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Developmental Course of Peer Problems and Co-occurring Behavioural Problems During Childhood and Adolescence (Ages 5–17)

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Purpose: Peer relationships are crucial to psychosocial development, and peer difficulties in childhood predict behavioural difficulties later in life. Yet, there is a lack of literature on the developmental trajectory of peer problems. I aim to identify common peer problem profiles and map their longitudinal transitions across childhood and adolescence.

Method: Strengths and Difficulties Questionnaire data from the population-representative Millennial Cohort Study was analysed with factor analysis, followed by a data-driven clustering approach to extract subgroups of peer and co-occurring problems from ages 5 to 17. I then mapped the transitions between profiles and identified risk factors predicting significant transitions.

Results: Peer problems often co-occurred with other behavioural problems. As children developed from 5 to 7, the peer problem clusters gradually became broader, encompassing emotional difficulties and hyperactivity. From 7 to 11 the profile became refined, returning to mainly peer problems; then from 11 to 14 the peer problem phenotype expanded again to include emotion and hyperactivity issues. Longitudinal and concurrent risk factors at ages 5, 7 and 11 were identified to predict these negative transitions.

Conclusion: Peer problems show a non-linear trajectory of change when tracked longitudinally through childhood and adolescence. Whilst they generally increase with time, they are associated with different co-occurring difficulties and form complex profiles throughout development. These transitions are, to some extent, predictable on the basis of risk factors such as child longstanding illness, time spent on sports and exercise, and parental mental health.

INTRODUCTION

Peer relationships are crucial to child development. They facilitate the acquisition of social, emotional and cognitive skills needed to navigate society competently when they become adults (Cicchetti, 1987). However, the peer environment is also fertile ground for early development of internalising (e.g., anxiety, depression) and externalising (e.g., hyperactivity, conduct disorder) problems (Masten, 2006). Peer problems in childhood and adolescence, which is defined as difficulties in peer relations (e.g., being bullied), predict socioemotional difficulties later in life, such as peer rejection, bully victimisation, and poor self-esteem (McDougall et al., 2001). However, current research lacks longitudinal insight into the dynamic changes of peer problems and their interactions with other behavioural issues throughout development. By examining the developmental trajectory of peer problems, we can better tailor interventions to prevent or alleviate emotional and behavioural problems at different timepoints throughout childhood and adolescence.

Peer problems predict later difficulties

Interpersonal difficulties in childhood predict later psychopathology (Furman et al., 1979), such as the onset of depression (Daley et al., 2006; Rubin et al., 2011). Katz et al. (2011) demonstrated that social withdrawal in childhood predicted adolescent social impairment, which in turn predicted depression in young adulthood. Withdrawal, the tendency to isolate oneself from peers, predicts internalising problems, potentially because it may elicit further peer rejection, increase anxiety, distress, and the risk of developing internalising problems (Caspi et al., 1988; Gazelle & Ladd, 2003). The adverse long-term effects of peer problems extend to the non-clinical population as well. Research shows that the lack of a friend during childhood and adolescence predicts greater levels of unhappiness and loneliness up to 6 years later (Pedersen et al., 2007).

In addition to internalising problems, Ladd and Troop-Gordon (2003) proposed that aberrant peer relations are also a precursor of externalising problems, such as conduct problems. Dodge and colleagues (2003) found that social rejection in early elementary school is associated with later antisocial behaviour and aggression, even after controlling for initial levels of aggressive behaviour. Dishion and Connell (2006) hypothesised that early peer rejection leads to increased affiliation with deviant peer groups, which exacerbates delinquent behaviour, aggression and drug use, as well as emotional dysregulation. Therefore, there is strong evidence that poor peer interactions in childhood and adolescence predict a plethora of emotional and behavioural problems later on in life.

Peer problems co-occur with other internalising/externalising problems

A key aspect of developmental research is comorbidity, which is the co-occurrence of distinct disorders (Valderas et al., 2009). As the current study concerns behavioural difficulties in the wider population and not clinical disorders specifically, the concept of co-occurrence will be adopted instead of comorbidity. Other than causal/predictive relationships, previous research has shown that peer difficulties often co-occur with internalising/externalising problems during childhood and adolescence (Boivin et al., 2005; van Lier & Koot, 2010). There is a bidirectional relationship between depressed mood and peer problems, potentially because depressed children may display more dysregulated emotions during stressful peer interactions, which worsens peer exclusion and depressive symptoms over time (Dishion & Connell, 2006). Peer problems are also shown to co-occur with conduct problems and hyperactivity. Hyperactivity may cause poorer attention to social feedback and disruption in social activities, which increases the risk of peer rejection and victimisation (Becker et al., 2017). Conduct problems often co-occur with hyperactivity; 60% of children meeting criteria for conduct problems also meet criteria for hyperactivity/attention problems, and 50% of children meeting criteria for hyperactivity/attention problems also meet criteria for conduct problems (Connor et al., 2010). The mechanisms underlying hyperactivity, conduct problems, and peer problems are thus likely to be interlinked, but more longitudinal research is needed to clearly depict the dynamic development of co-occurring difficulties in childhood and adolescence.

Developmental cascade of behavioural problems

Closely related to the concept of co-occurrence is the phenomena of developmental cascades. For example, externalising difficulties may cascade to internalising problems via aberrant peer interactions over time (van Lier & Koot, 2010). An aggressive and hyperactive child may struggle with finding friends; their loneliness and lack of social support may contribute to anxiety and depression in the long term. There are therefore complex interaction effects between different emotional and behavioural issues across development. In order to understand the growth and persistence of behavioural problems, research should focus on the trajectories of behaviours over time (Dodge, 1993).

I examine longitudinal cohort data from the Millennial Cohort Study (MCS) to understand the complex and dynamic developmental trajectories of peer problems and co-occurring internalising/externalising problems throughout childhood and adolescence. I have chosen the MCS as it provides a large and representative sample with data from five timepoints throughout childhood and adolescence. It contains not just clinical samples but population-level samples, which is methodologically advantageous as it sidesteps problems of ill-fitting diagnostic criteria and disparities in access to mental healthcare, thus enabling a better understanding of the large heterogeneous population (Astle et al., 2022).

In this study, I first conducted an exploratory factor analysis to reduce the Strengths and Difficulties Questionnaire (SDQ) items into fewer factors, followed by a data-driven clustering approach which shed light into the co-occurring problems at five ages: 5, 7, 11, 14, and 17. I then mapped transitions of peer problems and their co-occurring behavioural difficulties across these five age groups to better understand how the subgroups of problem profiles evolved throughout childhood and adolescence. Lastly, I used LASSO logistic regression to identify longitudinal and concurrent risk factors that predicted these transitions.

METHODS

Participants

This analysis is conducted with longitudinal data from the Millennial Cohort Study (MCS), which follows the lives of approximately 19,000 young people born between 2000 and 2002 in England, Scotland, Wales and Northern Ireland. It obtains measures of cohort members' physical, socio-emotional, cognitive, and behavioural development across sweeps, as well as information on their family lives, economic circumstances and relationships from resident parents. Given its population-representativeness and comprehensive timeframes spanning childhood to adolescence, the MCS encapsulates a new form of research that adopts a population-level rather than clinical approach to developmental issues. Seven sweeps have been conducted at the time of writing, spanning age 9 months to 17, with another planned for 2022 (age 22). The current analysis uses data from sweeps three (age 5) through seven (age 17) (**Table 1**). The data was accessed online on 12 November, 2021 (2nd edition from the Centre of Longitudinal Studies; see Centre for Longitudinal Studies: https://www.cls.ioe.ac.uk).

