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ORIGINAL CONTRIBUTION

Latent class analysis reveals five homogeneous behavioural and developmental profiles in a large Dutch population sample of infants aged 14–15 months

Esmé Möricke · G. A. Martijn Lappenschaar · Sophie H. N. Swinkels · Nanda N. J. Rommelse · Jan K. Buitelaar

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Abstract Precursors of child psychiatric disorders are often present in infancy, but little is known about the prevalence and course of general psychopathology in population-based samples of children 0–3 years. We examined whether homogeneous behavioural and developmental profiles could be identified in children aged 14–15 months ($M = 14.84$; SD = 2.19), and we explored whether or not these profiles corresponded with existing classifications of DSM-IV-TR, ICD-10, and DC 0–3R. Parents of 6,330 children answered 74 items about externalizing, internalizing, and social-communicative behaviour. Exploratory factor analysis revealed nine factors: deviant communication, negative emotionality, deviant reactive behaviour, deviant play behaviour, demanding behaviour, social anxiety/inhibition, advanced social interaction problems, basic social interaction problems, and sleep problems. Latent class analysis yielded five profiles, of which three were associated with increased behavioural and developmental problems. Some infants (5.7 %) had communication and social interaction problems corresponding to multisystem developmental disorders (DC 0–3R) and suggestive of anxiety, mood, or pervasive developmental disorders (DSM-IV-TR, ICD-10). Other infants (16.4 %) had communication problems, possibly precursors of communication, language, or speech disorders (DSM-IV-TR, ICD-10). Yet other infants (10.8 %) showed negative and demanding behaviour suggestive of regulation disorders (DC 0–3R), attention-deficit and disruptive behaviour disorders (DSM-IV-TR), or hyperkinetic and conduct disorders (ICD-10). Thus, even in infancy certain distinct behavioural and developmental profiles can be recognized. This combined approach will enable follow-up research into the stability of factors, classes, and profiles over time, and will facilitate early detection, diagnosis, and treatment of behavioural and developmental problems.

Keywords Exploratory factor analysis · Latent class analysis · Behavioural and developmental profiles and problems · Infants · General population

E. Möricke (✉) · G. A. M. Lappenschaar · S. H. N. Swinkels · N. N. J. Rommelse
Department of Psychiatry (966), Nijmegen Centre for Evidence-Based Practice, Radboud University Nijmegen Medical Centre, P.O. Box 9101, 6500 HB Nijmegen, The Netherlands
e-mail: e.moricke@psy.umcn.nl

N. N. J. Rommelse · J. K. Buitelaar
Karakter Child and Adolescent Psychiatry University Centre, Nijmegen, The Netherlands

J. K. Buitelaar
Department of Cognitive Neuroscience, Donders Institute for Brain, Cognition and Behaviour, Radboud University Nijmegen Medical Centre, Nijmegen, The Netherlands

Introduction

It is generally accepted that psychopathology can develop in young children and that some early behavioural and social-emotional problems persist over time [1, 2]. Neuropsychiatric disorders such as autism spectrum disorders (ASD) and attention-deficit hyperactivity disorders (ADHD) are frequently characterized by an early onset (0–3 years) of symptoms [3–5]. Disruptive behaviour disorders (oppositional defiant disorders and conduct disorders) and emotional disorders (depressive disorders and anxiety disorders) also have precursors which are often seen at an early age [6]. However, little is known about the prevalence and course of general psychopathology in population-based

samples of children aged 0–3 years [1, 7], in part due to methodological problems concerning assessment procedures and diagnostic classifications [2, 6, 8].

Dimensional and categorical approaches are currently used to describe the distributions and manifestations of psychopathology in young children and their developmental and contextual correlates. Tools such as the Child Behavior Checklist for ages 1½–5 (CBCL 1½–5) [9] and the Infant-Toddler Social and Emotional Assessment (ITSEA) [10] enable evaluation of the frequency and severity of clinically relevant behavioural problems, providing dimensional data regarding mental health problems in children. For example, confirmatory factor analyses of parental ratings on the CBCL 1½–5 of 19,106 children aged 18–71 months showed a good fit of the standard seven-syndrome model for 23 societies separately [11]. Further, confirmatory factor analyses of parental ratings on the ITSEA of 1,235 children aged 12–36 months supported the presence of 4 global domains (internalizing, externalizing, regulatory, and competence), 17 individual scales, and 3 additional indices (atypical, maladaptive, social relatedness) [12].

Dimensional assessment tools are essential in psychopathology research and provide complementary data that are relevant to clinical practice. They can be used to identify broad domains of behavioural problems and enable comparisons among individuals of the same age and sex. However, they cannot replace valid and reliable diagnostic classification procedures in very young children, because they are not specific enough with regard to the onset, duration, frequency, and intensity of symptoms. Besides, while many tools include common problems, they often exclude behaviours with low occurrence rates, even though these may be suggestive of child psychopathology [13, 14].

Available categorical classification systems for childhood psychiatric disorders, such as the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR) [15] and the International Statistical Classification of Diseases and Related Health Problems (ICD-10) [16], lack appropriate diagnostic categories to assess more or less common mental health problems in very young children. For example, there are no developmentally sensitive criteria for diagnosing ASD in children younger than 3 years. This may lead to unacceptably rates of very young children with inaccurate diagnoses and labels of child psychiatric disorders. Further, these systems often neglect interpersonal relationships and other interactional factors [17]. To fill these gaps, the Diagnostic Classification of Mental Health and Developmental Disorders of Infancy and Early Childhood (DC 0–3R) [18] was developed, mainly for use in clinical settings. DC 0–3R has a multi-axial framework, and new diagnostic constructs with symptoms reflecting early developmental stages [13, 17]. Regulation disorders are characterized by deficits in the regulation of neurophysiological, sensory-motor, emotional and behavioural functioning [14]. Multisystem developmental disorders may be an alternative to ASD in children aged 0–24 months who show evidence of problems in relating, communicating, thinking, sensory processing and motor planning [19].

