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Social behavior and characteristics of autism spectrum disorder in Angelman, Cornelia de Lange and Cri du Chat syndromes.

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Abstract

We evaluated autism spectrum (ASD) characteristics and social behavior in Angelman (AS; N=19; mean age =10.35 years), Cornelia de Lange (CdLS; N=15; mean age =12.40) and Cri du Chat (CdCS, also known as 5 p-syndrome; N=19; mean age=8.80) syndromes. The proportion of individuals meeting the ASD cut off on the Social Communication Questionnaire was significantly higher in AS and CdLS than CdCS ($p < .01$). The groups demonstrated divergent social behavior profiles during social conditions in which adult availability, adult familiarity, and social demand were manipulated. Social enjoyment was significantly heightened in AS while social approaches were heightened in individuals with CdCS. Social motivation, social-communication and enjoyment were significantly lower in CdLS. The findings highlight the importance of detailed observation when evaluating ASD and social behavior in genetic syndromes.

Key words: Cornelia de Lange syndrome, Angelman syndrome, Cri du Chat syndrome, behavioral phenotypes, Autism Spectrum Disorder, social interaction skills.

Introduction

There has been growing interest in the manifestation of autism spectrum disorder (ASD) in genetic syndromes. The number of genetically defined syndromes reported to be associated with ASD, and the variability in behavioral phenomenology identified in these syndromes, has led to the nature of these associations being questioned (Skuse, 2007). Detailed studies of the profile of autistic features in genetic syndromes have highlighted important distinctions and heterogeneity in ASD symptomatology between individuals with specific genetic syndromes and those with idiopathic ASD (e.g., Hall, Lightbody, Hirt, Rezvani, & Reiss, 2010; Moss, Oliver, Berg, Kaur, Jephcott & Cornish, 2008; Mount, Charman, Hastings, Reilly, & Cass, 2003; Trillingsgaard & Østergaard, 2004). This heterogeneity often appears to be described in the domain of social impairment, although this is not always the case. The nature and cause of these differences and heterogeneity clearly has implications for the conceptualization and identification of ASD in those with genetic syndromes. Studies describing atypicalities have highlighted the issue of the applicability of prevailing diagnostic criteria for those with genetic syndromes (Moss & Howlin, 2009).

Among the syndromes associated with severe/profound intellectual disability (ID) in which a strong association with atypical autistic features has been reported are Angelman syndrome (AS) and Cornelia de Lange syndrome (CdLS), although the nature of the impairment of social interactions in these syndromes differs markedly. AS occurs in 1 in 12,000 to 15,000 live births (Clayton-Smith & Pembry, 1992; Kyllerman, 1995) and is caused by anomalies on the maternal chromosome 15q11-13. Intellectual disability is typically within the severe to profound range (Peters, Beaudit, Madduri & Bacino, 2004). Characteristic features include seizures, mobility difficulties, hyperactivity, short attention span and stereotyped motor behaviors; speech is also typically poor or absent (Clarke & Marston, 2000; Horsler & Oliver, 2006). Recent studies have suggested that a large proportion of individuals with AS may score above cut off for ASD on autism specific assessments, with estimates ranging from 50% to 81% (Peters et al., 2004; Trillingsgaard &

Østergaard 2004; Bonati et al., 2007). According to Peters et al. (2011), these rates may vary depending on the type of genetic abnormality. The pattern of social behavior that is characteristic of individuals with AS appears inconsistent with core features of ASD and there is a particularly striking characteristic of excessive sociability with familiar and unfamiliar adults and strong motivation to seek out adult contact (Horsler & Oliver, 2006; Oliver, Horsler, Berg, Bellamy, Dick, & Griffiths, 2007). This seemingly indiscriminate sociability with familiar and unfamiliar adults has clear implications regarding the safety and vulnerability of children with the syndrome.

CdLS occurs in approximately 1 in 50,000 live births (Beck, 1976). The genetic etiology of CdLS is not yet fully understood. A deletion in the NIP-BL gene on chromosome 5 (locus 5p13) is thought to account for up to 50% of cases (Krantz et al., 2004; Tonkin, Wang, Lisgo, Bamshad, & Strachan, 2004). Mutations on chromosomes 10 and X have also been identified (Deardorff et al., 2007; 2012; Musio et al., 2006) and account for a further 5% of cases. Each of the genes identified in individuals with CdLS to date are implicated in the Cohesin pathway (Liu and Krantz, 2008). Associated ID is typically within the severe to profound range, although a proportion of individuals may have moderate or even mild ID (Sloneem et al., 2009). Behavioral characteristics include social avoidance, repetitive and self-injurious behaviors (Berney, Ireland, & Burn, 1999; Hyman Oliver, & Hall, 2002; Moss, Oliver, Arron, Burbidge & Berg, 2009; Oliver, Arron, Sloneem, & Hall, 2008). Estimates of the proportion of individuals meeting ASD criteria on a variety of autism specific assessments range from 50 – 67% (Basile, Villa, Selicorni & Molteni, 2007; Berney, et al., 1999; Bhuiyan et al., 2006; Moss et al., 2008; Oliver et al., 2008; Oliver, Berg, Moss, Arron, & Burbidge, 2011). Detailed observations of the characteristic social impairment reveal behaviors such as selective mutism, extreme shyness, and social anxiety that are not typical of idiopathic autism (Collis, Oliver & Moss, 2006; Goodban, 1993; Moss et al., 2008; Oliver, Arron, Hall, Sloneem, Forman, & McClinktock, 2006; Richards, Moss, O'Farrell, Kaur & Oliver, 2009).

Distinguishing between autism spectrum-related patterns of social interaction and social impairments that arise for other reasons remains a challenge, both in clinical practice and research.

“Gold-standard” diagnostic instruments, such as the Autism Diagnostic Observation Schedule (ADOS; Lord, Rutter, DiLavore, & Risi, 2000) or the Autism Diagnostic Interview (ADI; Rutter, LeCouteur, & Lord, 2003), may identify the presence of social impairments in those with genetic syndromes but these social impairments may be qualitatively different from those seen in idiopathic ASD or, given the difficulties in distinguishing ASD in individuals with severe and profound ID, may simply be a manifestation of associated ID. Thus, a possible explanation for the putative increased levels of ASD symptomatology in individuals with AS and CdLS, may be that unusual patterns of social interaction, together with severe/profound intellectual impairments, results in scoring above cut-off on standardized assessments of ASD. Recognizing shared characteristics of ASD in genetic syndromes is clearly important for appropriate intervention and management. However, we must be certain that these are indeed shared and be able to clearly identify areas of difference that may require alternative approaches.

In this study, we argue that in individuals with genetic syndromes, a broader approach to evaluating social impairments and skills is required, with less reliance upon traditional measures of ASD that are highly specific, developmentally weighted and unlikely to be sufficiently sensitive or broad in their approach to accurately characterize the social profiles of these groups.

