Children enrolled | Analysis set | Age range | Clinical sites |
|---|---|---|---|
| 546 | 458 | 2–12 | 4 |
| US n=246 · Qatar n=300 | 83.6% met A/V quality criteria | years | 2 US · 2 Qatar |

### Reference Standard

Doctoral-level clinicians established each child's reference diagnosis by integrating DSM-5 criteria, ADOS-2®, cognitive testing, adaptive behavior assessment, validated screening instruments, and parent interview. Where individual instruments disagreed, the integrated clinical diagnosis served as the final classification.

### Validation Methodology



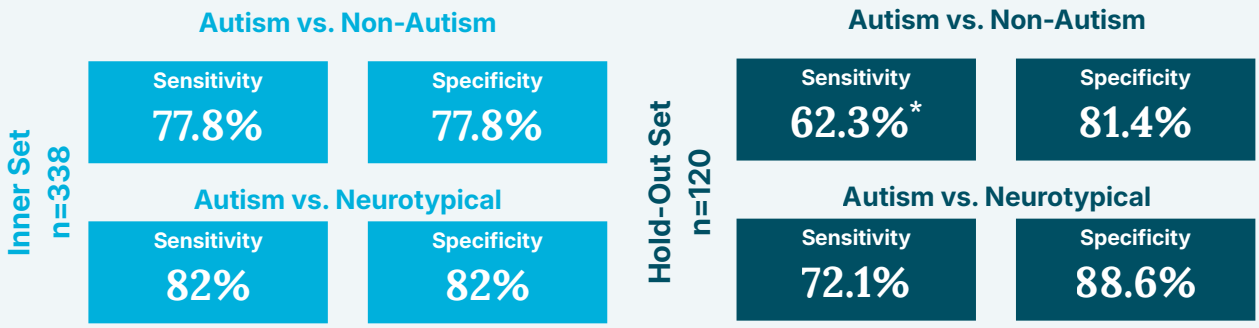

| Stage 1 · Internal Testing | Stage 2 · Independent Confirmation |
|---|---|
| Each child was tested individually while the algorithm learned from the biometric features of all other children in the cohort, providing an internal performance estimate. | The algorithm was locked, then applied to the biometric features of a separate group of children it had never encountered. Clinicians remained blinded throughout. |

### Module-Level Validation

Each detection module (speaker separation, gaze, facial action units) was independently validated against frame-level annotations from FACS-certified and trained human coders before any diagnostic results were evaluated. Every module met or exceeded its pre-registered threshold.

## DIAGNOSTIC ACCURACY

Robust accuracy across two continents, four sites, and a phenotypically diverse sample, including children with ADHD, Fragile X syndrome, and developmental delay.




* The hold-out cohort's higher rate of co-occurring conditions (notably fragile X syndrome) and smaller size both weigh on sensitivity; specificity held steady (77.8% → 81.4%), indicating the system stayed conservative.

**Probability scores assigned to children with autism were significantly higher than those assigned to children without autism across every developmental level (Mann-Whitney-Wilcoxon $p < 0.001$).**

## EQUITY NOTE

This study includes one of the most diverse samples in autism digital health research to date, spanning age, developmental level, verbal ability, clinical profile, and cultural background. Models were stratified by verbal ability to account for differences in communication style.

## PERFORMANCE ACROSS SUBGROUPS

Inner set (n=338) unless noted. Sensitivity/specificity for autism vs. neurotypical.