Table 1 | Table showing the sweeps used in the current study, the developmental period in question, and the size of sample.

Sweep (age)	Development	Sample size (*n*)
MCS3 (5)	Mid-childhood	15,460
MCS4 (7)	Mid-childhood	14,043
MCS5 (11)	Late-childhood	13,469
MCS6 (14)	Mid-adolescence	11,872
MCS7 (17)	Mid-adolescence	10,757

Strengths and Difficulties Questionnaire

In all sweeps, the Strengths and Difficulties Questionnaire (SDQ) was administered to cohort members to measure five attributes: emotional symptoms, conduct problems, hyperactivity/inattention, peer relationship problems, and prosocial behaviour. The 5 scales were composed of 25 items, with discrete scales of three points. Symptom scores ranging from 0 to 10 were calculated for each scale, adding up parental responses on the corresponding five items. Teacher ratings and self-report ratings were obtained for some sweeps, but for consistency only parent ratings are considered in the current analysis. The pre-processing pipeline is indicated in **Figure 1**.

Removing outliers was not needed here as the SDQ data were used categorically. Although SDQ can be used as a continuous variable, it is commonly characterised into meaningful groups for comparison (Thompson et al., 2021). I divided cohort members into 'peer' and 'non-peer' groups with the cut-off score of 3 (out of 10) on peer problems, based on the 3-band categorisation proposed by Goodman (1997). The 'peer' group refers to children with scores from the 'borderline' or 'abnormal' bandings, while the 'non-peer' group ('normal' banding) presents with no or mild behavioural difficulties on the peer sub-scale, and is used for comparison. The CONSORT diagrams for exclusion and imputation for all sweeps can be found in **Appendix 1**.

Exploratory factor analysis

After completing the above steps, I conducted exploratory factor analysis (EFA) to reduce the dimensionality of the SDQ data, now composed of 20 items rated on a three-point Likert-type scale (0 = not true, 1 = somewhat true, or 2 = certainly true). For each sweep, I calculated the polychoric correlations using the *polychor* package v0.7.9 (Olsson, 1979), and carried out EFA with the *psych* v2.1.9 package under *R* 4.1.2 with *varimax* rotation, to maximise high- and low-value factor loadings and create orthogonal factors (Zeller, 2005). The number of factors was determined through inspection of the scree plots and parallel analysis (see **Appendix 2**). Subsequently, factor scores were z-scored, univariate outliers were removed using the median absolute deviation method, and multivariate outliers were removed using the Mahalanobis method to account for extreme and unreliable responses (Zijlstra et al., 2011). Subsequently, ANOVA and post-hoc tests were carried out to assess significant differences (see **Appendix 3**).

Clustering analysis

To identify clusters within the 'peer problem' group, clustering analysis was conducted. Firstly, the data was projected into a lower-dimension Euclidean space using uniform manifold approximation and projection (UMAP) to avoid clustering in a sparse dimensional space and improve

Table 2 | Table showing 22 risk factors across five domains, assessed for predictive capacity of identified transitions. Risk factors without indication of sweep number are present in all sweeps.

Child cognition	Child health	Parental mental health & personality	Parent-child relationship	Family relationship	Demographics
Naming vocab [sweep 3]	General level of health	Kessler K6 scale	Time spent with child	Marital status	Income OECD
Picture similarities [sweep 3]	Sports and exercise	Life satisfaction	Parent-child relationship	Parent satisfaction with partner	Parent education NVQ
Pattern construction [sweeps 3, 4]	Longstanding illnesses	Neuroticism [sweep 4]		Use of force	Area of upbringing [sweeps 3, 5]
Word reading [sweep 4]	Mental health [sweeps 4,5]			Number of siblings	
Verbal similarities [sweep 5]				Proximity of friends/family	

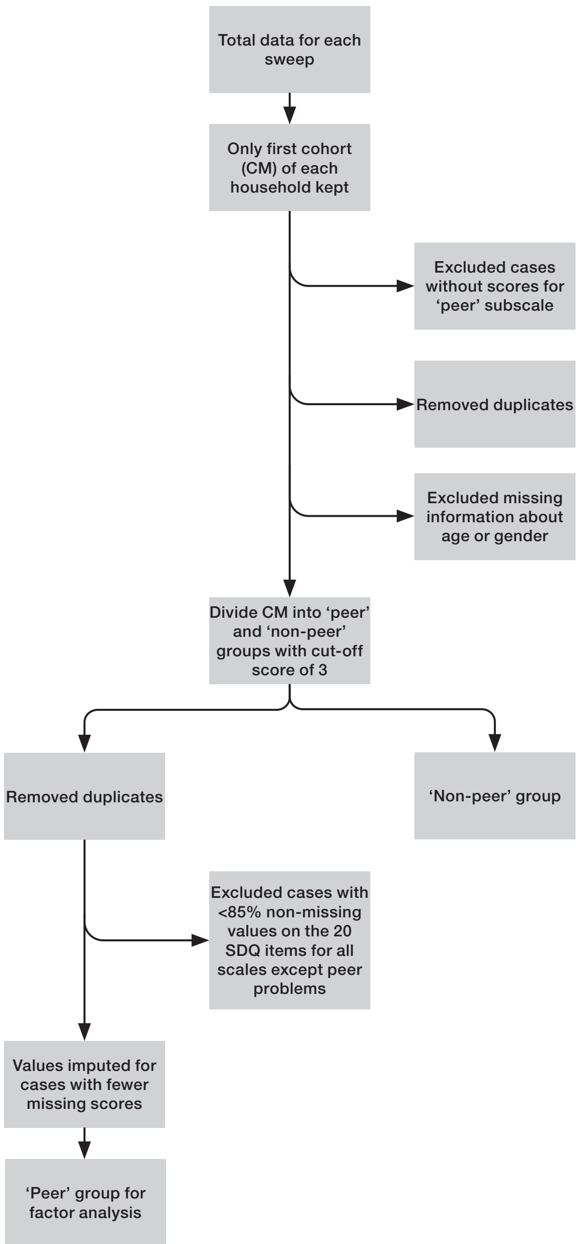


Figure 1 | Data pre-processing on Python v3.8.3. For cases with fewer missing scores than 15%, values were imputed using the *k*-nearest neighbour (KNN algorithm; Beretta & Santaniello, 2016).

clustering performance (Dalmaijer et al., 2020; details of parameters in **Appendix 4**). UMAP was implemented using UMAP v.0.5.2 Python implementation.

The transformed data was then clustered using the k-means algorithm, and the number of clusters determined from the silhouette scores. A score larger than 0.50 indicates sufficiently good separation between clusters (Albalate & Minker, 2011). I then characterised and labelled clusters based on their profiles of behavioural ratings.

Transition analysis

To examine the transitions between clusters across the five sweeps, I conducted proportional z-tests with Bonferroni correction to account for multiple comparisons. I compared the proportion of participants transitioning from one cluster at one timepoint to another cluster at the next timepoint, with the proportion of participants equally transitioning to each cluster at the next timepoint (e.g., in the case of 5 clusters, an equal split would be 20%). Only transitions significantly above the equal split proportion; i.e., transitions that occurred more than we would expect by chance, will be reported here.