We will evaluate ASD symptomatology and broader social impairments and skills in individuals with AS and CdLS in comparison to a group of individuals with Cri du Chat syndrome (CdCS; also known as 5p- syndrome). Cri du Chat syndrome is a genetic syndrome associated with similar levels of severe/profound ID, social communication deficits and stereotyped behavior to those with AS and CdLS, making them a useful contrast group for these two syndrome groups. However, ASD symptoms in CdCS are not reported more frequently than would be expected in the wider ID population (Moss et al., 2008). In fact, ASD symptoms were found to be less severe in individuals with CdCS relative to a matched control group by Claro, Cornish and Gruber (2011). CdCS is caused by a deletion on the short arm of chromosome 5 (5p; Godhart, Simmons, Grady, Rojas, Moysis, Lovett, & Overhauser, 1994; Overhauser et al., 1994) and occurs in one in 50,000

live births (Cornish & Pigram, 1996). It is characterized by hyperactivity, aggression, self-injury, stereotyped behavior and impairments in expressive language (Cornish, Bramble, Munir & Pigram, 1999; Collins & Cornish, 2002; Cornish & Munir, 1998). Social interaction skills are reported to be relatively preserved (Carlin, 1990; Cornish & Pigram, 1996) and children are typically described as having a 'happy and friendly' demeanor (Carlin, 1990; Cornish & Pigram, 1996; Udwin & Kuczynski, 2007). However, Cornish and Pigram (1996) noted that almost half (48%) of their group of 27 children with CdCS were inappropriately friendly with others.

In the present study, we used a traditional screening tool for ASD; the Social Communication Questionnaire (SCQ; Rutter et al., 2003) alongside observations of broad social behavior responses, impairments and skills across a range of experimental social conditions to characterize the broad nature of social impairments and strengths of children with AS and CdLS; selected because these syndromes have been reported to show a strong association with ASD symptomatology and discrepant profiles of ASD symptomatology, in contrast to a group of children with CdCS, who are considered to be relatively skilled in social interaction. This syndrome contrast approach using fine grained quantitative methods and broader ratings of the quality of behavior alongside screening for ASD related symptomatology, provides the opportunity to consider both behavioral difference and similarity across syndromes in which characteristics such as degree of ID and communication skills are shared, while the profile and prevalence of ASD-type phenomenology and sociability is variable.

The principal aims of the study were:

1. To replicate previous findings showing elevated ASD symptomatology in individuals with CdLS and AS compared with CdCS when using an autism screening tool.
2. To examine differences in the profile of social interaction skills (observable skills and behaviors used to *maintain social interaction*), social motivation (behaviors used specifically to *solicit social interaction from others*) and social enjoyment (behaviors indicative of *enjoyment of*

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social interaction) in CdLS, CdCS and AS with familiar and unfamiliar adults and across different social conditions.

3. To evaluate the impact of social context and adult familiarity on observable social interaction skills, social motivation and social enjoyment in individuals with CdLS, AS and CdCS.
4. To highlight differences and similarities in reported outcomes between measures of ASD symptomatology and broader measures of social impairments and skills when using these two different approaches to evaluate social behavior in individuals with CdLS, CdCS and AS.

We hypothesized that:

1. The CdLS and AS groups would score higher on a questionnaire measure of ASD symptomatology than the CdCS group.
2. Individuals with AS, CdLS and CdCS would demonstrate divergent profiles in social interaction skills and behaviors indicative of social motivation and social enjoyment, with individuals with AS demonstrating the highest frequency of these behaviors and individuals with CdLS showing the lowest frequency of these behaviors.
3. Individuals with AS will be less likely to discriminate between familiar and unfamiliar adults, showing similar patterns of social responses with both individuals, in comparison to individuals with CdLS and CdCS.
4. Individuals with AS would show discrepant outcomes on a questionnaire measure of ASD symptomatology relative to broad observations of behavioral responses during social situations. Outcomes on these measures will be more consistent in the CdLS group.

Method

Recruitment:

Participants were recruited as part a wider study of challenging behavior (anonymised for blind review, 2008; anonymised for blind review et al., 2011) via syndrome support groups and direct

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invitation. Consequently, all participants were selected to meet the criteria of this broader study which included: 1) confirmed clinical or genetic diagnosis of AS, CdLS or CdCS; 2) aged 2-19 years and 3) engaged in self injurious and/or aggressive behavior at least once a day. Challenging behavior of this kind occurs in 70% of individuals with CdLS, 73% with AS and 76% with CdCS (Oliver et al., 2011). Therefore, the participant groups reported in this study are considered to be broadly representative of the wider syndrome group. Families who were contacted directly had previously participated in research at the (anonymised for blind review) and had agreed to be contacted with information about future projects. For the current analyses, inclusion also required: 1) completion of all assessment conditions, and 2) the familiar adult completing the assessment was a primary carer (i.e. parent or legal guardian). Ethical approval was provided at each research base: (anonymised for blind review).

Procedure:

Following the return of consent forms, and one week prior to the observational assessment, parents completed questionnaires and a telephone interview. Direct observations of the child were conducted in a quiet, distraction free room in the school or home.

Participants:

Of the 60 children (20 in each group) initially recruited, five (1 CdCS; 4 CdLS) were excluded due to incomplete observational data; two (1 CdLS; 1 AS) were excluded because the familiar adult involved in the data collection was not their primary carer. In total, 53 children and their parents participated (19 AS, 19 CdCS, 15 CdLS); 23 (43%) were male; 16 (30%) had some expressive communication skills (> than 30 words or signs) and thirty-one (58%) were mobile (able to walk unaided) (See Table 1). There was a significant group difference with regard to verbal ability. Pairwise post-hoc chi-squared tests indicated that participants with CdCS were more likely to use more than 30 words or signs than those with AS. The CdCS group was younger than the AS and

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CdLS groups, although this difference was not significant. There were fewer males in the CdCS group and this is consistent with the gender ratio associated with the syndrome. There were no significant group differences on age equivalence scores on VABS subdomains (all $p > .05$), suggesting that the groups were comparable for mental age.

++++Table 1 about here++++

Measures:

Informant measures:

Social Communication Questionnaire (SCQ; Rutter, Bailey, Lord, & Berument, 2003):

The SCQ (previously known as the Autism Screening Questionnaire) is a 40 item informant questionnaire that screens for behaviors associated with ASD: Reciprocal Social Interaction, Communication, and Restricted, Repetitive and Stereotyped Patterns of Behavior. The maximum score is 39 with cut-offs of 15 for ASD and 22 for autism suggested (Rutter et al., 2003). The sensitivity and specificity of the SCQ for distinguishing individuals with autism and ASD from those with ID is reported to be good (Berument et al., 1999; Rutter et al., 2003). The measure has also been shown to have good concurrent validity with the Autism Diagnostic Interview and with the Autism Diagnostic Observation Schedule (Berument et al., 1999; Bishop & Norbury, 2002). Internal consistency is also good (Berument et al., 1999). Howlin and Karpf (2004) report good internal consistency and concurrent validity with the Autism Diagnostic Observation Schedule and the Autism Diagnostic Interview in individuals with Cohen syndrome, supporting the validity of using this screening tool for evaluating ASD symptomatology in individuals with genetic syndromes.

