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What do home videos tell us about early motor and socio-communicative behaviours in children with autistic features during the second year of life – an exploratory study

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Abstract

Background—Little is known about the first half year of life of individuals later diagnosed with autism spectrum disorders (ASD). There is even a complete lack of observations on the first 6 months of life of individuals with transient autistic behaviours who improved in their socio-communicative functions in the pre-school age.

Aim—To compare early development of individuals with transient autistic behaviours and those later diagnosed with ASD.

Study design—Exploratory study; retrospective home video analysis.

Subjects—18 males, videoed between birth and the age of 6 months (ten individuals later diagnosed with ASD; eight individuals who lost their autistic behaviours after the age of 3 and achieved age-adequate communicative abilities, albeit often accompanied by tics and attention deficit).

Method—The detailed video analysis focused on general movements (GMs), the concurrent motor repertoire, eye contact, responsive smiling, and pre-speech vocalisations.

Results—Abnormal GMs were observed more frequently in infants later diagnosed with ASD, whereas all but one infant with transient autistic behaviours had normal GMs ($p < 0.05$). Eye contact and responsive smiling were inconspicuous for all individuals. Cooing was not observable in six individuals across both groups.

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Conflict of interest

None to declare.

Conclusions—GMs might be one of the markers which could assist the earlier identification of ASD. We recommend to implement the GM assessment in prospective studies on ASD.

Keywords

Autism spectrum disorder; cooing; early signs; eye contact; fidgety movements; general movements; home video analysis; responsive smiling; Tourette syndrome

1 Introduction

Delay in motor and/or speech-language development is often the first sign to raise parental and professional concerns, leading to further clinical examinations and assessments. In rare occasions, children may fail to progress after a period of relatively normal development or may even lose acquired functions (regression). A typical example is Rett syndrome (RTT), where regression usually occurs between 6 and 18 months of age, may last for several months and is followed by a developmental plateau and a late deterioration stage [1]. Home video analysis of the prodromal period in RTT, previously considered inconspicuous, has demonstrated abnormalities in early spontaneous movements [2,3]. These findings contributed to our growing knowledge of the natural history of RTT, suggesting that the corresponding genetic mutations (*MECP2* in 95–97%; [1]) are operant before birth. The most frequently occurring pattern of early spontaneous movements are the so-called general movements (GMs). GMs are spontaneously generated by so-called central pattern generators that are most probably located in the brain stem and are modulated by more rostral parts of the brain [4,5]. Hadders-Algra proposed that the most important features of GMs, complexity and variation, are generated by the cortical subplate [6]. GMs can be observed from 9 weeks' gestation until 5 months after term, and their quality is considered one of the most reliable indicators for (dys)function of the developing nervous system [4–7].

Regression occurs in every third individual with autism spectrum disorder (ASD) [8]. Parental reports, retrospective video analyses, and prospective studies of infants at high risk revealed that individuals with ASD already had a number of more or less subtle atypicalities in their pre-regressional motor and socio-communicative behaviours (for a recent review, see [9]). Among the atypicalities observed as early as the first half year of life were postural asymmetries while lying [10,11], head lag during the pull-to-sit transition [12], fluctuating muscle tone [13], oral-motor abnormalities [14], and abnormalities in GMs (for a recent review, see [15]).

Such early observations are lacking for a subgroup of toddlers with transient autistic behaviours during the second year of life. After several months or even years, they lose their autistic behaviours, and eventually acquire age-adequate communicative and cognitive abilities, albeit often accompanied by tics and/or attention deficit [16–23]. To shed light on the early development of these individuals (i.e. from birth to 6 months), we collected family videos and compared early behaviours of individuals with such transient autistic behaviours with observations of infants later diagnosed with ASD. Our exploratory study focused on the following developmental areas: (a) GMs, (b) the concurrent motor repertoire, (c) eye contact and responsive smiling, and (d) pre-speech vocalisations.

