Social perception in children born at very low birthweight and its relationship with social/behavioral outcomes

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Background: Research has shown that children born very prematurely are at substantially elevated risk for social and behavioral difficulties similar to those seen in full-term children with autism spectrum disorders (ASDs). **Methods:** To gain insight into core deficits that may underlie these difficulties, in this study, we assessed the social perceptual skills of 8- to 11-year-old children born at very low birthweight (VLBW) (<1,500 g) and age-matched, full-term controls, using the Child and Adolescent Social Perception Measure. We also assessed social and behavioral outcomes with two parent-report measures used in ASD screening. **Results:** Children in the preterm group had normal range estimated verbal IQ. However, we found that they were impaired in their ability to use nonverbal cues from moving faces and bodies, and situational cues, to correctly identify the emotions of characters depicted in videotaped social interactions. Their performance on this task was related to the number of 'autistic-like' traits they displayed. **Conclusions:** This research highlights links between social perceptual deficits and poor social and behavioral outcomes in children born very prematurely. The results also suggest that even those who have escaped major intellectual/language problems are at risk for social and behavioral problems that can be of clinical concern. **Keywords:** Prematurity, low birthweight, autism spectrum disorder, social perception, social cognition.

Introduction

Children born very prematurely are at risk for peer rejection and low self-esteem (Rickards, Kelly, Doyle, & Callanan, 2001), and for psychiatric symptoms and disorders associated with inattention, anxiety, and social difficulties (Aarnoudse-Moens, Weisglas-Kuperus, van Goudoever, & Oosterlaan, 2009; Bhutta, Cleves, Casey, Cradock, & Anand, 2002; Dahl et al., 2006; Johnson, 2007). Of great concern is the fact that these children are also at substantially elevated risk of screening positive for (Kuban et al., 2009; Limperopoulos et al., 2008; Moore, Johnson, Hennessy, & Marlow, 2012), and being diagnosed with (Johnson et al., 2010; Pinto-Martin et al., 2011), an autism spectrum disorder (ASD). The 'autistic phenotype' of preterm children, however, is thought to represent a milder form of the disorder than that seen in full-term children (Indredavik, Vik, Skranes, & Brubakk, 2008), and to arise from a different causative pathway – one that is nongenetic and stems from brain injuries and altered neurodevelopment associated with very premature birth (Johnson & Marlow, 2011; Limperopoulos, 2009).

It is important for researchers, clinicians, and educators to understand the core deficits that underlie the social difficulties, and other 'autistic-like' symptoms, displayed by certain preterm children. Some argue that internalizing and behav-

ioral problems such as excessive shyness or withdrawal (Hille et al., 2008; Nadeau, Boivin, Tessier, Lefebvre, & Robaey, 2001), or externalizing problems such as inattentiveness and impulsivity (Elgen, Sommerfelt, & Markestad, 2002), underlie many of the problems that preterm children have in establishing and/or maintaining social contacts. Others have suggested that impaired social perception plays an important role (Indredavik et al., 2008). Of course, these possibilities are not mutually exclusive. This study explores problems with social perception in children born prematurely at very low birthweight (VLBW; <1,500 g) and how these relate to symptoms associated with ASDs.

Social perception refers to the initial stage where information needed to assess another person's mental state or intentions is received, processed, and interpreted (Allison, Puce, & McCarthy, 2000). It involves the ability to selectively attend to and extract those verbal and nonverbal social cues most relevant in the current situation. Several recent studies suggest that children born very prematurely are at risk for problems with social perception and cognition. For example, work carried out in several laboratories has shown that these children have impaired ability to process biological motion (Pavlova et al., 2005; Taylor, Jakobson, Lewis, & Maurer, 2009; Williamson, 2014) – a skill widely considered a hallmark of social cognition (Pavlova, 2012). Recently, Pavlova, Sokolov, Birbaumer, and Krageloh-Mann (2008) reported that preterm children with periventricular leukomalacia show impaired ability to infer the intentions of others in social interactions, as measured by the Event

Conflict of interest statement: No conflicts declared.

Arrangement task. Complementing this study, we have shown that VLBW children underattribute intentionality to shapes that move in ways that typical viewers describe using mental state words (e.g., one triangle 'coaxing' the other), and that performance on this test of social attribution ability is related to the number of 'autistic-like' traits parents attribute to their children (Williamson & Jakobson, in press).

Recently, Wocadlo and Rieger (2006) found that VLBW children had problems recognizing facial expressions, and that these problems were linked to poor social skills. Two major limitations of this study were the absence of a full-term control group, and the use of static photographs as opposed to more naturalistic, dynamic displays. To address these limitations, in this study, we assessed the social perceptual skills of well-matched samples of preterm and full-term children using the Child and Adolescent Social Perception Measure (CASP; Magill-Evans, Koning, Cameron-Sadava, & Manyk, 1995) – a test in which children are shown videotaped vignettes of realistic social interactions and are then asked to identify the emotions of the characters, and describe the nonverbal cues that convey these emotions.

In addition to testing children on the CASP, we also collected data using two parent-rating forms: the Autism Quotient – Child Version (AQ; Auyeung, Baron-Cohen, Wheelwright, & Allison, 2008) and the Behavior Assessment System for Children – Second Edition (BASC-2; Reynolds & Kamphaus, 2004). The *total score* from the AQ and the *Developmental Social Disorder content score* from the BASC-2 were used to provide two measures of the number of 'autistic-like' traits each child displays. While the traits sampled in these questionnaires are ones that are represented in the general population, it is unusual for a neurotypical individual to display a large number of them. Indeed, as outlined below, cut-scores have been identified for both measures that distinguish typically developing individuals from those with ASDs with a high degree of accuracy – validating their use in ASD screening, and as part of more comprehensive diagnostic assessments (Auyeung et al., 2008; Volker et al., 2010). Our goal in collecting these data was to allow us to explore links between social perceptual

deficits (as measured with the CASP) and the presence of social difficulties and other 'autistic-like' traits in children born very prematurely.