Vineland Adaptive Behavior Scales- II (Sparrow, Balla, & Cicchetti, 2005):

Adaptive behavior was assessed using the Vineland Adaptive Behavior Scales -II (VABS, Survey form; Sparrow et al., 2005). Standard and age equivalent scores were obtained on the Vineland

Adaptive Behavior Composite score (VABS ABC) and the three domains (communication, daily living skills, socialization) scored for all children and young people.

Direct observation of social interaction:

Experimental Social Conditions:

The experimental social conditions provided standardized social settings which enabled observation of social interaction behaviors and indicators of social enjoyment and motivation in individuals with severe and profound ID (Anonymised for blind review, et al., 2010 and 2009). The level of social demand, adult availability for social attention and familiarity of the adult was systematically varied in four social conditions in order to evaluate the impact of social context on behavioral responses. Each condition was conducted with an unfamiliar adult and repeated with a familiar adult (parent or guardian). The manipulation of these three factors enabled observation of the frequency, duration and quality of social interaction skills (used for initiation and response to social interaction) and behaviors indicative of social motivation and enjoyment of social interaction under conditions of high and low social demand and high and low levels of adult social attention. The manipulation of adult familiarity enables assessment of the impact that adult familiarity has on these behaviors. The four conditions were as follows:

1. High Interaction (HI; 10 minutes). This condition creates an intensive social interaction environment in which social demand is high and adult availability for social attention is high. The adult works through a number of specific social tasks including turn taking games, social routines (e.g., peek-a-boo), joint play and other games which place a high level of social demand on the participant. The adult responds to all social approaches made by the participant.
2. Responsive Interaction (RI; 3 minutes). This condition creates an environment in which social demand is low and adult availability for social attention is high. The adult does not

initiate interaction with the participant but responds to social approaches made by the participant. The adult is in proximity to the individual and makes it clear that they are available for interaction by smiling at the participant and watching them throughout the condition.

3. No Interaction (NI; 3 minutes). This condition creates an environment in which social demand and adult availability for social attention are both low. In this condition, play materials are available for the participant. The adult is in proximity to the participant and indicates that they are going to talk to someone else for a few minutes. The adult does not respond to social approaches.
4. No Interaction Control (NIC; 3minutes). This condition controls for the availability of materials and toys during the no interaction condition to identify whether availability of these items may restrict social interaction if the individual is preoccupied with engaging with novel items. In this condition social demand and adult availability for social attention are both low but no play materials are available to engage the participant. The adult is in proximity to the participant and indicates that they are going to talk to someone else for a few minutes. The adult does not respond to social approaches.

A two minute warm up period preceded the presentation of these four conditions, enabling the participant to become familiar with the assessment materials and signaling that the adult was available for social engagement. To evaluate social motivation behaviors effectively, conditions in which adult availability was absent (and thus social motivation behaviors might be expected to be higher - NI and NIC) were preceded by conditions in which adult availability was present, to ensure that all participants had experienced interaction with the adult prior to their availability being terminated. Thus, conditions were presented in the following order: 2 minute warm up, Responsive Interaction, No Interaction, High Interaction, and No Interaction Control. All conditions began with the adult in close proximity to the participant. More detailed information about each condition is

available from the authors. All conditions were video recorded and coded using the Child Sociability Rating Scale and real time coding methods.

The Child Sociability Rating Scale:

The Child Sociability Rating Scale (CSRS; anonymised for blind review) was developed for the current study to assess the nature and quality of social interaction skills, social enjoyment and social motivation in children with a range of intellectual ability. The CSRS is designed to rate behavior during interaction with familiar and unfamiliar adults in a variety of settings. The scale includes 14 items, rated on a five point Likert scale. Items that independently rate the frequency and nature of the same behavior (i.e. frequency of eye contact and nature of eye contact) are combined to create a single item score from 0-4 by multiplying the scores on each item together and rescaling according to the following criteria: $0=0$, $1-4=1$, $6/8 = 2$, $9/12 = 3$, $16=4$. This rescaling is required for items regarding eye contact and social-communication. Spearman coefficients for inter-rater reliability across familiar and unfamiliar assessments (based on a sample of 24 individuals with a range of genetic syndromes) range from .47 to .88 at item level (mean $r = .75$, 84.6% of items above .60), indicating good reliability. Validity between the CSRS and the frequency of observable behaviors was found to be good ($r=.50-.82$). Further details regarding the individual items included in the CSRS are available from the authors. For the purposes of the current study four items were removed from the analysis due to low frequency ratings (negative affect, social anxiety, social avoidance, nature of physical contact). Items included in analyses were as follows: *positive affect*, *social responsiveness* (social enjoyment domain), *motivation for adult interaction*, *spontaneous initiation of interaction*, *spontaneous initiation of physical contact*, *focus of child attention* (social motivation domain), *social-communication* and *eye contact* (social interaction skills domain). The motivation for adult interaction item was only rated during the No Interaction and No Interaction Control conditions and the social responsiveness item was only coded during the High Interaction condition,

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due to lack of opportunity to score in other conditions. A description of the selected items can be found in Table 2.

++++Insert Table 2 about here++++

Real time coding of experimental social conditions:

Behavioral responses were coded using Obswin 32 software (Martin, Oliver & Hall, 2000), which uses real time coding to record the frequency and duration of operationally defined behavioral responses. Inter-rater reliability of behavior definitions was calculated for 30% of the total sample across groups. Kappa values for variables based on 10s intervals ranged from .42-.77 (Mean= .62) indicating good inter-rater reliability (Fleiss, 1981). Operational definitions and Kappa coefficients are described in Table 3. Variables were combined to create five domains: *social interaction skills* (eye contact, show, give, point) and *communication skills* (communicative vocalizations, gesture, verbalizations, sign) were recorded to assess behaviors and skills used to initiate and maintain social interaction and to assess responses to the social approaches of others. *Spontaneous social approach* (approach examiner, touch) was recorded to evaluate motivation to access social interaction from others. *Positive affect* (positive facial expression, positive vocalizations) and *joint play* (social play, functional play with examiner) were recorded to assess the individual's enjoyment of social interaction. Frequency data are expressed as a proportion of time (percentage occurrence) spent engaging in these behaviors in order to ensure comparability across conditions of different duration (HI vs. RIC, NI & NIC) and behaviors with different response times (e.g. event behaviors such as give or show vs. duration behaviors such as eye contact).

+++Table 3 about here+++

Data analysis:

Non-parametric analyses were conducted where data were not normally distributed. To identify broad group differences in demographics and SCQ scores, one way ANOVAs were conducted and post-hoc analyses were carried out using Scheffé contrasts. Categorical data (mobility, verbal ability, reaching ASD or autism cut off scores) were assessed using chi-squared tests with follow-on 2x2 chi-squared tests to identify the source of differences across the three groups.

Mixed ANOVAs were conducted to identify interactions between syndrome group and adult familiarity on mean CSRS ratings and mean percentage occurrence of behavioral responses across social conditions. Bonferonni corrections were applied to these comparisons. Pearson correlations were used to evaluate the association between SCQ total scores, mean CSRS ratings and mean percentage occurrence of behavioral responses. Correlations were conducted within syndrome groups as the association between these variables was predicted to be different for each group (see hypothesis 4).

