

The Relation between Severity of Autism and Caregiver-Child Interaction: a Study in the Context of Relationship Development Intervention

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Abstract The aim of this study was to examine the relations between severity of children's autism and qualities of parent-child interaction. We studied these variables at two points of time in children receiving a treatment that has a focus on social engagement, Relationship Development Intervention (RDI; Gutstein 2009). Participants were 18 parent-child dyads where the child (16 boys, 2 girls) had a diagnosis of autism and was between the ages of 2 and 12 years. The severity of the children's autism was assessed at baseline and later in treatment using the autism severity metric of the Autism Diagnostic Observation Schedule (ADOS; Gotham et al. *Journal of Autism and Developmental Disorders*, 39, 693–705 2009). Although the ADOS was designed as a diagnostic measure, ADOS calibrated severity scores (CSS) are increasingly used as one index of change (e.g., Locke et al. *Autism*, 18, 370–375 2014). Videotapes of parent-child interaction at baseline and later in treatment were rated by independent coders, for a) overall qualities of interpersonal relatedness using the Dyadic Coding Scales (DCS; Humber and Moss *The American Journal of Orthopsychiatry*, 75, 128–141 2005), and b) second-by-second parent-child Co-Regulation and Intersubjective Engagement (processes targeted by the treatment approach of RDI). Severity of autism was correlated with lower quality of parent-child interaction. Ratings on each

of these variables changed over the course of treatment, and there was evidence that improvement was specifically related to the quality of parent-child interaction at baseline.

Keywords Autism · Joint attention · Parent-child interaction · Relationship Development Intervention (RDI)

When Kanner (1943) first described autism, he emphasized the children's biologically based impairment in affective contact with other people. Substantial evidence now supports the view that impairments in intersubjective engagement are pivotal for the development of the syndrome (Hobson 1993, 2004; Mundy et al. 2009; Volkmar et al. 2005). Studies of individuals with autism across a wide age span report limitations in interpersonal engagement (e.g., Capps et al. 1998; Dawson et al. 1998; Dawson et al. 2004; García-Pérez et al. 2007; Hobson and Lee 1998; Kasari et al. 1990). Direct observations of infants (e.g., Charman et al. 1997) and retrospective parent reports (e.g., Wimpory et al. 2000) indicate that even very young children with autism have less frequent and/or less intense eye contact, turn-taking, and referential looking.

Prospective research, involving infant siblings of children with autism who themselves later go on to receive a diagnosis of autism, has revealed indications of social disengagement by the end of the first year (Ozonoff et al. 2010). On the basis of such research, there is a growing consensus that early risk factors for the emerging diagnosis of autism may disrupt parent-child interaction (Green et al. 2015). For example, at 11 months of age, high-risk infants later diagnosed with autism exhibited reduced social engagement in free play with their parents (Campbell et al. 2014). Additional evidence suggests that infants at risk for developing autism may elicit a more directive style of interaction from their parents (Wan

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et al. 2012). These systemic patterns of interaction may contribute to an increasingly atypical developmental trajectory. Recent research indicates that lower quality of interaction between infants at risk for developing autism and their caregivers predicts a subsequent diagnosis of autism (Wan et al. 2013).

It is widely recognized that children's characteristics affect their relations with caregivers, just as interactions and relationships with adults affect a child's functioning (Bell 1968; DeMol and Buysse 2008; Fogel 2009; Kuczynski et al. 2003; Sameroff 2009; Sameroff and Chandler 1975). Autism severity may interact with features of caregiver-child interaction, with implications for development. For example, children with autism were less likely to smile in response to their mothers' smiles, and their mothers smiled at them less frequently and were less likely to smile in response to their children's smiles (Dawson et al. 1990). Siller and Sigman (2002, 2008) coded videotaped interactions between caregivers and children with autism, and reported how caregiver-child synchrony predicted subsequent joint attention and language development (also Koren-Karie et al. 2009; Ruble et al. 2008; Spiker et al. 2002). Compared to those without autism, verbally able school-aged children with autism and their parents showed a reduced capacity to share experiences and co-regulate during play-based social interaction (Larkin et al. 2015). Caregivers of more able children with autism did tend to engage in mutual play and positive feedback, whereas parents of children with autism who had poorer joint attention and fewer expressive language skills spent more time keeping their child physically contained and oriented to tasks (Kasari et al. 1988). The experience of parenting a son or daughter with autism is also associated with higher parent-reported levels of stress, and reduced psychological health (Abbeduto et al. 2004; Blacher and McIntyre 2006; Eisenhower et al. 2005; Hoffman et al. 2009; Seltzer et al. 2010; Stuart and McGrew 2009), with potential implications for quality of child-caregiver interaction.

A number of therapeutic approaches are being designed with the aim of enhancing joint engagement between toddlers with autism and their caregivers. These attempts to foster social relatedness among young children with autism and their caregivers have yielded promising results (Aldred et al. 2004; Gulsrud et al. 2010; Rogers et al. 2014; Schertz and Odom 2007; Siller et al. 2014). Recent evidence suggests that parent-delivered coaching interventions may also help with parenting stress early in the diagnostic process (Estes et al. 2014). In a randomised control trial of a parent-mediated video-aided intervention (the Preschool Autism Communication Trial, PACT), treatment was reported to enhance quality of parent-child interaction (Aldred et al. 2012; Green et al. 2010). Change in parent-child synchrony was a significant mediating factor in reducing autism symptomology as assessed by the Autism Diagnostic Observation Schedule (ADOS; Lord et al. 2002).

The present study involves children with autism and their parents who were participating in a family-based treatment designed for a wide age-range of affected individuals, Relationship Development Intervention (RDI; Gutstein 2009). RDI is a parent-delivered, video-aided approach to developing social-communication in the context of guided participation in meaningful activity (Rogoff 2003; Vygotsky 1987). Trained consultants guide parents to develop communication involving co-regulation and intersubjective engagement. RDI also focuses on family quality of life, stress and coping, parent mindfulness, emotion-regulation, and decision-making. Unlike the early intervention programs designed for very young children described above, RDI is designed for children and individuals with autism across the life span and their families.

One aim of the present study was to examine how far severity of autism, as assessed with the ADOS, corresponds with measures of the qualities of parent-child interaction in semi-structured cooperative activity. A second aim was to explore whether specific dyadic processes targeted for intervention in RDI were associated with the ADOS and with qualities of parent-child interaction.

