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British Journal of Clinical Psychology (2022), 61, 836–858

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Developmental profiles of schizotypy in the general population: A record linkage study of Australian children aged 11–12 years

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Objectives. The detection of young people at high risk for psychotic disorders has been somewhat narrowly focused on overt symptom-based markers that reflect mild reality distortion (e.g., psychotic-like experiences), or prodromal syndromes that are proximal to psychosis onset. The concept of schizotypy represents a broader framework for investigating risk for schizophrenia (and other disorders) in childhood, before the onset of prodromal or overt symptoms. We sought to detect profiles of risk for psychosis (schizotypy) in a general population sample of 22,137 Australian children aged 11–12 years, and to determine early life risk factors associated with these profiles from data available in linked records (registers).

Methods. Fifty-nine self-reported items were used as indicators of schizotypy across six broad domains; z-scores for each domain were subjected to latent profile analyses (LPA). A series of multinomial logistic regressions was used to examine the association between resulting profile (class) membership and several childhood and parental risk factors, and

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DOI:10.1111/bjc.12363

the proportion of children with mental disorders among each schizotypy profile was examined.

Results. The LPA revealed three person-centred profiles referred to as *True Schizotypy* (n = 1,323; 6.0%), *Introverted Schizotypy* (n = 4,473; 20.2%), and *Affective Schizotypy* (n = 4,261; 19.2%), as well as a group of children showing no risk (n = 12,080; 54.6%). Prior exposure to perinatal and familial adversities including childhood maltreatment, as well as poor early childhood development and academic functioning, was variously associated with all risk groups. There was a higher proportion of childhood mental disorder diagnoses among children in the *True Schizotypy* group, relative to other profiles.

Conclusion. Subtle differences in the pattern of exposures and antecedents among schizophrenia liability profiles in childhood may reflect distinct pathogenic pathways to psychotic or other mental illness.

Practitioner points

- Children aged 11–12 years report characteristics of schizotypy which can be classified into three distinct profiles that may represent different pathological processes towards later mental ill-health.
- Early life exposure to perinatal and familial adversities including childhood maltreatment, early childhood developmental vulnerability, and poor academic functioning predict membership in all three childhood schizotypy profiles.
- Latent liability for schizophrenia (and potentially other mental disorders) may be represented by different profiles of functioning observable in childhood.

The concept of schizotypy as reflecting latent liability for schizophrenia (Claridge, 1997; Meehl, 1990; Raine, 2006) provides a useful framework for understanding the origins and development of psychotic and related disorders (Debbané & Barrantes-Vidal, 2015; Debbané et al., 2015; Lenzenweger, 2006). Different causal paths to psychosis may be represented in different profiles of developmental schizotypy in the general population, and may be able to accommodate the heterogeneity observed in clinical manifestations of schizophrenia (Moskowitz & Heim, 2011) in a way that is consistent with contemporary aetiological models of gene–environment interactions over the life course (Belsky, 2016; Gottesman & Shields, 1982). Schizotypy is a multidimensional construct which spans a range of cognitive, behavioural, social, and perceptual components, for which evidence of association with later psychotic disorders has been reported in both experimental high-risk (Chapman, Chapman, Kwapil, Eckblad, & Zinser, 1994) and birth cohort studies (Filatova et al., 2018). Here, we set out to delineate distinct phenotypic expressions of risk for schizophrenia (or psychosis more broadly) at age 11–12 years, according to person-centred patterns of cognitive, behavioural, social, and perceptual indices of schizotypy, and further sought to determine early life risk factors associated with these schizotypal risk profiles from data available in linked records (registers) for the children and their parents.

Recent studies of schizotypal characteristics in children have focused on a single dimension of suspiciousness and paranoia (Wong, Freeman, & Hughes, 2014; Wong & Raine, 2018, 2019) and/or psychotic-like experiences (PLEs) reflecting reality distortion (positive symptoms) (Fisher et al., 2013; Laurens et al., 2020; Poulton et al., 2000). Children reporting PLEs are more likely to receive a schizophrenia spectrum diagnosis in adulthood (Fisher et al., 2013; Poulton et al., 2000), though PLEs are often transient (Linscott & van Os, 2013) and relatively common in children aged 11–12 years (Laurens,

Hobbs, Sunderland, Green, & Mould, 2012; Laurens et al., 2020). This focus on positive symptoms is further reflected in definitions of Ultra High Risk (UHR) or Clinical High Risk (CHR) states based on emerging psychotic symptoms in the context of distress (van Os & Guloksuz, 2017). However, considerable evidence suggests that positive symptoms are not necessarily the most central, distinctive, or enduring features of schizophrenia; rather, cognitive, social, and negative features are arguably more consistent, chronic, and debilitating characteristics (Lepage, Bodnar, & Bowie, 2014). Nor is the onset of overt psychotic symptoms in adolescence likely to represent the initiation of the processes of deterioration associated with psychotic disorder, which have likely begun much earlier. Intervening at the stage of onset may be too late to prevent emergence of clinical symptoms and decline in functioning (Sommer et al., 2016).

Thus, children who display distinct patterns of risk at key stages of development could benefit from early intervention before cognitive impairment and social dysfunction, and negative symptoms become entrenched (Laurens & Cullen, 2016). To date, person-centred analyses of schizotypy have been conducted in older samples of undergraduate university students (Fonseca-Pedrero, Ortuño-Sierra, Muñiz, & Bobes, 2019; Tab ak & Weisman de Mamani, 2013) or high school-age adolescents (Cella et al., 2013; Fonseca-Pedrero, Ortuño-Sierra, de Álbeniz, Muñiz, & Cohen, 2017; Lucas-Molina et al., 2020; Tab ak & Weisman de Mamani, 2013). For example, a study of 1,032 adolescents (mean age 17.3 years) using the four domains of the Oxford-Liverpool Inventory of Feelings and Experiences (O-LIFE) delineated three subgroups that differed in levels of severity across all domains (Cella et al., 2013). The class with the highest level of schizotypy (22% of the sample) was associated with a family history of psychosis and greater levels of distress than the other two groups. Other studies reporting four latent classes include one of 1,506 students (mean age 16.5 years)(Lucas-Molina et al., 2020) in which the two highest risk groups were associated with greater academic difficulties, and two other studies of 1,002 college students (mean age 21 years; 26.7% males) (Fonseca-Pedrero et al., 2017) and 1,588 adolescents (mean age 16.1 years; 46.5% males) (Fonseca-Pedrero et al., 2019); in the adolescent sample, those classed in the *high schizotypy* group were more likely to have experienced a range of mental health problems including suicidal ideation, and there was evidence of a subtype characterized by reality distortion items in isolation, distinct from a group with high levels of negative and cognitive components of schizotypy. A similar distinction was evident in a study of 420 university students' (mean age 19.5–years) responses to the OLIFE, which revealed six latent profiles (Tab ak & Weisman de Mamani, 2013). Finally, results of two studies of the latent structure of symptoms expressed by UHR/CHR groups indicated that negative and disorganized symptoms best distinguished subgroups of individuals at high risk for psychosis (Ryan et al., 2018; Valmaggia et al., 2013).