Methods
Participants

Preterm participants were recruited through the High-Risk Newborn Follow-Up Programs at Children's Hospital and at St. Boniface Hospital (both in Winnipeg, MB, Canada). Letters outlining the general nature of the study were sent to all children born at VLBW who were between the ages of 8–11 years, with the exception of those having a history of major sensory impairment (e.g., blindness or deafness) and/or ventriculo-peritoneal shunting for posthemorrhagic hydrocephalus. Parents and children who indicated a willingness to participate were then contacted and an appointment was set up for testing. At the beginning of the testing session, parental consent was obtained to access potentially relevant medical variables from neonatal/follow-up medical records. None of the 35 preterm children who agreed to participate were subsequently excluded on the basis of their performance on our screening tests (see below). However, one child (the only participant with a fetal alcohol spectrum disorder diagnosis) was unable to complete the test battery due to pronounced attentional problems and, as such, his data were not included in the data analysis. This left a final sample of 34 preterm children. Details of their early medical histories are provided in Table 1. Two of the children had mild spastic diplegia, but this did not interfere with their ability to complete the tests in the present battery.

A comparison sample of 36 full-term children was recruited through elementary schools and the community, and through word-of-mouth. They were born within 2 weeks of their due date, without medical complications, and at an appropriate size for their gestational age, and had no known history of developmental problems. In Table 2, we present demographic information and screening test results for both the preterm and the full-term samples.

General procedure

A parent of each child provided informed written consent and the child provided verbal assent for participation. Each parent then completed a general information questionnaire and two questionnaires designed to assess social and behavioral outcomes in children, as described below. Each child completed a series of screening tests, the CASP, and several other tests used for separate purposes. All tests were administered individually in a quiet room. The research protocol was approved by the Human Research Ethics Board of the University of Manitoba.

Table 1 Medical variables describing the preterm sample

Continuous Variables	Mean	SD	Minimum	Maximum
Birthweight (g)	1,080.8	247.0	600	1,467
Gestational age (weeks)	28.3	2.3	25	33
Apgar at 5 min	7.4	1.3	4	9
Days on supplemental oxygen	38.5	35.1	0	103
Days on mechanical ventilation	15.4	18.0	0	61
Days in hospital	71.6	27.6	30	128

Dichotomous variables	Negative history	Positive history	Comments
Retinopathy of prematurity	10	20	4 missing data
Bronchopulmonary dysplasia	19	15	Diagnosed at 28 days
Intraventricular hemorrhage	21	13	8 mild (grades 1–2); 5 severe (grades 3–4)
Periventricular leukomalacia	32	2	

Table 2 Demographic and screening measures for the full-term and preterm samples

	Full-term children (FT) $n = 36$		Preterm children (PT) $n = 34$	
Age (years: months)	10:2 (*SD* 14.7 months), range of 8:1–11:11		10:0 (*SD* 15.0 months), range of 8:0–11:9	
Gender distribution	17 Female:19 Male		18 Female:16 Male	
Handedness	5 Left: 31 Right		4 Left:30 Right	
Parental education (median/mode)	Partial or completed college/ university or specialized training		Partial college/university or specialized training	
Family income (median/mode)	Over CAD $75,000		Over CAD $75,000	
Cancelation (time in s)	37.6 (*SD* 16.6)		37.3 (*SD* 14.7)	
Cancelation (errors)	0.8 (*SD* 1.1)		1.4 *(SD* 1.4)	
PPVT-4 (standard score)[a]	112.5 (*SD* 11.2)		108.4 (*SD* 12.3)	
Visual acuity	20/20: 33	20/25: 2	20/20: 28	20/25: 4
	20/50: 0	20/63: 1	20/50: 1	20/63: 1
Binocular fusion	34 Passed; 2 Failed		32 Passed; 2 Failed	
Stereoacuity	34 Passed; 2 Failed		31 Passed; 3 Failed	

[a]Age-corrected standard scores on the Peabody Picture Vocabulary Test, 4th edition were used to estimate verbal intelligence; see *Intellectual screening* and *Results* sections for further details.

Demographic and screening measures

General information questionnaire. A parent of each child completed a questionnaire regarding the child's early developmental history, and demographic variables such as parental education and family income that have been linked to cognitive development in preterm children (Braid, Donohue, & Strobino, 2012; Sommerfelt, Ellertsen, & Markestad, 1995; Voss, Jungmann, Wachtendorf, & Neubauer, 2012).

Visual screening. All participating children completed three visual screening measures, which were administered and scored according to standard procedures, using established cut-offs (see Kniestedt & Stamper, 2003; Taylor et al., 2009). Linear acuity was measured with the Lighthouse Distance Acuity Chart (Lighthouse International, New York, NY, USA), binocular fusion was measured with the Worth 4 Dot Test (Richmond Products, Albuquerque, NM, USA), and stereoacuity was measured with the Titmus Test of Stereoacuity (Stereo Optical Company, Chicago, IL, USA).

Letter cancellation task (Geldmacher, 1996). Visual attention and processing speed were assessed using a letter cancellation task. In this task, the child was asked to cross out all 20 instances of a target letter 'X' in an array of 100 letters. The time taken to complete the task (in s) and the number of errors were recorded.