The effect of social condition on the percentage occurrence of behavioral responses was evaluated using within group, repeated measures Friedman tests (data were not normally distributed). Post-hoc, pair-wise repeated measures tests were conducted to identify the source of difference. This analysis was not conducted for CSRS ratings, as this measure was designed to provide a broad evaluation of the quality of social responses rather than to identify discreet differences in behavioral responses. A conservative p value of $\leq .01$ was used for primary analysis; a p value of $.05$ was employed for post-hoc analyses.

Results

The prevalence of ASD symptomatology in CdLS, AS and CdCS:

The proportion of participants reaching SCQ cut-off scores and also total and domain SCQ scores are displayed in Table 4 along with information about statistical comparisons. As predicted, significantly more participants with CdLS and AS scored above the ASD cut-off (score ≥ 15) on the

SCQ than those with CdCS (See Table 4). Although there was no statistically significant group difference in the proportion reaching cut off for autism (≥ 22), 46% of individuals with CdLS and 40% of individuals with AS scored above this cut-off compared to 13% of those in the CdCS group. The CdLS group scored significantly higher than the CdCS group on the social interaction domain, the group difference on the total SCQ score approached significance ($p = .06$).

++++Table 4 about here++++

The broader profile of social interaction, motivation for social interaction and enjoyment of social interaction in CdLS, AS and CdCS with familiar and unfamiliar adults.

Figure 1 shows the mean CSRS item scores within the social enjoyment, social motivation and social interaction domains across social conditions. Mixed ANOVA were conducted to evaluate the effect of familiarity and group on CSRS scores. A main effect of syndrome group was identified for *positive affect* (Social enjoyment domain; $F_{2,50} = 12.41$; $p < .001$), with the AS group scoring significantly higher than both the CdCS and CdLS groups ($p < .001$). A significant familiarity by group interaction was identified for *motivation for adult interaction* (social motivation domain; $F_{2,50} = 6.27$; $p = .004$). Individuals with CdCS scored higher on this item than both the AS and CdLS groups when engaging with familiar adults while no significant group differences were identified during interaction with an unfamiliar adult. The same pattern of findings was observed for *spontaneous initiation of physical contact* (social motivation domain), although the interaction approached significance ($F_{2,50} = 5.01$; $p = .01$). A main effect of familiarity was identified for *spontaneous initiation of interaction* (social motivation domain; $F_{1,50} = 11.305$; $p = .001$), with significantly higher scores for spontaneous initiation of interaction with familiar compared to unfamiliar adults ($p < .001$). The main effect of group for this item approached significance ($F_{2,50} =$

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4.63; $p = .01$), with the AS and CdCS groups scoring higher than the CdLS group. Finally, main effects of familiarity ($F_{1,50} = 14.42$; $p < .001$) and syndrome group ($F_{2,50} = 7.48$; $p = .001$) were observed for *social-communication skills* (social interaction skills domain). Scores on this item were significantly higher during interactions with familiar compared to unfamiliar adults ($p < .001$) and significantly higher in the CdCS group compared to the AS ($p < .05$) and CdLS ($p < .001$) groups. No significant main effects or interactions were identified for *social responsiveness* (social enjoyment domain), *focus of child attention* (social motivation domain) and *eye contact* (social interaction skills domain).

Consistent with this, analysis of the mean percentage occurrence of behavioural responses across conditions (i.e. real time coding; see Figure 2 for data reported by condition) indicated a main effect of syndrome group for *positive affect* ($F_{2,50} = 7.571$; $p = .001$) and a main effect of familiarity for *spontaneous social approach* ($F_{1,50} = 8.57$; $p = .005$). Main effects of familiarity ($F_{1,50} = 4.67$; $p = .04$) and syndrome group ($F_{2,50} = 4.78$; $p = .01$) for *communication skills* approached significance. No significant interactions or main effects were identified for *social interaction skills* or *joint play skills*.

Association between ASD symptomatology scores and broader social behavior responses:

++++**Insert Table 5 here**++++

Within group correlations between mean item CSRS scores, mean percentage occurrence of behavioral responses and SCQ total scores were conducted (see Table 5). In the AS group, there were no significant correlations between the CSRS items and total SCQ scores. The correlation between total SCQ score and mean percentage occurrence of *spontaneous social approach* with

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familiar adults was significant at $p < .05$ but not at the more conservative alpha level of $p \leq .01$. In the CdCS group there was a significant, negative correlation between the total SCQ score and CSRS mean ratings of *eye contact* with familiar adults and CSRS mean ratings of *social responsiveness* with familiar and unfamiliar adults. Significant, negative correlations between total SCQ score and *social responsiveness* (mean CSRS rating) with familiar adults, mean percentage occurrence of *positive affect* with familiar adults and *focus of attention* (mean CSRS rating) during interaction with unfamiliar adults were identified in the CdLS group. Moderate to large correlations (.56-.65) were also identified for eight further CSRS ratings and two further behavioral responses which were significant at the $p < .05$ but not at the more conservative alpha level of $p \leq .01$.

The effect of social context on behavioral responses in CdLS, AS and CdCS:

+++++Figure 2 about here:+++++

Mean percentage occurrence of behavioral responses was compared across the four social conditions, in which adult availability and level of social demands were manipulated. This enabled us to consider the impact of social context on behavioral responses in individuals with CdLS, AS and CdCS and was considered particularly important in order to evaluate motivation for social contact and social responsiveness within the groups. Figure 2 shows the median percentage occurrence of behavioral responses during each condition with both familiar and unfamiliar adults. Within group repeated measures comparisons using Friedman tests and follow-on pairwise Wilcoxon Signed Ranks analyses were conducted to assess the effect of condition (High Interaction; HI, Responsive Interaction; RI, No Interaction; NI and No Interaction Control, NIC) on the frequency of each behavioral response domain. Joint social play was excluded since there was no or limited opportunity for joint play in all but one of the conditions. The findings from these

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analyses are reported below for each syndrome group. For conciseness within the text, post hoc analyses are reported with condition notations in parentheses.

Cornelia de Lange syndrome:

In the CdLS group, significant differences across conditions were identified for *social interaction skills* ($\chi^2(3) = 18.95; p < .001; RI, HI > NI$) and *positive affect* ($\chi^2(3) = 10.93; p = .01; HI > RI, NIC$) in the unfamiliar adult conditions only. These findings show the CdLS group was more likely to engage in social interaction skills and positive affect during conditions when adult availability and social demands were high. No significant differences were identified for *communication skills* or *spontaneous social enjoyment*.