While these studies suggest that there may indeed be distinct patterns of schizotypy evident in the general population, there has been very little study of early life risk factors for schizotypy in childhood. In the present study, we used data from a longitudinal population cohort of children in New South Wales (NSW), Australia (Green et al., 2018) to investigate early life risk factors and antecedents of mental disorders associated with person-centred profiles of schizotypy in childhood. We specifically used latent profile analysis (LPA) to delineate homogeneous subgroups of children according to individual patterns of function on six dimensions of schizotypy that were assessed via self-report in middle childhood (aged 11–12 years). We then examined associations between membership in each subgroup and antecedent risk factors evident in linked administrative data, including perinatal events, parental mental illness, childhood maltreatment, and

poor educational attainment. We also explored the proportion of children in each subgroup who had been diagnosed with mental disorders by the age of 13 years. This approach considered each dimension of schizotypy as operating within the normal range of function (Grant, Green, & Mason, 2018), from which discrete classes of individuals can be detected according to their pattern of functioning across the full set of schizotypal domains (Linscott & van Os, 2010).

Method

Sample

Participants were 22,137 children (mean age = 13.19-years, *SD* = 0.36; range = 11.6–14.9) drawn from the NSW Child Development Study (NSW-CDS), with complete data on the Middle Childhood Survey (MCS) (Laurens et al., 2017) as well as linked administrative records for their biological mothers (Green et al., 2018). From the full MCS cohort (n = 27,808) we excluded 4,893 children whose births were *not* registered in NSW (i.e., no linked parental records) and a further 778 children without specific MCS items required for the present analyses.

Instruments

Demographic indicators

Age, sex, and residential postcode were self-reported in the MCS. Dichotomous demographic variables were used to index the child's sex (boys vs. girls), socio-economic disadvantage (yes vs. no), and Indigenous status (yes vs. no; determined via the identification of the child or either of their parents as Aboriginal or Torres Strait Islander in any of the available record sets). The index of socio-economic disadvantage was based on the Australian Bureau of Statistics' Index of Relative Disadvantage (IRSD) from the Socio-Economic Index for Areas (Pink, 2013); Quintile 1 was regarded as disadvantaged (vs. quintiles 2–5 as not disadvantaged).

Schizotypy

Fifty-nine items from the MCS were used to index schizotypal characteristics according to six domains that were chosen to match constructs measured by two commonly-employed adult schizotypy questionnaires (the O-LIFE and the Schizotypal Personality Questionnaire) (Liu, Wong, Dong, Raine, & Tuvblad, 2019; Mason & Claridge, 2006; Raine, 1991): *Unusual Experiences* (12 items; Cronbach's alpha = .83); *Cognitive Disorganization* (6 items; Cronbach's alpha = .73); *Impulsive Non-conformity* (14 items; Cronbach's alpha = .82); *Introversion-Asociality* (9 items; Cronbach's alpha = .77); *Anxiety and Depression* (6 items; Cronbach's alpha = .78); *Self-Other disturbance* (11 items; Cronbach's alpha = .84). Further details regarding content and psychometric properties of each domain are provided in the Tables S1-S4. Summed scores on each of the six domains were converted to z-scores for LPA.

Perinatal risk factors

Three dichotomous perinatal indicators were derived from data in the NSW Ministry of Health's Perinatal Data Collection (PDC, 2003–2005), including prenatal maternal smoking

exposure, low birth weight for gestational age (<10th percentile) (Dobbins, Sullivan, Roberts, & Simpson, 2012), and pregnancy complications (i.e., maternal diabetes, gestational diabetes, hypertension or pre-eclampsia). A fourth indicator of young maternal age at the child's birth (≤ 21-years) was derived from the NSW birth registration data.

Child protection reports and out-of-home-care placements

A two-level categorical indicator of child protection contact in early childhood (i.e., up to age 5–6 years) as recorded by the NSW Department of Communities and Justice (DCJ) Child Protection Case Management System (2000–2009) was used as an index of child maltreatment. One level comprised all instances of a child protection notifications but excluded children placed in out-of-home care; the other level comprised children who had been placed in out-of-home care (i.e., removal from the care of parents). Each of these groups was compared to a subgroup with no history of child protection contact (reference category).

Early developmental vulnerability

The Australian Early Development Census (AEDC) (Brinkman, Gregory, Goldfeld, Lynch, & Hardy, 2014) is a teacher-reported assessment of early developmental vulnerability across a range of five functional domains: *Social Competence, Emotional Maturity, Physical Health and Wellbeing, Language and Cognitive Skills (school-based), and Communication and General Knowledg*e (Janus, Brinkman, & Duku, 2011). The 104-item AEDC was completed during the first year of formal schooling by the child's teacher (Brinkman et al., 2014). Children scoring in the lowest 10th centile of the national population were classified as developmentally vulnerable in a particular domain (Brinkman et al., 2007). Dichotomous variables indicating developmental vulnerability (0–10th centiles) or no vulnerability (11–99th centiles) for each domain were available for 19,298 (87%) children. We also derived a three-level index of (non-specific) developmental vulnerability on *any one* AEDC domain, *any two* AEDC domains, or *any three or more* AEDC domains, for comparison to children showing no vulnerability (11–99th centiles) on any domain (reference group).

Academic attainment (3rd grade, age ~8 years)

A binary indicator of poor academic attainment (scoring *below the national minimum standard*) at approximately 8 years of age was indexed via the National Assessment Program of Literacy and Numeracy (NAPLAN) tests for NSW (ACARA, 2016), delivered annually to all Australian school students in 3rd grade, for the following domains: reading, writing, spelling, grammar and punctuation, and numeracy.