This study was intended as a partial replication and extension of a previous study (Beurkens et al. 2013). Beurkens and colleagues (2013) studied a different sample of 25 parent-child dyads including children with autism aged between 4 and 14 years. There we reported that ADOS-assessed severity of a child's autism was related to global qualities of parent-child relatedness, as assessed by the Dyadic Coding Scales (DCS; Humber and Moss 2005). In contrast, autism severity was not related to quality of the caregiver's self-reported parent-child relationship. The present investigation with a new group of participants extends the research on parent-child relatedness by introducing specific measures of second-by-second co-regulation and intersubjective engagement during a semi-structured period of caregiver-child interaction.

We chose to study children and caregivers who were receiving an intervention which has a focus on fostering and enhancing child-caregiver relations, RDI (Gutstein 2009). The rationale was that if, as we anticipated, such intervention promotes change in caregiver-child social engagement, then it should be possible not only to examine the relations among variables of interest at two time points, but also explore predictors of change over time. It is important to stress that this is not a study of the outcome of RDI. For such a study, one would need a treatment manual, assessments of treatment delivery and compliance, multiple measures of outcome, and a randomly allocated control group of participants who were not receiving RDI. Having said this, we were aware that the findings might provide preliminary suggestive evidence regarding whether RDI may be associated with measureable benefit and worthy of further study.

In order to test the predicted associations between autism severity and parent-child engagement, it was necessary to

employ independent measures of each. The assessment of autism severity was a child's performance on the ADOS (Lord et al. 2002), administered by a clinician. It should be noted that the focus of ADOS coding is on scoring the individual participant (often on the basis of the presence or absence of specific behaviours) rather than the tester-child dyad. In addition, the calibrated severity score (CSS) of the ADOS (Gotham et al. 2009), also known as the Autism Severity Metric, focuses on a child's autism as a syndrome, where clinical manifestations include not only expressions of social-communicative ability but also restricted and repetitive behaviour such as cognitive rigidity, sensory interests, stereotyped language, and hand mannerisms.

Our assessment of parent-child relations included two separate approaches. Firstly, we had independent coders make global ratings of qualities of caregiver-child relatedness by applying the DCS (Humber and Moss 2005) to half an hour of semi-structured parent-child interaction. The DCS includes ratings of social coordination, communication, appropriate role assumption, emotional expression, responsivity/sensitivity, tension/relaxation, mood, and enjoyment. It has been established that ratings on the DCS are associated with autism severity (Beurkens et al. 2013), and that these ratings can distinguish between parent-child dyads in which the child does and does not have autism (Larkin et al. 2015).

Next, we conducted second-by-second ratings of the first 10 min of the videotaped procedure (which comprised spontaneous, unstructured caregiver-child interactions) using measures of (i) Co-Regulation, involving contingency and elaboration in ongoing collaborative exchange and (ii) Intersubjective Engagement, involving the degree of mutual experience-sharing and affective contact. At a low level of Co-Regulation, members of a dyad may simply monitor one another without making adjustments, whereas at a higher level of Co-Regulation partners may adjust their actions to one another in a mutually responsive way whilst adding variability and novelty to the interactive exchange (Palmiotto 2015). At a low level of Intersubjective Engagement, members of a dyad may engage in instrumental communication, whereas at a higher level of Intersubjective Engagement, members of the dyad may express excited anticipation for the response of their partner (Palmiotto 2015). We included second-by-second ratings of Co-Regulation and Intersubjective Engagement because these corresponded with the processes specifically being targeted by the treatment approach of RDI.

Our prediction was that both at baseline and at the time of subsequent assessment at least 1 year later, there would be significant inverse correlations between severity of children's autism as assessed on the ADOS, and qualities of parent-child relations as reflected in a) scores on the DCS and b) observations of Co-Regulation and Intersubjective Engagement. We also anticipated that there would be improvements over time, not only in ADOS assessments, as reported in a previous pilot

study of RDI (Gutstein et al. 2007), but also in measures of interpersonal relations between parents and their children. We conducted exploratory analyses to examine whether qualities of parent-child relations might be predictors of change on the ADOS, and thus merit further study.

Method

Participants

Participants in the study were 18 children (16 boys, 2 girls) and their primary caregivers (16 mothers, 2 fathers) who took part in RDI for at least 1 year. Parent-child dyads were recruited through a psychology clinic in the Midwestern United States. The clinic agreed to take part in the project and was selected on the basis that (a) RDI was the primary treatment approach used by clinicians in the clinic, (b) the clinicians were certified RDI Consultants, and (c) standard ADOS administration as well as videotaped assessments of parent-child interaction assessments had taken place at the onset and later during each family's participation in RDI.

Families who met criteria for the study were approached by their clinician and asked for permission for these previously recorded assessment videos to be independently coded by a research team at University College, London, as part of a study looking at change in children with autism taking part in Relationship Development Intervention. The study received approval from the ethics review board of University College, London.

According to clinic records, seven of the children had comorbid diagnoses in addition to autism, namely: epilepsy, attention deficit disorder, articulation disorder, septo-optic dysplasia, feeding disorder, and tuberous sclerosis. Apart from educational services provided through schools, none of the children were receiving additional intervention. Seven of the children were on medication for: anxiety ($n = 4$), growth hormone ($n = 1$), seizures ($n = 1$), and attention/impulsivity ($n = 1$). All of the children who took part in this study were Caucasian. For the majority of the children ($n = 15$), their primary caregiver had at least a College education. The remaining three children had parents who had completed High School.

At the time of the baseline assessment (Time 1, henceforth T1), the mean chronological age of the children was 6 years, 11 months (range = 2 years; 6 months to 12 years; 10 months). Due to the wide range of chronological age and developmental levels in this community sample, clinic assessments of baseline cognitive/language functioning were highly variable and made with a variety of instruments. Thus, although for each child it was possible to calculate an index of developmental age, it should be noted that these were based on highly variable assessment procedures. The mean developmental age

of the children at baseline was 5 years; 10 months (range = 1 year; 0 months to 11 years; 8 months).

Assessments

Assessments were conducted by clinicians who were unaware the videos would later be used for research purposes. Videotapes of the assessments were coded subsequently by a team of researchers, blind to characteristics of the sample and study.