Risk factor analysis

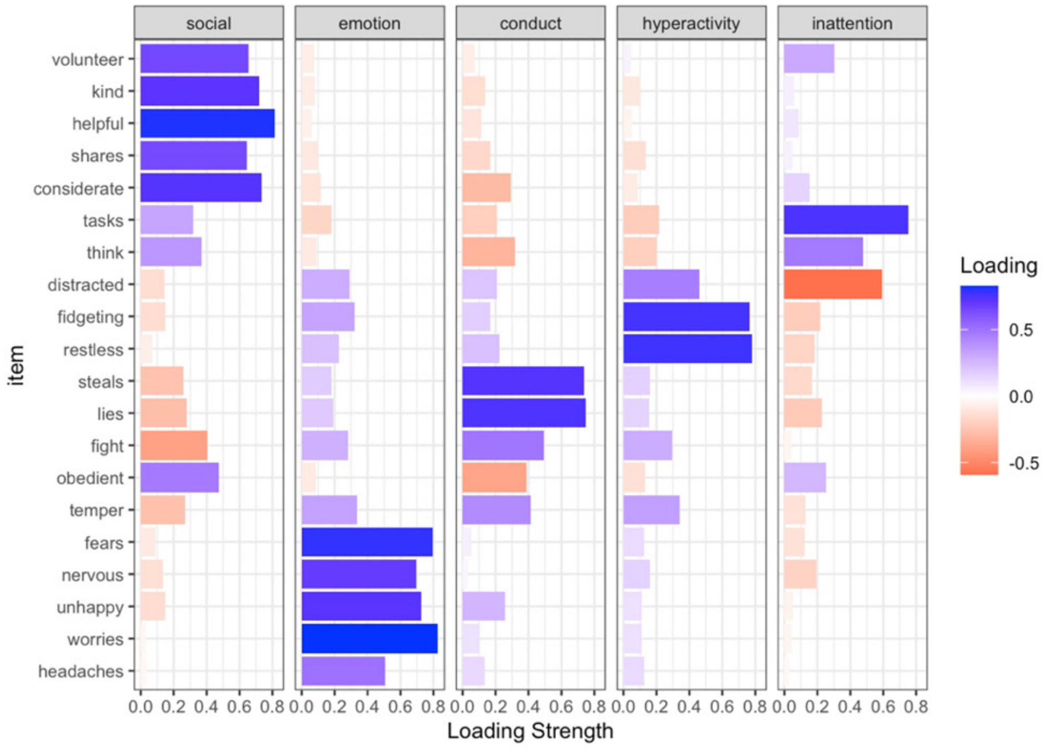
To identify longitudinal risk factors predicting the transition between subgroups, I used logistic regression with regularisation through Least Absolute Shrinkage and Selection Operator (LASSO) with Python. It selects features that are useful and discards less important variables by shrinking their coefficients to zero. I examined 22 risk factors from six domains and whether they could predict notable transitions (**Table 2**).

Each domain was chosen because they have previously been linked with behavioural difficulties in childhood and adolescence. They were: child cognitive ability (Bellanti & Bierman, 2000), child physical health (La Greca et al., 2002; Pinquart & Teubert, 2012), parental mental health and personality (Manning & Gregoire, 2006; Mensah & Kiernan, 2010), parent-child relationship (Rubin et al., 2004; Vanassche et al., 2013), family relationships (Brown & Bakken, 2011; Llorca et al., 2017), and demographics (Ross & Howe, 2009; Li et al., 2020).

Participants with more than 30% missing data on risk factors were excluded, while those with less than 30% missing data had missing values imputed with the KNN algorithm. Risk factors with categorical data were dummied, such as marital status. Refer to **Appendix 5** for a more detailed table of risk factors and their variable codes in the MCS.

Stratified split-sampling validation divided the sample into a train set with 70% of data for training of the model, and the remaining 30% for testing. Within the train sample, each sweep underwent 1000 bootstrapping iterations with logistic regression with LASSO regularisation and five-fold cross-validation. As the method selects important variables and discards useless or redundant features, only variables that were non-zero 95% of the time (950 iterations) were selected. To assess the predictive accuracy of this model, the selected factors from the training sample were used to predict transitions in the test sample through standard logistic regression. The selected transitions were the significant transitions from previous analysis, compared to the control transitions of 'peer' to 'non-peer' groups. Variables that survived all the above steps were considered as genuine risk factors for a specific transition of interest.

a



b

	Social	Emotion	Conduct	Hyperactivity	Inattention
SS loadings	3.494	3.172	2.187	1.881	1.571
Proportion variance	0.175	0.159	0.109	0.094	0.079
Cumulative variance	0.175	0.333	0.443	0.537	0.615

Figure 2 | Results of factor analysis for MCS7 (age 17) (**a**) Factor loading plot. (**b**) Loading matrix showing the cumulative variance.

RESULTS

Exploratory factor analysis

After parallel analysis, five factors were identified as latent variables for the 20 SDQ items in all sweeps. As a reminder, the 5 SDQ items corresponding to peer problems were removed for this analysis as I used the validated 'peer problems' subscale for the rest of my analysis. The five-factor model could explain between 51% and 62% of variance in data for all timepoints. According to the loading strength of SDQ items for each factor, I have labelled the 5 factors as: Prosocial behaviour (Social), Emotion regulation (Emotion), Conduct problems (Conduct), Hyperactivity, and Inattention. See **Figure 2** for a graphical representation of factor loadings with associated SDQ items for the age 17 factor model. The SDQ items associated with each factor, full loading matrices and correlation plots for the other sweeps can be found in **Appendices 6** and **7**.

Clusters within peer problem subgroup

Dimensionality reduction and clustering analysis revealed two or three clusters for the 'peer problem' sub-group depending on the sweep. The optimal number of clusters were chosen based on silhouette coefficients exceeding or closest to 0.5, indicating a good separation between clusters. See **Figure 3** for a full representation of the UMAP, silhouette coefficient diagrams, radar plots, and demographic table for age 17, and **Appendix 8** for the visualisation of remaining sweeps. Two clusters were found for sweeps 3 to 5, and three clusters for sweeps 6 and 7 (**Table 3**). For clearer comparison, the clusters were primarily labelled according to the factors indicating a large significant difference with the 'non-peer' comparison group (Cohen's effect size d >1), but factors with 0.5 < d <1 were also indicated in brackets and shown in **Figure 3d**.

Clustering analysis has thus shown that co-occurring behavioural difficulties vary across ages. The next step is to identify the transitions between clusters across sweeps.

Transitions in behavioural problem profiles

Transition analysis showed that there were significant transitions across all sweeps (see **Appendix 9** for all tables). For the purposes of our discussion, I will focus on three transitions: age 5–7, age 7–11, and age 11–14. In the transition from age 5 to 7, there were significant transitions from all clusters at age 5 to the non-peer group at age 7 (**Table 4**). Approximately 37% of children in the 'peer' cluster also transitioned to the 'peer, hyperactivity and emotion' cluster.

In the transition from age 7 to age 11, there were once again significant transitions from all clusters at age 7 to the non-peer group at age 11. ~40% of children transitioned from the 'peer, hyperactivity and emotion' cluster to the 'peer' cluster (**Table 5**).