Childhood mental disorders

Childhood mental disorder was defined using International Classification of Disease (ICD)-10 codes for specific mental disorders, and for self-harm, recorded as primary or secondary diagnoses in the NSW Ministry of Health's Mental Health Ambulatory (i.e., public community-based or outpatient services), Admitted Patient (including both public and private hospital admissions), and Emergency Department Data Collections (within which a small proportion of codes from the Systematized Nomenclature of

Medicine – Clinical Terms [SNOMED CT] were converted to ICD-10 codes where possible). These data were available in the years 2001–2016 (approximate child age spanning from birth to 13 years). Diagnostic categories were not mutually exclusive (i.e., a child could appear in more than one category if multiple records existed with different diagnoses recorded in each). Given small numbers of children in some mental disorder categories (we are unable to report cells <15), we reported results for three broad categories of 'Internalizing', 'Externalizing', and 'Developmental Disorders', as well as for specific mental disorders with sufficient prevalence to allow reporting (that is, Anxiety and Neurotic Disorders, Phobias and Anxiety, Stress Reactions, Hyperkinetic Disorders, Conduct Disorders, Autism Spectrum and other Developmental Disorders, Sleep Disorders, and Mental Disorders Unspecified). Information about ICD-10 codes included in each of the 'broad' and 'specific' mental disorder categories is provided in Table S5.

Parental mental disorders

A binary indicator of any parental mental disorder recorded in the Emergency Department Data Collection (EDDC, 2005–2016), Admitted Patient Data Collection (APDC, 2001–2016), or Mental Health Ambulatory Data Collection (MH-AMB, 2001–2016), according to F-codes of the International Statistical Classification of Diseases and Related Health Problems (World Health Organization, 1992) Tenth Revision, Australian Modification (ICD-10-AM).

Parental offending

A binary indicator was used to indicate a criminal offence history for either parent, according to the Australian and New Zealand Standard Offence Classification, obtained from the NSW Bureau of Crime Statistics and Research Reoffending Database (ROD; 1994–2016).

Procedures

Middle Childhood Survey (MCS)

Recruitment for the MCS was conducted with ethical approvals obtained from the University of NSW Human Research Ethics Committee (HC14307) and the NSW Department of Education State Education Research Applications Process (2015082). The school leaders of 829 schools (35% of 2,371 eligible schools in NSW) consented to participate; all 6th-grade children (and their parents) in these 829 schools received information about the MCS and procedures to opt-out should they wish. Of 32,389 children enrolled at consenting schools, 27,808 (85.9%) participated; opt-outs were received from 816 children and 573 parents, and 3,192 children did not participate for other reasons (e.g., absence from school or technical failure of the online survey platform). Participating schools and children were found to be representative of the NSW population on a range of sociodemographic indicators (Laurens et al., 2017).

Record linkages

Record linkage of multi-agency data to the MCS was conducted by the Centre for Health Record Linkage (CHeReL; http://www.cherel.org.au/), with ethical approval from the NSW Population and Health Services Research Ethics Committee (PHSREC AU/1/

1AFE112), using probabilistic linkage methods with estimated false positive linkage rate of <0.5%. Parental data were linked to child data via the NSW Registry of Birth, Deaths and Marriages Birth Registrations (2000–2006).

Statistical analyses

LPA models were estimated using Mplus 7.4 (Muthén & Muthén, 1998-2017). To identify the optimal LPA solution, we fitted models for six standardized schizotypy (domain) indices. All LPA models employed the maximum likelihood estimation with robust standard errors (MLR) and 20 random starts (10 iterations) to allow thorough investigation of multiple solutions and to ensure loglikelihood replicability (Berlin, Williams, & Parra, 2014). The optimal number of profiles was determined at each time point by taking into account fit and classification indices (including Akaike [AIC] and Bayesian Information Criterion [BIC], the Sample-Size-Adjusted BIC [ssBIC], estimated entropy value, and the Vuong-Lo-Mendell-Rubin Likelihood Ratio Test [VLMR-LRT]) as well as theoretical justification, parsimony, and interpretability (Jung & Wickrama, 2008). Solutions with two to six distinct profiles were fitted to the data and compared on these features (Celeux & Soromenho, 1996). We interpreted the final LPA models using the item scale means and probabilities. A latent profile membership value was assigned to each child based on their most likely predicted profile membership and saved as a nominal variable.

Following delineation of profiles using Mplus, a series of bivariate multinomial logistic regression (MLR) analyses were conducted using IBM SPSS version 26.0 (IBM Corporation, 2019) to examine the pattern and magnitude of crude and adjusted (for the child's sex, socio-economic disadvantage, and Indigenous status) associations between each childhood risk factor and membership of the schizotypy subgroups emerging from the LPA. These analyses yielded odds ratios (ORs) and their 95% confidence intervals (CIs) as measures of effect size, with ORs of 1.00 to 1.49 (or 1.00 to 0.66) interpreted as small effects, 1.50–2.49 (or 0.67 to 0.39) as medium, and 2.50–4.00 (or 0.40 to 0.25) as large effects (Rosenthal, 1996). We also examined the proportion of children in each subgroup who had been diagnosed with mental disorders by the age of 13 years.

Results

Descriptive statistics

Prevalence rates for exposure to demographic and perinatal risk factors, child protection contacts and out-of-home-care placement, early developmental vulnerability, academic underachievement, parental mental disorders and criminal offending, and child mental disorders are presented in Table 1.

Latent profile analyses

Model fit and classification indices for 2- through 6-profile solutions are presented in Table S6. The most substantial decreases in AIC and BIC indices were evident up to the model with four latent profiles, after which changes in fit indices were much smaller. The VLMR-LRT suggested significant difference in fit began to decrease when comparing the 4-class to a 5-class model. With consideration of these fit indices and the acceptable entropy value (.78), the four-profile solution was chosen as the most parsimonious and is depicted in Figure 1 according to group mean *z*-scores for each dimension. The proportion of

Table 1. Sociodemographics and Risk Exposure Rates for 22,137 Children Included in the Study

Risk exposures	*n*	%
Sociodemographic factors		
Child sex (male)	11,151	50.4
Socio-economic disadvantage (SEIFA lowest quintile)	4,055	18.3
Indigenous (Aboriginal or Torres Strait Islander)	1,607	7.3
Perinatal factors		
Young maternal age (<21 years) at childbirth	1,272	5.8
Maternal smoking during pregnancy	3,066	14.0
Low birth weight for gestational age	2,389	10.9
Maternal pregnancy complications	2,413	11.0
Child protection contacts in early childhood		
Child protection report but no out-of-home-care placement	3,524	15.9
Out-of-home-care placement	326	1.5
Total	3,850	17.4
AEDC early childhood developmental vulnerability (age ~5-years)		
Physical Health and Wellbeing	1,397	7.2
Social Competence	1,438	7.5
Emotional Maturity	1,173	6.1
Language and Cognitive Skills (school-based)	804	4.2
Communication and General Knowledge	1,363	7.1
Developmental vulnerability on 1 AEDC domain	1,845	9.6
Developmental vulnerability on 2 AEDC domains	841	4.4
Developmental vulnerability on ≥ 3 AEDC domains	744	3.9
Academic achievement (NAPLAN; Age ~8 years; 3rd grade)		
Reading (below minimum standard)	643	3.1
Writing (below minimum standard)	299	1.4
Spelling (below minimum standard)	612	2.9
Grammar and Punctuation (below minimum standard)	951	4.5
Numeracy (below minimum standard)	710	3.4
Parental factors		
Parental mental disorder	5,199	23.5
Parental criminal offending	6,985	31.6
Childhood Mental Disorders	1,096	5.0

Note. SEIFA=Socio-Economic Index for Areas; AEDC = Australian Early Development Census; NAPLAN = National Assessment Program for Literacy and Numeracy.

children represented in each of these four profiles and group mean *z*-scores are presented in Table 2.