Cri du Chat syndrome:

In the CdCS group, significant differences were identified for *social interaction skills* (Familiar adult; $\chi^2(3) = 15.72; HI > NI, NIC; RE > NI; p = .001$; Unfamiliar adult; $\chi^2(3) = 12.56 p = .006; HI > RI, NI$), *spontaneous social approach* (Familiar adult; $\chi^2(3) = 20.53; p < .001; NI, NIC > RI, HI$), *positive affect* (Familiar adult; $\chi^2(3) = 32.05; p < .001; HI > NI, NIC, RI$; Unfamiliar adult ($\chi^2(3) = 22.98; p < .001; HI > NI, NIC; RI > NI$) and *communication* (Familiar adult; $\chi^2(3) = 12.89; RI, HI > NI p = .005$; Unfamiliar adult; $\chi^2(3) = 19.12; p < .001; HI > NIC > NI; RI > NI$) were identified.

These results show that the CdCS group was more likely to show positive affect, social interaction and communication skills when adult availability for social attention and levels of social demand were high while spontaneous social approach behaviors were more likely to occur when availability for adult social attention was low. This is consistent with CSRS findings of motivation for adult interaction.

Angelman syndrome:

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In the AS group, significant differences were identified for *social interaction skills* (Familiar adult; $\chi^2(3) = 14.03$; $p = .003$; HI>NI, NIC; RI>NIC), *spontaneous social approach* (Familiar adult ; $\chi^2(3) = 22.24$; $p < .001$; NIC>RI,NI,HI) and *positive affect* (Familiar adult; $\chi^2(3) = 30.66$; HI>RI>NI, NIC $p < .001$; Unfamiliar adult; $\chi^2(3) = 19.42$; $p < .001$; HI, RI,NI, NIC). No significant differences were identified for *communication skills*.

Similarly to the CdCS group, these results show that the AS group was more likely to show positive affect and social interaction skills when adult availability and level of social demand were high and more likely to show spontaneous social approach behaviors when adult social attention and access to play materials was low.

Discussion:

In this study we examined the presence of ASD symptomatology and the nature and quality of social interaction and social motivation in individuals with AS, CdLS and CdCS. The behavioral responses of participants were recorded during conditions in which adult availability and familiarity and the level of social demand were systematically varied. Social interaction and social motivation were evaluated using both fine grained and broader assessments that evidenced robust reliability and convergent validity. Autism spectrum characteristics were assessed using the Social Communication Questionnaire (Rutter et al., 2003).

Consistent with our hypothesis, individuals with AS and CdLS were significantly more likely to score above the cut-off for ASD, as measured by the SCQ, than individuals with CdCS. All participants with CdLS and 18 of 19 individuals with AS met the cut off score for ASD compared to 12 of 19 individuals with CdCS. The number of individuals scoring above the autism cut-off on the SCQ in the three groups were six (CdLS), six (AS) and two (CdCS). Both the CdLS and AS

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groups had higher total scores on the SCQ than the CdCS group (differences approached significance $p = .06$) and the CdLS group had the highest scores on social impairments ($p < .05$). This pattern of results is consistent with previous reports in the literature (Basile et al., 2007; Berney, et al., 1999; Bhyuian et al., 2006; Moss et al., 2008; Peters et al., 2004; Trillingsgaard & Ostergaard, 2004). Our findings indicate that individuals with CdLS and AS show similar levels of ASD characteristics, while individuals with CdCS do not evidence ASD characteristics at a comparable level. There were no significant group differences on chronological age or adaptive behavior age equivalence scores, which suggests that these findings are not accounted for by the mental age characteristics of the three groups.

Social interaction skills and behaviors indicative of social enjoyment and social motivation were assessed in greater detail in these three syndrome groups using two observational measures; the Child Sociability Rating Scale, which allows for the broad quality of social interaction to be coded and percentage occurrence of behavioral responses, which provides a more fine-grained approach. Consistent with previous literature (Horsler & Oliver, 2006; Oliver et al., 2007), individuals with AS showed more positive affect (positive facial expression and positive vocalizations) than both the CdCS and CdLS groups on both observation measures. These behaviors were more likely to occur in individuals with AS during conditions of high social attention compared to conditions of low social attention, supporting the suggestion that these behaviors are appropriate, social in nature and influenced by the environment (Horsler & Oliver 2006; Oliver, Demetriades & Hall, 2002; Oliver et al., 2007). Greater spontaneous initiation of interaction (CSRS rating) was also observed in individuals with AS and CdCS compared to the CdLS group, although this difference only approached significance ($p = .01$). The findings confirm previous findings in AS (Horsler & Oliver 2006; Oliver et al., 2007) and supports previous descriptions of heightened social interaction in individuals with CdCS (Carlin, 1990; Cornish & Pigram, 1996; Udwin & Kuczynski, 2007).

Communication skills used to solicit social interaction were significantly less impaired and were used more frequently in the CdCS group compared to the AS and CdLS groups. CdCS is associated with deficits in verbal expression (likely due to physical abnormalities resulting in poor articulation; Cornish et al., 1999; Collins & Cornish, 2002; Cornish & Munir, 1998), while non-verbal communication skills appear to be an area of relative skill (Cornish & Munir 1998; Sarimski, 2002). As the present study assessed both verbal and non-verbal communication skills, this relative skill in CdCS may account for the higher communication abilities observed in this group.

All groups were significantly better at utilizing social-communication skills and spontaneous initiation of social contact during interactions with familiar compared to unfamiliar adults. This pattern of findings was confirmed in the real time frequency data and indicates that stranger discrimination is intact in these areas. Interestingly, this trend was not identified in all aspects of social behavior evaluated in this study. In all three groups, social enjoyment and social interaction skills were unaffected by whether the engaging adult was familiar or unfamiliar. Individuals with CdCS, however, showed stronger motivation for adult interaction and spontaneous initiation of physical contact (according to scores on the CSRS) when engaging with familiar adults compared to unfamiliar adults (results regarding physical contact approached significance; $p < .01$). This pattern of discrimination was not evident in either the AS or the CdLS groups and this is consistent with previous descriptions of social motivation in individuals with AS (Horsler & Oliver, 2006; Oliver, Horsler, Berg, Bellamy, Dick, & Griffiths, 2007). The strong distinction between motivation for interaction with familiar vs. unfamiliar adults made by individuals with CdCS specifically, may be associated with the highly idiosyncratic expressive communication that is characteristic of this group (Cornish & Pigram, 1996), and the likelihood that familiar adults are better able to understand and communicate/interact effectively with their children than unfamiliar adults. These discrepancies in social responses when interacting with familiar vs. unfamiliar adults also have significant clinical implications. For example, social abilities may be underestimated in individuals

with Cri du Chat syndrome if they are only considered in the context of an interaction with an unfamiliar adult. The influence of the interacting adult may be an important consideration when evaluating social abilities in children with other neurodevelopmental disorders

Analysis of the effect of social context on the percentage occurrence of behavioral responses indicated that individuals with AS and CdCS both demonstrated appropriate adaptation of social interaction skills and positive affect across conditions, with heightened frequency of these behaviors during conditions of high social attention and increased social approaches during periods of low attention. This suggests high levels of social enjoyment and a strong motivation to seek adult contact. Previous studies have demonstrated this tendency in AS (Horsler & Oliver 2006; Oliver et al., 2007). This study confirms anecdotal reports of elevated motivation for adult engagement in people with CdCS. (Carlin, 1990; Cornish & Pigram, 1996; Udwin & Kuczynski, 2007).