Autism Severity The ADOS (Lord et al. 2002) is a semi-structured assessment of social interaction, play and flexible thinking/imagination. During a 30–45 min period of interaction and observation, an examiner provides the child with a series of structured and unstructured tasks and opportunities for communication. Children were administered the ADOS by a clinician who was trained and highly experienced in the use of this assessment. The assessment was videotaped. At baseline, five of the children in the study received a Module 1 (non-verbal), three received a Module 2 (phrase speech), and ten received a Module 3 (verbally fluent). The children were administered a further ADOS about 2 years after treatment commenced ($M = 26.11$ months; $SD = 10.09$ months, range = 1–3.67 years). At Time 2 (T2), three children received a Module 1, two received a Module 2, and thirteen received a Module 3.

ADOS Coding The 36 baseline and outcome ADOS videos were randomized in order and given to an independent coder who had received training and achieved research reliability standards in the administration and coding of the ADOS. The naïve coder was not aware of the children's clinical diagnoses and she was not informed about the children's participation in treatment. The independent coder used the calibrated severity score (CSS) of the ADOS (Gotham et al. 2009), which has been used to assess change in autism symptom presentation (e.g., Harker et al. 2011; Locke et al. 2014). This metric ranges from 1 to 10, and allows for standardized comparison of total scores across modules, so that one can compare severity across Modules and assess change over time. A CSS of 1–3 is considered consistent with non-spectrum, a CSS of 4–5 is considered consistent with milder forms of autism (e.g., autism spectrum disorder), and a CSS of 6–10 is considered consistent with the diagnosis of autism. At baseline, all of the children received a score of 6 or higher on the ADOS CSS.

Due to the nature of this study, the naïve rater of the ADOS videos was not able to score the ADOS live (during the administration) and instead conducted her coding using videotapes of the assessments. Therefore, as an additional check on the reliability of this independent coding, we asked the clinic to provide us with the original codes they had assigned for each item

on the ADOS, for each for the baseline and outcome ADOS administrations, for one-third of the sample, selected at random. They were able to provide us with 11 of the 12 requested sets of codes, as one set of original codes was no longer available. We calculated the CSS on the basis of these 11 original live codes, and the inter-rater reliability was excellent ($ICC = 0.84$) between the clinic live coding and our blind/naïve independent coding of the assessment on the basis of video.

Quality of Parent-Child Interaction Caregiver-child interaction was assessed within a semi-structured procedure, the Relationship Development Assessment (RDA; Gutstein 2003) in which dyads were provided with a series of activities designed to provide opportunities for joint attention, communication, cooperation/collaboration, and social engagement. In the first 10 min of this procedure, known as 'Getting Comfortable', the parent and child enter the room and are given no particular instructions except to 'make yourselves comfortable'. The parent is asked to set limits as they would at home. The room contains a standard set of toys, such as foam noodles, beanbags, soft balls, and ball games (e.g., zoom ball, which requires coordination between partners). These activities provided varied opportunities for parents and their children to coordinate shared games and activities. Following the Getting Comfortable activity, the parent and child are given a series of tasks to do together including building a house (using tape, scissors and index cards), playing drums, looking at silly/fun pictures, and building with blocks. These activities take place over the course of approximately half an hour. The videotaped RDA assessments took place at T1 and the dyads received a repeat videotaped assessment of parent-child interaction (T2) between one and two-and-a-half years after the beginning of treatment ($M = 19.4$ months, $SD = 6$ months, range = 12–30 months). There were two sets of coding applied to these videotapes.

Global Quality of Parent-Child Interaction Videotapes of the entire RDA were coded using the DCS (Humber and Moss 2005) to assess qualities of parent-child relatedness for school-age children. Nine domains are rated on a scale of 1 (*very low*) to 7 (*very high*), indicating the quality of the following aspects of interaction: coordination, communication, partner roles, emotional expression, responsivity/sensitivity, tension/relaxation, mood, and enjoyment. An overall rating was also assigned based on the quality of parent-child interaction. Here low scores reflect a sense of indifference, lack of pleasure, and/or overt conflict. Further details of the rating scales are presented in Table 1.

We made an a priori decision to use the mean of all subscales as our primary variable to provide a summary of quality of interaction, as we did not have specific predictions regarding the subscales and our sample size was small. Therefore, scores on the DCS had a possible range of 1–7.

Table 1 Dyadic coding scales, coding descriptors adapted from Humber and Moss (2005)

Item	General description
Coordination	The flow of interaction or smoothness of transitions toward mutually understood goals. (e.g. little flexibility, lack of smoothness, little interaction, or intense friction vs. synchrony, harmony, and a balance of who initiates and responds).
Communication	Quality of verbal and non-verbal messages (e.g. irrelevant talking, missed messages, awkward silence vs. comfortable silence, meaningful messages, communication reflected back).
Partner roles	Appropriate role assumption for parent and child (e.g. rigid or laissez-faire patterns, child dominance vs. parent assume guidance and control).
Emotional expression	Quality and balance of emotional expression to support interaction (e.g. lack or exaggeration of emotional expression vs. balanced and shared expression of positive and negative emotional states).
Responsivity/ Sensitivity	Mutual sensitivity to the needs of the other (e.g. intrusive/ignoring vs. empathy and ability to see the other's perspective).
Tension/Relaxation	Anxiety or tension (vs. relaxed, open manner).
Mood	Predominance of positive mood (vs. negative affect).
Enjoyment	Warmth and pleasure (vs. disinterest or boredom).

The 36 videotaped RDA assessments were rated by a trained coder who was naïve to the study details and the children's diagnoses. A second 'blind' judge coded the baseline and outcome RDA assessments for nine of the participants. On the basis of these 18 videos (50 % of the sample) inter-rater agreement was excellent for Coordination (ICC = 0.84), Communication (ICC = 0.81), Responsivity/Sensitivity (ICC = 0.84), Tension/Relaxation (ICC = 0.83), Mood (ICC = 0.81), and Overall Interaction (ICC = 0.83). Inter-rater agreement was good for Emotional Expression (ICC = 0.73) and Enjoyment (ICC = 0.68). Inter-rater agreement was in the fair to moderate range for the Partner Roles subscale (ICC = 0.50). Inter-rater agreement for the mean score on the DCS was excellent (ICC = 0.86). This latter score was used as an index of the global quality of parent-child interaction.