In the four-profile model, the largest class (54.9%) comprised children who did not show any signs of schizotypy; this can be described as the *No Risk* class. The remaining three profiles had distinct patterns of functioning on the six domains of schizotypy: one profile, representing 5.9% of the sample included children with high levels of cognitive disorganization, impulsive non-conformity, introversion, and self-other disturbance; we labelled this the *True Schizotypy* class given its resemblance to a taxon proposed by Meehl (1990). The other two profiles were characterized by patterns of psychopathology that may mimic true schizotypy (also following Meehl's original conjectures). One profile comprising approximately 19% of the sample, which we labelled *Introverted Schizotypy*,

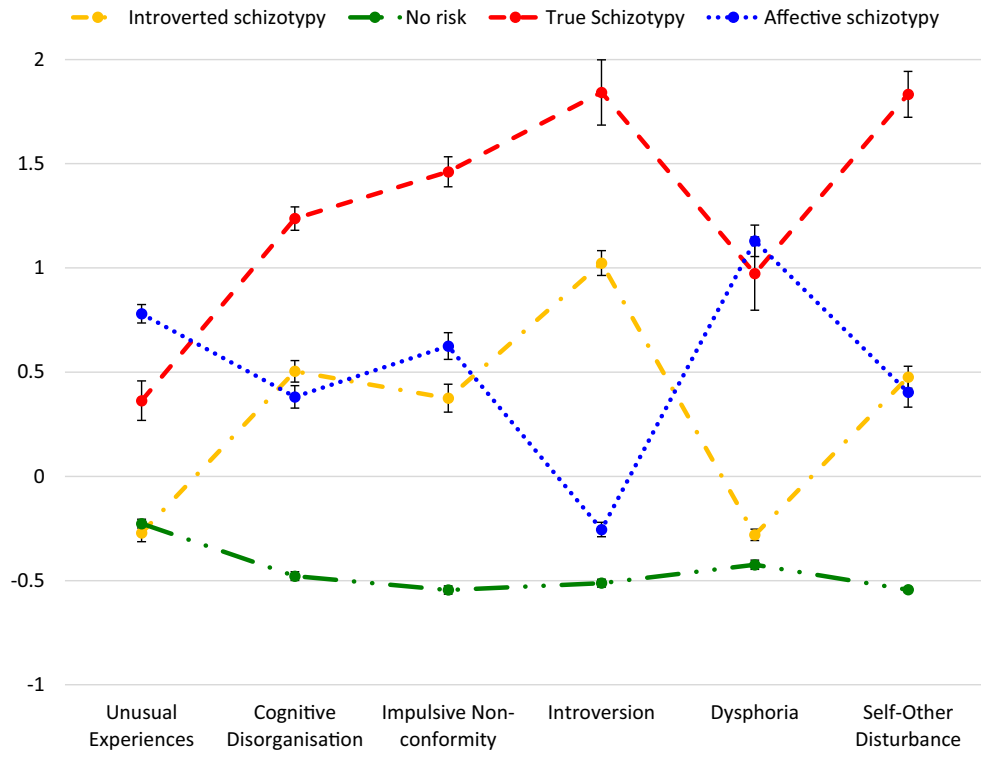

Figure 1. Z-Score profiles (and 95% Confidence Intervals) for the four-class model of six schizotypy domains.

was made up of children who reported high levels of introversion-asociality and intermediate levels of cognitive disorganization, impulsive non-conformity, and self-disturbance, but no unusual experiences or anxiety or depression. Notably, the *Introverted Schizotypy* profile appeared to represent an attenuated version of the *True Schizotypy* profile, with a similar relational pattern between schizotypal characteristics each expressed at lower thresholds (Figure 1). Another profile representing approximately 20% of the sample, which we labelled *Affective Schizotypy*, was characterized by prominent unusual experiences (e.g., PLEs and other perceptual disturbances) alongside high levels of anxiety and depression.

Associations between risk profile membership and early life risk factors

The unadjusted and adjusted (for sex, socio-economic disadvantage, and Indigenous status) associations of risk exposures with membership in each schizotypal risk class, relative to the *No Risk* class, are presented in Tables 3 and 4, respectively. In general, the children in the *True Schizotypy* class showed the greatest likelihood of exposure to all risk factors in early childhood, compared to the *No Risk* group. Large unadjusted associations were evident between exposure to particular perinatal events (e.g., maternal smoking *in utero*), multiple early developmental vulnerabilities, placement in out-of-home care, and academic underachievement and membership in the *True Schizotypy* class (Table 4), and Indigenous children were more than 2.5 times as likely to be represented in *True*

Table 2. Average Posterior Probabilities for most likely Class Membership and Mean z-scores for the 4-Class Model of Schizotypy

	Most likely class membership			
Class and schizotypy attribute	Class 1: No risk	Class 2: Introverted (pseudo) schizotypy	Class 3: Affective (pseudo) schizotypy	Class 4: True schizotypy
Mean posterior probabilities				
Class 1: No risk (54.5%; *n* = 12,080)	**.92**	.04	.04	.00
Class 2: Introverted schizotypy (20.2%; *n* = 4,473)	.08	**.82**	.06	.04
Class 3: Affective schizotypy (19.2%; *n* = 4,261)	.08	.06	**.84**	.01
Class 4: True schizotypy (5.9%; *n* = 1,323)	.00	.09	.05	**.86**
Mean z-score (*SE*)				
Unusual Experiences	−0.23 (0.01)	−0.27 (0.03)	0.78 (0.03)	0.36 (0.06)
Cognitive Disorganization	−0.48 (0.01)	0.50 (0.03)	0.38 (0.03)	1.24 (0.03)
Impulsive Non-conformity	−0.55 (0.01)	0.38 (0.04)	0.63 (0.04)	1.46 (0.05)
Introversion (Asociality)	−0.51 (0.01)	1.02 (0.36)	−0.26 (0.02)	1.84 (0.10)
Anxiety/Depression	−0.43 (0.01)	−0.28 (0.02)	1.13 (0.05)	0.97 (0.11)
Self-disturbance	−0.55 (0.01)	0.48 (0.03)	0.40 (0.04)	1.83 (0.07)

Note. SE = Standard Error. Boldfaced type indicates the average posterior probabilities reflecting the classification accuracy; values closer to 1.00 indicate greater precision.