2 Methods

2.1 Participants

Videos of 34 individuals (born in Italy between 2004 and 2010) who experienced autistic behaviours during their second year of life were donated by families for the assessment of movements, posture and socio-communicative behaviour during the first 6 months of life. This material had been recorded by the families as part of their family archive without knowing that the child might eventually develop an adverse neurodevelopmental outcome. All parents reported the development within the first year of life as normal. For this study we had a footage of 18 male individuals at hand that contained sufficient recordings performed during the first half a year of life. All boys had been born at term with an appropriate birth weight. Table 1 provides the age at the onset of autistic behaviours and the further neuropsychiatric development. Ten children (Cases 9 to 18) were diagnosed with ASD at an age between 3;6 and 7;1 (years;months). Cases 1 to 8 showed no autistic behaviours after age 3. Seven individuals with transient autistic behaviours were later diagnosed with Tourette syndrome (TS) (Cases 2 to 8); TS also occurred as a co-morbidity in four individuals later diagnosed with ASD (Cases 9, 10, 11, 18). Attention deficit hyperactivity disorder (ADHD) was found in five individuals with transient autistic behaviours (Cases 2, 4, 5, 7, 8), and occurred as a co-morbidity to ASD in Cases 9, 10, 11, 13 and 17. Case 1 showed no psychiatric disorder at his last examination at age 7;4. (Table 1)

The parents of the study cases gave their informed consent for participation in the study and publication of the results. The Institutional Review Board of the Medical University of Graz approved the method of retrospective video analyses.

2.2 Data analysis

Video sequences that were suitable for analysis (314 minutes in total; duration per infant for the 1- and 2-month analysis: median = 7 minutes [IQ: 6 to 11 minutes]; for the 3- and 4-month analysis: median = 4 minutes [IQ: 3 to 7 minutes]; and, for the 5- and 6-month analysis: median = 6 minutes [IQ: 4 to 11 minutes]) included the following settings: the infant in supine and prone position, held semi-upright by the caregiver or in a relaxing chair, sitting with or without support, feeding, and bathing (Table 2). The videos were analysed by three scorers (C.E., K.D.B., P.B.M.) who did not know the further development of the infants.

Apart from age-specific swiping and wiggling-oscillating arm movements, kicking, movements towards the midline and antigravity movements [24], we assessed the age-specific GMs. GMs have a writhing character during the first 2 months after term, and a fidgety character thereafter. Writhing GMs comprise the entire body and manifest themselves in a variable sequence of arm, leg, neck and trunk movements. They come and go gradually, varying in intensity and speed. Rotations and frequent slight variations of the direction in motion make them appear complex and smooth [4]. Abnormal writhing movements are classified as (a) poor repertoire GMs, whereby the sequence of movement components is monotonous and the amplitude, speed and intensity lack the normal variability; or (b) cramped-synchronised GMs which lack the usual smoothness and fluent

character, appearing rigid as the limb and trunk muscles contract almost simultaneously and relax almost simultaneously [4]. Fidgety GMs (observable from 3 to 5 months and sometimes even a few weeks longer) are small movements of the neck, trunk and limbs in all directions and of variable acceleration. Fidgety movements of an abnormal quality are exaggerated in amplitude, speed and jerkiness [4,7]. The absence of fidgety movements at 3 to 5 months is indicative of an adverse outcome and is typically related to the development of severe neurological deficits [e.g., 4,7,25,26].

As it is impossible to evaluate muscle tone from a video, we concentrated on sequences in which postural stiffness or a slumped posture occurred. Postural stiffness referred to e.g. a resting posture with extended legs lifted from the surface, or hyperextension of the trunk/neck. A slumped posture mainly referred to poor head control either in prone position (head could not be lifted) or in a semi-upright position (head needed to be supported by the caregiver even at 4 to 6 months of age); “head lag” was noted when head retroflexion occurred when the caregiver pulled the infant from lying to a (semi)upright position.

Eye contact was scored as present if the infant and the caregiver looked at each other’s eyes at the same time. Responsive smiling was scored as present if the infant answered a smile immediately after the caregiver initiated social contact. Vocalisations were classified as crying, fussing, unspecific vocalisations (basic sounds or vowel-like sounds), pleasure vocalisations and laughter, or cooing (i.e. vocalisations of melodic modulated character) [27,28].

Separate scoring resulted in substantial to almost perfect inter-scorer agreements. Cohen’s Kappa ranged from $K = 0.69$ (for vocalizations) to $K = 0.96$ (for GMs). Video clips causing disagreement were discussed together until final agreement was reached.