Intellectual screening. The Peabody Picture Vocabulary Test – Fourth Edition (PPVT-4; Dunn & Dunn, 2007) was administered to each child to estimate verbal intelligence. This allowed us to determine whether any difficulties experienced by the preterm children on the experimental tasks could be attributed to a general cognitive delay. Standard administration and scoring procedures were followed. Raw scores were converted to standard scores ($M = 100$, $SD = 15$) based on published age norms; when making this conversion, the child's age was not corrected for prematurity.

Experimental measures

Child and adolescent social perception measure. The CASP has good internal consistency, test–retest reliability, and inter-rater reliability (Magill-Evans et al.,

1995). It consists of 10-videotaped scenes depicting children, adolescents, and adults in typical social interactions. Each scene is audio-filtered, rendering the verbal content unintelligible, but preserving vocal tone and prosodic features. Scenes last from 19 to 40 s, with a mean length of 29 s.

The CASP was administered and scored according to the standard procedure, and the time taken to complete the task was recorded for each child. After viewing each scene, the child was asked to describe what happened, the feelings of each character, and how they knew how each character was feeling. Verbal responses were recorded and scored off-line by the primary researcher and two independent raters who were blinded to group membership; final scores were reached through consensus. The *emotion score* provides a measure of the participant's ability to identify and label the emotions displayed by each character. For each emotion identified by the viewer, a *nonverbal cues score* is derived based on the participant's ability to identify specific face, body, situational, and voice cues that could be used to determine the character's emotional state. Face cues include facial expressions, such as smiling. Body cues include hand gestures and other body movements. Situational cues include aspects of the situation that would be expected to affect the character's emotional state (e.g., he is happy *because his mom gave him a gift*). Voice cues include changes in tone, inflection, or rhythm. For purposes of this study, we generated a subscore for each type of nonverbal cue. Each subscore was expressed as a percentage of the maximum score possible for that cue, to allow for direct comparison across cue types.

We also developed a new measure to assess incidental recall of nonsocial information presented visually in the scenes: the incidental memory score. This was scored off-line and, as such, the collection of these data did not in any way interfere with the standard administration of the CASP. Participants were awarded one point if their verbal description specified the correct number of characters in the scene, and one point for correctly specifying the location in which the scene took place. They could also receive from 3 to 8 additional points (depending on the scene) for including in their descriptions correct details about a character's clothing or appearance, or about specific objects in the environment. The maximum possible score was 76.

Social and behavioral outcomes. Social and behavioral outcomes were assessed using two psychometrically sound, parent-rating scales: the Behavior Assessment System

for Children – Second Edition (BASC-2; Reynolds & Kamphaus, 2004) and the Autism Quotient – Child Version (AQ; Auyeung et al., 2008).

The BASC-2 (parent form) includes 160 items, each rated using a four-point Likert scale. Through standard scoring, one derives four *composite index scores* (externalizing problems, internalizing problems, overall behavioral symptoms, and adaptive skills), six *behavioral content scores*, and one *adaptive content score*. For purposes of this study, we focused on the developmental social disorder (DSD) content score, which measures deficits in social skills, communication, interests and activities that are associated with ASDs (Reynolds & Kamphaus, 2004; Volker et al., 2010). Raw DSD scores were converted to age-sex standardized T scores ($M = 50$, $SD = 10$) using published norms. *Clinically significant* T scores are defined as scores ≥70, whereas *at-risk* T scores are defined as 60–69. Using a cut-score of 60, Volker et al. accurately identified 98% of the students in their sample with Asperger Syndrome/high functioning autism (AS/HFA) and accurately screened out 95% of those who were typically developing.

The AQ is a 50-item, parent-report questionnaire designed to measure autistic-like traits in children ages 4–11 years. Ten items relate to functioning in each of five areas: social skills, attention switching, attention to detail, communication, and imagination. Each item is rated on a four-point scale, with full endorsement of all autistic-like traits resulting in a maximum score of 150. We categorized children scoring 76 and higher as falling in the *clinically significant* range, and those with scores of 66–75 as falling in the *at-risk* range. Using the cut-score of 66, Auyeung et al. (2008) accurately identified 98.9% of children with AS/HFA and accurately screened out 90.3% of controls.

Results

As can be seen in Table 2, the preterm and full-term samples were comparable in terms of age-in-months (independent samples *t*-test, $p = .49$) and had similar handedness and gender distributions, parental education levels, and family incomes (χ^2 tests, $p > .24$). It is important to note, however, that the majority of children in each sample were right handed, came from families in the higher income brackets, and had relatively well-educated parents. These factors precluded the possibility of carrying out supplementary analyses involving these variables and may limit the generalizability of some of the findings.

Preterm and full-term children obtained comparable scores on the cancellation task (measuring visual information processing speed/attention), and the PPVT-4 (used to estimate verbal intelligence) (independent samples *t*-tests, $p > .06$). With one exception, all children in the preterm sample obtained standard scores on the PPVT-4 that fell in the average range or above (89–141); the exception was one child who obtained a standard score of 78.

Preterm and full-term children had low and comparable rates of problems (5.6%–8.8%) with binocular fusion and stereoacuity (χ^2 tests, $p > .59$). Visual acuity was also comparable in the two groups (χ^2 test, $p = .30$), being 20/25 or better in 97% of participating children. The remaining 3% of participants (one preterm and one full-term child) had visual acuity of 20/63 or better, which is considered

adequate for neuropsychological testing (Capruso, Hamsher, & Benton, 1995; Norman, Payton, Long, & Hawkes, 2004).