A landmark study applying both dimensional and categorical approaches to investigate infant psychopathology at the population level is the Copenhagen Child Cohort, a prospective birth cohort study of all 6,090 children born in 2000 in the County of Copenhagen. Elaborate assessments in a random sample of more than 200 children aged 18 months revealed that 16–18 % had diagnoses according to ICD-10 and DC 0–3, with disturbances of emotion, behaviour and eating, and regulatory disorder as described in DC 0–3 being the most common problems [20]. The prevalence, distribution, and manifestation of psychopathology in 18-month-old children seem to be similar to those in older children, but no systematic studies have been performed in even younger children.

The purpose of the present study was to extend our knowledge of psychopathology in infants in two ways. Firstly, we used a questionnaire covering common and less common behavioural manifestations, and collected parental ratings for a large population-based sample of children aged 14–15 months. We chose this age because of the need to learn about infant psychopathology. Most research in population samples is performed with children of 18 months and older [e.g. 7, 11, 12, 20], whereas there are also indications that certain features or precursors of some disorders can already be observed around the age of 14 months. Although externalizing behaviour seems to be relatively common, and not necessarily pathological in infancy [21], internalizing behaviour and especially social-communicative problems may point at early emerging child psychiatric disorders [22–24]. This is also reflected by the growing interest in the early detection of ASD and concurrent [25–27] or later [28, 29] problems in motor, cognitive, and language development. Secondly, in an attempt to overcome the limitations of existing classification systems, we used latent class analysis (LCA) [30], a statistical technique to identify mutually exclusive classes, in this case consisting of children with homogeneous behavioural and developmental profiles. This dimensional and bottom-up approach has the advantage that valuable information about subjects and behaviour is not lost, in contrast to strict categorical classification systems in which those who score just below diagnostic thresholds are regarded as non-cases.

We investigated how many homogeneous behavioural and developmental profiles can be identified in 14- to 15-month-old children, and descriptively compared the

empirically derived classes and profiles with existing classifications to identify similarities and differences.

Methods

Participants

The study was approved by the Medical Ethics Committee of University Medical Centre Utrecht. The sample was a subsample from a birth cohort of children born between August 2000 and August 2001 in the province of Utrecht in The Netherlands ($n = 12,297$). Parents received a 74-item questionnaire concerning infant behaviour and development when their child was 14–15 months old, and those who responded automatically consented to participate. We included all children who had no more than seven missing values, resulting in 6,330 participants (i.e. a response rate of 51.5 % of 12,297 children eligible). The questionnaire was completed by mothers ($n = 5,203$; 82.2 %), fathers ($n = 689$; 10.9 %), or both ($n = 36$; 0.6 %); in 6.4 % of the cases ($n = 402$), the respondent was unknown. The sample consisted of roughly equal numbers of boys ($n = 3,201$; 50.6 %) and girls ($n = 3,020$; 47.7 %). For 109 children (1.7 %), sex was unknown. The mean child age was 14.84 months (SD = 2.19). The majority of infants seemed to be developing normally, as indicated by the parents. Of all infants, 74 (1.2 %) had a physical or mental handicap, 261 (4.1 %) had a physical disease, and 398 (6.3 %) used medication. For 122 (1.9 %), information about health was lacking.

Because access to information about the non-responders was not allowed, we investigated possible selection bias by comparing the data of the responders with demographic data for the general population [31]. The sample was 90.6 % Dutch ($n = 5,737$), 1.6 % European ($n = 101$), 3.1 % Moroccan or Turkish ($n = 198$), and 2.8 % from other nationalities ($n = 179$); the nationality of 1.8 % of the sample was not known ($n = 115$). Our sample contained more Dutch children than the population average (sample 90.6 %; population 82.1 %) and the parents had a higher educational level (college or university degree) than persons in the general population (mothers 43.0 vs. 38.9 %; fathers 44.0 vs. 36.0 %). The socioeconomic status (SES) of the families, based on mean level of education and occupation of both parents, varied from low ($n = 802$; 12.7 %) through moderate ($n = 2,483$; 39.2 %) to high ($n = 2,912$; 46.0 %); in 2.1 % ($n = 133$) of the cases SES was unknown.

Instruments

Experts with clinical and research experience with infants and toddlers developed the Utrecht Screening Questionnaire (USQ) [21] on the basis of selected items from the Child Behavior Checklist 1½–5 [9], the Infant-Toddler Social and Emotional Assessment [10], the Vineland Social-Emotional Early Childhood Scales [32], and the Early Screening of Autistic Traits Questionnaire (ESAT) [22, 23]. All selected items had to be specific for externalizing, internalizing, or social-communicative problems, and had to be suitable for children younger than 18 months. Of 79 potentially relevant items, 5 items about obedience and child rearing were excluded, leaving 74 items (Table 1). Fourteen ESAT items were scored on a yes or no scale (corresponding with scores 0 or 1), and the other 60 items were rated on a three-point Likert scale (0 'not at all true', 1 'somewhat/sometimes true', 2 'clearly/often true'). The items were presented in an arbitrary order. Previous analyses [21] with a subset of 55 items revealed a reliable factor structure consisting of oppositional behaviour, language development, attention, explorative behaviour, communicative intent, dysregulation, and inhibition. The internal consistency (Cronbach's alpha) of the factors varied from 0.45 to 0.83 (low to good reliability), and the percentage of variance explained amounted to 34.7 %. Factors showed moderate stability over a 5-month period.

Statistical approach

Some items were reversely coded, so that all items could be interpreted similarly. A score of 0 meant that a child showed normal behaviour; a score of 1 or 2 implied that a child lacked competences or experienced problems to a moderate or severe degree. The items were considered as ordinal variables. Maximally seven missing values were allowed (<10 % of 74 items), which were imputed by means of single imputation using expectation maximization techniques [33]. Sixty children were excluded because of more than seven missing values, which left the data for 6,330 children available for further analyses.