2.3 Statistics

Statistical analysis was performed using SPSS package for Windows, version 22.0 (SPSS Inc., Chicago, IL). Due to the small sample size, we used Fisher’s Exact Test to evaluate associations between the nominal data. Throughout the analyses, $p < 0.05$ (two-tailed) was considered to be statistically significant.

3 Results

Cases 3, 10 and 17 did not demonstrate abnormal signs, although their recordings did not allow a full assessment (Tables 2 and 3). In all other 15 cases, a series of abnormal signs was observed during the first 6 months of life.

3.1 General movements

GMs could be assessed in 14 infants (Table 3). With the exception of Case 9, all infants with normal GMs had transient autistic behaviours. Case 9 was diagnosed with high functioning autism (Table 1). With the exception of Case 6, all infants with abnormal GMs were later diagnosed with ASD. Hence, abnormal GMs were significantly more likely to precede ASD diagnosis, whereas normal GMs occurred more often in infants whose autistic behaviours were transient ($p < 0.05$, Table 4).

Within the first 2 months of life, three out of five infants later diagnosed with ASD (and with assessable recordings) had abnormal poor repertoire GMs. Fidgety GMs were abnormal in five out of six infants later diagnosed with ASD (with assessable recordings; Table 3). Cases 13, 14, 15, and 16 had abnormal fidgety movements, i.e. exaggerated in amplitude, speed and jerkiness. Case 12 had monotonous and slow fidgety-like movements.

Case 6, who was later diagnosed with TS, had also abnormal fidgety movements. Case 9, with high functioning autism, had consistently normal GMs. All other individuals whose autistic behaviours were transient but who developed ADHD and/or TS (Table 1), and Case 1 with a normal outcome, had normal GMs (Table 3).

3.2 The concurrent motor repertoire (aside from GMs)

Irrespective of their later diagnosis, the majority of infants demonstrated a number of age-adequate movement patterns such as kicking, swiping and wiggling-oscillating arm movements, reaching and grasping, transferring an object, hand(s) to midline, antigravity movements, sitting with support and sitting alone. Despite achieving these motor milestones, six infants (three of them with a later diagnosis of ASD) had tremulous arm movements (small amplitude, high frequency; uni- or bilateral), independent of crying or excitement. The overall movement character was monotonous in six infants with later ASD diagnosis and in Case 7, who was later diagnosed with TS and ADHD (Table 3). Case 13 (later diagnosed with ASD) displayed long-lasting tongue protrusion at 4 months, which could not be observed at 5 and 6 months.

Postural stiffness was observed in four infants (Table 3), including Case 1 with a normal outcome. A slumped posture and/or even head lag could be observed in six infants; four of them were later diagnosed with ASD (Table 3). Please note that “head lag” refers to pulling-to-sit or pulling-to-a (semi)upright position carried out by the caregiver and not to a standardised manoeuvre during a neurological examination.

3.3 Eye contact and responsive smiling

All infants showed long lasting eye contact. Cases 11 and 14 (both with ASD diagnosis) occasionally did not show eye contact although frequently called or touched by the caregiver(s). Both of them, however, demonstrated normal eye contact during other sequences (Table 3).

Responsive smiling was also observed in all infants, regardless of their further development. While Case 13 did not smile at 4 months, although the care-giver tried to elicit it, he did show nice social smiling at 5 and 6 months (Table 3).

3.4 Pre-speech vocalisations

Twelve infants demonstrated normal age-specific vocalisations, especially cooing and pleasure vocalisations. In the remaining six infants (three of them later diagnosed with ASD), cooing did not evolve during the first 6 months. Their vocalisations remained unspecific and hardly modulated (Table 3).

4 Discussion

Until now, the early development of individuals with transient autistic behaviours during the second year of life has been described as normal [16]. This is the first study to shed light on the first 6 months of children affected in such a way, though only in a small number of cases. Their early socio-communicative development assessed on the basis of eye contact and responsive smiling was indeed inconspicuous. Cooing, however, was not observable in three out of eight individuals with transient autistic behaviours. Concerning their early motor development, we observed postural stiffness in another three infants, sometimes coinciding with tremulous arm movements, whereas age-specific motor patterns including fidgety movements were normal in all but one of them (Tables 3 and 4). Only Case 6 had abnormal fidgety movements, an overall tremulous movement character, and hardly modulated vocalisations at 5 to 6 months (Table 3).