While the CdLS group also demonstrated heightened social interaction skills and positive affect during the high interaction condition relative to other conditions, the overall frequency of these behaviors was comparatively low, and no differences in social approach behaviors were reported, indicating lower levels of social motivation in this group. The findings suggest that while environmental factors do influence some aspects of social behavior in this group, this impact is mitigated in comparison to the AS and CdCS groups. Given that the groups are comparable on chronological age and mental age equivalence, these differences are unlikely to be solely accounted for by degree of intellectual disability.

These findings are interesting with regard to the putative association between ASD and AS and CdLS. There were no significant correlations between scores on the SCQ and occurrence and quality of behavioral responses in the AS group. Indeed, the behavioral profile of increased positive affect and spontaneous social initiation in individuals with AS is inconsistent with the view that

their generally high scores on the SCQ are related to the presence of a typical ASD and with previous reports within the literature of a strong association between AS and ASD (Peters et al., 2004; Trillingsgaard & Ostergaard, 2004). Conversely, medium to large correlations were identified across a range of behavioral responses in the CdLS group. The profile of very low levels of social interaction and a lack of social initiation identified in the CdLS group is in line with their high scores on the SCQ and with reports of ASD symptomatology in this population (Basile et al., 2007; Berney, et al., 1999; Bhyuian et al., 2006; Moss et al., 2008). This provides support for our hypothesis that high scores on the SCQ in individuals with AS are not reflective of broader social interaction in this group. The findings highlight that detailed observation of social interaction may better characterize the social behavior profile of individuals with severe/ profound levels of ID and that autism-specific assessments might be less sensitive to atypical social functioning when it is not autism related.

The study is limited by the fact that participants were initially recruited for a larger study of self-injurious and aggressive behavior. Consequently, the sample for this study may not be entirely representative of the wider syndrome group populations. However, the prevalence of challenging behavior is reported to be between 70% and 76% in these syndrome groups, thus the participant groups are likely to be broadly similar to the wider syndrome group. It is also notable that the findings from this study are consistent with previous studies of these groups in which the inclusion criteria for challenging behaviour have not been applied. The lack of a direct assessment of intellectual ability is also a potentially limiting factor. However, the VABS-II (Sparrow et al., 2005), used in the current study, is a robust, reliable and valid tool for evaluating adaptive behavior skills in individuals with severe and profound intellectual disability, in whom direct assessment of intellectual ability can be challenging.

Summary and conclusions:

This study is the first to evaluate concurrently ASD symptomatology, phenomenology of autistic presentation and detailed description of social interaction and behaviors indicative of social enjoyment and social motivation in individuals with AS, CdLS and CdCS. The findings demonstrate that while individuals with AS and CdLS achieve similar scores on the SCQ, the profile of social behavior in each of these groups differs significantly. The findings highlight that caution should be exercised when evaluating the association between ASD and genetic syndromes and that detailed observation of specific behavioral profiles is important to characterize accurately the social behavior of these groups (see DiGuseppi et al., 2010 and anonymised for blind review et al., in press for examples of this approach). The study also shows that environmental factors may influence performance in social interaction, even in those individuals for whom social interaction is impaired and motivation for social interaction is very low.

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Table 1: Participant characteristics.

		CdLS (N=15)	CdCS (N=19)	AS (N=19)	F/χ^2	p	Post hocs
Age (in yrs)	Mean	12.40	8.80	10.35	2.63	.08	-
	(SD)	(3.74)	(4.79)	(4.84)			
	Range	6.13- 18.52	2.09- 16.78	3.04- 18.54			
Gender	N male (%)	9 (60.0)	4 (21.1)	10 (52.6)	6.21	.05	CdLS, AS>CdCS
Speech	N verbal (%)	4 (26.7)	10 (52.6)	2 (10.5)	7.88	.02	CdCS>AS
Mobility	N mobile (%)	7 (46.7)	12 (63.2)	12 (63.2)	1.22	.88	
Communication¹							
	<i>Expressive</i>	1.17 (.81) .70-3.50	2.14 (1.69) .80-6.60	1.21 (1.80) .10-8.00	2.31	.11	-
	<i>Receptive</i>	1.20 (1.48) .10-4.70	2.15 (1.60) .11-5.60	1.62 (1.47) .10-8.00	1.67	.20	-
	<i>Written</i>	2.41 (2.06) 1.10- 6.90	3.15 (1.88) 1.10-7.10	2.01 (1.17) 1.10- 4.30	2.09	.14	-
Daily Living Skills¹							
	<i>Personal</i>	1.39 (1.14) .10-3.11	1.74 (1.36) .10-4.60	1.59 (.69) .70-3.20	.42	.66	-
	<i>Domestic</i>	1.61 (2.09) .10-5.60	1.53 (1.63) .10-6.50	1.05 (1.00) .10-3.11	.61	.55	-
	<i>Community</i>	1.71 (2.31) .10-7.00	2.02 (1.91) .01-7.60	1.63 (1.41) .11-4.60	.22	.80	-
Socialisation Skills¹							
	<i>Interpersonal</i>	.96 (.82) .10-3.20	1.65 (1.57) .11-6.70	1.06 (.73) .50-3.80	1.99	.15	-
	<i>Play and leisure</i>	1.34 (.92) .10-3.11	1.92 (1.78) .10-6.60	1.50 (.66) .70-3.70	.98	.38	-
	<i>Coping skills</i>	1.43 (1.30) .10-4.80	1.48 (1.27) .10-5.60	1.07 (.68) .10-2.10	.72	.49	-

¹ Age equivalence scores in years, from Vineland Adaptive Behavior scale second edition (VABS II, Sparrow, Cicchetti, & Balla, 2005).

Table 2: Selected items from the Child Sociability Rating Scale.