Processes of Parent-Child Interaction The second set of ratings was applied to the unstructured, initial 10 min of the assessment procedure, when the caregiver and child were left to play by themselves with the materials but no specific instructions. Videotapes of this period were rated on a second-by-second basis using the Observer[®] XT event-logging

software package (Noldus Technologies 2005). The coding was made by a separate pair of naïve, 'blind' coders with regard to two scales. Co-Regulation refers to contingency and elaboration within the dyad, and the work each member does to sustain coordination of activity with the other. Intersubjective Engagement refers to the level of experience-sharing or affective contact judged to take place between the members of the dyad. Detailed definitions and illustrative examples are provided in Table 2.

These processes were each rated on the discrete scales detailed in Table 2 on a second-by-second basis for the full 10 min. If two levels appeared to be descriptors of the engagement state (for example, if the physical activity and conversation within a dyad necessitated different levels) then the higher interaction state was assigned. Therefore, on a second-by-second basis, the dyad was always in one discrete level of Co-Regulation and one discrete level of Intersubjective Engagement. Using the percentage of time in seconds (out of the total time) spent in each state, a mean level of interaction, out of a possible range of 0 to 3, was then calculated for each scale.

A naïve reliability coder was trained on ten videos (five dyads) and then rated one video for each of the remaining thirteen dyads, equating to seven baseline recordings and six outcome recordings (36 % of the total). Calculation of inter-rater reliability was carried out on the mean level achieved by the dyad throughout the interaction. Inter-rater reliability was excellent for both Co-Regulation (ICC = 0.86) and Intersubjective Engagement (ICC = 0.91).

Results

Descriptive Data

Descriptive data for the baseline and outcome scores on the ADOS CSS, the play-based observation coded with the DCS, and the moment-by-moment coding of states of Co-Regulation and Intersubjective Engagement appear in Table 3.

Given that part of our rationale for completing measures at two time points was to analyse correlations among variables when levels of functioning might have changed, we include *p*-values for paired *t*-test analyses comparing T1 and T2 in Table 3. Between T1 and T2 administration of the ADOS, the CSS was significantly reduced, $t(17) = -3.07$, $p < 0.01$. Importantly, there were individual differences in the degree of change. There were eight children (44 %) for whom the CSS score reduced by between two and seven points. Ten children in the sample had CSS scores that did not change (i.e., either increased by one, $n = 3$, stayed the same, $n = 3$, or decreased by one, $n = 4$).

Global ratings of parent-child interaction improved, as assessed by the DCS coding, $t(17) = 2.82$, $p < 0.05$. At T2,

Table 2 Co-regulation and intersubjective engagement state descriptions and examples

State	Description	Example
Co-regulation		
Lack = Absence of contingency (score 0)	No contingency between the dyad. There may be a state of disruption, absent engagement or a lack of coherence.	The child does not respond to parent invitation to play a game of Frisbee.
Static = Contingency without elaboration (score 1)	The dyad coordinates but there is no elaboration or variability. Interaction is fixed and rigid.	Parent and child pass the Frisbee for 2 min without communication or variations in how they throw.
Unbalanced = Contingency with unbalanced elaboration (score 2)	All adjustments and elaborations are made by one member of the dyad, while the other follows.	The child instructs the parent where to stand, to catch and throw the Frisbee, and the parent complies.
Balanced = Contingency with balanced elaboration (score 3)	Partners take equal responsibility for remaining coordinated and for introducing variations.	Parent and child both introduce variations, such as aiming the Frisbee at a goal and then using the Frisbee as a bat to hit a ball.
Intersubjective engagement		
Lack of coordination (score 0)	No engagement between the dyad, apart from physical contact.	The child ends a game by dropping the Frisbee and wandering over to the window where he stands on his own.
Coordination of actions (score 1)	The dyad influences each other for discrete actions; communication is instrumental.	The child asks the parent for the Frisbee.
Coordination of intentions (score 2)	Partners anticipate each other's actions, in relation to joint goals.	While playing Frisbee, the parent and child decide to see if they can hit the ceiling. The child takes his turn, and then hands the Frisbee to the parent to try.
Coordination of experiences (score 3)	Partners show affective responses to each other. They are interested in each other's reactions. They may discuss shared experiences in the past or future.	When the parent hits the ceiling with the Frisbee, they look at each other and laugh.

parent-child dyads achieved higher mean states of Co-Regulated activity (CR), $t(17) = 3.60$, $p < 0.01$, and higher mean states of Intersubjective Engagement (IE), $t(17) = 2.40$, $p < 0.05$.

Although mean levels of scores differed between Time 1 and Time 2, it is important to note that our novel second-by-second coding of Co-Regulation was correlated across the two time-points, $r(17) = 0.57$, $p < 0.05$. This was also the case for our novel second-by-second coding of Intersubjective Engagement, $r(17) = 0.79$, $p < 0.001$. Furthermore, the CSS was correlated at both time-points, $r(17) = 0.65$, $p < 0.01$. These results suggest that in each respect there was stability of individual differences over time.

Autism Severity and Parent-Child Interaction

As predicted, at T1 ADOS CSS scores (range 6–10) were inversely correlated with scores for parent-child interaction. This was the case both for the global ratings of relatedness on the DCS, $r(17) = -0.61$, $p < 0.01$, and for moment-by-moment coding of Co-Regulation, $r(17) = -0.66$, $p < 0.01$ and Intersubjective Engagement, $r(17) = -0.72$, $p < 0.001$.