To examine empirically derived behavioural and developmental domains, exploratory factor analysis (EFA) was used. Oblique promax rotation, which allows factors to be correlated, was chosen because of the large dataset. Only items with a factor loading ≥ 0.30 and factors with an eigenvalue ≥ 1.50 were included in the factor solution [34]. Each item was assigned to the factor on which it had the highest loading; cross-loadings were neglected. Internal consistency and variance explained were computed to explore reliability. Factor correlations were calculated to get insight into their interrelatedness.

Thereafter, homogeneous behavioural and developmental profiles were identified by latent class analysis (LCA) [30]. Two parameters were estimated: (1) latent class membership probabilities, representing the probability that a child belonged to each of the classes; (2) class-specific

Table 1 Proportion of children with deviant scores and factor loadings of USQ-items in exploratory factor analysis with promax rotation ($n = 6{,}330$)

Item	Factor	Proportion of children with deviant score	Factor-loading[a]	Cronbach's alpha
	1. Deviant communication			0.70
47[b]	Uses gestures appropriately to express him/herself	15.9	0.808	
48[b]	Points at things to show	6.7	0.727	
46[b]	Understands at least ten words	10.1	0.687	
45[b]	Imitates simple gestures	5.1[c]	0.602	
75[b]	Uses common names like 'mummy/daddy'	6.1	0.580	
14[b]	Gives or shows something to somebody	3.1	0.491	
74[b]	Imitates sounds made by parents	3.9	0.488	
76[b]	Reacts when name is called	5.8[c]	0.476	
41[b]	Pays attention when being spoken to	10.3	0.383	
	2. Negative emotionality			0.82
78	Is stubborn, sullen or irritable	3.4	0.789	
73	Is fussy, whiny	1.9	0.771	
66	Is extremely loud	1.5	0.718	
65	Is uncooperative	2.6	0.668	
72	Changes mood suddenly	4.2	0.656	
58	Screams a lot	4.4	0.646	
38	Is easily upset	7.4	0.635	
31	Cries a lot	2.6	0.600	
27	Cannot sit still; is restless or hyperactive	11.0	0.581	
64	Seems unhappy without clear reason	5.6[c]	0.562	
69	Bites, hits or kicks others	1.2	0.524	
54	Hurts animals or persons	1.6	0.509	
24	Cannot concentrate or pay attention for long	8.3	0.464	
57	Refuses to play active games him/herself	1.8	0.440	
30	Wants help constantly	2.9	0.427	
40	Has less fun than other children	5.8[c]	0.422	
60	Will not share toys or other things	6.0	0.328	
	3. Deviant reactive behaviour			0.23
19[b]	Reacts when being spoken to	0.1	0.858	
9[b]	Reacts normally to sensory stimuli	0.1	0.723	
	4. Deviant play behaviour			0.10
6[b]	Plays with different toys/objects	0.2	1.074	
7[b]	Plays in various ways	1.3	0.782	
10[b]	Shows clear facial expressions	1.4	0.350	
59[b]	Plays more than five minutes with toys	3.0	0.309	
	5. Demanding behaviour			0.50
34	Demands must be met immediately	14.2	−0.636	
28	Cannot stand waiting; wants everything now	16.4	−0.572	
22	Has angry moods	9.7	−0.419	
67	Wants a lot of attention	14.4	−0.320	
	6. Social anxiety/inhibition			0.38
33	Is quiet or inactive in new situations	5.7	0.493	
15[b]	Shows interest in other children/adults	0.8	0.441	
36	Is easily frightened	2.4	0.383	
50[b]	Shows interest in children other than siblings	7.9	0.372	

Table 1 continued

Item	Factor	Proportion of children with deviant score	Factor-loading[a]	Cronbach's alpha
42	Is afraid of certain animals, things or places	4.1	0.371	
18[b]	Likes to play games with others	1.0	0.324	
	7. Advanced social interaction problems			0.66
44[b]	Distinguishes parents from other persons	9.6[c]	0.728	
53[b]	Shows that he/she distinguishes parents from others	1.6	0.699	
70[b]	Babbles or makes noises spontaneously	6.9[c]	0.620	
61[b]	Utters sounds of joy	7.6[c]	0.593	
26[b]	Shows interest in new objects/persons	7.6[c]	0.523	
20[b]	Is easy to comfort by parents	5.8[c]	0.510	
25[b]	Shows interest in familiar objects/persons	1.7	0.475	
79[b]	Follows with eyes when someone moves	9.2[c]	0.426	
71[b]	Stops wailing when being spoken to	6.4	0.384	
43[b]	Reaches when he/she wants to be held	2.3	0.365	
37[b]	Finds other things to do when finished	2.3	0.362	
35[b]	Enjoys learning new things	2.5	0.330	
	8. Basic social interaction problems			0.19
17[b]	Directs social smile to parents and others	0.5	1.011	
11[b]	Makes eye contact easily	2.0	0.452	
16[b]	Likes cuddling	4.2	0.334	
13	Repeats stereotypic movements	6.7	0.311	
	9. Sleep problems			0.33
39	Cannot sleep alone	5.1	0.704	
63	Finds it difficult to fall asleep	7.3	0.514	
51[b]	Clings on when he/she wants to be held	3.4	−0.350	

[a] Total number of items was 74. Only items with factor loading ≥0.30 were included (61). Other items were omitted (13)

[b] Items were reversely coded

[c] Proportions of children with score '1' and '2' were combined and considered as deviant

symptom endorsement profiles, giving conditional probabilities that children in a particular class would show specific behaviour. Children could only be admitted to one class. To get an idea of mutual proportions, prevalence estimates and the distribution of sex, nationality, and SES were analysed across latent classes by means of crosstabs, Chi-square tests, and adjusted residuals. Differences in mean age per class were evaluated with oneway ANOVA and Bonferroni corrected post hoc tests.