	0	1	2	3	4
<p>Positive emotional affect (Eg. positive <u>facial expressions</u>, <u>vocalisations</u> and <u>manner</u> such as <u>smiling</u>, <u>laughing</u>, <u>clapping hands</u>.)</p>	No examples of positive affect at any stage.	Some examples of positive affect but only <u>tentative</u> or <u>occasional</u> .	Affect positive about <u>half of the time</u> . May consist of brief expressions of positive affect in response to <u>particular activities</u> for example, but affect <u>not sustained</u> between these instances.	Affect positive <u>most of the time</u> . May consist of brief expressions of positive affect in response to <u>particular activities</u> for example, but also <u>sometimes sustained</u> between these instances.	Affect generally positive <u>throughout</u> and <u>often sustained</u> between expressions of positive affect in response to particular activities.
<p>Frequency of spontaneous physical contact (Include all <u>participant initiated</u> physical contact, regardless of nature of contact or intent.)</p>	No spontaneous physical contact initiated with the examiner or other adult.	<u>One or two</u> examples of spontaneous initiation of physical contact.	<u>Several</u> examples of spontaneous initiation of physical contact.	Spontaneous physical contact initiated <u>frequently</u> but not to an <u>excessive</u> or <u>socially inappropriate</u> degree.	Spontaneous physical contact initiated <u>frequently</u> to an <u>excessive</u> or <u>socially inappropriate</u> degree.
<p>Social responsiveness * Responds to specific behavioural requests, suggestions, questions or their name (if used). ** Elaboration is defined as when the participant <u>spontaneously</u> builds on what is expected of them e.g. the participant independently initiates building the block tower again once it has been knocked down.</p>	<u>Unresponsive and disinterested</u> . <u>Does not respond</u> *. Largely <u>ignores</u> what the examiner is doing.	<u>Unresponsive</u> but <u>some interest</u> . <u>May not respond</u> * but <u>attends</u> to what examiner is doing (this must be <u>more than a fleeting glance</u>).	<u>Interested and occasionally responsive</u> . <u>Responds*</u> at <u>least once</u> but interactions are <u>examiner led</u> and <u>not reciprocal</u> . Participant <u>mostly attentive</u> to examiner.	<u>Interested and highly responsive</u> . <u>Responds*</u> <u>more often than not</u> . Interactions are <u>reciprocal</u> . <u>At least one or two</u> examples of a back and forth exchange of <u>several steps</u> but participant <u>does not elaborate**</u> beyond initial examiner suggestions (interaction <u>not necessarily verbal</u>).	<u>Interested and elaborately responsive</u> . <u>Responds*</u> <u>more often than not</u> . <u>More than two</u> examples of back and forth exchanges of <u>several steps</u> . Participant <u>elaborates**</u> on initial examiner suggestions (interaction <u>not necessarily verbal</u>).
<p>Spontaneous initiation of interaction * Initiation of interaction may be verbal or non-verbal (e.g. <u>approaching</u> the examiner, <u>offering or requesting</u> objects, <u>speaking</u> or <u>signing</u>, <u>touching</u> the examiner to attempt to gain their attention (aggressively or otherwise), <u>gesturing</u> or <u>pointing</u> to an object while looking at examiner.</p>	No clear spontaneous initiation of interaction* with examiner.	<u>One or two examples</u> of spontaneous initiation of interaction* with examiner but for <u>personal demands</u> or other unclear purpose only.	<u>Three or more examples</u> of spontaneous initiation of interaction* with the examiner but for <u>personal demands</u> or unclear purpose only	<u>One or two examples</u> of spontaneous initiation of interaction* with the examiner which appears to be <u>socially motivated</u> (e.g. for the purpose of being friendly) and not merely for personal demands (e.g. giving or showing an object).	<u>Three or more examples</u> of spontaneous initiation of interaction* with the examiner which appear to be <u>socially motivated</u> (e.g. for the purpose of being friendly) and not merely for personal demands (e.g. giving or showing an object).
<p>Focus of attention (objects focus vs. people focus)</p>	Focus of the participant's attention either <u>unclear</u> or <u>entirely object focussed</u> . Participant <u>does not</u> attend to or show any interest in other <u>people</u> .	Focus of the participant's attention <u>mostly on objects</u> . <u>Some</u> attention paid to other <u>people</u> even if only for <u>monitoring</u> purposes.	Focus of the participant's attention <u>shared</u> between <u>people</u> and <u>objects</u> .	Focus of the participant's attention <u>mostly on people</u> . Attention appears to be <u>socially motivated</u> at least <u>some of the time</u> and <u>not</u> simply for purpose of <u>monitoring</u> .	Focus of the participant's attention almost <u>entirely</u> on <u>people</u> perhaps to an excessive degree. Attention appears to be mostly <u>socially motivated</u> .
<p>Motivation for adult engagement * Interaction may be verbal or non-verbal (e.g. <u>approaching</u> the examiner, <u>offering or requesting</u> objects, <u>speaking</u> or <u>signing</u>, <u>touching</u> the examiner to attempt to gain their</p>	The participant <u>does not</u> attempt to initiate interaction*. Either <u>sits passively</u> or <u>entertains self</u> (e.g. plays with the toys or passively listens	The participant makes <u>one or two</u> attempts to initiate interaction* but when attention is not given they <u>give up quickly</u> and <u>entertain self</u> .	The participant makes <u>three or more</u> attempts to initiate interaction* but <u>eventually gives up</u> and <u>entertains self</u> . May subsequently return for renewed attempt to engage	The participant makes <u>persistent</u> attempts to initiate interaction* throughout the observation but stays <u>within socially appropriate limits</u> (e.g. approaching, vocalising (not	The participant makes <u>persistent</u> attempts to initiate interaction* throughout the observation and through <u>several different means</u> , to the extent of using <u>socially</u>

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attention (aggressively or otherwise), <u>gesturing</u> or <u>pointing</u> to an object while looking at examiner.	to conversation between examiners).		with adult but there must be a <u>clear gap</u> in their efforts.	high volume), touching hand or tapping shoulder).	<u>inappropriate methods</u> (e.g. face grabbing, physical aggression such as hair pulling or through engaging in challenging behaviour).
Frequency of eye contact *Eye contact defined as the participant looking up/at the examiner, fixating on their eyes or face.	<u>No</u> eye contact* made with examiner.	<u>Occasional, fleeting</u> eye contact* made with examiner.	<u>Frequent, fleeting</u> eye contact* made with examiner	<u>Frequent fleeting AND occasionally sustained</u> eye contact* made with examiner.	<u>Frequent, sustained</u> eye contact* made with examiner.
Nature of eye contact * Appropriate integration of eye contact with other social-communication skills including gesture, pointing or facial expressions e.g. participant checks what examiner is looking at, or points, then follows examiner's gaze to check point has been registered. *Inappropriate eg. staring or avoidant.	<u>No</u> eye contact made with examiner.	Eye contact <u>obviously awkward or inappropriate*</u> in nature on <u>all occasions - not naturally integrated</u> with other behaviours during interaction. Includes participants who show prolonged eye contact (e.g. staring)	Eye contact <u>somewhat awkward or inappropriate*</u> in nature - <u>not naturally integrated</u> with other behaviours on every occasion but on <u>some</u> .	Eye contact <u>slightly awkward or inappropriate*</u> in nature - <u>mostly naturally integrated</u> with other behaviours during interaction but <u>not always</u> .	Eye contact <u>consistently naturally and appropriately integrated*</u> with other behaviours during social interaction.
Social communication style (Rate the majority of examples of social- communication demonstrated by the participant rather than the best example)	<u>Little</u> or <u>no</u> verbal or non-verbal communication at all.	<u>Some</u> vocalisations or gestures <u>mostly indicating affect</u> (e.g. laughing or crying sounds indicating excitement) and <u>not</u> specifically <u>communicative</u> or directed at others AND/OR attempts to communicate through <u>grabbing/touching</u> or other physical means that has clear communicative intent.	<u>Some clearly communicative</u> vocalisations (verbal or non-verbal) or gestures (e.g. pointing, nodding and shaking head). Makes attempts to communicate <u>specific desires</u> but <u>does not</u> use speech or signing.	<u>Some clearly communicative</u> vocalisations (verbal or non-verbal) or gestures (e.g. pointing, nodding and shaking head). Makes attempts to communicate <u>specific desires AND</u> shows <u>some</u> use of speech or signing which may be <u>infrequent or unclear</u> (not full sentences).	<u>Regular clear</u> speech and or signing (e.g. BSL or Makaton). Makes attempts to communicate <u>specific desires</u> which may be for the purpose of being friendly or otherwise.
Quality of social communication skills * Communication of simple desires may include indicating desire for attention, for assistance such as to be lifted up or desire for an object.	The participant either <u>rarely</u> attempts to communicate or makes attempts to communicate which <u>cannot be understood</u> .	The participant's attempts to communicate are <u>often difficult to understand</u> but they are <u>occasionally</u> able to communicate <u>simple*</u> desires.	The participant's attempts to communicate are <u>sometimes difficult to understand</u> but they are <u>mostly</u> able to communicate <u>simple*</u> desires and <u>sometimes</u> more <u>complex</u> desires, ideas and thoughts.	The participant is <u>mostly</u> able to communicate even <u>complex</u> desires, ideas and thoughts although to someone who does not know them well it is <u>not always easy</u> to understand them (e.g. they may have problems with articulation).	The participant is <u>able to communicate</u> and it is <u>easy to understand</u> their intentions and desires.