Child and adolescent social perception measure

The groups did not differ in incidental memory scores [$t(68) = -1.35$, $p = .18$], but full-term children took slightly longer to complete the CASP than preterm children [$t(68) = -2.03$, $p = .046$]. As both measures were positively correlated with emotion scores and with nonverbal subscores for body, voice and situational cue identification ($.28 \leq r \leq .48$, $p < .01$ in all cases), both variables were included as covariates in subsequent analyses.

A univariate analysis of covariance (ANCOVA) performed on the CASP emotion scores produced a significant main effect of Group [$F(1, 66) = 9.41$, $p = .003$, $\eta^2 = .13$], with full-term children outperforming preterm children [$M_{\text{full-term}} = 36.8$, $SEM = 1.5$; $M_{\text{preterm}} = 30.2$, $SEM = 1.5$]. This group difference remained significant when PPVT-4 standard scores were entered as a third covariate. Age (in months) was positively correlated with performance in both groups ($r > .64$, $p < .001$, in both cases).

The percentage of nonverbal cues of each type that were correctly identified by participants was entered into a 2 (Group: Preterm, Full-term) × 4 (Cue Type: Face, Body, Situational, Voice) mixed ANCOVA. Significant main effects of Group [$F(1, 66) = 14.08$, $p < .001$, $\eta^2 = .18$] and Cue Type [$F(3, 198) = 9.36$, $p < .001$, $\eta^2 = .12$] were observed, with full-term children outperforming preterm children, and participants being most accurate at identifying available situational cues, followed by face, voice, and body cues, in that order ($p < .001$ for all comparisons). These main effects had to be interpreted in light of a significant Group × Cue Type interaction [$F(3, 198) = 2.89$, $p < .05$, $\eta^2 = .04$] (see Figure 1). Follow-up tests confirmed that, after controlling for administration time and incidental memory, full-term children correctly identified significantly more face, body, and situational cues than preterm children ($p < .01$, in all cases), but the groups did not differ in their ability to identify voice cues. Adding PPVT-4 standard scores as an additional covariate did not change these results. In both groups, the ability to recognize all four cue types improved with age ($r > .34$, $p < .05$).

BASC-2

Preterm children were rated by parents as displaying significantly more symptoms of developmental social disorder than their full-term peers [$t(68) = 2.30$, $p < .05$; $M_{\text{preterm}} = 52.5$, $SEM = 2$ vs. $M_{\text{full-term}} = 47.2$, $SEM = 1.3$], but the mean score of the preterm group was much lower than that reported previously for children/youth with AS/HFA ($M = 74.1$, $SEM = 1.04$; Volker et al., 2010). Having said that,
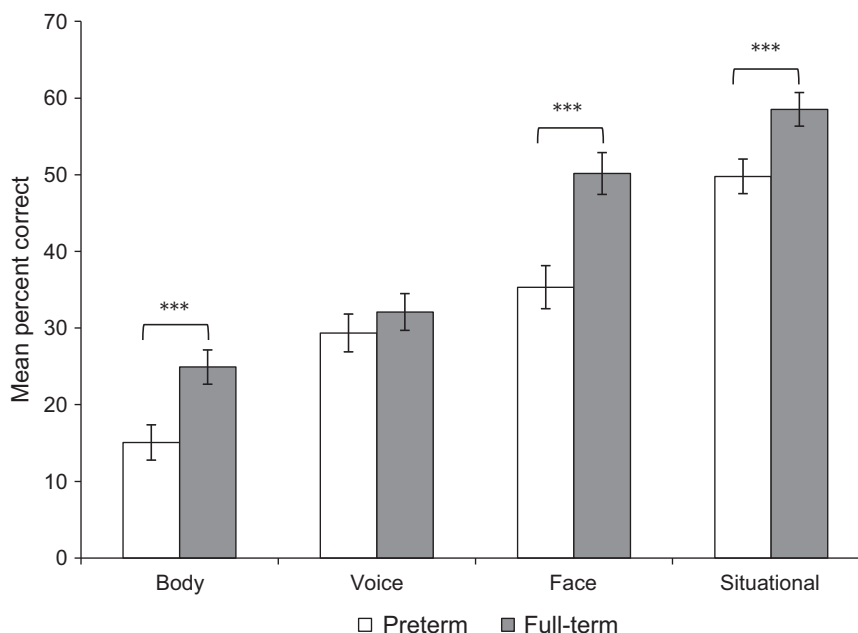
Figure 1 Mean percent correct for each type of nonverbal cue in the CASP (*SEM* indicated), displayed as a function of group membership. Follow-up tests showed group differences in the correct identification of face, body, and situational nonverbal cues, with full-term children outperforming preterm children. *** Group difference significant at the 0.001 level

preterm children did show higher rates of impairment than full-term peers [$\chi^2(2) = 8.95$, $p = .01$], with 9 of 34 preterm children (vs. 1 of 36 full-term controls) obtaining a score that fell above the cut-score of 60 recommended by Volker et al. (2010). The mean score for this subgroup ($M = 68.3$, $SEM = 2.3$) was comparable to that of Volker et al.'s AS/HFA group.

Autism quotient

The mean AQ total score for children in the preterm sample was significantly higher than that of full-term controls [$t(68) = 2.06$, $p < .05$; $M_{\text{preterm}} = 60.3$, $SEM = 2.3$ and $M_{\text{full-term}} = 53.8$, $SEM = 2.3$], yet still well below the mean value reported by Auyeung et al. (2008) for children with AS/HFA ($M = 104.8$, $SEM = 0.84$). Nonetheless, twice as many preterm children (35.3% vs. 16.7% of controls) scored in the *at-risk/clinically significant* range specified by these researchers. Although in the expected direction, the group difference in distribution of scores was not statistically significant [$\chi^2(1) = 3.28$, $p > .05$], and the mean score of those preterm children who scored above the cut-score of 66 ($M = 75.8$, $SEM = 2.1$) still fell well below that of children with an AS/HFA diagnosis.