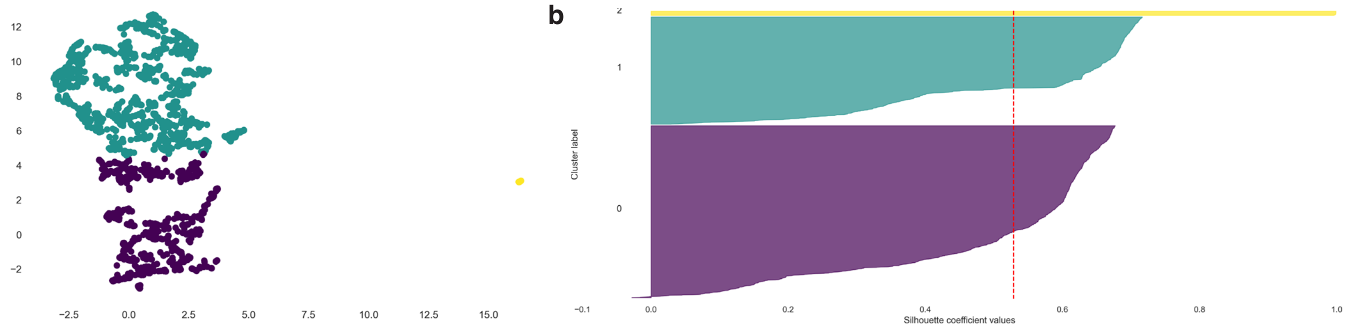
From age 11 to age 14, three significant transitions were found from all clusters to the non-peer comparison group in mid-childhood (**Table 6**). The only 'negative' transition (between problem behaviour clusters) found was from the 'peer' cluster to the 'peer, hyperactivity and emotion' cluster, with 37% of cohort members transitioning.

A pattern emerges from the three transitions: the peer-focused cluster at age 5 'expands' to a peer, hyperactivity and emotion-focused cluster at age 7, becomes more refined at age 11 with a peer problem-focused cluster, then expands again to a peer, hyperactivity and emotion-focused

Table 3 | Table showing the number of clusters generated by k-means clustering for MCS3 to MCS7, and all labelled clusters for both 'peer' and 'non-peer' subgroups for each sweep.

Sweep (age)	Optimal no. of clusters from k-means clustering (for 'peer' group)	All clusters (both 'peer' and 'non-peer' subgroups)
MCS3 (5)	2	A0 Non-peer comparison group (n = 11,657; 83.60%) A1 Peer problems (n = 1,627; 11.65%) A2 Peer and emotional problems (n = 663; 4.75%)
MCS4 (7)	2	B0 Non-peer comparison group (n = 10,393; 82.2%) B1 Peer, hyperactivity, and emotional problems (n = 1,341; 10.55%) B2 Peer problems (n = 917; 7.25%)
MCS5 (11)	2	C0 Non-peer comparison group (n = 10,398; 81.3%) C1 Peer problems (n = 1,554; 12.2%) C2 Peer and emotional problems (n = 831; 6.5%)
MCS6 (14)	3	D0 Non-peer comparison group (n = 7,447; 73.50%) D1 Peer, hyperactivity, and emotional response (n = 1,243; 12.27%) D2 Peer problems (n = 964; 9.51%) D3 Peer and emotional problems (n = 479; 4.72%)
MCS7 (17)	3	E0 Non-peer comparison group (n = 5,609; 73.5%) E1 Peer and emotional problems (n = 1,229; 12.5%) E2 Peer and antisocial problems (n = 767; 10.0%) E3 Peer problems (n = 31; 4.0%)

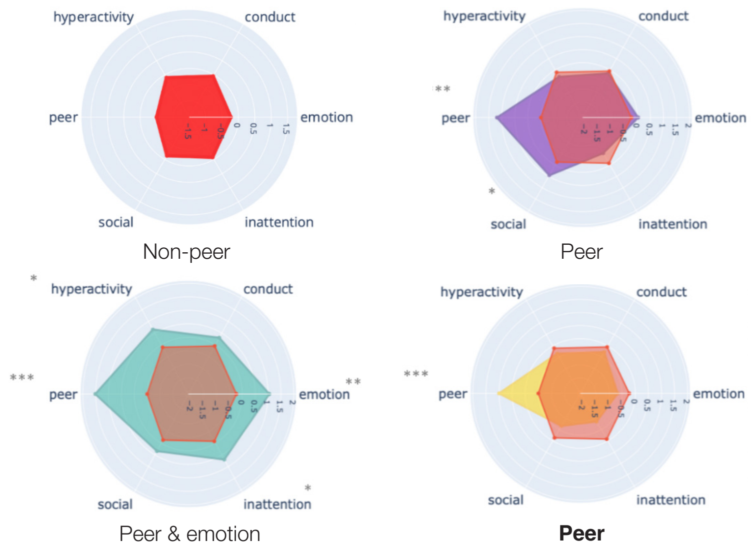
a b



c

n_clusters	Average silhouette score
2	0.51
3	0.52
4	0.47
5	0.47
6	0.46
7	0.45
8	0.42
9	0.43

d



e

Cluster	Cluster label	Size	% of total sample	No. of females	No. of females (% of total sample)	Wellbeing
E0	Non-peer	5,609	73.45	2,885	37.78	22.85
E1	Peer	1,229	16.09	615	8.05	21.00
E2	Peer & emotion	767	10.04	387	5.07	22.11
E3	Peer	31	0.41	13	0.17	24.29
Total	Total	7,636	100.00	3,900	51.07	22.46

Figure 3 | Visualisation of MCS7 (age 17) clusters. (**a**) Projection with KMeans clustering in UMAP space showing 3 clusters. (**b**) Silhouette plot with optimal method generating 3 clusters (UMAP transformation, KMeans clustering), with a silhouette score of 0.5286251. (**c**) Table showing the average silhouette scores for different number of clusters. The number of clusters with the largest silhouette score >0.5 was chosen. (**d**) Radar plots for non-peer comparison group (E0) and 3 'peer' clusters (E1,2,3). Asterisks indicate Cohen's d relative to the standard deviation across clusters in the sweep: ***>1.5, **>1.0, *>0.5. Clusters were labelled according to factors with large effect sizes (>1.0); those representing medium effect size (0.5 < d <1) were indicated but not represented in the cluster label. (**e**) Table showing descriptive statistics of each cluster, including size, percentage of total sample, number of females and percentage of the sample, and wellbeing. Wellbeing was quantified on the Warwick-Edinburgh Mental Wellbeing Scale (WEMWBS), whereby 14 items were answered on a 1 to 5 Likert scale and scored out of 35 in the case of MCS7; the range in the sample was 7–35.

Table 4 | Table showing significant transitions from age 5 (MCS3) to age 7 (MCS4). All significant transitions are in bold. Transitions in red are 'positive' transitions as the proportions are greater than an equal split (~0.33, as there are 3 clusters).

MCS3 \ MCS4	B1 Peer, Hyperactivity, Emotion, (Conduct, & Antisocial)	B2 Peer (& Emotion)	B0 Non-peer
A1 Peer & Emotion	**0.197**	**0.195**	**0.608**
A2 Peer, (Antisocial, Inattention, Emotion, & Hyperactivity)	**0.371**	**0.172**	**0.457**
A0 Non-peer	**0.058**	**0.052**	**0.889**

Table 5 | Table showing significant transitions from age 7 (MCS4) to age 11 (MCS5). All significant transitions are in bold. Transitions in red are 'positive' transitions as the proportions are greater than an equal split (~0.33, as there are 3 clusters).