4.1 General movements

Abnormal GMs were the only sign clearly distinguishing between individuals with and without a later diagnosis of ASD following autistic behaviours during the second year of life (Table 4). Seven out of eight individuals whose autistic behaviours were transient had shown normal GMs, although Case 1 was the only participant without psychiatric or neurological diagnosis.

In total, 11 individuals were diagnosed with TS, four of them with co-morbid ASD. In three infants (Cases 3, 7, 10) GM assessment could not be performed as none of the video clips provided an adequate setting (i.e. infant in supine, trunk and limbs observable [4]). Of the remaining eight individuals, five had normal writhing and fidgety GMs. The question as to whether these findings indicate that TS, which most likely involves cortical-striatal-thalamo-cortical pathways and their numerous neurotransmitters [29], does obviously not have an early onset, has to remain open. The sample is far too small to draw general conclusions.

Several individuals had ADHD as a co-morbidity (Table 1). GMs were normal in those individuals whose autistic behaviours were transient. This supports previous studies, which were also unable to identify an increased risk for ADHD on the basis of GM assessment [30–32]. Cases 11 and 13 (with ADHD as a co-morbidity to ASD) had abnormal GMs, which also corresponds to previous findings demonstrating that abnormal GMs were related to ADHD accompanied by other psychiatric disorders [30].

The GM assessment revealed clear findings in individuals diagnosed with ASD: abnormal monotonous (i.e. poor repertoire) writhing GMs were followed by abnormal monotonous fidgety movements in all but one infant with assessable video recordings. This observation confirms previous reports [32–34]. Only the infant who was later diagnosed with high-functioning autism showed normal GMs (Table 2). Poor repertoire GMs is a rather unspecific abnormal motor pattern, which can be also observed in individuals who will develop e.g. poorer eye-hand coordination [35], poorer cognition [36], or even dyskinetic cerebral palsy [37]. Fast and exaggerated fidgety movements or monotonously slow fidgety movements with a higher amplitude, however, seem to be more specifically related to ASD [15,32–34].

4.2 The concurrent motor repertoire (aside from GMs)

The majority of our study cases (irrespective of their later diagnosis) achieved early motor milestones such as hand(s) to midline, reaching and grasping, transferring an object, or sitting. However, six infants attracted attention by demonstrating tremulous arm movements; some of them even up to 6 months of age (Cases 6, 15; Table 3). A similar observation was made in a 3-month-old boy later diagnosed with ASD [13], and also in 1- to 6-month-old females later diagnosed with RTT [2]. In that study, tremulous arm movements were associated with postural stiffness [2], which could also be observed in the present study. In their case study of a boy later diagnosed with ASD, Dawson and colleagues described excessive muscle tone, especially in the extremities at 4 months [13].

Six infants with a later ASD diagnosis were conspicuous because of their monotonous movement character. To our knowledge, this is the first description of monotonous repetitive movements (in infants later diagnosed with ASD) at such an early age. The observation of a slumped posture including head lag in our sample supports previous reports on early signs of ASD [e.g., 11,12]. Previously documented oral-motor abnormalities [14] might be seen in Case 13, who demonstrated frequent and long-lasting tongue protrusion.

4.3 Eye contact and responsive smiling

Deficits in eye contact are a hallmark of autism [38–40]. Our results, however, showed inconspicuous eye contact and inconspicuous responsive smiling in all individuals, irrespective of their later diagnosis. This is in line with the report of a normal socio-communicative behaviour during a neurological examination of a 2.5-month-old infant who later developed ASD [13]. However, neither a neurological examination nor family recordings allow for the evaluation of (a) the duration of eye contact (as the videos might be discontinuing) or (b) preferential looking.

In their experimental study, Jones and Klin [39] showed that infants later diagnosed with ASD started eye fixation at a level similar to typically developing children. From the second month onwards, however, eye fixation declined steadily during the first 6 months of life, arriving at a level that was approximately half of that seen in typically developing children by the 24-month endpoint. Although their results demonstrated the earliest indicators of atypical socio-communicative development, they also showed that eye looking was present in those early months [39]. Other experimental studies (applying e.g. eye-tracking or event related potentials) revealed that 6-month-old infants later diagnosed with ASD spent, for example, less time looking into the face of a female in a social setting [41,42].