Next, weighted factor scores were computed by dividing the obtained factor sum score by the maximum factor sum score. They had a value between 0 and 1. These are presented in a table and a line chart, so that qualitative and quantitative differences in weighted factor scores can be examined. Size and significance of differences between classes were determined with ANOVA and Bonferroni corrected post hoc tests. Lastly, analyses were repeated with sex as covariate to determine whether it is necessary to distinguish between boys and girls. Analyses were performed using Mplus version 4.1 [35] or SPSS 17.0 [36].

Results

A relatively high proportion of children (10–17 %) had deviant scores (score '2') on seven items (Table 1), namely those referring to gesturing (item 47), understanding (item 46), paying attention (item 41), keeping quiet and patient (items 27 and 28), and demanding behaviour (items 34 and 67). As expected, fewer than 10 % of the children had deviant scores on the other items.

Exploratory factor analysis

EFA with promax rotation was run on 74 items, and those ($n = 61$) with factor loadings ≥0.30 were used. Thirteen items were omitted, namely 'Emotions are understandable' (item 8), 'Asks attention when being alone' (item 12), 'Stays close to parent or returns to him/her regularly' (item 21), 'Is accident prone' (item 23), 'Keeps on trying' (item 29), 'Wants to do things him/herself' (item 32), 'Does not eat well' (item 49), 'Sits still for five minutes during

reading' (item 52), 'Remains calm while being changed, dressed or washed' (item 55), 'Quickly shifts from one activity to another' (item 56), 'Cries, stays at place, waits for parent when scared' (item 62), 'Uses objects for imaginative play' (item 68), and 'Is attached to unusual (hard) objects' (item 77).

A solution with nine factors fitted the data best, because it had a lower root mean square residual (RMSR) (0.0403) than the solutions with fewer factors and because it had only three negative estimated residual variances (ERV). The factors were termed deviant communication, negative emotionality, deviant reactive behaviour, deviant play behaviour, demanding behaviour, social anxiety/inhibition, advanced social interaction problems, basic social interaction problems, and sleep problems. These factors showed overlap with the regulation factors of Beernink et al. [21]. Deviant communication corresponded with language development. Negative emotionality and demanding behaviour mainly consisted of items from oppositional behaviour. Social anxiety/inhibition had three items from inhibition. Advanced social interaction problems were a combination of items from communicative intent and explorative behaviour. Sleep problems included two items from dysregulation. As expected, our factors deviant reactive behaviour, deviant play behaviour, and basic social interaction problems did not have an equivalent, because most social-communicative items were not part of the questionnaire of Beernink et al.

To make a clear distinction between typical children, and children with minimal competences and/or severe problems, we dichotomized the scores. In general, an ESAT-score of 0 pointed at normal behaviour and a score of 1 pointed at deviant behaviour. For most other items, scores of '0' and '1' were considered to reflect relatively normal behaviour, and a score of '2' to reflect deviant behaviour. However, for ten items (20, 26, 40, 44, 45, 61, 64, 70, 76, and 79) both scores '1' and '2' were considered as deviant, because the combined proportion of children with these scores was still below the used limit of 10 %. Items, factors, factor loadings, and proportions of children with a deviant score are given in Table 1.

The internal consistency (Cronbach's alpha) of the separate factors varied from 0.10 to 0.82 (Table 1). The factors with a low reliability mostly contained a small number of items and/or items which point at rare or extreme behaviour. The percentages of variance explained amounted to 39.0 %. When all 61 items were considered together, reliability was good ($\alpha = 0.82$) and variance explained was 71.7 %. Interrelationships between the nine factors were computed, resulting in 36 correlations: 12 were negligible ($r < 0.10$), 17 were small ($r = 0.10$–0.30), and 7 were moderate ($r = 0.30$–0.50). The highest correlations ($r \geq 0.30$) were found between factors involving aspects of communication, social interaction, and play.

Latent class analysis

LCA was used to identify specific behavioural and developmental profiles and the accompanying proportions of children. Measures of fit and accuracy [37] indicated that a solution with five classes fitted the data best (see Table 2). This model had acceptably low (sample size adjusted) Bayesian information criterion values (BIC 377,610.826; SSA BIC 375,850.359) and significantly low p values on Vuong–Lo–Mendell–Rubin likelihood ratio test and Lo–Mendell–Rubin adjusted likelihood ratio test (VLMR LRT 0.0357; LMR adj. LRT 0.0358). Using a non-parametric bootstrapping procedure, the bootstrapped likelihood ratio test (BLRT) had a p value <0.001, indicating that a model with five classes was preferred above a model with four classes. Entropy was 0.853, which means that about 85 % of the children were classified correctly on the basis of the highest estimated latent class membership probability.

A total of 31.2 % of the children belonged to class 1, 35.9 % to class 2, 5.7 % to class 3, 16.4 % to class 4, and 10.8 % to class 5. There was a significant age difference between the classes ($p < 0.001$), with children in class 3 being significantly older ($M = 16.11$ months) than the children in the other classes, who were about the same age ($M = 14.75$ months). In class 1, the percentage of boys was lower and the percentage of girls was higher than the overall mean percentage. The opposite applied to class 4. Class 1 consisted of relatively many Dutch children (94.8 %) and children from families with a high socio-economic status (54.7 %), compared to the total mean. In contrast, classes 3 and 5 contained considerably more children with a non-European nationality (27.9 and 14.5 %, respectively) and children from low SES backgrounds (30.7 and 21.1 %, respectively) than average (see Table 3).