In order to take into account potential confounds introduced by the wide age range in this sample, we examined results in relation to the children's chronological age. At T1, chronological age was not correlated with scores on the ADOS, $r(17) = -0.09$, nor with scores on moment-by-

Table 3 Descriptive data for study variables at Time 1 and Time 2

Variable	<i>M</i> (<i>SD</i>)	Range	Paired t-test <i>p</i> -value
T1: ADOS Calibrated Severity Score	8.39 (1.20)	6–10	0.007
T2: ADOS Calibrated Severity Score	6.83 (2.73)	1–10	
T1: DCS Score	3.91 (1.28)	1.33–5.89	0.012
T2: DCS Score	4.58 (1.08)	2.89–6.33	
T1: Co-Regulation Score	1.30 (0.42)	0.45–2.22	0.002
T2: Co-Regulation Score	1.63 (0.41)	1.10–2.60	
T1: Intersubjective Engagement Score	1.48 (0.60)	0.37–2.59	0.028
T2: Intersubjective Engagement Score	1.69 (0.50)	0.71–2.44	

ADOS = Autism Diagnostic Observation Schedule; DCS = Dyadic Coding Scales

moment coding of Co-Regulation and Intersubjective Engagement, $r(17) = 0.19$ and 0.29 . There was a non-significant association between chronological age and global ratings on the DCS, $r(17) = 0.47$, $p = 0.051$, suggesting there was a better quality of parent–child relatedness in dyads where the child was older. Importantly, however, the significant inverse correlation between scores on the ADOS and global ratings on the DCS remained strong even after considering variance associated with chronological age, partial- $r = -0.64$, $p < 0.01$.

At T2, the pattern of results was mostly similar. Once again, the CSS scores (range 1–10) were inversely correlated with scores both for parent-child relatedness on the DCS, $r(17) = -0.64$, $p < 0.01$, and for second-by-second coding on Intersubjective Engagement, $r(17) = -0.52$, $p < 0.05$. However, the relation between the CSS and Co-Regulation was no longer significant, $r(17) = -0.41$, *ns*. At T2, the child's chronological age was not associated with scores on the ADOS, $r(17) = 0.26$ nor with scores on global ratings of parent-child relatedness on the DCS, $r(17) = 0.01$. However, child chronological age was correlated with moment-by-moment coding of Co-regulation and Intersubjective Engagement, $r(17) = 0.69$ and 0.47 , $p < 0.01$ and 0.05 . Once variance in Intersubjective Engagement associated with chronological age was taken into account, the association between ADOS CSS and moment-by-moment coding of Intersubjective Engagement strengthened, partial- $r = -0.76$, $p < 0.001$. When variance in Co-Regulation associated with chronological age was taken into account, the correlation between ADOS CSS and moment-by-moment coding of Co-Regulation also strengthened, partial- $r = -0.85$, $p < 0.001$.

Predictors of Change

Given the many potentially interacting factors that might bear upon the likelihood of change in measures between T1 and T2 in this study – factors such as the age of the children and the severity of their autism and associated intellectual difficulties, as well as the variable time elapsed (and treatment received) between T1 and T2, it is clearly not possible to provide more than tentative observations on predictive factors that might have influenced changes in severity of autism. For these purposes, our measure of improvement is the difference in the CSS between T1 and T2 ($M = 1.56$, $SD = 2.42$). We focus on whether baseline (T1) measures were related to change. As a background to this exploratory analysis, we noted that neither baseline autism severity on the ADOS, nor children's chronological age at baseline, nor time in between ADOS administrations were correlated with improvement, $r(17) = -0.27$, -0.19 , and 0.14 respectively.

In contrast, however, there was a pattern of association between baseline scores for quality of parent-child interaction, and change on the ADOS CSS. Improvements on the ADOS

over time were non-significantly associated with baseline scores on overall quality of parent-child interaction on the DCS $r(17) = 0.44$, $p = 0.071$, and baseline scores for Intersubjective Engagement $r(17) = 0.44$, $p = 0.065$. Baseline scores for Co-Regulation were significantly correlated with improvements on the ADOS over time, $r(18) = 0.57$, $p = 0.014$. This significant correlation between baseline Co-Regulation and ADOS change remained strong, even when variance in the Co-Regulation scores associated with baseline ADOS CSS scores was taken into account, partial- $r = 0.48$, $p = 0.051$.

Finally, we explored how scores on the ADOS CSS and the parent-child interaction variables might measure related but differing constructs, through the strength of their associations with each other alongside diverging associations with improvement (Steiger 1980). The correlations between the baseline ADOS CSS and ADOS improvement were significantly different from the correlations between the parent-child interaction process measures and ADOS improvement (CR $z = 2.01$, $p = 0.044$; IE $z = 2.17$, $p = 0.029$). However, the correlation between the baseline ADOS CSS and ADOS improvement was not significantly different from the correlation between the parent-child interaction global measures and ADOS improvement (DCS $z = 1.49$, *ns*).

Discussion

Our first outcome was to replicate a finding by Beurkens and colleagues (2013), namely that children's severity of autism as measured by the ADOS CSS was inversely correlated with quality of parent-child relatedness assessed by the DCS (Humber and Moss 2005). The DCS were developed to assess “the smoothness and fluidity of the goal-corrected partnership” and to pick up such features as escalating conflict, controlling behavior, rigidity, and task-oriented behavior in parent-child dyads characterized by insecure forms of attachment (Humber and Moss 2005, p. 129). The strong inverse correlation between autism severity and scores on the DCS was found not only at pre-treatment baseline, replicating the finding by Beurkens et al. (2013), but also at a second time point when there had been substantial changes in the functioning of the children.

It is important to note that ADOS assessments conducted by a clinician on the one hand, and ratings of parent-child relatedness on the other, each have a focus on social reciprocity, communication, and co-ordination (including ‘triadic’ relations that include joint reference to a shared world). Given these measures both assess social engagement, it is not surprising to find associations between them. However, the ADOS is designed to be a formal assessment of autism severity, and is usually administered by a clinician who is

unfamiliar to the child. As such, the ADOS cannot yield data on parent-child interaction.

The next part of this study involved analysing parent-child interaction in more detail. Focused second-by-second coding of Co-Regulation and Intersubjective Engagement allowed us to explore the specific aspects of social relating targeted through RDI. This brings us to our second set of findings, namely that severity of autism was also correlated with these detailed measures of parent-child Co-Regulation and Intersubjective Engagement, both at baseline and later in treatment. These forms of coding are designed to capture the dyads' ability to establish and sustain balanced, coordinated interactions characterized by emotional connection.

There is another way to think about the findings, and that is from the point of view of measurement. Measures of Co-Regulation and Intersubjective Engagement achieved satisfactory inter-rater reliability, and yielded data that had meaningful connections with valid and reliable data from an independent measure of functioning, the ADOS. From a complementary perspective, the findings suggest that the CSS may have validity as a measure that not only integrates information derived from different ADOS modules, but also relates to global and detailed qualities of parent-child interaction. More than this, the finding that there were changes in participants' CSS over time and treatment points towards the potential of the measure to document the effects of intervention.