Table 3. Unadjusted Odds Ratios (uOR) and 95% Confidence Intervals (CI) for Associations between Childhood Risk Factors and Schizotypal Risk Profiles

	True Schizotypy			Introverted Schizotypy			Affective Schizotypy		
Risk exposure	*uOR*	(95% CI)	*p*	*uOR*	(95% CI)	*p*	*uOR*	(95% CI)	*p*
Sociodemographic factors									
Male sex	1.80[a]	(1.60–2.02)	<.001	2.24[a]	(2.08–2.41)	<.001	0.86	(0.80–0.93)	<.001
Socio-economic disadvantage[a]	1.71[a]	(1.50–1.96)	<.001	1.37	(1.26–1.50)	<.001	1.29	(1.19–1.42)	<.001
Indigenous	2.52[b]	(2.10–3.03)	<.001	1.77[a]	(1.55–2.01)	<.001	1.67[a]	(1.46–1.90)	<.001
Pregnancy and birth factors									
Young maternal age (<21 years) at child's birth	2.47[a]	(2.03–3.00)	<.001	1.56[a]	(1.34–1.80)	<.001	1.52[a]	(1.31–1.76)	<.001
Exposed to maternal smoking in utero	2.70[b]	(2.35–3.09)	<.001	1.68[a]	(1.53–1.86)	<.001	1.63[a]	(1.48–1.81)	<.001
Low birth weight for gestational age	1.31	(1.11–1.56)	.002	1.19	(1.06–1.32)	.002	1.12	(0.99–1.25)	.053
Pregnancy complications	1.17	(0.98–1.39)	.082	1.00	(0.89–1.12)	.994	1.20	(1.08–1.34)	<.001
Child protection contact									
Child protection report but no care placement	2.46[a]	(2.15–2.82)	<.001	1.53[a]	(1.34–1.68)	<.001	1.67[a]	(1.53–1.83)	<.001
Out-of-home care placement	5.16[b]	(3.66–7.29)	<.001	2.48[a]	(1.87–3.29)	<.001	2.38	(1.78–3.19)	<.001
Early childhood (5 years) developmental vulnerability									
Physical Health and Wellbeing	2.46[a]	(2.01–3.01)	<.001	1.75[a]	(1.52–2.09)	<.001	1.97[a]	(1.72–2.26)	<.001
Social Competence	3.08[b]	(2.55–3.73)	<.001	1.97[a]	(1.71–2.26)	<.001	2.09[a]	(1.82–2.40)	<.001
Emotional Maturity	3.50[b]	(2.84–4.30)	<.001	2.44[a]	(2.10–2.82)	<.001	2.24[a]	(1.92–2.62)	<.001
Language and Cognitive Skills (school-based)	2.07[a]	(1.58–2.72)	<.001	1.87[a]	(1.56–2.25)	<.001	1.83[a]	(1.53–2.19)	<.001
Communication and General Knowledge	1.81[a]	(1.46–2.25)	<.001	1.66[a]	(1.45–1.91)	<.001	1.68[a]	(1.46–1.93)	<.001
Developmental vulnerability on 1 AEDC domain	1.98[a]	(1.64–2.39)	<.001	1.64[a]	(1.45–1.85)	<.001	1.48	(1.30–1.68)	<.001
Developmental vulnerability on 2 AEDC domains	3.01[b]	(2.34–3.85)	<.001	2.00[a]	(1.68–2.39)	<.001	2.06[a]	(1.73–2.46)	<.001
Developmental vulnerability on ≥ 3 AEDC domains	3.53[b]	(2.71–4.60)	<.001	2.42[a]	(2.05–2.92)	<.001	2.58[b]	(2.14–3.11)	<.001
Poor Academic Attainment (8 years) – 3rd grade									
Reading	3.91[b]	(3.01–5.06)	<.001	2.48[a]	(2.03–3.02)	<.001	2.10	(1.70–2.59)	<.001
Writing	5.05[b]	(3.45–7.40)	<.001	3.66[b]	(2.72–4.91)	<.001	2.75[b]	(2.01–3.79)	<.001
Spelling	3.58[b]	(2.72–4.71)	<.001	2.31[a]	(1.87–2.84)	<.001	2.48[a]	(2.02–3.05)	<.001
Grammar and Punctuation	3.34[b]	(2.65–4.20)	<.001	2.36[a]	(1.99–2.79)	<.001	2.45[a]	(2.11–2.95)	<.001
Numeracy	3.07[b]	(2.38–3.96)	<.001	1.78[a]	(1.48–2.19)	<.001	2.14	(1.77–2.59)	<.001

Continued

Table 3. (*Continued*)

	True Schizotypy			Introverted Schizotypy			Affective Schizotypy		
Risk exposure	*uOR*	(95% CI)	*p*	*uOR*	(95% CI)	*p*	*uOR*	(95% CI)	*p*
Parental factors									
Any parental mental illness	2.27[a]	(2.01–2.56)	<.001	1.39	(1.29–1.51)	<.001	1.54[a]	(1.42–1.67)	<.001
Any parental criminal offending	2.03[a]	(1.81–2.84)	<.001	1.44	(1.34–1.54)	<.001	1.56[a]	(1.45–1.68)	<.001

Note. Reference group was the '*No Risk*' class; AEDC = Australian Early Development Census.
[a]Medium effect size.; [b]Large effect size.

Table 4. Adjusted Odds ratios (aOR) and 95% Confidence Intervals (CI) for Associations between Childhood Risk Factors with Schizotypal Risk Profiles