Table 3: Operational definitions and Kappa scores for participant behavioral responses.

Behaviour	Operational Definition	Kappa
Social interaction skills domain:		
Eye contact	Participant looks up/at the examiner and fixates on the examiners eyes or face.	.69
Point	The participant spontaneously points/reaches (arm is stretched out with the index finger outstretched or an open reach point) to an object or activity in order to express interest, get help or a request.	.64
Give	The participant hands an object to the examiner in order to share, to get help or as part of a routine (includes <i>spontaneously</i> putting toys in box packing the toys away- not if in direct response to request).	.65
Show	The participant brings objects to the examiner or places an object in front of the examiner for the purpose of showing. There is no other clear motivation for showing the object such as asking for help or making a request.	.47
Communication skills domain:		
Communicative vocalisations	Vocalization or verbalization where no particular word is clearly heard but where the participant demonstrates clear communicative intent to indicate that they want something or need something or are trying to be friendly. The vocalization is neither positive nor negative.	.64
Verbalisation	Intelligible words, phrases or sentences.	.71
Gesture	Participant spontaneously uses a descriptive (describes an action such as brushing teeth), conventional (waving, nodding, shaking head, shrugging), emphatic gesture. This code is not used for Makaton or BSL signs.	.59
Sign	Participant spontaneously uses Makaton or BSL signs for the purpose of communicating (i.e. to get help, make a request or to comment on an object or activity). Do not include any stereotyped hand movements.	.66
Spontaneous social approach domain:		
Approach examiner	The participant spontaneously moves towards the examiner designated for the session for the purpose of social interaction, requesting and object or to get help.	.49
Touch	The participant deliberately touches the adult with any part of their body e.g. taking the adult's hand, sitting on the adults lap. This must be initiated by the participant and not the examiner.	.74
Positive affect domain:		
Positive Affect	The participant demonstrates a positive facial expression, for example laughing or smiling. Facial expression must clearly indicate expression of pleasure in activity or conversation. Facial expression may or may not be directed towards the examiner.	.68
Positive vocalisation	The participant engages in non-speech sounds which may or may not be for the purpose of communication but which clearly indicate that the person is experiencing enjoyment or pleasure in an activity or object e.g. laughing or squealing.	.77
Joint play domain:		
Functional play with adult	The participant engages in play with the toys alongside or in response to the adult play for the purpose of functional play. The participant uses the object as it is intended and for the appropriate purpose (e.g. building a tower with the examiner, helping to set out a tea party with the examiner, closing the pop up that the examiner has opened).	.51

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Social play with adult.	The participant engages in joint social play with the adult. Social play includes activities such as the peek-a-boo game, tickling games or any games requiring turn taking with the adult such as rolling the ball back and forth. Participant must actively engage in the activity with the examiner or demonstrate clear enjoyment (by laughing and smiling) in the joint activity and a desire to continue the play (by requesting the activity again) even if they do not actively take part (by engaging in turn taking).	.42
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Table 4: Subscale, total scores and percentage of participants meeting cut off scores on the Social Communication Questionnaire:

		CdLS	CdCS	AS	F/χ^2	p	Post hoc
ASD cut off	% (N)	100 (13)	53.3 (8)	93.3 (14)	12.18	.002	CdLS,AS>CdCS
Autism cut off		46.2 (6)	13.3 (2)	40.0 (6)	4.00	.14	-
SCQ Total	Mean (SD) Range	21.62 (4.44) 15.00-31.00	16.65 (5.86) 10.00-30.00	19.61 (5.41) 6.00-27.00	3.12	.06	-
<i>Communication</i>		5.54 (1.81) 1.00-7.00	4.53 (1.81) 2.00-8.00	5.61 (1.82) 1.00-7.58	1.62	.21	-
<i>Social Interaction</i>		9.46 (3.62) 2.00-15.00	6.25 (3.35) 1.00-15.00	7.53 (2.95) 1.00-13.00	3.31	.04	CdLS>CdCS
<i>Repetitive Behavior</i>		4.69 (1.84) 1.00-7.00	3.82 (5.86) .00-7.00	4.8 (5.41) 1.00-7.00	1.30	.28	-

Table 5: Correlations between CSRS scores, frequency of behavioral responses and SCQ total score

	AS	CdCS	CdLS
Total SCQ score			
CSRS scores			
<i>Interaction with Familiar Adult</i>			
Positive Affect	-.20	-.31	-.59*
Physical Contact	.01	.28	-.20
Social Responsiveness	-.15	-.76**	-.73**
Spontaneous Initiation	-.27	-.48	-.62*
Focus of Attention	-.30	-.32	-.43
Motivation for Adult	.01	-.21	-.48
Eye Contact	.01	-.63**	-.61*
Social Communication	.27	-.43	-.46
<i>Interaction with Unfamiliar Adult</i>			
Positive Affect	-.31	.50	-.39
Physical Contact	.49	.50	-.47
Social Responsiveness	-.17	-.63**	-.56*
Spontaneous Initiation	-.10	-.11	-.59*
Focus of Attention	-.16	-.20	-.67**
Motivation for Adult	.16	.22	-.58*
Eye Contact	-.38	-.30	-.64*
Social Communication	.30	-.26	-.65*
Real time observations			
<i>Interaction with Familiar Adult</i>			
Social interaction skills	-.27	-.10	-.52
Communication skills*	-.16	-.51	-.57*
Spontaneous social approach	-.58*	.35	.17
Positive affect	.13	-.17	-.67**
Joint play	-.27	-.42	-.54
<i>Interaction with Unfamiliar Adult</i>			
Social interaction skills	-.2	-.16	-.59*
Communication skills*	-.02	-.37	-.37
Spontaneous social approach	.34	.28	-.32
Positive affect	.02	.41	-.46
Joint play	.19	-.51	-.54

CSRS scores and real time frequencies are summed across conditions

* $p < .05$

** $p \leq .01$