4.4 Pre-speech vocalisations

Several authors have suggested that it is not eye contact or smiling alone that is impaired but their combination in communication that is deficient [9,43,44]. Recently, Patten and colleagues [45] reported that canonical babbling was not age-adequately developed in 9- to 12-month-old individuals later diagnosed with ASD; particularly canonical syllable volubility was lower compared to typically developing infants. Such findings raised the question as to if and when early vocal patterns may prove a useful component for screening. In our study, 12 out of 18 infants had normal age-adequate vocalisations during the first 6

months. However, three infants later diagnosed with ASD and another three infants with transient autistic behaviours had not developed cooing until 5 to 6 months (Table 3). Their vocalisations were hardly modulated and similar to those typically observed around 2 months of age. Atypical vocalisations during the first year of life and even the lack of cooing was also described for females with RTT [46–48] and its variants [49], as well as for 18- to 24-month-olds with ASD [50,51]. Zwaigenbaum and colleagues [44] described parental observations that 6-month-old infants (later diagnosed with ASD) vocalised less than typically developing infants. By contrast, Dawson and colleagues described in their aforementioned case study of an infant later diagnosed with ASD that “he made a lot of vocalizations during play and responded to social interaction from adults by smiling and cooing” at 4 months ([13], page 301). Although Kanner [38] described autism as a disorder that is apparent at birth, autism is nowadays seen as a spectrum with an individual-specific and gradual course of onset that might explain the inconsistencies of early findings.

4.5 Limitations

We are aware of several limitations to our study. Apart from the small sample size, we had to deal with a sample selection bias as the footage of our retrospective study stems from families with a personal relationship to the first author. We need to interpret our results on a cautionary note as our sample might not be representative for the population of toddlers with autistic behaviours. In addition, the number of videos suitable for analysis did not permit us to analyse all behaviours for each infant. To reliably assess GMs, for example, one needs a video recording of an infant in supine with all limbs observable [4]. Such recordings were not available for all infants (Table 3, indicated with ~). A limitation for all studies based on home videos [52] is that they have different contents; they are discontinuous, and they mainly reflect situations that the parents would like to keep as pleasant memories. Nevertheless, some conspicuous behaviours or even signs – either unrecognized by parents, or which they believe to be harmless – do not escape the eye of the camera.

5 Conclusion

The majority of our participants who lost their autistic behaviours after the age of 3 and achieved age-adequate communicative abilities had an inconspicuous early development. By contrast, GMs, which are known to be an early marker for the (dis)integrity of the developing nervous system [e.g., 4,7,25,26], were abnormal in all but one individual later diagnosed with ASD; the exception was the participant diagnosed with high-functioning autism. Pre-speech vocalisations did not differentiate between the two groups. Social reciprocity, assessed through eye contact and responsive smiling, was likewise inconspicuous in all individuals. We therefore recommend the implementation of the GM assessment in larger scale studies, and also in prospective studies in infants at risk for ASD.

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Ethical statement

The parents of the study cases gave their informed consent for participation in the study and publication of the results. The Institutional Review Board of the Medical University of Graz approved the method of retrospective video analyses.

Highlights

- 7/8 individuals with autism had abnormal general movements in early infancy.
- 5/6 individuals with transient autistic behaviour had normal general movements.
- Global observation indicated typical eye contact and smiling in infants with autism spectrum disorder.

Table 1

Age and examination at the onset of autistic behaviours, and further neuropsychiatric development of our sample (n=18)