The AQ samples traits in five different domains. To determine if the mildly elevated scores we observed in our preterm sample were primarily attributable to problems in a particular area of functioning, we submitted subscores from the AQ to a 2 (Group: Preterm, Full-term) × 5 (Domain: social skills, attention switching, attention to detail, communication, and imagination) ANOVA. This analysis produced main effects of Group [$F(1, 68) = 4.23$,

$p < .05$, $\eta^2 = .06$] and Domain [$F(4, 272) = 78.36$, $p < .001$, $\eta^2 = .54$], and a significant Group × Domain interaction [$F(4,272) = 3.42$, $p = .01$, $\eta^2 = .05$]. Post hoc tests performed on the interaction confirmed that (a) both preterm and full-term children showed more problems in attention switching and attention to detail than in other areas; and (b) group differences were especially evident in the areas of imagination and communication (group comparisons, $p < .02$), followed by social skills (group comparison, $p = .07$). In the Auyeung et al. (2008) study, the AS/HFA group received significantly higher ratings than controls on all five subscales. In this study, preterm children who scored above the cut-score of 66 ($n = 12$) had mean subscale scores that were higher than controls' on four of the five subscales (independent samples t-tests, $p < .001$ in all cases), the exception being attention to detail. While elevated relative to controls, their scores on these subscales were still below those of children with AS/HFA.

Relationships between variables

Table 3 presents relationships between parent-report measures and CASP scores, in full-term and preterm children. In both groups, AQ total and DSD content scores were strongly correlated with one another; indeed, all children who scored above the cut-off on the DSD also scored above the cut-off on the AQ. In full-term children, elevated AQ and DSD scores were most strongly associated with problems with the identification of body cues. In contrast, in preterm children, elevated AQ and DSD scores were especially evident in those who could most *accurately* identify

Table 3 Relationships among AQ, DSD, and CASP scores in full-term and preterm children

	DSD	Emotion	Face	Body	Situation	Voice
Full-term						
AQ	0.61***	−0.31*	−0.14	−0.38*	−0.11	−0.22
DSD	–	−0.14	0.11	−0.35*	−0.20	−0.31*
Emotion		–	0.28	0.51***	0.39*	0.30*
Face			–	−0.03	0.17	−0.07
Body				–	0.36*	0.37*
Situation					–	−0.01
Preterm						
AQ	0.75***	−0.05	−0.25	0.02	**0.45****	−0.06
DSD	–	−0.03	−0.25	0.04	**0.43****	0.07
Emotion		–	0.25	0.43**	0.38*	0.41*
Face			–	0.16	−0.13	0.17
Body				–	0.18	0.36*
Situation					–	0.24

Notes: Correlations with CASP measures control for age-in-months, administration time, and incidental memory score. Bold values denote significant difference between groups, $p < .05$. AQ, Autism Quotient total score; DSD, developmental social disorder content score.
*$p < .05$; **$p < .01$; ***$p < .001$.

situational cues. These findings raise the possibility that social difficulties in preterm children arise, in part, because – given their impaired ability to decipher face and body cues – they rely too heavily on situational cues to interpret social interactions. This can create difficulty if another person's reaction to a given situation is unexpected; for example, if someone gets a birthday present, but finds it disappointing. While this interpretation is intriguing, it is important to note that the correlations between CASP scores and measures of 'autistic-like' traits reported in Table 3 are generally weak or moderate in strength. We return to this point in the Discussion.

Medical risk factors

Preterm children with a positive history of broncho-pulmonary dysplasia had higher AQ scores than those without such a history [$t(32) = −2.26$, $p = .03$]. After controlling for age-in-months, administration time, and incidental memory, children with a positive history of retinopathy of prematurity performed more poorly than those without on the CASP emotion and nonverbal situational subscores [$F (1, 25) > 4.34$, $p < .05$ in both cases]. Although no differences in performance were seen in subgroups

defined by the presence/absence of abnormality in brain imaging, it is important to note that only neonatal cranial ultrasound scans were available. It is difficult to detect subtle signs of white matter damage using this technology (e.g., Woodward, Anderson, Austin, Howard, & Inder, 2006). This, coupled with our relatively small sample size (and the even smaller number of preterm children who scored above the cut-scores), may have made it difficult to detect any relationship that is present. In a recent study involving a large cohort of low birthweight children, Movsas et al. (2013) reported that those showing evidence of white matter injury (but not isolated germinal matrix/intraventricular hemorrhage) were at increased risk of screening positive for, or being diagnosed with, an ASD.

Table 4 presents correlations between test scores and continuous medical variables. Lower Apgar scores at 5 min were associated with higher (i.e., more problematic) DSD scores on the BASC-2. After controlling for age-in-months, administration time, and incidental memory, CASP emotion scores and nonverbal face and body subscores were significantly correlated with several of the continuous medical variables, with children at higher medical risk performing more poorly.