	True schizotypy			Introverted schizotypy			Affective schizotypy		
Risk exposure	*aOR*	(95% CI)	*p*	*aOR*	(95% CI)	*p*	*aOR*	(95% CI)	*p*
Pregnancy and birth factors									
Young maternal age (< 21 years) at child's birth	1.98[a]	(1.61–2.42)	<.001	1.37	(1.17–1.59)	<.001	1.35	(1.16–1.57)	<.001
Exposed to maternal smoking in utero	2.35[a]	(2.04–2.73)	<.001	1.56[a]	(1.41–1.73)	<.001	1.50[a]	(1.36–1.66)	<.001
Low birth weight for gestational age	1.26	(1.06–1.50)	.008	1.17	(1.05–1.31)	.005	1.09	(0.97–1.22)	.135
Pregnancy complications	1.16	(0.97–1.38)	.107	0.98	(0.88–1.10)	.787	1.21	(1.08–1.35)	<.001
Child protection contact in early childhood									
Child protection report but no care placement	2.17[a]	(1.89–2.50)	<.001	1.42	(1.28–1.56)	<.001	1.57[a]	(1.43–1.73)	<.001
Out-of-home care placement	4.09[b]	(2.87–5.84)	<.001	2.09	(1.56–2.80)	<.001	2.13	(1.58–2.86)	<.001
Early childhood (5 years) developmental vulnerability									
Physical Health and Wellbeing	2.03[a]	(1.65–2.48)	<.001	1.46	(1.62–1.68)	<.001	1.95[a]	(1.69–2.24)	<.001
Social Competence	2.56[b]	(2.11–3.11)	<.001	1.63[a]	(1.42–1.88)	<.001	2.09[a]	(1.82–2.40)	<.001
Emotional Maturity	2.85[b]	(2.30–3.51)	<.001	*1.92*[a]	*(1.65–2.24)*	<.001	2.33[a]	(1.99–2.73)	<.001
Language and Cognitive Skills (school-based)	1.62	(1.23–2.14)	<.001	1.53[a]	(1.28–1.83)	<.001	1.75[a]	(1.46–2.10)	<.001
Communication and General Knowledge	1.49	(1.20–1.86)	<.001	1.40	(1.22–1.62)	<.001	1.65[a]	(1.43–1.90)	<.001
Developmental vulnerability on 1 AEDC domain	1.72[a]	(1.42–2.08)	<.001	1.42	(1.25–1.60)	<.001	1.49	(1.31–1.69)	<.001
Developmental vulnerability on 2 AEDC domains	2.49[a]	(1.93–3.20)	<.001	1.65[a]	(1.38–1.98)	<.001	2.08[a]	(1.74–2.49)	<.001
Developmental vulnerability on ≥ 3 AEDC domains	2.73[b]	(2.08–3.55)	<.001	1.87[a]	(1.55–2.27)	<.001	2.60[b]	(2.15–3.14)	<.001
Poor Academic Attainment (8 years) – 3rd grade									
Reading	3.11[b]	(2.39–4.04)	<.001	2.04[a]	(1.67–2.50)	<.001	2.00[a]	(1.62–2.48)	<.001
Writing	3.54[b]	(2.40–5.22)	<.001	2.64[b]	(1.96–3.56)	<.001	2.64[b]	(1.92–3.64)	<.001
Spelling	2.69[b]	(2.03–3.56)	<.001	1.82[a]	(1.47–2.25)	<.001	2.33[a]	(1.89–2.88)	<.001
Grammar and Punctuation	2.54[b]	(2.01–3.21)	<.001	1.87[a]	(1.57–2.22)	<.001	2.39[a]	(2.01–2.83)	<.001
Numeracy	2.49[a]	(1.92–3.24)	<.001	1.58[a]	(1.29–1.92)	<.001	1.97[a]	(1.63–2.38)	<.001
Parental factors									
Any parental mental illness	2.04[a]	(1.80–2.31)	<.001	1.30	(1.19–1.41)	<.001	1.47	(1.35–1.59)	<.001
Any parental criminal offending	1.79[a]	(1.59–2.02)	<.001	1.34	(1.24–1.45)	<.001	1.46	(1.36–1.59)	<.001

Note. Reference group was the '*No Risk*' class; All models were adjusted for the child's sex, socio-economic disadvantage, and Indigenous status. AEDC = Australian Early Development Census.

[a]Medium effect size.; [b]Large effect size.; The relevance use pf 'italic values' is to provide an index of medium and large effect sizes.

Schizotypy class than the *No Risk* class. Memberships in the other two schizotypy groups had large unadjusted associations with some specific domains of academic underachievement (Table 4), and medium associations with out-of-home-care placement, early childhood developmental vulnerability, and educational underachievement.

All associations were slightly attenuated following adjustment for sex, socio-economic disadvantage, and Indigenous status (Table 4). For the *True Schizotypy* group, adjusted associations with pregnancy and birth risk factors, parental risk factors, and child protection reports without out-of-home care were small to medium in magnitude. Large effect sizes were observed for associations with out-of-home care, vulnerabilities in social and emotional competence, vulnerabilities on three or more developmental domains, and all four literacy domains of academic underachievement. For both the *Affective Schizotypy* and *Introverted Schizotypy* classes, the strongest associations (of large effect size) were evident for academic underachievement in the writing domain, with smaller associations (of small to medium effect) evident for other domains of academic underachievement, child protection reports and out-of-home care, early childhood vulnerabilities, and exposure to maternal smoking *in utero*. Interestingly, the *Affective Schizotypy* but not the *Introverted Schizotypy* group showed large odds of early childhood vulnerability on three or more domains of the AEDC, and for domains reflecting poor social competence and emotional development.

Mental disorder diagnoses among schizotypy risk profiles

The proportion of children with mental disorder diagnoses in each of the schizotypy (and no risk) subgroups is presented in Table 5, alongside Chi-square statistics testing differences in expected/observed distributions of each category of mental disorder across these four groups; the absolute numbers of children diagnosed with some categories of disorder were too small to be reported, but these diagnoses are represented in the 'Any mental disorder' category (see Table S5 for details). Children in the *True Schizotypy* group had the highest proportion of mental disorder diagnoses; 10.1% of children classified with *True Schizotypy* had been diagnosed with any kind of mental disorder (or had a report of self-harm) by age 13 years, compared to 3.1% of the *No Risk* group, 5.5% of the *Introverted Schizotypy* group, and 6.5% of the *Affective Schizotypy* group. This pattern of distribution was consistent for the three broad diagnostic categories (Internalizing, Externalizing, and Developmental Disorder) diagnoses, and all specific mental disorder diagnoses except for sleep disorders (Table 5).