Table 2 Summary of results of latent class analyses of USQ ($n = 6{,}330$)

Class	General tests of model fit			Technical 11 output	
No.	Entropy	BIC	SSA BIC	VLMR LRT p value	LMR adj. LRT p value
4	0.849	378,839.066	377,431.328	0.0000	0.0000
5	0.853	377,610.826	375,850.359	0.0357	0.0358
6	0.834	377,003.041	374,889.845	0.2286	0.2289

Entropy indicates classification accuracy

BIC Bayesian Information Criterion, *SSA BIC* Sample Size Adjusted Bayesian Information Criterion, *VLMR LRT* Vuong–Lo–Mendell–Rubin likelihood ratio test, *LMR adj. LRT* Lo–Mendell–Rubin adjusted likelihood ratio test

Combination of EFA and LCA

Results of EFA and LCA are presented together in Table 4 and Fig. 1 with separate weighted factor scores for each class. A higher score indicated that children lacked more competences or showed more problems. Globally, three groups could be distinguished, namely one group (classes 1 and 2) consisting of relatively normal children, one group

Table 3 Prevalence estimates and distribution of age, sex, nationality, and SES for five-class-model of USQ

	Class 1 *n* (%)	Class 2 *n* (%)	Class 3 *n* (%)	Class 4 *n* (%)	Class 5 *n* (%)	Total *n* (%)	*df*	*F*; *p* (age) χ^2; *p* (others)
Age (child) (*M*, SD)	14.76 (1.16)	14.82 (1.38)	16.11 (7.22)*	14.64 (1.57)	14.79 (1.52)	14.84 (2.19)	4, 6004	31.85; <0.001
Known	1,895 (95.9)	2,155 (94.8)	339 (93.6)	976 (94.1)	644 (94.6)	6,009 (94.9)		
Unknown	81 (4.1)	119 (5.2)	23 (6.4)	61 (5.9)	37 (5.4)	321 (5.1)		
Sex (child)							8	37.45; <0.001
Boys	915 (46.3)[b]	1,151 (50.6)	201 (55.5)	578 (55.7)[a]	356 (52.3)	3,201 (50.1)		
Girls	1,035 (52.4)[a]	1,081 (47.5)	151 (41.7)	440 (42.4)[b]	313 (46.0)	3,020 (47.7)		
Unknown	26 (1.3)	42 (1.8)	10 (2.8)	19 (1.8)	12 (1.8)	109 (1.7)		
Nationality (child)							16	547.19; <0.001
Dutch	1,874 (94.8)[a]	2,096 (92.2)	245 (67.7)[b]	967 (93.2)	555 (81.5)[b]	5,737 (90.6)		
European	23 (1.2)	45 (2.0)	6 (1.7)	14 (1.4)	13 (1.9)	101 (1.6)		
Moroccan/Turkish	15 (0.8)[b]	33 (1.5)[b]	69 (19.1)[a]	21 (2.0)	60 (8.8)[a]	198 (3.1)		
Other	37 (1.9)	56 (2.5)	32 (8.8)[a]	15 (1.4)	39 (5.7)[a]	179 (2.8)		
Unknown	27 (1.4)	44 (1.9)	10 (2.8)	20 (1.9)	14 (2.1)	115 (1.8)		
SES (parents)							12	295.40; <0.001
Low	160 (8.1)[b]	243 (10.7)[b]	111 (30.7)[a]	144 (13.9)	144 (21.1)[a]	802 (12.7)		
Moderate	703 (35.6)[b]	915 (40.2)	155 (42.8)	412 (39.7)	298 (43.8)	2,483 (39.2)		
High	1,081 (54.7)[a]	1,066 (46.9)	82 (22.7)[b]	461 (44.5)	222 (32.6)[b]	2,912 (46.0)		
Unknown	32 (1.6)	50 (2.2)	14 (3.9)	20 (1.9)	17 (2.5)	133 (2.1)		
Prevalence	1,976 (31.2)	2,274 (35.9)	362 (5.7)	1,037 (16.4)	681 (10.8)	6,330 (100.0)		

Percentages of demographic characteristics are given for each individual class, so that the total counts to hundred vertically. However, percentages regarding prevalence count to hundred horizontally

* Children in class 3 are significantly older than children in other classes ($p < 0.001$). Adjusted residuals revealed significant differences in percentages of children in classes on variables sex, nationality, and SES ($p < 0.001$)

[a] Percentage is significantly *higher* than the overall average percentage

[b] Percentage is significantly *lower* than the overall average percentage

Table 4 USQ weighted factor scores per class (proportions) ($n = 6{,}330$)

Factor	Class 1 31.2 %	Class 2 35.9 %	Class 3 5.7 %	Class 4 16.4 %	Class 5 10.8 %	*F* (4, 6325); *p*
1 Deviant communication	0.06	0.09	0.40	0.31	0.14	1,546.84; <0.001
2 Negative emotionality	0.07	0.22	0.29	0.10	0.44	4,353.42; <0.001
3 Deviant reactive behaviour	0.00	0.00	0.01	0.00	0.00	16.90; <0.001
4 Deviant play behaviour	0.03	0.06	0.16	0.08	0.12	177.07; <0.001
5 Demanding behaviour	0.27	0.22	0.32	0.31	0.53	308.72; <0.001
6 Social anxiety/inhibition	0.09	0.15	0.27	0.15	0.25	280.39; <0.001
7 Advanced social interaction problems	0.04	0.07	0.28	0.14	0.11	1,066.10; <0.001
8 Basic social interaction problems	0.01	0.03	0.13	0.03	0.08	176.71; <0.001
9 Sleep problems	0.09	0.16	0.29	0.13	0.31	273.82; <0.001

The weighted factor score is the obtained factor sum score divided by the maximum factor sum score, and has a value between 0 and 1. Higher scores indicated that children lacked more competences or showed more problems. Most differences in weighted factor scores between classes were significant ($p < 0.001$). However, the following contrasts were *not* significantly different: *factor 3* classes 1, 2, 4, and 5; *factor 5* classes 3 and 4; *factor 6 and 8* classes 2 and 4; and *factor 6 and 9* classes 3 and 5