There is substantial research evidence to suggest that CSS scores generally remain stable (Locke et al. 2014; Shumway et al. 2012). Other studies suggest that a substantial number (3–25 %) of children with autism receiving intervention appear to achieve optimal outcome (Helt et al. 2008), suggesting that in many cases autism may be remediable (Fein et al. 2013). Fein et al. (2013) suggest that good quality intervention and involved parents are important for outcome. The fact that, in our study, measures of parent-child relations also showed significant improvement over time with treatment suggests the need for further study of the sources and implications of these effects. There remain questions regarding the course of change through treatment, and the conditions that make improvement possible.

This study provided an additional pointer in this regard, insofar as improvement in the ADOS CSS was specifically predicted by baseline scores of parent-child relatedness. There are different interpretations that might be given to this result. Dyads who had relatively good relational functioning at baseline might benefit most from the strategic changes encouraged by the intervention (so that here there might be more opportunity for change in autism severity), whereas dyads with relatively poor functioning might need substantial input (with more potential improvement in their relations) before broader changes in the children could be achieved. Whether or not these speculations are correct, it is clear that further research is needed into the many interacting factors that might

influence the potential for different kinds of change in both affected individuals and the dyadic interactions in which they take part.

This research contributes to a broader set of studies suggesting how the social-communicative difficulties of children with autism, or children at-risk for developing autism, may affect and/or be affected by caregiver interaction style (Wan et al. 2012; Wan et al. 2013). A progressively atypical developmental trajectory may be important not only in predicting the emergence of autism, but also in predicting the course of autism over time. It is being increasingly recognised that measures of parent-child interaction are needed to study relational phenomena (Dent et al. 2013). In this regard, the current study offers a valid and reliable approach to assessing parent-child interaction (Hobson et al. 2015; Larkin et al. 2015). Larkin et al. (2015) reported more modest associations between Co-Regulation (CR) and Intersubjective Engagement (IE) and ADOS calibrated severity scores. In the Larkin et al. (2015) study, high-functioning verbally able school-age children with autism and their caregivers were more likely than dyads without autism to spend time in the CR state of 'Contingency without Elaboration' and in the IE state of 'Coordination of Actions' (Larkin et al. 2015). Another study has recently applied the clinical rating scales of CR and IE to naturalistic, home-based parent-child guided participation interactions (Palmiotto 2015). In a qualitative analysis of each of the CR and IE levels, Palmiotto (2015) coded themes within each engagement state and noted such attributes as: monitoring and aligning, control and rigidity, warmth, connectedness, and even "loving gaze" between co-participants. The nature of these qualitative observations supports our quantitative study in suggesting that parent-child interaction may offer a unique context for assessing important aspects of social engagement.

One limitation of this study is that there was not a comparison group that had received an effective alternative treatment. This would have allowed us to evaluate treatment effects that might have been specific to RDI, on the one hand, or common to different treatments, on the other. Secondly, there was unavoidable variability in the timing of the first and second assessment. Finally, there may have been a degree of overlap between the areas of functioning measured by the ADOS and the RDA. Nevertheless, it seems unlikely that any of these limitations cast doubt on the principal findings.

We conclude with a reminder that the present study was conducted in the context of participants receiving a particular form of family-based, relationship-orientated intervention, RDI. This is an intervention for children and adolescents with autism that addresses the pacing, structuring, and sensitive adjustment of everyday guiding activities that involve children and their parents. RDI aims to foster interpersonal engagement and promote the affected individuals' initiative and flexibility. It should not be overlooked that it was in the setting

of this treatment that we recorded improvements in autism severity and parent-child relatedness for a number of the children. Although some studies have found no change in ADOS symptom severity scores following intervention (Locke et al. 2014), other treatment studies have also reported improvements in calibrated severity scores on the ADOS (Zachor and Itzchak 2010).

Zachor and Itzchak (2010) reported that cognitive ability did not predict ADOS CSS change, and suggested future studies should explore whether other child and family characteristics might do so. In the present study, for families taking part in RDI, baseline quality of parent-child interaction was the best predictor of change. Moreover, if it is the case that impairments in intersubjective engagement and social relatedness are central to autism (whether in its pathogenesis or expression), as well as profoundly important in their own right, then it makes sense to pay attention to interventions that address these impairments directly. Although many interventions with a focus on enriching social experience through parent-infant/toddler interaction are currently being developed and tested, there is no reason to conclude that this approach will only be helpful for young children. Controlled trials of such relationship-orientated interventions for children with autism of all ages are needed.