MCS4 \ MCS5	C1 Peer, Emotion (& Inattention)	C2 Peer, (Antisocial, Emotion, Hyperactivity, & Conduct)	C0 Non-peer
B1 Peer, Hyperactivity, Emotion, (Conduct, & Antisocial)	**0.124**	**0.404**	**0.472**
B2 Peer (& Emotion)	**0.168**	**0.204**	**0.628**
B0 Non-peer	**0.046**	**0.072**	**0.883**

Table 6 | Table showing significant transitions from age 11 (MCS5) to age 14 (MCS6). All significant transitions are in bold. Transitions in red are 'positive' transitions as the proportions are greater than an equal split (0.25, as there are 4 clusters in MCS6).

MCS5 \ MCS6	D1 Peer, Hyperactivity, Emotion, (Conduct & Inattention)	D2 Peer, (Antisocial, Emotion & Inattention)	D3 Peer (& Emotion)	D0 Non-peer
C1 Peer, Emotion (& Inattention)	**0.197**	**0.165**	**0.166**	**0.472**
C2 Peer, (Antisocial, Emotion, Hyperactivity, & Conduct)	**0.373**	**0.057**	0.240	**0.330**
C0 Non-peer	**0.078**	**0.038**	**0.067**	**0.817**

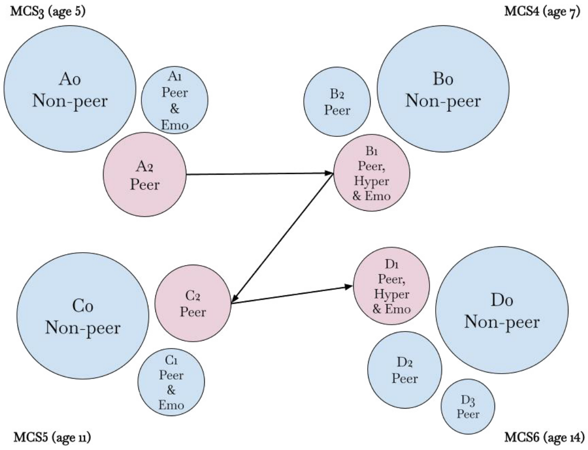


Figure 4 | Visualisation of transition pattern from MCS3 to MCS6, highlighting the expansion and reduction of peer and comorbid problems.

cluster at age 14 (**Figure 4**).

Risk factor analysis

Given the expansion then refinement of the peer problem behavioural phenotype across sweeps, I assessed risk factors that predicted the expansion of peer-focused problems at ages 5 and 11 to peer problems with both internalised and externalised co-occurring problems (hyperactivity and emotional problems) at ages 7 and 14 respectively.

Five risk factors at age 5 predicted the transition from the 'peer' group at age 5 (sweep 3) to the 'peer, hyperactivity and emotion' group at age 7 (sweep 4): parental mental health as measured by the Kessler scale (ß = 4.07), child involvement in sports and exercise (ß = 3.81), child cognitive abilities in naming vocabulary (ß = 3.49) and pattern construction (ß = 2.25), and proximity of family/friends (ß = 1.45) (**Figure 5**).

The transition from the 'peer' group at age 11 (sweep 5) to the 'peer, hyperactivity and emotion' group at age 14 (sweep 6) could also be predicted by risk factors at age 5, 7, and 11 respectively. At age 5, five risk factors predicted the transition from age 11 to 14: parental mental health

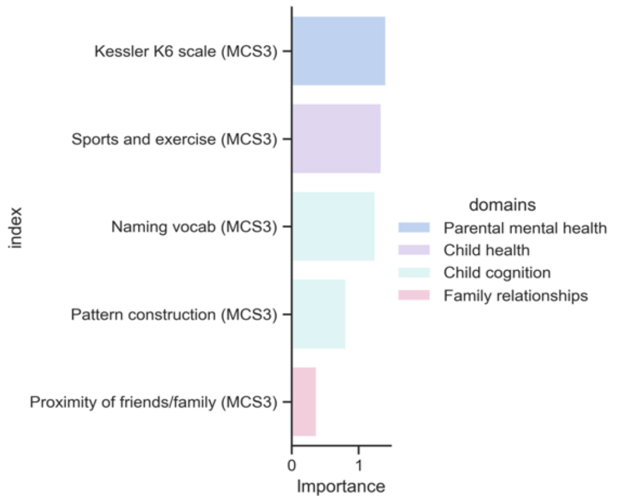


Figure 5 | Feature importance diagram of concurrent risk factors at age 5 predicting the transition from age 5 to 7.

(ß = 4.35), child performance on pattern construction (ß = 4.34), child longstanding illness (ß = 1.71), parental marital status (married or not) (ß=1.51), and proximity of friends/family (ß = 1.49). At age 7, two risk factors predicted the transition from age 11 to 14: child longstanding illness (ß = 1.62), and child general level of health (ß = 3.02). At age 11, three risk factors predicted the transition: child longstanding illness (ß = 2.91), child involvement in sports and exercise (ß = 3.22), and the amount of time parent spends with child (ß = 2.05) (**Figure 6**).

DISCUSSION

Understanding the complex developmental trajectories of peer problems is crucial to the development of effective interventions at targeted age ranges. In the following sections, I will evaluate the results of the current study by discussing the importance of a population-representative approach, the most common co-occurring difficulties with peer problems, and their transitions from mid-childhood to mid-adolescence. I will then close with key limitations and directions for future research.

The value of adopting a dimensional, population-level approach

The MCS provides a solid foundation for research into developmental trajectories of problem behaviours as it tracks the development of a population-representative sample. The current study evaluates SDQ data from the MCS and adopts a dimensional approach, conceptualising SDQ factors as continuous dimensions with graduated levels spanning typical and atypical functioning. This approach is important in developmental research as it includes children that are typically developing, clinically diagnosed, as well as showing borderline problems insufficient for diagnoses (Astle et al., 2022). Population-level, rather than clinical-level analyses, may sidestep problems with current diagnostic criteria (e.g., comorbidity, symptom specificity) and better capture the full range of profiles in the population (Kendall & Drabick, 2010). Moving towards a population-level, dimensional approach is thus fundamental for the field to better conceptualise subconstructs of problem behaviours in order to understand their underlying mechanisms more clearly.

Peer problems most commonly co-occurred with emotional and hyperactivity problems

Across all sweeps, the largest cluster was consistently the non-peer comparison group, with the remaining 20-30% being individuals with peer problems. These clusters were often characterised by multiple domains of problems, the most common co-occurrences being peer problems and emotional problems, or peer hyperactivity and emotional problems. Previous studies have shown that peer problems and emotional dysregulation often manifest hand-in-hand, but usually in samples of youth with learning difficulties (Conti-Ramsden et al., 2019; Bryant et al.,

