**Title**: An ADOS-Derived Joint Attention Factor for Module 3: Construct Validity and Links to Intelligence in Autistic Children

**Authors**: Andrew Dakopolos1,2, Olivia Surgent1,2, Brianna Heath1,2, Sally Rogers1,2, Marjorie Solomon1,2, David Amaral1,2, Peter Mundy1,3, and Christine Wu Nordahl1,2

**Introduction**: The Autism Diagnostic Observational Schedule, Second Edition (ADOS-2) is a gold-standard diagnostic instrument for the evaluation of autism. Its ubiquity in the clinical diagnosis of autism and widespread use in autism research provides a unique opportunity to use results of the ADOS-2 in clinical investigations. When ADOS-2 calibrated severity scores (CSSs) were updated in 2007, a third factor emerged in those foundational analyses for modules 1 and 2, which was termed the “joint attention factor” and was comprised of items including pointing, gestures, showing, initiating joint attention, and unusual eye contact (Gotham et al., 2007). This factor structure was replicated in a new sample (Gotham et al., 2008), and corroborated by other investigators (Oosterling et al., 2010). The ADOS-2 joint attention factor has been used in subsequent investigations and been found to be associated with intelligence in autistic children without intellectual disability (Sano et al., 2021), as well as with cognition and adaptive behavior (Harrison et al., 2016) among autistic children. Furthermore, there is evidence that once autistic children have begun communicating predominantly with speech, their joint attention skills remain significantly diminished compared to typically developing peers, even for those whose mental age is commensurate with their chronological age (Dakopolos & Jahromi, 2019). Given that individual differences in joint attention skills persist into childhood, the purpose of the present study was to explore a novel joint attention factor derived from module 3 ADOS-2 items, with the express goals of 1) investigating the construct validity of the module 3 joint attention factor, and 2) examining the association between joint attention (ADOS-2 modules 1, 2, and 3 combined) and IQ compared to other ADOS-2 summary scores.

**Method**: Longitudinal data was collected in 314 autistic children between the ages of 2-5 years at Visit 1 (n = 139 at Visit 2, 2-years after Visit 1; n = 120 at Visit 3, 4-5 years after Visit 2). All children enrolled in the study received a clinical diagnosis of autism at Visit 1, and diagnosis was confirmed via full clinical evaluation at Visit 2 and 3. ADOS-2 module 3 items were selected that had strong theoretical alignment to joint attention, and exploratory graph analysis and factor analysis were utilized to derive a final factor structure. These two methods were chosen to establish corroboration of the factor. Joint attention scores across ADOS-2 modules 1, 2, and 3 and Visits 1, 2, and 3 were analyzed, and then combined. Finally, ADOS-2 calibrated severity scores (CSSs), as well as the social affect (SA) and restricted and repetitive behavior (RRB) subscales were compared to the joint attention factor in relation to intelligence at each study visit. The Mullen Scales of Early Learning (MSEL) was used at Visit 1 to obtain a developmental quotient (DQ), and the Differential Ability Scales-II (DAS-II) was used to measure IQ at Visit 2 and 3.

**Results**: Results of the exploratory graph analysis and factor analysis corroborated each other, and identified five ADOS-2 module 3 items that loaded onto our joint attention factor which included: facial expressions, shared enjoyment, offering information, reporting events, and gestures. The module 3 joint attention factor was significantly and strongly associated with the module 1 and 2 joint attention factor (*r*(77) = .53, *p* < .001). The ADOS-2 combined Joint attention factor (combined across modules 1, 2, and 3) was strongly associated with DQ at Visit 1 (*r*(312) = .61, *p* < .001), Visit 2 (*r*(137) = .78, *p* < .001) and Visit 3 (*r*(118) = .65, *p* <. 001). Importantly, utilizing Fisher’s r to z transformation, the ADOS-2-derived joint attention factor was superior in predicting concurrent *and* future DQ/IQ than ADOS-2 CSSs, the SA subscale, and the RRB subscale (range *z*-differences = 3.76 – 6.85, all p’s < .001).

**Discussion:** The present study offers a preliminary investigation to extend joint attention measurement derived from the ADOS-2 developmentally upward, incorporating scores and items from module 3 into already-existing joint attention structures for modules 1 and 2. Results of this work indicate 1) consistency in the module-3 factor items given corroboration across multiple dimension reduction approaches; 2) our module 3-derived joint attention factor is conceptually aligned with that of modules 1 and 2; and 3) the ADOS-2 joint attention factor is capturing unique variability – particularly in relation to IQ/DQ across time – compared to CSSs, the SA subscales and the RRB subscale. Taken together, we present strong preliminary evidence of the utility of capturing joint attention-related behaviours from early to middle childhood longitudinally with ADOS-2-derived items.

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 UC Davis MIND Institute

2 UC Davis Heath, Department of Psychiatry and Behavioral Sciences

3 UC Davis School of Education