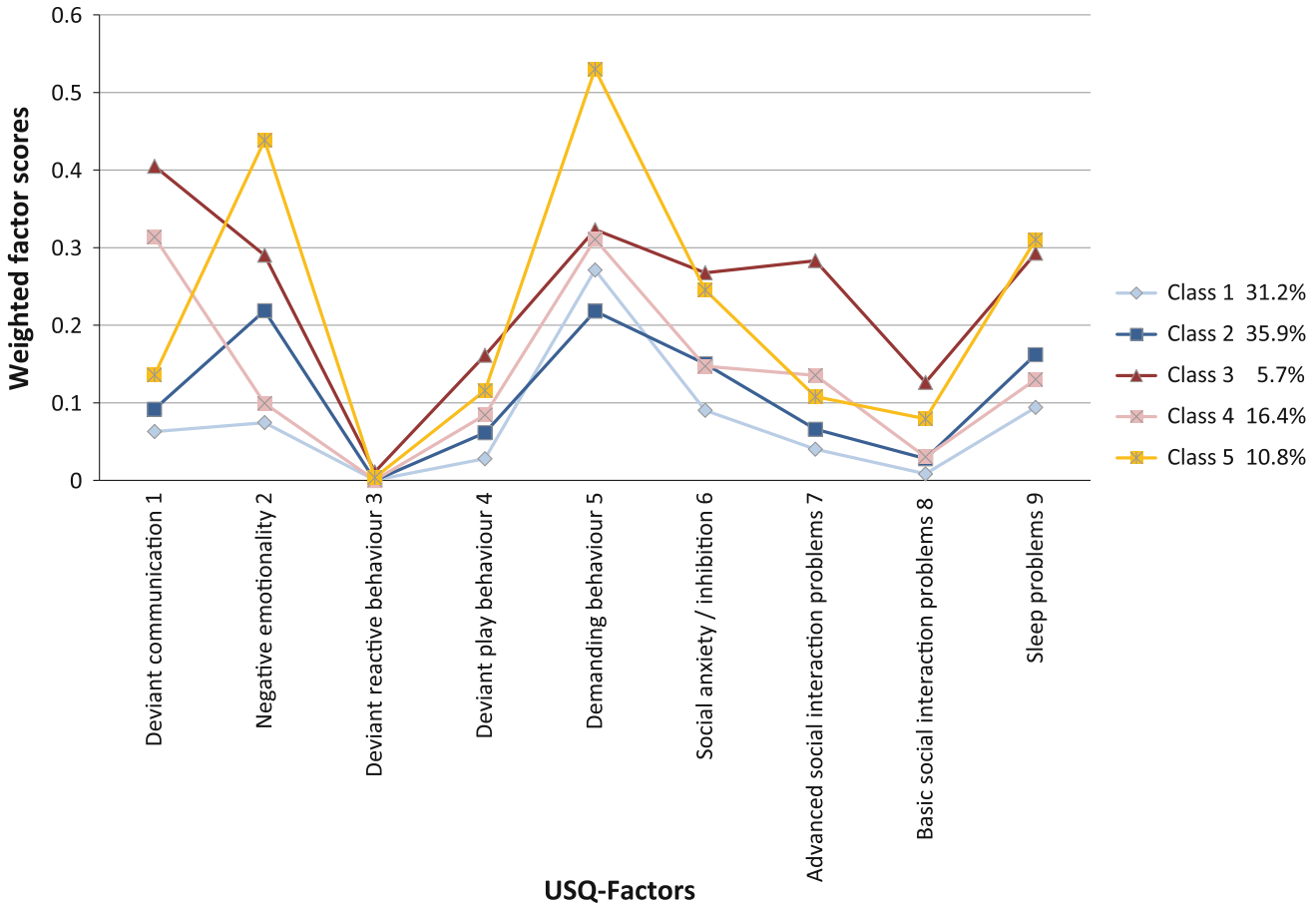

Fig. 1 USQ weighted factor scores per class ($n = 6{,}330$)

(classes 3 and 4) consisting of children with problems in communication and/or social interaction, and one group (class 5) consisting of children with negative and demanding behaviour. The five classes and profiles showed both quantitative and qualitative differences. Class 1 was characterized by relatively low scores on all factors and was considered the reference group with normal children. Class 2 was characterized by slightly higher scores on some factors than class 1; the children expressed more negative emotions (factor 2), but were less demanding (factor 5) than the children in the first class. Thus, both classes had comparable profiles which showed mainly differences in intensity. Class 4 showed many similarities with class 1, but the profile was clearly different on deviant communication (factor 1) and slightly different on advanced social interaction problems (factor 7), making it a distinct type of problem class, which may be associated with problems in gestural and verbal behaviour. Class 3 stood out because of the relatively high scores on deviant communication (factor 1) and deviant social interaction (factors 7 and 8), which may be related to internalizing and/or social-communicative problems. Class 5 stuck out on negative emotionality (factor 2) and demanding behaviour (factor 5) and, therefore, these children seemed to be at relatively high risk for externalizing problems. The profiles of these two deviant classes differed in type from the other classes.

For each separate factor, the weighted factor scores of all five classes were compared with each other. ANOVA and Bonferroni corrected post hoc tests showed that most differences in weighted factor scores between classes were significant ($p < 0.001$). The weighted factor score of class 3 was significantly higher than those of all other classes on deviant reactive behaviour (factor 3). The scores of classes 3 and 4 were almost the same on demanding behaviour (factor 5) ($p = 1.000$). Classes 2 and 4 had nearly equal scores on social anxiety/inhibition (factor 6) ($p = 1.000$) and basic social interaction problems (factor 8) ($p = 1.000$). Classes 3 and 5 had comparable scores on social anxiety/inhibition (factor 6) ($p = 0.071$) and sleep problems (factor 9) ($p = 1.000$). See Table 4 and Fig. 1.