### DEVELOPMENTAL LEVEL

| | |
|---|---|
| Few-to-no words | 89% / 73% |
| Phrase speech | 75% / 90% |
| Fluent speech | 65% / 82% |

### CO-OCCURRING CONDITION · SENSITIVITY

| | |
|---|---|
| ADHD | 84% |
| ID / DD | 67% |
| Fragile X Syndrome (FXS) | 94% |

*Standard ADOS-2® sensitivity reported as low as 58.3% in comparable profiles.*

### BY SEX

| | |
|---|---|
| Female | 75% / 84% |
| Male | 79% / 70% |

*Comparable across sex; meaningful where female autism is historically under-detected.*

### BY SITE

| | |
|---|---|
| Qatar | 86% / 77% |
| United States | 62% / 78% |

*Site differences reflect recruitment strategy: only the U.S. sample included FXS, ID/DD, ADHD, and anxiety.*

## LIMITATIONS AND FUTURE PLANS



**Decision support only.**
Not a stand-alone screening or diagnostic instrument; for use alongside clinical judgment.

**Feature scope.**
Gestures and restricted/repetitive behaviors will be captured in future versions.

**Differential diagnosis.**
Sensitivity to other clinical conditions is lower than in ASD vs. neurotypical, consistent with known limitations of standard tools in complex samples.

**Dataset expansion.**
Ongoing dataset expansion to ensure a robust, diverse sample.

## BOTTOM LINE

Neurora provides measurements of social-communication behavior to complement expert clinical judgment during a routine ADOS-2® session. Validated across a diverse U.S. and Qatar cohort in children ages 2 through 12, with consistent performance across sites, developmental levels, and clinical profiles.

## INTERESTED IN LEARNING MORE?

**Contact the Neurora Team at Argus Cognitive**
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## REFERENCES

1. Shaw KA, Williams S, Patrick ME, et al. Prevalence and early identification of autism spectrum disorder among children aged 4 and 8 years -- Autism and Developmental Disabilities Monitoring Network, 16 Sites, United States, 2022. *MMWR Surveill Summ.* 2025;74(SS-2):1--22. DOI: 10.15585/mmwr.ss7402a1
2. Zeidan J, Fombonne E, Scorah J, et al. Global prevalence of autism: a systematic review update. *Autism Res.* 2022;15(5):778--790. DOI: 10.1002/aur.2696
3. Bisgaier J, Levinson D, Cutts DB, Rhodes KV. Access to autism evaluation appointments with developmental-behavioral and neurodevelopmental subspecialists. *Arch Pediatr Adolesc Med.* 2011;165(7):673--674. DOI: 10.1001/archpediatrics.2011.90
4. Gabrielsen TP, Farley M, Speer L, Villalobos M, Baker CN, Miller J. Identifying autism in a brief observation. *Pediatrics.* 2015;135(2):e330--e338. DOI: 10.1542/peds.2014-1428
5. Colombi C, Fish A, Ghaziuddin M. Utility of the ADOS-2 in children with psychiatric disorders. *Eur Child Adolesc Psychiatry.* 2020;29(7):989--992. DOI: 10.1007/s00787-019-01411-8
6. Lord C, Rutter M, DiLavore PC, Risi S, Gotham K, Bishop SL. *Autism Diagnostic Observation Schedule, Second Edition (ADOS-2) Manual (Part I): Modules 1--4.* Torrance, CA: Western Psychological Services; 2012.
7. Lebersfeld JB, Swanson M, Clesi CD, O'Kelley SE. Systematic review and meta-analysis of the clinical utility of the ADOS-2 and the ADI-R in diagnosing autism spectrum disorders in children. *J Autism Dev Disord.* 2021;51(11):4101--4114. DOI: 10.1007/s10803-020-04839-z
8. Maciver D, Singh Roy A, Johnston L, et al. Waiting times and influencing factors in children and adults undergoing assessment for autism, ADHD, and other neurodevelopmental differences. *Autism Res.* 2025;18(4):788--801. DOI: 10.1002/aur.70011
9. Loomes R, Hull L, Mandy WPL. What is the male-to-female ratio in autism spectrum disorder? A systematic review and meta-analysis. *J Am Acad Child Adolesc Psychiatry.* 2017;56(6):466--474. DOI: 10.1016/j.jaac.2017.03.013
10. Ekman P, Friesen WV. *Facial Action Coding System: A Technique for the Measurement of Facial Movement.* Consulting Psychologists Press; 1978.