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References

- Abbeduto, L., Seltzer, M. M., Shattuck, P., Krauss, M. W., Osmond, G., & Murphy, M. M. (2004). Psychological well-being and coping in mothers of youths with autism, down syndrome, or fragile X syndrome. *American Journal of Mental Retardation*, *109*, 237–254.
- Aldred, C., Green, J., & Adams, C. (2004). A new social communication intervention for children with autism: pilot randomized controlled treatment study suggesting effectiveness. *Journal of Child Psychology and Psychiatry*, *45*, 1420–1430.
- Aldred, C., Green, J., Emsley, R., & McConachie, H. (2012). Brief report: mediation of treatment effect in a communication intervention for preschool children with autism. *Journal of Autism and Developmental Disorders*, *42*, 447–454.
- Bell, R. Q. (1968). A reinterpretation of the direction of effects in studies of socialization. *Psychological Review*, *75*, 81–95.
- Beurkens, N. M., Hobson, J. A., & Hobson, R. P. (2013). Autism severity and qualities of parent-child relations. *Journal of Autism and Developmental Disorders*, *43*, 168–178.
- Blacher, J., & McIntyre, L. L. (2006). Syndrome specificity and behavior disorders in young adults with intellectual disability: cultural differences in family impact. *Journal of Intellectual Disability Research*, *50*, 184–198.
- Campbell, S. B., Leezenbaum, N. B., Mahoney, A. S., Day, T., & Schmidt, E. N. (2014). Social engagement with parents in 11-month-old siblings at high and low genetic risk for autism spectrum disorder. *Autism*. 2014, Nov 28. [Epub ahead of print] doi:10.1177/1362361314555146
- Capps, L., Kehres, J., & Sigman, M. (1998). Conversational abilities among children with autism and children with developmental delays. *Autism*, *2*, 325–344.
- Charman, T., Swettenham, J., Baron-Cohen, S., Cox, A., Baird, G., & Drew, A. (1997). Infants with autism: an investigation of empathy, pretend play, joint attention, and imitation. *Developmental Psychology*, *33*, 781–789.
- Dawson, G., Hill, D., Spencer, A., Galpert, L., & Watson, L. (1990). Affective exchanges between young autistic children and their mothers. *Journal of Abnormal Child Psychology*, *18*, 335–345.
- Dawson, G., Meltzoff, A. N., Osterling, J., Rinaldi, J., & Brown, E. (1998). Children with autism fail to orient to naturally occurring social stimuli. *Journal of Autism and Developmental Disorders*, *28*, 479–485.
- Dawson, G., Toth, K., Abbott, R., Osterling, J., Munson, J., Estes, A., & Liaw, J. (2004). Early social attention impairments in autism: social orienting, joint attention, and attention to distress. *Developmental Psychology*, *40*, 271–283.
- DeMol, J., & Buysse, A. (2008). The phenomenology of children's influence on parents. *Journal of Family Therapy*, *30*, 163–193.
- Dent, A. K. Carr, T., Leitman, S., & Lord, C. E. (2013). Effects of parent-mediated early intervention on child behavioral outcomes in an underserved population. Paper presented at the International Meeting for Autism Research, Spain.
- Eisenhower, A. S., Baker, B. L., & Blacher, J. (2005). Preschool children with intellectual disability: syndrome specificity, behavior problems, and maternal well-being. *Journal of Intellectual Disability Research*, *49*, 657–671.
- Estes, A., Vismara, L., Mercado, C., Fitzpatrick, A., Elder, L., Greenson, J., Lord, C., Munson, J., Winter, J., Young, G., Dawson, G., & Rogers, S. (2014). The impact of parent-delivered intervention on parents of very young children with autism. *Journal of Autism and Developmental Disorders*, *44*, 353–365.
- Fein, D., Barton, M., Eigsti, I., Kelley, E., Naigles, L., Schultz, R. T., & ... Tyson, K. (2013). Optimal outcome in individuals with a history of autism. *Journal of Child Psychology & Psychiatry*, *54*, 195–205.
- Fogel, A. (2009). What is a transaction. In A. J. Sameroff (Ed.), *The transactional model of development: How children and contexts shape each other*. Washington, D.C.: American Psychological Association.
- García-Pérez, R. M., Lee, A., & Hobson, R. P. (2007). On intersubjective engagement in autism: a controlled study of nonverbal aspects of conversation. *Journal of Autism and Developmental Disorders*, *37*, 1310–1322.
- Gotham, K., Pickles, A., & Lord, C. (2009). Standardizing ADOS scores for a measure of severity in autism spectrum disorders. *Journal of Autism and Developmental Disorders*, *39*, 693–705.
- Green, J., Charman, T., McConachie, H., Aldred, C., Slonims, V., Howlin, P., et al. (2010). Parent-mediated communication-focused treatment in children with autism (PACT): a randomised-controlled trial. *Lancet*, *375*, 2152–2160.