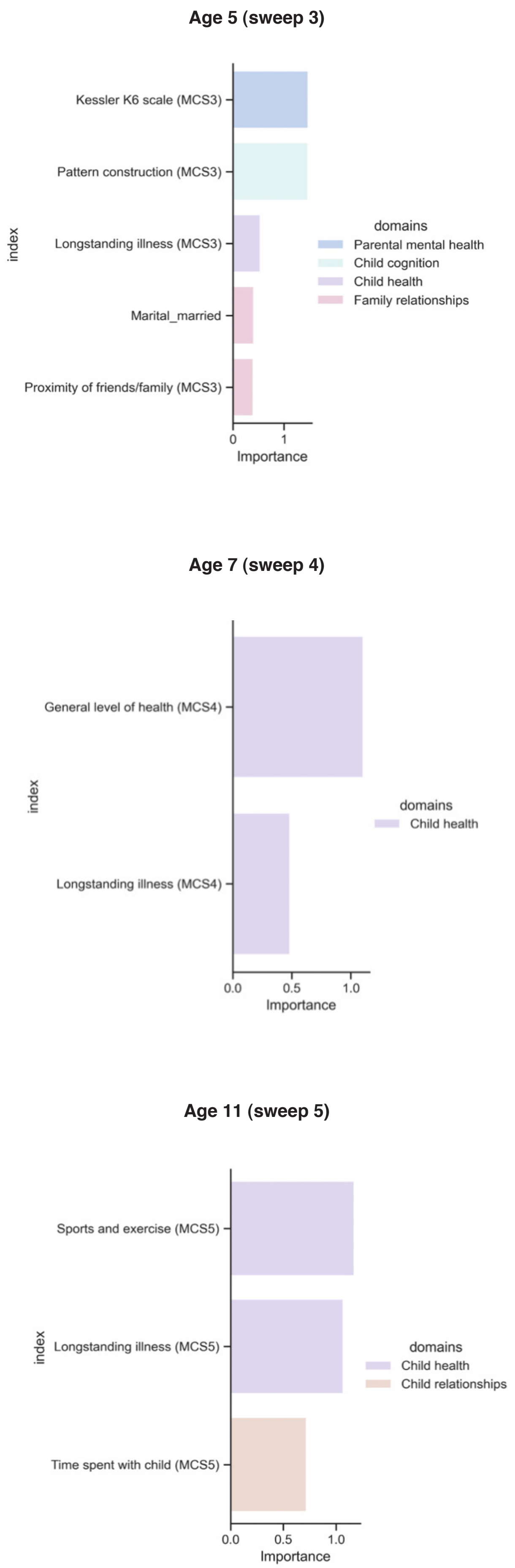


Figure 6 | Feature importance diagrams of concurrent and longitudinal risk factors at ages 5, 7 and 11 predicting the transition from age 11 to 14.

2020). There is also rich literature linking peer victimisation specifically to emotional problems like anxiety and depression in childhood and adolescence (Arseneault, 2017; Adrian et al., 2019). Hyperactivity in the current field is often studied through the lens of attention deficit hyperactivity disorder (ADHD), and inattention and hyperactivity/impulsivity have been associated with difficulties in social functioning, peer rejection, and a greater risk of developing emotional problems (Hoza, 2007; Thorell et al., 2017). This is the first study which demonstrates a link between peer problems and hyperactivity in a non-clinical population. However, there is little literature on non-clinical populations, calling for further research with longitudinal population-level data, to the likes of the MCS. This study has also not found any comorbidities between peer problems and antisocial problems or conduct problems, despite previous suggestions that both types of externalising problems would predict peer problems (Dishion et al., 1991; Mikami & Lorenzi, 2011). It is unclear why hyperactivity, but not other externalising problems, is significant in the analysis of peer problems in MCS data. A potential cause would be bias in parental ratings, as parents may not be willing to report their children as antisocial.

Expansion of comorbidities occurred at age 7 and 14

Across all profiles in the five sweeps, the most common transition was from behavioural difficulty clusters into the 'non-peer' comparison group. This dovetails Bathelt et al. (2021) research into the British Cohort study with similar clustering and transition analysis methods. In this study, transition into 'non-peer' profiles only means that individuals have transitioned out of peer problems, but may have other issues like inattention or antisocial behaviour, which is not the focus of this study.

The most notable transition observed was the cyclical expansion and refinement of the behavioural phenotype observed from ages 5 to 14. A significant proportion transitioned from the 'peer' cluster at age 5 to 'peer, hyperactivity and emotion' at age 7, which shrunk back to the 'peer' cluster at age 11, and then transitioned once again to the constellation of 'peer, hyperactivity and emotion' problems at age 14. This specific finding was not found in previous studies of developmental trajectories.

What is special about ages 7 and 14 that make individuals more susceptible to co-occurrence of behavioural difficulties? Peer relationships play a particularly important role in the development of social and emotional capacities during mid-childhood (age 7) because children spend most of their time during the day at school or play settings with peers, and this continues through to adolescence (La Greca & Prinstein, 1999). As children move into mid-adolescence (age 14–16), which is also the start of upper secondary, peer relations gradually extend to encompass romantic relationships, adding an extra dimension to the complex social landscape. Changes in intensity and duration of the peer environment at these ages may potentially explain the expansion of problem profiles. However, more research is needed to elucidate differences between different age points.

Risk factors predicting the expansion of comorbidities

I identified risk factor variables in sweeps 3, 5 and 6 that predicted the transitions from 'peer' to 'peer, hyperactivity and emotion' cluster at age 5–7 and age 11–14. Overall, it was observed that there were more risk factors affecting early childhood (5 factors identified) than mid-childhood and adolescence (2–3 factors identified). The age 5 risk factors were also from a wider range of domains, including child health, parental mental health, family relationships, and child cognition, compared to risk factors at ages 7 and 11 which were restricted to the domains of child health and parent-child relationship.

As parents are the first with whom children develop a relationship with, family environments and relationships play the most important role in the emotional and social growth of the developing child (Riahi et al., 2012). This study found that parental mental health (on the Kessler scale), marital status (married or not) and proximity of friends/family predicted the expansion of problem behaviour phenotypes from ages 5–7 and 11–14. Parental stability is thus key to children and adolescents' behavioural and emotional functioning. Child cognition, operationalised as pattern construction and naming vocabulary in sweep 3, is also a significant predictor of negative transitions. This is in line with previous research of associations between cognitive ability and peer interactions (Bellanti & Bierman, 2000). Another potential reason for the greater number of risk factors at age 5 is that it is when children first start school, meaning that there are drastic changes in the social environment which make children more vulnerable to the cumulative effect of multiple risk factors (Christenson & Reschly, 2009).

Across the entire duration of childhood, child health is an important risk factor predicting the expansion of peer problems to peer, hyperactivity and emotion difficulties. This includes the general level of health, whether child has longstanding illness, and time spent on sports and exercise. This dovetails previous research on the associations between child physical health and behavioural problems (Pinquart & Teubert, 2012). Chronic illnesses are a significant source of stress, which may cause elevations of internalising problems and peer problems, perhaps due to the feeling of being different from peers and not fitting in (Compas et al., 2012; Helgeson & Holmbeck, 2015). It is also interesting that shorter time spent on sports and exercise is a significant predictor of negative transitions. Perron and colleagues (2012) found that among children facing peer victimisation, those who often participated in team sports had fewer emotional difficulties at age 8 and fewer externalising problems at age 10. Therefore, there may be links between sports, peer problems and internalising/externalising problems, but further research is needed to uncover the underlying mechanisms.

Parent-child relationship at age 11 (early adolescence) predicted the increase to peer, emotion and hyperactivity problems at age 14, but it was not a risk factor at other ages. Milkie and colleagues (2015) found that the link between time spent with mother and child's psychosocial outcomes was more evident in adolescence than childhood, suggesting that parental stability is more important in childhood, while parent-child relationship may play a bigger role in adolescence. There are several potential reasons: time with parents may increase adolescents' sense that they matter (Rosenberg & McCullough, 1981), prevent opportunities for delinquency, and encourage more prosocial behaviour during joint activities (Milkie et al., 2015).

While previous literature has drawn links between demographic factors and peer problems (Ross & Howe, 2009), the current study did not find significant demographic risk factors. However, although income, parent education and area of upbringing did not predict negative transitions, it does not mean that demographic factors do not impact peer relations. It may be that demographics affected whether individuals faced peer problems per se, rather than the transition to more co-occurring problems.