Table 4 Relationships between medical risk variables and performance in the preterm sample

	Birthweight	Gestational Age (wks)	Apgar (5 min)	Days on oxygen	Days on ventilation	Length of hospital stay
Emotion	0.303*	0.379*	0.453**	−0.518***	−0.434**	−0.481**
Face	0.019	0.109	0.324*	−0.411**	−0.281	−0.280
Body	0.266	0.459**	0.052	−0.285	−0.238	−0.400**
Situational	0.140	0.214	−0.113	−0.049	−0.133	−0.174
Voice	0.046	0.278	0.264	−0.087	−0.266	−0.229
AQ	0.178	−0.128	−0.139	0.169	−0.082	0.104
DSD	0.117	−0.040	−0.291*	0.055	−0.111	0.014

Notes: Emotion, Face, Body, Situational, and Voice scores are from the CASP; AQ, AQ total score; DSD, Developmental Social Disorder content score from the BASC-2. Correlations with CASP measures control for age-in-months, administration time, and incidental memory score.
*$p < .05$; **$p < .01$; ***$p < .001$.

Discussion

A key finding from this study was that VLBW preterm children – even those who have escaped major language/intellectual impairments – experience problems with social perception as measured by the CASP. Specifically, they have difficulty interpreting the emotions of others correctly, due largely to a failure to identify key nonverbal cues (from facial and body movements, and situational cues) that could be used to make these determinations. These problems are of clinical concern as they are likely to play a significant role in the social difficulties that this group is known to be at risk for (e.g., Aarnoudse-Moens et al., 2009; Bhutta et al., 2002; Dahl et al., 2006; Johnson, 2007).

Preterm children's poor performance on the CASP could not be attributed to demographic factors such as gender, family income, or parental education, as preterm and full-term groups were matched on these variables. Interestingly, preterm children showed intact ability to identify nonverbal *vocal* (prosodic) cues, suggesting that their difficulties primarily reflected a visual processing deficit. It will be important to test this in future work by comparing preterm children's performance with visually and verbally presented social vignettes. By controlling for individual differences in incidental memory and administration time, we were able to show that the problems preterm children experienced did not arise from general difficulties recalling visual details about the scenes. We argue, instead, that they reflect an underlying problem with the visual processing of 'life motion,' broadly defined. This interpretation gains support from findings of several other studies we have conducted with this same group of children, showing that they also have difficulty processing biological motion stimuli (Williamson, 2014), and analyzing and interpreting 'animate motion' displays like those used by Abell, Happé, and Frith (2000); see Williamson and Jakobson (in press).

Although preterm children performed worse than controls on the CASP, both groups did show age-related improvement in performance. Based on this study, it is not clear whether social perception skills might plateau earlier in preterm children than in full-term peers (which would mean that deficits would persist), or whether they show a developmental lag (which might suggest that catch-up would still be possible). Additional research, utilizing more age-sensitive measures of social perceptual function, and longitudinal research designs are needed to shed light on this issue.

Like the preterm children tested here, adolescents with AS/HFA show impaired performance on the CASP (Koning & Magill-Evans, 2001; Semrud-Clikeman, Walkowiak, Wilkinson, & Minne, 2010). However, whether difficulties with social perception arise for the *same reasons* in these two groups is not clear. Some tentative support for this proposal comes from the fact that, as a group, children in the preterm sample showed more 'autistic-like' traits than their peers on two measures that have shown good sensitivity and specificity for ASDs, and performance on the CASP was related to the presence of these traits. Despite this, the relationships between these variables were weak-to-moderate, with several preterm children who scored below the cut-offs on the DSD or the AQ nonetheless experiencing difficulties processing and interpreting nonverbal social cues. This suggests that problems with 'life motion' perception may represent a distinct deficit that is not related to ASD, *per se*, but could contribute to social difficulties/poor socialization and, as such, be expected to inflate scores on ASD screening instruments.

Many recent reports have shown that preterm children are at high risk for screening positive for (Kuban et al., 2009; Limperopoulos et al., 2008; Moore et al., 2012) or being diagnosed with (Johnson et al., 2010; Pinto-Martin et al., 2011) an ASD. Future research aimed at uncovering *why* this is the case is essential. Studies directly comparing the neuropsychological and social/emotional/behavioral profiles of preterm children who meet strict diagnostic criteria for ASD to those of full-term children with this diagnosis will be particularly helpful in this regard. One aim of this research should be to determine the role that associated factors such as internalizing or externalizing problems might play in the social difficulties that many preterm children experience. In the present report, we found that even those preterm children who received *at-risk/clinically significant* ratings on the AQ-Child scored well below those with AS/HFA who took part in a large-scale study conducted by Auyeung et al. (2008). However, like those children, the preterm children in our sample showed elevated scores across multiple domains (communication, imagination, social skills, and attention switching). These findings support the suggestion that the 'autistic-like' phenotype of preterm children represents a milder form of the disorder than that seen in full-term children (Indredavik et al., 2008). Support for the idea that this phenotype is associated with brain damage or altered neurodevelopment associated with preterm birth (Johnson & Marlow, 2011; Limperopoulos, 2009) comes from the relationships we observed between several medical risk factors and both social perceptual deficits and high scores on the AQ/DSD. Additional support comes from recent findings that white matter damage is a strong predictor of screening positive for, or being diagnosed with, an ASD in individuals born at low birthweight (Movsas et al., 2013). Future studies using larger samples of preterm children, and more sophisticated structural and functional neuroimaging techniques, will help to shed additional light on the neural bases of the social difficulties experienced by preterm children.

Limitations

There are a number of limitations of this study. First, our study sample was small, and it is possible that our recruitment process created some selection bias. Second, there was an over-representation of children with relatively well-educated parents from the higher income brackets. Given these factors, it is important to try to replicate the present results in larger samples that are representative of the entire cohort of surviving VLBW children.