Discussion

In a large population sample of children aged 11-12 years, we delineated three distinct profiles of schizotypy that may represent different types of risk for psychotic and related disorders in childhood. One subgroup, representing around 6% of the population, was characterized by high levels of cognitive disorganization, impulsive non-conformity, introversion, and self-other disturbance, moderate levels of dysphoria, but low levels of unusual experiences. We have tentatively labelled this group *True Schizotypy* because it most closely resembles the taxon proposed by Meehl (1990), as discussed in further detail below. Two other subgroups of children were characterized by patterns of psychopathology that may *mimic* true schizotypy, also in line with Meehl's theory. That is, a profile that we labelled *Introverted Schizotypy*, representing 19% of the population,

Table 5. Proportion of children with mental disorder diagnoses among Schizotypal Risk and No Risk Profiles

	True Schizotypy		Introverted Schizotypy		Affective Schizotypy		No risk		Pearson Chi-Square statistics		
	N = 1,323		*N* = 4,473		*N* = 4,261		*N* = 12,080				
Mental disorder diagnoses	*n*	% (column)	*n*	% (column)	*n*	% (column)	*n*	% (column)	X^2	*df*	*p*-value
Any mental disorder	134	10.1	244	5.5	275	6.5	443	3.7	140.54	3	<.001
Broad Diagnostic categories											
Internalizing disorders[a]	34	2.6	55	1.2	49	1.1	100	0.8	32.58	3	<.001
Externalizing disorders[b]	23	1.7	33	0.7	24	0.6	42	0.3	46.01	3	<.001
Developmental disorders[c]	16	1.2	23	0.5	40	0.9	35	0.3	39.35	3	<.001
Specific diagnostic categories											
Phobias and Anxiety	20	1.5	25	0.6	36	0.8	65	0.5	20.31	3	<.001
Hyperkinetic disorders	<15	–	20	0.4	15	0.4	21	0.2	14.60	3	.002
Conduct disorders	17	1.3	18	0.4	<15	–	26	0.2	44.60	3	<.001
Sleep disorders	<15	–	29	0.6	25	0.6	67	0.6	0.56	3	.905
Mental disorders unspecified	95	7.2	173	3.9	180	4.2	256	2.1	134.88	3	<.001

[a]Internalizing Disorders comprised ICD-10 codes relating to 'Emotional disorders of childhood', 'Phobias and Anxiety', 'Obsessive Compulsive Disorders', 'Stress Reactions', 'Dissociative/Conversion Disorders', and 'Somataform and other neurotic disorders'.; [b]Externalizing Disorders comprised ICD-10 codes relating to 'Hyperkinetic Disorders' such as Attention-Deficit Hyperactivity Disorder (ADHD), 'Conduct Disorders', and 'Mixed Disorders of Conduct and Emotion'.; [c]Developmental Disorders comprised ICD-!0 codes relating to 'Developmental Disorders', 'Autism Spectrum Disorders', and 'Developmental Disorders Unspecified'. ICD-10 codes per category are presented in Table S5. Cell sizes <15 cannot be reported.

was characterized by high levels of introversion-asociality and intermediate levels of cognitive disorganization, impulsive non-conformity, and self-disturbance, alongside very low levels of unusual experiences or dysphoria (anxiety/depression). A third profile that we labelled *Affective Schizotypy*, representing a different 20% of the child population, was characterized by prominent unusual experiences (i.e., PLEs and other experiences of perceptual distortion) alongside anxiety and depression, but with extremely low levels of introversion, and similar levels of cognitive disorganization, impulsive non-conformity, and self-disturbance as the *Introverted Schizotypy* profile.

While the children in the *True Schizotypy* group appear (*prima facie*) to be at highest risk for schizophrenia or related psychotic disorders, this group showed the highest proportion of nearly all types of childhood mental disorder diagnoses emerging before age 13 years; the proportion of the *True Schizotypy* group with existing mental disorders was at least double that of the *Introverted Schizotypy* and *Affective Schizotypy* groups, with the exception of Sleep Disorders which were more prevalent in the latter groups. It is highly probable that children classified into these other subgroups at this age may be at risk of various forms of psychopathology in later life (e.g., children belonging to the *Affective Schizotypy* class may be at risk of later affective psychoses or indeed other mental disorders that are more common in the general population, such as depression, anxiety, and/or personality disorder). Early life mental disorder diagnoses in all risk profiles may yet reflect homotypic or heterotypic patterns of emerging psychopathology that can be examined in later follow-up of these children. The cohort will be followed into adulthood to test these hypotheses in the context of life-course events.

Our findings of four latent schizotypy classes in primary/elementary school-aged children are in line with latent schizotypy class structures identified in studies of older university students (Fonseca-Pedrero et al., 2019; Tab ak & Weisman de Mamani, 2013) or high school-age adolescents (Cella et al., 2013; Fonseca-Pedrero et al., 2017; Lucas-Molina et al., 2020; Tab ak & Weisman de Mamani, 2013), in which three to five distinct subgroups of individuals have been reported. The present findings are perhaps most similar to those of Fonseca-Pedrero et al. who identified four classes including a small (6.7%) class showing high levels of schizotypy, and two medium sized classes, one characterized by high unusual experience and one by social difficulties, along with a large class showing no risk. The main difference between findings is that our small *True Schizotypy* class was characterized by cognitive dysfunction, which Fonseca-Pedrero et al. did not measure.

The pattern of schizotypal characteristics represented in the class labelled here as *True Schizotypy* is reminiscent of the schizotaxia phenotype Meehl proposed in his neurodevelopmental model of schizotypy (Meehl, 1962, 1989, 1990), with prevalence in line with the expected base rate (<.10) in the general population. Meehl proposed that schizophrenia was the result of complex interactions among three critical factors: (a) a genetically determined neuro-integrative defect (or brain disturbance observable in *cognitive slippage*), termed *schizotaxia*, which served as the foundation upon which (b) environmentally mediated social learning experiences could influence the development of *schizotypal personality organization*, and which could be pushed towards decompensation into clinical forms of illness via interaction (of schizotaxia) with (c) other polygenetically determined dimensions of personality (e.g., anxiety, introversion). Meehl referred to other forms of *pseudo-schizotypy* that could mimic true schizotypy, providing alternative pathways to psychotic illness; these individuals were not deemed to have inherited the schizotaxic brain but had the propensity to manifest personality features and cognitive disturbances observable as phenotypically similar to schizotypy, via a

combination of polygenically determined personality traits (e.g., anxiety, introversion, hypohedonia) and traumatic events (either physical or social), or even just *bad luck*, but lacking the underlying schizotaxic brain pathology. This idea of a pseudo-schizotypy syndrome that mimics the signs and symptoms of schizotypy but has a different pathogenic pathway has received little empirical attention, despite strong evidence for traumagenic neurodevelopmental models of psychosis (Read, Perry, Moskowitz, & Connolly, 2001). A similar proposal of two distinct subtypes of schizotypy has been proposed (Raine, 2006), in which (a) *neurodevelopmental schizotypy* is proposed to be associated predominantly with genetic, prenatal, and early postnatal factors, while (b) *pseudo-schizotypy* is proposed to be associated predominantly with psychosocial adversity. Our distinction between *True Schizotypy* and two putative pseudo-schizotypy classes could be interpreted to fit this model, given large associations between the *True Schizotypy* class and several perinatal risk factors. However, the *True Schizotypy* class was also strongly associated with childhood maltreatment experiences (e.g., as inferred from child protection reports and out-of-home-care placements), and both our 'pseudo-schizotypy' classes were also associated with early life psychosocial stressors (child protection reports, parental offending). Identifying potential forms of 'pseudo-schizotypy' as distinct from any 'true schizotypy' taxon is complicated by the idea that many polygenically determined personality traits and environmental factors also act as potentiators of schizotypy (i.e., pushing those with schizotaxia towards transition to schizophrenia).