Limitations and directions for future research

There are limitations of the current study that are important to acknowledge. Firstly, the SDQ scores from MCS analysed in this study were entirely based on parent report, meaning that the collected data may not be an accurate reflection of children's actual functioning, as some parents may be reluctant to report their children's behavioural difficulties (e.g., picked on or bullied), or may not be aware of the child's state (e.g., often unhappy). However, this bias is inevitable as young children may not be able to complete questionnaires independently. A report by Gutman et al. (2015) on MCS results suggested that findings differed between parent and teacher report, making it difficult to objectively measure child adjustment; yet behavioural observations are impractical for cohort studies. By collecting teacher-report and self-report data for some age groups, some studies have reported good validity and reliability of estimates of emotional and behavioural problems (Goodman et al., 2003; Pastor et al., 2012). Future longitudinal cohort data studies may thus consider combining multi-informant data for a better assessment of cohort members' conditions.

As the current study focuses on peer problems, results only addressed the developmental trajectory of peer problems and co-occurrence with other problems. However, this means that for the large proportion of individuals transitioning out from 'peer' clusters to the 'non-peer' comparison group, whether they transition into other difficulties is unknown. Though not feasible for the current study, a more large-scale

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analysis could be conducted to examine transitions across all SDQ scales and sweeps. As the MCS investigators are in the process of collecting new data for sweep 8 (age 22) in 2022–3, with data available in 2025, future studies can extend the timeframe beyond mid-adolescence to include late adolescence/early adulthood, which is also a period of great change in social environment.

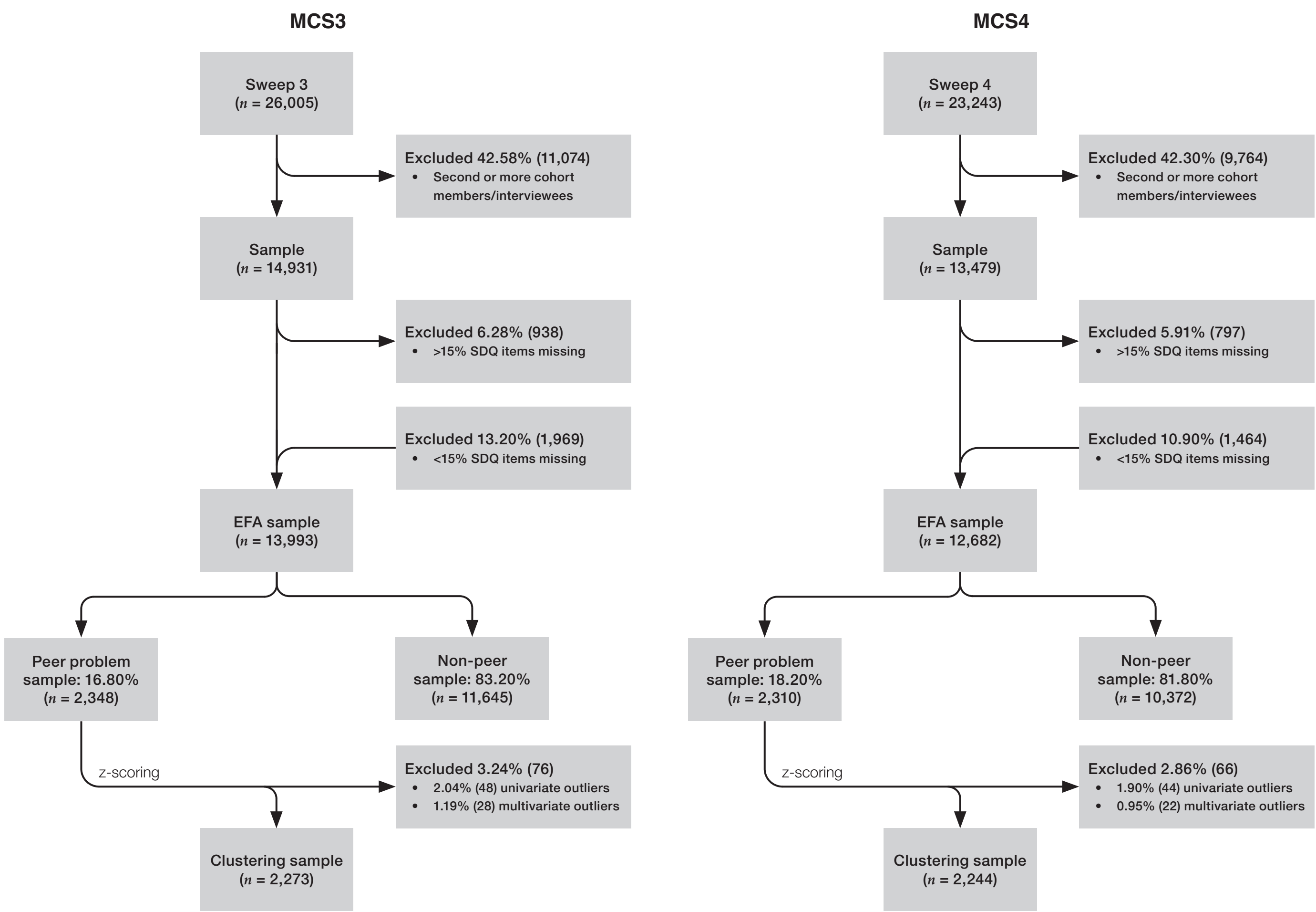
A further question to be asked may be how the developmental trajectories of peer problems differs across generations. For example, the current MCS may be compared to the British Cohort Study (BCS) of children born in 1970. A study comparing the BCS and a cohort from 2006 indicated increased prevalence of behavioural problems in the 2006 cohort (Collishaw et al., 2010). This may be attributed to the increased awareness and diagnosis of behavioural problems over time, or evolving environmental factors such as the internet. Future cohort studies measuring psychosocial adjustment in the general population (not clinical) may continue to provide insight into the developmental trajectory of behavioural problems as well as intergenerational differences, without being affected by changes in diagnostic criteria.

CONCLUSION

Through a data-driven clustering approach, I identified key problem profiles in the development of peer problems and mapped transitions from age 5 to 17. The prevalence and severity of peer problems increased throughout childhood and adolescence, peaking at age 17. Clustering analysis showed that peer problems often co-occur with other behavioural difficulties, the most significant being emotional dysregulation and hyperactivity. Transition analysis demonstrated a cyclical expansion then refinement of problem behaviour phenotype from ages 5 to 14. I then identified risk factors at different ages predicting the expansion of peer problems to include emotional and hyperactivity problems, the most significant being child physical health. The transitions depicted in the current study highlight that profiles of peer problems differ substantially across ages, hence policies should be revised to account for the dynamic trajectories of development. This study also highlights the value of adopting a population-representative approach rather than a diagnosis-based approach to explore the full range of developmental profiles.