A third limitation of this study concerns the selection of some of the research instruments. We used the PPVT-4 to estimate verbal IQ, and the AQ-Child and the BASC-2 to quantify the number of 'autistic-like' traits in study participants. Clearly, it would have been preferable to conduct a more thorough assessment of intellectual and language functions in our study participants. It would also have been beneficial to complete a comprehensive, diagnostic work-up on those children who obtained high DSD and/or AQ scores, given that elevations of these scores could be associated with poor socialization, or with a number of childhood conditions (other than ASD) that are characterized by deficits in social cognition. Nonetheless, the present results are intriguing and suggest several avenues for future research.

Conclusion

The results of this study demonstrate that children born prematurely at VLBW have difficulty decoding the emotions of individuals engaged in naturalistic (dynamic) social interactions. This difficulty arises primarily from problems processing nonverbal cues from moving faces and bodies, and situational cues. Precisely how/if these problems contribute to, or exacerbate, emotional and behavioral problems (such as anxiety, excessive shyness, or withdrawal) remains to be seen. Further work exploring the links between problems in social perception and the 'autistic-like' preterm phenotype is warranted. In addition, however, the present results underscore the importance of performing comprehensive assessments even in those survivors of very preterm birth who are experiencing social difficulties but who have escaped major impairments, are functioning in the normal range intellectually, and do *not* meet criteria for an ASD diagnosis.

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Key Points

- VLBW children are at high risk for screening positive for, or being diagnosed with, an autism spectrum disorder (ASD).
- We show that even those without major cognitive/language impairment have difficulty using cues from moving faces and bodies, and nonverbal situational cues, to identify the emotions of individuals engaged in naturalistic social interactions.
- Links between the ability to process these cues and "autistic-like" traits were demonstrated.
- Given their problems with social perception, VLBW children may rely too heavily on situational cues to interpret social interactions. This could create difficulties when others' responses to a given situation are unexpected.
- Clinicians should routinely screen for problems with social perception and poor social/emotional/behavioral outcomes in this high-risk population.

References

Aarnoudse-Moens, C.S.H., Weisglas-Kuperus, N., van Goudoever, J.B., & Oosterlaan, J. (2009). Meta-analysis of neurobehavioral outcomes in very preterm and/or very low birth weight children. *Pediatrics*, *124*, 717–728.

Abell, F., Happé, F., & Frith, U. (2000). Do triangles play tricks? Attribution of mental states to animated shapes in normal and abnormal development. *Cognitive Development*, *15*, 1–16.

Allison, T., Puce, A., & McCarthy, G. (2000). Social perception from visual cues: Role of the STS region. *Trends in Cognitive Sciences*, *4*, 267–278.

Auyeung, B., Baron-Cohen, S., Wheelwright, S., & Allison, C. (2008). The autism spectrum quotient: Children's version (AQ-Child). *Journal of Autism and Developmental Disorders*, *38*, 1230–1240.

Bhutta, A.T., Cleves, M.A., Casey, P.H., Cradock, M.M., & Anand, K.J. (2002). Cognitive and behavioural outcomes of

school-aged children who were born preterm: A meta-analysis. *Journal of the American Medical Association*, 288, 728–737.

Braid, S., Donohue, P.K., & Strobino, D.M. (2012). The impact of wealth on the cognitive development of children who were preterm infants. *Advances in Neonatal Care*, 2, 225–231.

Capruso, D.X., Hamsher, K. deS., & Benton, A.L. (1995). Assessment of visuocognitive processes. In R.L. Mapou, & J. Spector (Eds.), *Clinical neuropsychological assessment: A cognitive approach* (pp. 137–169). Plenum Press, New York.

Dahl, L.B., Kaaresen, P.I., Tunby, J., Handegard, B.H., Kvernmo, S., & Ronning, J.A. (2006). Emotional, behavioral, social and academic outcomes in adolescents born with very low birth weight. *Pediatrics*, 118, e449–e459.

Dunn, L.M., & Dunn, D.M. (2007). *Peabody Picture Vocabulary Test*, 4th edn. Bloomington, MN: Pearson Assessments.

Elgen, I., Sommerfelt, K., & Markestad, T. (2002). Population based, controlled study of behavioural problems and psychiatric disorders in low birthweight children at 11 years of age. *Archives of Disease in Childhood-Fetal and Neonatal Edition*, 87, F128–F132.

Geldmacher, D.S. (1996). Effects of stimulus number and target-to-distractor ratio on the performance of random array letter cancellation tasks. *Brain and Cognition*, 32, 405–415.

Hille, E., Dorrepaal, C., Perenboom, R., Gravenhorst, J.B., Brand, R., & Verloove-Vanhorick, S.P. (2008). Social lifestyle, risk-taking behavior, and psychopathology in young adults born very preterm or with a very low birthweight. *The Journal of Pediatrics*, 152, 793–800.

Indredavik, M.S., Vik, T., Skranes, J., & Brubakk, A.M. (2008). Positive screening results for autism in ex-preterm infants. *Pediatrics*, 122, 222.

Johnson, S. (2007). Cognitive and behavioural outcomes following very preterm birth. *Seminars in Fetal and Neonatal Medicine*, 12, 363–373.

Johnson, S., Hollis, C., Kochhar, P., Hennessy, E., Wolke, D., & Marlow, N. (2010). Autism spectrum disorders in extremely preterm children. *The Journal of Pediatrics*, 156, 519–521.

Johnson, S., & Marlow, N. (2011). Preterm birth and childhood psychiatric disorders. *Pediatric Research*, 69, 11R–18R.

Kniestedt, C., & Stamper, R.L. (2003). Visual acuity and its measurement. *Ophthalmology Clinics of North America*, 16, 155–170.