- Green, J., Pickles, A., McConachie, H., Jones, E., Gilga, T., Charman, T., & Johnson, M. H. (2015). *Early interventions for autism: Mechanism and developmental science*. Keynote Panel Session presented at the International Meeting for Autism Research, May 13–16, Salt Lake City, UT.
- Gulsrud, A. C., Jahromi, L. B., & Kasari, C. (2010). The co-regulation of emotions between mothers and their children with autism. *Journal of Autism and Developmental Disorders, 40*, 227–237.
- Gutstein, S. (2003). *Administration manual for the relationship development assessment*. Houston:RDI Press.
- Gutstein, S. (2009). *The RDI book: forging new pathways for autism, Asperger's syndrome and PDD with the relationship development intervention program*. Houston:Connections Center Press.
- Gutstein, S., Burgess, A. F., & Montfort, K. (2007). Evaluation of the relationship development intervention program. *Autism, 11*, 397–411.
- Harker, C. M., Resinger, E. M., Sherman, A. D., Xie, M., Shin, S., Mandell, D. S., (2011). Using the ADOS severity metric to evaluate a behavioural intervention in a large public school district. Poster presented at the *International Meeting for Autism Research*, San Diego, CA.
- Helt, M., Kelley, E., Kinsbourne, M., Pandey, J., Boorstein, H., Herbert, M., & Fein, D. (2008). Can children with autism recover? If so, how? *Neuropsychology Review, 18*, 339–366.
- Hobson, R. P. (1993). *Autism and the development of mind*. Hove: Erlbaum.
- Hobson, R. P. (2004). *The cradle of thought*. Oxford University Press.
- Hobson, R. P., & Lee, A. (1998). Hello and goodbye: a study of social engagement in autism. *Journal of Autism and Developmental Disorders, 28*, 117–127.
- Hobson, J. A., Garlington, M., Hollaway, L., & Moore, J. A. (2015). *Clinical utility of the Relationship Development Assessment – Research Version (RDA-RV) for children with autism in a preschool setting*. Poster presented at the International Meeting for Autism Research, May 13–16, Salt Lake City, UT.
- Hoffman, C. D., Sweeney, D. P., Hodge, D., Lopez-Wagner, M. C., & Looney, L. (2009). Parenting stress and closeness: mothers of typically developing children and mothers of children with autism. *Focus on Autism and Other Developmental Disabilities, 24*(3), 178–187.
- Humber, N., & Moss, E. (2005). The relationship of preschool and early school age attachment to mother-child interaction. *The American Journal of Orthopsychiatry, 75*, 128–141.
- Kanner, L. (1943). Autistic disturbances of affective contact. *Nervous Child, 2*, 217–250.
- Kasari, C., Sigman, M., Mundy, P., & Yirmiya, N. (1988). Caregiver interactions with autistic children. *Journal of Abnormal Child Psychology, 16*, 45–56.
- Kasari, C., Sigman, M., Mundy, P., & Yirmiya, N. (1990). Affective sharing in the context of joint attention interactions of normal, autistic, and mentally retarded children. *Journal of Autism and Developmental Disorders, 20*, 87–100.
- Koren-Karie, N., Oppenheim, D., Dolev, S., & Yirmiya, N. (2009). Mothers of securely attached children with autism spectrum disorder are more sensitive than mothers of insecurely attached children. *Journal of Child Psychology and Psychiatry, 50*, 643–650.
- Kuczynski, L., Loulis, S., & Koguchi, Y. (2003). Reconstructing common sense: Metaphors of bidirectionality in parent-child relations. In L. Kuczynski (Ed.), *Handbook of dynamics in parent-child relations* (pp. 421–437). Thousand Oaks: SAGE.
- Larkin, F., Guerin, S., Hobson, J. A., & Gutstein, S. (2015). The relationship development assessment – research version: preliminary validation of a clinical tool and coding schemes to measure parent-child interaction in autism. *Clinical Child Psychology and Psychiatry, 20*, 239–260.
- Locke, J., Rotheram-Fuller, E., Xie, M., Harker, C., & Mandell, D. (2014). Correlation of cognitive and social outcomes among children with autism spectrum disorder in a randomized trial of behavioural intervention. *Autism, 18*, 370–375.
- Lord, C., Rutter, M., DiLavore, P., & Risi, S. (2002). *Autism diagnostic observation schedule manual*. Los Angeles:Western Psychological Services.
- Mundy, P., Sullivan, L., & Mastergeorge, A. M. (2009). A parallel and distributed-processing model of joint attention, social cognition and autism. *Autism Research, 2*, 2–21.
- Noldus Information Technology (2005). *The observer XT reference manual version 6.1*. Wageningen, The Netherlands: Noldus Information Technology.
- Ozonoff, S., Iosif, A. M., Baguio, F., Cook, I. C., Hill, M. M., Hutman, T., Rogers, S. J., Rozga, A., Sangha, S., Sigman, M., Steinfeld, M. B., & Young, G. S. (2010). A prospective study of the emergence of early behavioural signs of autism. *Journal of the American Academy of Child and Adolescent Psychiatry, 49*, 256–266.
- Palmiotto, J. (2015). *A qualitative content analysis of parent-child interactions within relationship development intervention*. San Diego: Alliant International University.
- Rogers, S. J., Vismara, L., Wagner, A. L., McCormick, C., Young, G., & Ozonoff, S. (2014). Autism treatment in the first year of life: a pilot study of infant start, a parent-implemented intervention for symptomatic infants. *Journal of Autism and Developmental Disorders, 44*, 2981–2995.
- Rogoff, B. (2003). *The cultural nature of human development*. New York: Oxford University Press.
- Ruble, L., McDuffie, A., King, A. S., & Lorenz, D. (2008). Caregiver responsiveness and social interaction behaviors of young children with autism. *Topics in Early Childhood Special Education, 28*, 158–170.
- Sameroff, A. J. (2009). The transactional model. In A. J. Sameroff (Ed.), *The transactional model of development: How children and contexts shape each other*. Washington, D.C.: American Psychological Association.
- Sameroff, A. J., & Chandler, M. J. (1975). Reproductive risk and the continuum of caretaking casualty. *Review of child development research, 4*, 187–244.
- Schertz, H. H., & Odom, S. L. (2007). Promoting joint attention in toddlers with autism: a parent-mediated developmental model. *Journal of Autism and Developmental Disorders, 37*, 1562–1575.
- Seltzer, M. M., Greenberg, J. S., Hong, J., Smith, L. E., Almeida, D. M., Coe, C., & Stawski, R. S. (2010). Maternal cortisol levels and behaviour problems in adolescents and adults with ASD. *Journal of Autism and Developmental Disorders, 40*, 457–469.
- Shumway, S., Farmer, C., Thurm, A., Joseph, L., Black, D., & Golden, C. (2012). The ADOS calibrated severity score: relationship to phenotypic variables and stability over time. *Autism Research, 5*, 267–276.
- Siller, M., & Sigman, M. (2002). The behaviors of parents of children with autism predict the subsequent development of their children's communication. *Journal of Autism and Developmental Disorders, 32*, 77–89.
- Siller, M., & Sigman, M. (2008). Modeling longitudinal change in the language abilities of children with autism: parent behaviors and child characteristics as predictors of change. *Developmental Psychology, 44*, 1691–1704.
- Siller, M., Swanson, M., Gerber, A., Hutman, T., & Sigman, M. (2014). A parent-mediated intervention that targets responsive parental behaviors increases attachment behaviours in children with ASD: results from a randomized clinical trial. *Journal of Autism and Developmental Disorders, 44*, 1720–1732.
- Spiker, D., Boyce, G. C., & Boyce, L. K. (2002). Parent-child interactions when young children have disabilities. *International Review of Research in Mental Retardation, 25*, 35–70.
- Steiger, J. H. (1980). Tests for comparing elements of a correlation matrix. *Psychological Bulletin, 87*, 245–251.

- Stuart, M., & McGrew, J. H. (2009). Caregiver burden after receiving a diagnosis of an autism spectrum disorder. *Research in Autism Spectrum Disorders, 3*, 86–97.
- Volkmar, F., Charwarska, K., & Klin, A. (2005). Autism in infancy and early childhood. *Annual Review of Psychology, 56*, 315–336.
- Vygotsky, L. S. (1987). *Mind in society*. Cambridge:Harvard University Press.
- Wan, M. W., Green, J., Elsabbagh, M., Johnson, M. H., Charman, T., Plummer, F., & the BASIS Team (2012). Parent-infant interaction in infant siblings at risk of autism: a controlled observational study. *Research in Developmental Disabilities, 33*, 924–932.
- Wan, M. W., Green, J., Elsabbagh, M., Johnson, M. H., Charman, T., Plummer, F., & the BASIS Team (2013). Quality of interaction between at-risk infants and caregiver at 12–15 months is associated with 3-year autism outcome. *Journal of Child Psychology and Psychiatry, 54*, 763–771.
- Wimpory, D. C., Hobson, R. P., Williams, J. M. G., & Nash, S. (2000). Are infants with autism socially engaged? A controlled study of recent retrospective parental reports. *Journal of Autism and Developmental Disorders, 30*, 525–536.
- Zachor, & Itzhak (2010). Treatment approach, autism severity and intervention outcomes in young children. *Research in Autism Spectrum Disorders, 3*, 425–432.