Analyses were repeated with the inclusion of sex as covariate in the model, which did not result in significantly different profiles. This means that the factor solution and class division were stable, which strengthens the interpretation of the main results.

Discussion

There have been few population-based studies of psychopathology in very young children (<18 months), even though virtually all neuropsychiatric disorders have their precursors at this age. Various studies indicated that many (but not all) children later diagnosed with ASD or ADHD already showed subtle abnormalities in the first years of life [4, 5]. By combining dimensional and categorical approaches to study psychopathology in a large population sample ($n = 6{,}330$) of Dutch infants ($M = 14.84$ months; SD = 2.19 months), we investigated how many homogeneous behavioural and developmental profiles could be identified, and we explored whether or not these profiles corresponded to classifications defined by DSM-IV-TR, ICD-10, and DC 0–3R.

Our findings clearly indicated that even in infancy certain distinct behavioural and developmental profiles can be observed. EFA revealed nine factors, many of which showed overlap with the solution of Beernink et al. [21]. However, our questionnaire contained 16 extra items concerning communication and social interaction combined in extra factors. LCA yielded five classes which represented three main groups: relatively normal behaviour (classes 1 and 2), communication and/or social interaction problems (classes 3 and 4), and negative and demanding behaviour (class 5). The two normal classes (classes 1 and 2) mainly differed in a quantitative way, class 4 showed a clear qualitative difference on one important factor (deviant communication), and the two deviant classes (classes 3 and 5) were qualitatively distinct from the other classes on several factors (especially deviant communication, social interaction problems, negative emotionality, demanding behaviour, and sleep problems).

The use of a combination of dimensional and categorical approaches disclosed similarities and differences with the outcomes of dimensional questionnaires such as the CBCL 1½–5 [9] and the ITSEA [10]. The broad domains of internalizing and externalizing behaviours characteristic of the CBCL 1½–5 could be discerned clearly, in contrast to the empirically based and DSM-oriented scales. For instance, we found no separate factors for mood problems, anxiety problems, pervasive developmental problems, attention problems, or aggressive behaviour. The same was true for the ITSEA. While many aspects of the four global domains (internalizing, externalizing, regulatory, competence) and the three additional indices (atypical, maladaptive, social relatedness) could be recognized in our profiles, the distinction between our profiles was less specific, and there were differences in the number and content of separate factors and scales. This discrepancy is probably caused by the fact that we only used individual items and no complete (sub)scales or domains from the CBCL 1½–5 and the ITSEA. It also may be due to differences in the ages of the samples investigated. Our sample had a very small age range (infants aged 14–15 months), whereas the samples used to study the CBCL 1½–5 and the ITSEA had a much broader age range and included older children (generally >18 months). In infancy, development occurs rapidly, with small differences in age resulting in relatively substantial differences in acquired capacities and levels of functioning. In general, behaviour and development of infants are fairly diffuse and are subject to quick changes. Consequently, accompanying problems are best described in broad domains. In toddlers and preschool children, various aspects of motor, cognitive, communicative, social, and emotional functioning are further developed and more crystallized. From 18 months onwards, children learn to make symbolic representations and gain better receptive and expressive language skills, what enhances their emotional experiences and social relationships [38, 39]. There is more differentiation in types of behaviour and development, which is also reflected in a larger variety of problems.

Our profiles can also be compared with those of the categorical classification systems: DSM-IV-TR [15], ICD-10 [16], and DC 0–3R [18] (see Table 5 for a summary). Children in class 1 (31.2 %) could be considered as exhibiting typical behaviour. Children in class 2 (35.9 %) mainly differed from typical children in being less demanding, but they expressed more negative emotions. They scored slightly higher on other factors, but still within the normal range. Children in class 3 (5.7 %) had high scores on five factors, namely deviant communication, negative emotionality, social anxiety/inhibition, advanced social interaction problems, and sleep problems. This profile resembles that of the DC 0–3R diagnosis of multisystem developmental disorders, which are characterized by significant qualitative impairments in communication and social relationships as well as problems in sensory and motor functioning [19]. Similarities with internalizing and/or social-communicative problems in the broad sense also exist and may even point to there being more specific child psychiatric disorders such as anxiety disorders, mood disorders, or pervasive developmental disorders as formulated in DSM-IV-TR and ICD-10. Children in class 4 (16.4 %) had particularly high scores on deviant communication. As other scores were normal, these children would appear to have specific problems in communication, language, and speech development (such as communication disorders in DSM-IV-TR or speech and language disorders in ICD-10). Children in class 5 (10.8 %) had high scores on negative emotionality, demanding behaviour, social anxiety/inhibition, and sleep problems. This profile is rather similar to that of the DC 0–3R diagnosis of regulation disorders with clinical symptoms of hypo- or hyper-reactivity,

Table 5 Comparison of classes with dimensional domains and categorical classifications

Class (number and name) - *factors with high scores*	CBCL 1½-5	ITSEA	DSM-IV-TR	ICD-10	DC 0-3R
1 normal behavior	normal range	normal range	no classification	no classification	no classification
2 normal behavior with mild negative behavior	normal range	normal range	no classification	no classification	no classification
- *negative emotions*					
3 severe communication and interaction problems	broad band internalizing	global domaininternalizing	anxiety disorders, mood disorders, pervasive developmental disorders	anxiety disorders, mood disorders, pervasive developmental disorders	multisystem developmental disorder
- *deviant communication*					
- *advanced social interaction problems*					
- *social anxiety/ inhibition*					
- *negative emotionality*					
- *sleep problems*					
4 moderate communication problems	no domain	no domain	communication disorders	speech and language disorders	no classification
- *deviant communication*					
5 severe negative and demanding behavior	broad band externalizing	global domain externalizing, regulatory	attention-deficit and disruptive behavior disorders	hyperkinetic and conduct disorders	regulation disorders
- *negative emotionality*					
- *demanding behaviour*					
- *social anxiety/ inhibition*					
- *sleep problems*					

hypersensitivity, irritability, impulsivity, and sleeping and eating difficulties [14]. The profile also resembles externalizing behaviour and the problems may be a precursor of attention-deficit and disruptive behaviour disorders (DSM-IV-TR) or hyperkinetic and conduct disorders (ICD-10).