Koning, C., & Magill-Evans, J. (2001). Social and language skills in adolescent boys with Asperger syndrome. *Autism*, 5, 23–36.

Kuban, K.C.K., O'Shea, M., Allred, E.N., Tager-Flusberg, H., Goldstein, D.J., & Leviton, A. (2009). Positive screening on the modified checklist for autism in toddlers (M-CHAT) in extremely low gestational age newborns. *The Journal of Pediatrics*, 154, 535–540.

Limperopoulos, C. (2009). Autism spectrum disorders in survivors of extreme prematurity. *Clinics in Perinatology*, 36, 792–805.

Limperopoulos, C., Bassan, H., Sullivan, N.R., Soul, J.S., Robertson, R.L., Moore, M., ... & du Plessis, A.J. (2008). Positive screening for autism in ex-preterm infants: Prevalence and risk factors. *Pediatrics*, 121, 758–768.

Magill-Evans, J., Koning, C., Cameron-Sadava, A., & Manyk, K. (1995). The child and adolescent social perception measure. *Journal of Nonverbal Behaviour*, 19, 151–169.

Moore, T., Johnson, S., Hennessy, E., & Marlow, N. (2012). Screening for autism in extremely preterm infants: Problems for interpretation. *Developmental Medicine and Child Neurology*, 54, 514–520.

Movsas, T.Z., Pinto-Martin, J.A., Whitaker, A.H., Feldman, J.F., Lorenz, J.M., Korzeniewski, S.J., ... & Paneth, N. (2013). Autism spectrum disorder is associated with ventricular enlargement in a low birth weight population. *Journal of Pediatrics*, 163, 73–78.

Nadeau, L., Boivin, M., Tessier, R., Lefebvre, F., & Robaey, P. (2001). Mediators of behavioral problems in 7-year-old children born after 24 to 28 weeks of gestation. *Journal of Developmental & Behavioral Pediatrics*, 22, 1–10.

Norman, J.F., Payton, S.M., Long, J.R., & Hawkes, L.M. (2004). Aging and the perception of biological motion. *Psychology and Aging*, 19, 219.

Pavlova, M.A. (2012). Biological motion processing as a hallmark of social cognition. *Cerebral Cortex*, 22, 981–995.

Pavlova, M., Sokolov, A.N., Birbaumer, N., & Krageloh-Mann, I. (2008). Perception and understanding of others' actions and brain connectivity. *Journal of Cognitive Neuroscience*, 20, 494–504.

Pavlova, M., Sokolov, A., Staudt, M., Marconato, F., Birbaumer, N., & Krageloh-Mann, I. (2005). Recruitment of periventricular parietal regions in processing cluttered point-light biological motion. *Cerebral Cortex*, 15, 594–601.

Pinto-Martin, J.A., Levy, S.E., Feldman, J.F., Lorenz, J.M., Paneth, N., & Whitaker, A.H. (2011). Prevalence of autism spectrum disorder in adolescents born weighing < 2000 grams. *Pediatrics*, 128, 883–891.

Reynolds, C.R., & Kamphaus, R.W. (2004). *Behavior assessment system for children manual*, 2nd edn. Circle Pines, MN: American Guidance Service.

Rickards, A.L., Kelly, E.A., Doyle, L.W., & Callanan, C. (2001). Cognition, academic progress, behavior and self-concept at 14-years of very low birth weight children. *Journal of Developmental & Behavioral Pediatrics*, 22, 11–18.

Semrud-Clikeman, M., Walkowiak, J., Wilkinson, A., & Minne, E.P. (2010). Direct and indirect measures of social perception, behavior, and emotional functioning in children with Asperger's disorder, nonverbal learning disability, or ADHD. *Journal of Abnormal Child Psychology*, 38, 509–519.

Sommerfelt, K., Ellertsen, B., & Markestad, T. (1995). Parental factors in cognitive outcome of non-handicapped low birthweight infants. *Archives of Diseases in Childhood: Fetal and Neonatal Edition*, 73, F135–F142.

Taylor, N.M., Jakobson, L.S., Lewis, D., & Maurer, T.L. (2009). Differential vulnerability of global motion, global form, and biological motion processing in full-term and preterm children. *Neuropsychologia*, 47, 2766–2778.

Volker, M.A., Lopata, C., Smerbeck, A.M., Knoll, V.A., Thomeer, M.L., Toomey, J.A., & Rodgers, J.D. (2010). BASC-2 PRS profiles for students with high-functioning autism spectrum disorders. *Journal of Autism and Developmental Disorders*, 40, 188–199.

Voss, W., Jungmann, T., Wachtendorf, M., & Neubauer, A. (2012). Long-term cognitive outcomes of extremely low-birth-weight infants: The influence of the maternal educational background. *Acta Paediatrica*, 101, 569–573.

Williamson, K.E. (2014). Social cognition and social outcomes in children born very prematurely. (Unpublished doctoral dissertation). University of Manitoba, Winnipeg MB Canada.

Williamson, K.E., & Jakobson, L.S. (in press). Social attribution skills of children born preterm at very low birth weight. *Development and Psychopathology*.

Wocadlo, C., & Rieger, I. (2006). Social skills and nonverbal decoding of emotions in very preterm children at early school age. *European Journal of Developmental Psychology*, 3, 48–70.

Woodward, L.J., Anderson, P.J., Austin, N.C., Howard, K., & Inder, T.E. (2006). Neonatal MRI to predict neurodevelopmental outcomes in preterm infants. *New England Journal of Medicine*, 355, 685–694.