A striking element of the current evidence concerns longitudinal evidence of deficits in academic functioning (and particularly writing) that preceded classification in the *True Schizotypy* group at age 11–12 years; however, the putative *pseudo-schizotypy* classes also showed evidence of academic underachievement, albeit in fewer domains. These findings are consistent with a previous study using cross-sectional data (Lucas-Molina et al., 2020), and recent evidence indeed shows that cognitive performance deficits can appear early in life among children who go on to develop schizophrenia, such as lower mean IQ at age 4 and 7 years (Agnew-Blais et al., 2015), and poorer academic achievement by age 16 years (Dickson et al., 2020), relative to typically developing children. Furthermore, individuals identified as at UHR often have significant cognitive deficits at baseline (i.e., established *before* the prodrome) that do not respond readily to intervention (Bora & Murray, 2014), and there is evidence of overlap between genetic markers of cognitive ability and psychotic illness (Knowles et al., 2021).

Although the retrospective analysis of longitudinal data obtained via record linkage confers several advantages, including the avoidance of recall or interviewer bias and the minimization of sampling biases, several limitations of this study should be considered. First, potential errors in administrative data entry are possible, though likely to have limited impact in a sample of this size. Second, the items used to define subgroups of children were not specifically designed to measure schizotypy, but were selected according to their alignment with the O-LIFE (Mason & Claridge, 2006) and the SPQ (Raine et al., 1994), and demonstrated good psychometric properties (Supplementary Materials). There is clearly a need to develop reliable and valid self-report indices of schizotypy for children in this developmental stage, prior to adolescence. Use of self-report data may also be limited in measuring cognitive dysfunction in particular among children without insight but is arguably well-suited to measuring subjective experiences. Third, this study was not genetically informed.

In conclusion, this large population-based study suggests that latent liability for schizophrenia (and perhaps other mental disorders) may be represented by distinct

patterns of functioning across multiple domains in childhood, consistent with previous findings of discrete schizotypy taxa in adult samples (Linscott & van Os, 2010). These childhood schizotypal risk profiles may be useful to guide mitigation of risk of developing mental illness and perhaps other related adverse social outcomes (e.g., offending behaviour, education incompletion, unemployment) in the longer term. Adverse outcomes may not be inevitable: some children may develop psychological resources to recover from mental health challenges (Shannon, Beauchaine, Brenner, Neuhaus, & Gatzke-Kopp, 2007) whereas others may benefit from targeted interventions at critical periods of development (Bayer et al., 2009). The potential for a biological distinction between these subgroups of the population remains open for investigation via genetically informed studies (Morton et al., 2017).

Acknowledgements

This research used population data owned by the NSW Department of Education; Australian Curriculum, Assessment and Reporting Authority's (ACARA), managed by the NSW Education Standards Authority; NSW Department of Family and Community Services; NSW Ministry of Health; NSW Registry of Births, Deaths and Marriages; the Australian Coordinating Registry (on behalf of Australian Registries of Births, Deaths and Marriages, Australian Coroners and the National Coronial Information System); the Australian Bureau of Statistics; the NSW Bureau of Crime Statistics and Research; and NSW Police Force. This research used data from the Australian Early Development Census (AEDC); the AEDC is funded by the Australian Government Department of Education and Training. The findings and views reported are those of the authors and should not be attributed to these Departments or the NSW and Australian Government. MJG was a resident at the Bellagio Center, funded by the Rockefeller Foundation, during the production of the manuscript. Open access publishing facilitated by University of New South Wales, as part of the Wiley - University of New South Wales agreement via the Council of Australian University Librarians. [Correction added on 19th April 2022, after first online publication: CAUL funding statement has been added.]

Author contribution

Melissa Jayne Green: Conceptualization; Data curation; Formal analysis; Funding acquisition; Methodology; Project administration; Supervision; Visualization; Writing – original draft; Writing – review & editing. **Kirstie O'Hare:** Writing – original draft; Writing – review & editing. **Kristin Robyn Laurens:** Data curation; Funding acquisition; Project administration; Supervision; Writing – review & editing. **Stacy Tzoumakis:** Data curation; Funding acquisition; Methodology; Project administration; Writing – review & editing. **Kimberlie Dean:** Data curation; Funding acquisition; Project administration; Supervision; Writing – review & editing. **Johanna Badcock:** Funding acquisition; Writing – review & editing. **Felicity Harris:** Data curation; Project administration; Writing – review & editing. **Richard Linscott:** Conceptualization; Methodology; Writing – review & editing. **Vaughan James Carr:** Conceptualization; Data curation; Funding acquisition; Project administration; Writing – review & editing.

Conflict of interest

All authors declare no conflict of interest.

Funding

This research was financially supported by the Australian Research Council Linkage Project (LP110100150, with the NSW Ministry of Health, NSW Department of Education, and the NSW Department of Family and Community Services representing the Linkage Project Partners) and Future Fellowship (KL, FT170100294); the National Health and Medical Research Council (NHMRC) Project Grants (APP1058652 and APP1148055); and NHRMC Emerging Leadership grant (KD, APP1175408).

Data availability statement

The linked administrative data used in this study is owned by the Australian Government and cannot be made available to third parties by the authors.

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Received 6 December 2021

Supporting Information

The following supporting information may be found in the online edition of the article:

Table S1. Item content of schizotypy domains.
Table S2. Descriptive statistics for raw scores for schizotypy broad domains and subdomains in the NSW-CDS (n = 22,137).
Table S3. Correlations between schizotypy domains in the NSW-CDS (n = 22,137).
Table S4. Selected goodness-of-fit indices from confirmatory factor analysis models of subdomains (n = 22,137).
Table S5. ICD-10 codes used to define mental disorder diagnoses in the child cohort (categories are not mutually exclusive), from records in the Emergency Department Data Collection (EDDC; 2005-2016), Admitted Patient Data Collection (APDC; 2001-2016) and Mental Health Ambulatory data collection (MH-AMB; 2001-2016) from the NSW Ministry of Health.
Table S6. Model Fit and Classification Statistics for identifying the most parsimonious Latent Profile model.
Figure S1. AIC and BIC indices for 2- through 6- class models.
Figure S2. Entropy statistic for 2- through 6- class models.
Figure S3. Three profile solution for latent profile analysis.
Figure S4. Five profile solution for latent profile analysis.