Our findings suggest that even in infancy certain distinct behavioural and developmental profiles can be recognized and resemble diagnostic categories as described in existing classification systems. However, we found the proportion of children aged 14–15 months with severe behavioural problems (classes 3, 4, and 5 together 33 %) to be higher than that reported in other studies. Skovgaard et al. [20] found that 16–18 % of the 18-month-olds had a DC 0–3 and/or ICD-10 diagnosis. Egger and Angold [6] found that on average 19.5 % of the preschool children aged 2–5 years had a DSM-IV diagnosis. These discrepancies may exist because 14- to 15-month-old children are going through an intensive phase of development of new skills, and the prevalence of behavioural and developmental problems may be lower if these children are followed up at a later age. Furthermore, criteria for giving DSM-IV-TR or ICD-10 diagnoses are stricter than those for classifying children on the basis of several problems. In addition, we included more specific language, communication, and social interaction problems. We also identified children with problems in communication (class 4, 16.4 %), a group not explicitly mentioned by other researchers. However, the proportion of children with communication and social interaction problems (class 3, 5.7 %), or negative and demanding behaviour (class 5, 10.8 %) was consistent with that reported in studies involving older children. This concordance in the prevalence and distribution of psychopathology suggests that the basic architecture of risk is already present in infancy [6, 20, 40].

The present study had some limitations [2, 8]. First, Cronbach's alpha was low for several of the nine factors. The explanation for these findings is probably twofold, namely that these factors contained a small number of items and that these items assessed rare or extreme behaviour. It is known that Cronbach's alpha is affected by the number of items with few items negatively affecting its value [41]. In addition, it is inherent to rare or extreme behaviour that it occurs infrequently with very few children scoring high on all items. We could have removed these items, thereby excluding factors with low values for Cronbach's alpha. However, we thought that this was undesirable, because it was a deliberate decision to include these items which assessed less common problems in communication and social interaction [14]. Alternatively, optimizing Cronbach's alpha could have been realized by adding items to the questionnaire, which was not possible anymore in this stage of the research project. Furthermore, a solution with nine factors seemed to be best taking into consideration the criteria generally used, like a low RMSR, a low number of negative ERV, and the bend in the scree plot. According to Muthén, these factor determinants are more important in the context of factor analysis than Cronbach's alpha (http://www.statmodel.com/discussion/messages/9/213.html). Finally, the extraction of factors by means of EFA was not a target in itself, but rather meant as a method to combine items into factors, so that it became easier to interpret and report the data. In fact, EFA was subordinate and not necessary, because the LCA also could have been executed on the item level. This would have resulted in the same number and types of classes, although the profiles might have looked different. Thus, EFA and LCA are independent of each other and, therefore, a low Cronbach's alpha of some factors is less problematic in our view. Second, the results of the USQ are mainly applicable to a Dutch population and are not simply transferable to other populations, because cultural factors may determine the interpretation and judgement of behaviour and development, and may lead to different outcomes in other countries and cultures. Third, the large sample was not fully representative of the general population. Though children from middle and higher SES families were slightly overrepresented in our study, it is unlikely that this will have confounded the outcome of EFA and LCA in our sample to a relevant extent. There is evidence that low SES generally increases the risk of poor cognitive competence, maladaptive social-emotional functioning, and/or psychiatric symptoms, but this relation is less clear in very young children [42], and the effect of SES as a single risk factor is not as influential as a combination of negative environmental conditions [43]. Fourth, additional information about the child, parents, family, and environment was lacking, even though these aspects may have been risk or protective factors influencing the child's development [1, 7, 24, 38]. Fifth, we were dependent on parent participation and their reports. Extra information from other people and instruments may have led to a better insight into the behaviour and development of these infants. Unfortunately, at this young age there are few closely involved informants: only 25 % of infants attend a professional day care centre, with most children being cared for at home by an informal babysitter or the parents [44]. However, our findings based on a short parental questionnaire are consistent with those of researchers who used interviews or observations [e.g. 20]. Therefore, it seems that our screening list can be used as a simple first step in the diagnostic process, with more elaborate assessments being used where necessary.

In conclusion, five homogeneous behavioural and developmental profiles are identified, three of which are associated with increased problems, which may be predictors of disorders described in existing classification systems such as DSM-IV-TR, ICD-10, and DC 0–3. Clinically, these findings will facilitate the recognition, diagnosis, and treatment of problems at a very early age, but only if the validity of these profiles is confirmed in methodologically sound follow-up studies. Development is characterized by rapid changes, which justifies the regular monitoring of behaviour in infancy and childhood. Although there are indications that early behavioural and developmental problems are persistent, it remains difficult to make unambiguous prognoses regarding later child psychiatric disorders [1, 3, 7, 24, 45, 46]. Therefore, we have also evaluated the behaviour of these children when they were 36–37 months old, to establish the stability of factors, classes, and profiles over time [47]. This provides insight into the developmental trajectories of (problem) behaviour, and offers opportunities for improving screening and intervention strategies.

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Conflict of interest In the last 3 years, Jan K. Buitelaar has been a consultant to/member of advisory board of/and/or speaker for Janssen Cilag BV, Eli Lilly, Organon/Shering Plough, UCB, Shire, Medice, and Servier. He is not an employee or a stock shareholder of any of these companies. He has no other financial or material support, including expert testimony, patents, royalties. There is no conflict of interest for the other authors.

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