Case [*]	Age at the onset of autistic behaviours in months	Examination at the age of onset	Age at the last examination in years;months	ASD according to the last clinical examination	Cognitive status at the last clinical examination ^c	Tourette Syndrome	ADHD
1	18	Clin Eval ^b	7;4	-, CARS=15	normal	-	-
2	18	ABC=47	9;7	-, CARS=18	normal	+	+
3	18	ADOS=8	7;0	-, CARS=15.5	normal	+(f)	-
4	18	CARS=34	4;9	-, CARS=25	- 2 SD	+	+
5	18	Clin Eval ^b	9;0	-, CARS=15	- 1 SD	+	+
6	18	Clin Eval ^b	6;9	-, ABC=3	- 1 SD	+	-
7	20	CARS=33	5;9	-, CARS=16	normal	+(f)	+
8	24	ADOS=20	10;0	-, CARS=17	normal	+	+
18	14	Clin Eval ^b	4;6	+, ASD ^b	- 1 SD	+	-
10	15	CARS=36	7;1	+, ASD ^b	- 1 SD	+(f)	+
12	18	CARS=44.5	6;4	+, ADOS=19	normal	-	-
9	18	ADOS=10	7;1	+, HFA	normal	+	+
14	18	ADOS=20	3;10	+, ASD ^b	not testable	-	-
15	20	Clin Eval ^b	3;10	+, CARS=41	- 1 SD	-	-
11	12-24 ^a	CARS=37	7;0	+, ABC=48	- 2 SD	+(f)	+
13	12-24 ^a	Clin Eval ^b	4;3	+, ASD ^b	normal	-	+
16	12-24 ^a	Clin Eval ^b	3;6	+, ASD ^b	- 1 SD	-	-
17	12-24 ^a	CARS=32.5	5;10	+, ADOS=18	not testable	-	+

^{*} cases are rank-ordered within each group according to the age at the onset of autistic behaviours^a during the second year of life, no further specification^b clinical evaluation according to the ICD-10 criteria for autism spectrum disorders^c according to the Wechsler Intelligence Scale for Children (WISC-III), Leiter Scale, or Wechsler Preschool and Primary Scale of Intelligence (WPPSI).

Key: ADHD = attention deficit hyperactivity disorder; ABC = Autistic Behaviour Checklist; ADOS = Autistic Diagnostic Observation Schedule, subcategory communication and interaction (cut-off value = 6); ASD = autism spectrum disorders; CARS = Childhood Autism Rating Scale; HFA = high functioning autism; SD = standard deviation; + = present; - = absent; (f) = familial

Table 2

Conditions (position of the infant, presence/absence of the caregiver) and duration (in minutes) of home video recordings for each individual according to the three age-groups

Case ^d	1 st and 2 nd Months			3 rd and 4 th Months			5 th and 6 th Months		
	Position of the infant	Caregiver	Recording time ^a	Position of the infant	Caregiver	Recording time ^b	Position of the infant	Caregiver	Recording time ^d
1	semi-upright, ^c supine	present absent	2:00 3:00	supine supine	present absent	2:30 1:00	semi-upright supine	present absent	1:00 1:00
2	semi-upright supine	present present	45:00 12:00	supine supine	present absent	1:00 1:00	semi-upright supine	present present	6:00 6:00
3	supine	absent	5:00	semi-upright	present	1:00	supine	absent	3:00
4	semi-upright	present	4:30	supine	present	2:00			
5	supine	present	6:30	supine	present	1:00			
				supine	absent	2:00			
6							sitting	present	7:00
							semi-upright	present	7:00
							semi-upright	absent	1:00
							supine	present	4:00
							supine	absent	1:00
							semi-upright	present	2:30
							supine	absent	1:30
7	semi-upright supine	present present	4:00 2:00	supine	present	3:00			
8	semi-upright supine	present absent	4:00 2:30				semi-upright supine	present absent	7:30 1:30
18	semi-upright supine	present present	5:00 2:00	semi-upright	present	2:00	semi-upright	present	2:00
10	semi-upright	present	6:00	semi-upright	present	7:00	semi-upright	present	5:00
12				semi-upright	present	3:30	semi-upright	present	4:00
				supine	absent	1:30			
9	semi-upright	present	3:30	semi-upright	present	4:00	semi-upright	present	16:30

Case ^a	1 st and 2 nd Months			3 rd and 4 th Months			5 th and 6 th Months		
	Position of the infant	Caregiver	Recording time ^a	Position of the infant	Caregiver	Recording time ^b	Position of the infant	Caregiver	Recording time ^a
14	supine	absent	2:30	supine	present	1:30	supine	absent	1:30
	semi-upright	present	2:00	supine	absent	1:30			
	lateral	present	1:00	semi-upright	present	2:00	supine	present	1:00
15	supine	absent	1:00	supine	absent	1:30	supine	absent	2:00
	semi-upright	present	10:00	semi-upright	present	3:30	supine	present	4:30
	semi-upright	absent	1:00	semi-upright	absent	2:00	supine	absent	2:00
11	semi-upright	present	10:00	supine	absent	3:00			
	supine	absent	2:00	semi-upright	present	1:00	sitting	present	4:00
13	supine	present	7:00	supine	present	2:30			
				semi-upright	present	5:00	semi-upright	present	4:00
16				supine	present	2:00	supine	present	1:00
				supine	absent	2:00	supine	absent	2:00
				semi-upright	present	2:00			
17				supine	absent	1:00			
							sitting	present	3:00
							sitting	absent	2:30
							prone	absent	2:30

^a cases are in the same order as in Table 1

^b rounded off or up

^c semi-upright refers to being held by the caregiver or being in a relaxing chair.

Table 3

Behavioural phenotypes in our sample (n=18) during their first 6 months of life. Cases 9 to 18 were later diagnosed with ASD (for details on the outcome, see Table 1; cases are in the same order as in Table 1).

Case	General movements			Concurrent motor repertoire			Posture and tone			Eye contact			Responsive smiling			Pre-speech vocalisations		
	1-2	3-4	5-6	1-2	3-4	5-6	1-2	3-4	5-6	1-2	3-4	5-6	1-2	3-4	5-6	1-2	3-4	5-6
	mo	mo	mo	mo	mo	mo	mo	mo	mo	mo	mo	mo	mo	mo	mo	mo	mo	mo
1	N	N	N	N	N	N	stiff	N	stiff	N	N	N	N	N	N	N	N	N
2	N	N	N	N	N	N	HL	N	N	N	N	N	N	N	N	N	N	N
3	~	~	---	---	N	---	---	N	---	N	---	N	---	N	---	N	---	---
4	N	N	---	TR	N	---	stiff	N	---	N	---	N	---	N	---	N	---	---
5	---	---	N	---	---	N	---	---	N	---	N	---	N	---	N	---	---	unsp
6	---	---	AF	---	---	TR	---	---	N	---	N	---	N	---	N	---	---	unsp
7	~	~	---	TR	---	---	HL	stiff	N	~	---	---	---	---	---	---	---	---
8	N	---	N	N	---	N	N	---	N	~	---	N	---	---	N	---	---	unsp
18	PR	~	~	TR	~	N	N	N	N	N	N	N	N	N	N	N	unsp	unsp
10	~	~	~	~	N	~	N	N	N	N	N	N	N	N	N	N	N	N
12	---	A*	~	---	mon	N	---	N	N	---	N	---	N	N	N	N	unsp	unsp
9	N	N	N	TR	N	N	stiff	N	N	N	N	N	N	N	N	N	N	N
14	PR	AF	AF	mon	mon	mon	HL	N	N	no	N	N	N	N	N	~	N	N
15	N	AF	AF	N	mon	mon	~	SP	N	N	N	N	N	N	~	N	unsp	unsp
11	PR	~	~	mon	~	mon	HL	N	N	N	N	N	N	N	N	N	N	~
13	~	AF	AF	N	mon	N	~	N	N	N	N	N	N	N	N	N	N	N
16	---	AF	---	---	mon	---	---	HL	---	N	---	---	N	---	---	N	---	---
17	---	---	~	---	---	N	---	---	N	---	N	---	N	---	N	---	---	N

Key: ~ = the video recording did not allow an adequate assessment; --- = no recording available; A = abnormal; AF = abnormal fidgety movements; HL = head lag; mon = monotonous; N = normal, age-adequate; SP = slumped posture; PR = poor repertoire general movements; TP = tongue protrusion; TR = tremulous arm movements; unsp = unspecific (hardly modulated) vocalisation, not (yet) cooing; * fidgety-like movements are too monotonous and too slow.

Table 4

Number of infants/sample with normal motor and socio-communicative behaviours during the first half year of life according to their later neuropsychiatric diagnosis

Autistic behaviours during the second year of life			
	Transient (Details: Table 1) n=8	Later diagnosed with ASD n=10	p-Value ^a
General movements	5/6 ^b	1/8 ^b	0.026
Concurrent motor repertoire	5/8	2/10	0.145
Posture	4/8	5/10	1.000
Eye contact	8/8	10/10	n.a.
Responsive smiling	7/7 ^b	10/10	n.a.
Pre-speech vocalisations	5/8	7/10	1.000

^aFisher's Exact Test

^bthe assessment of a certain behavior was not possible for all individuals.

Key: ASD = autism spectrum disorders; n.a. = not applicable.