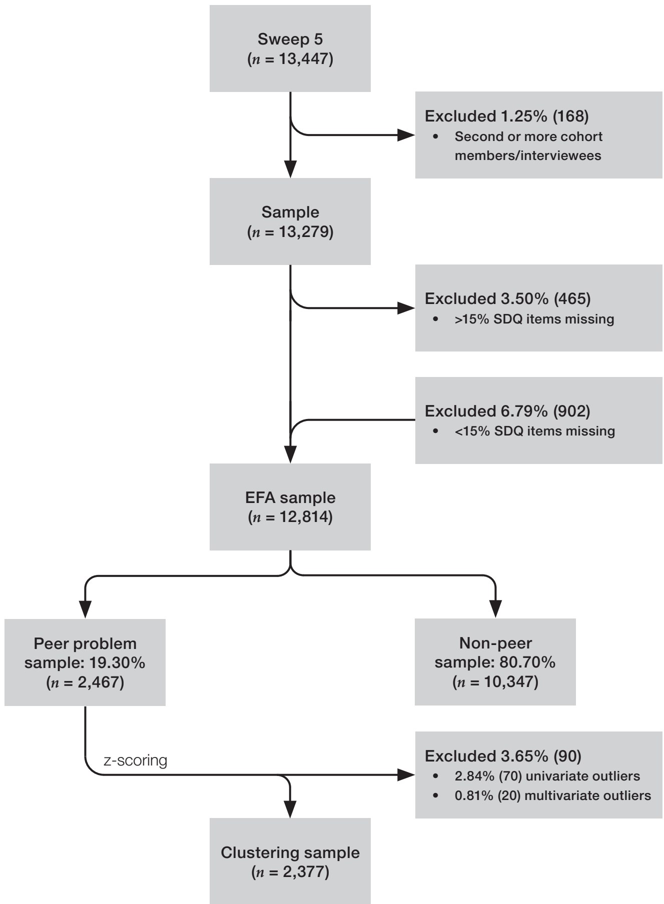
Appendix

1. CONSORT diagrams

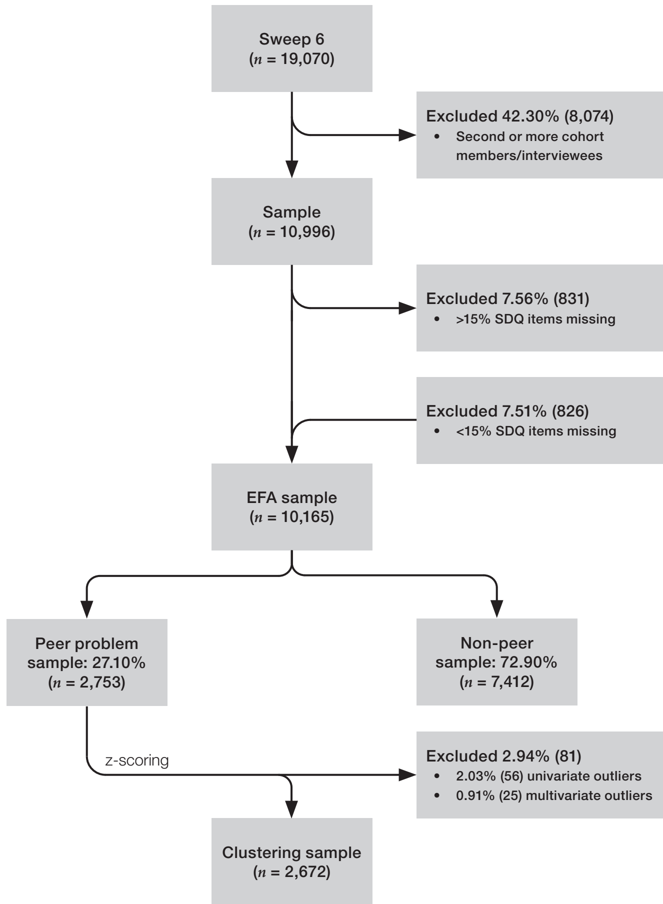


1. CONSORT diagrams (cont'd)

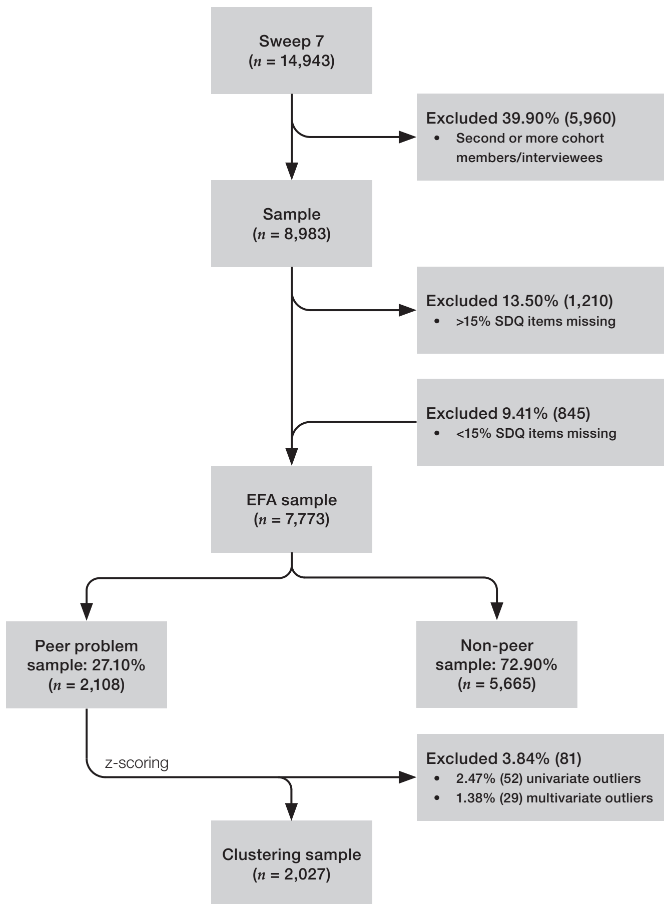
MCS5



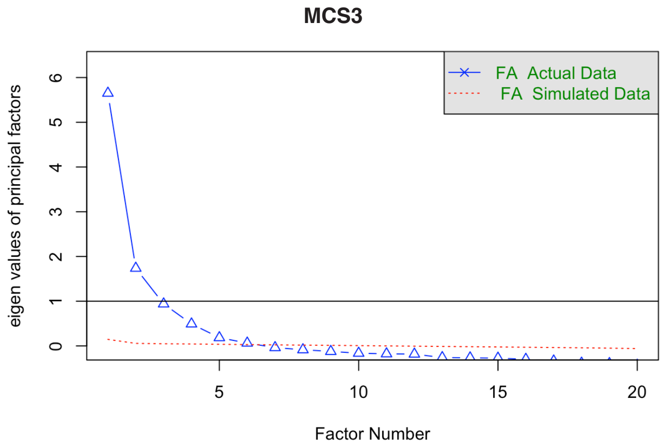
MCS6

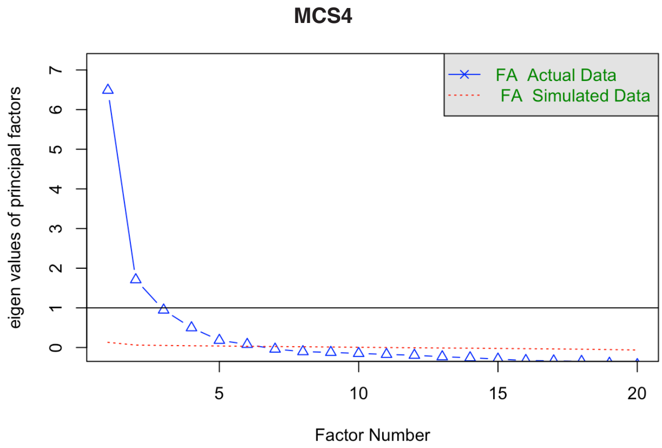


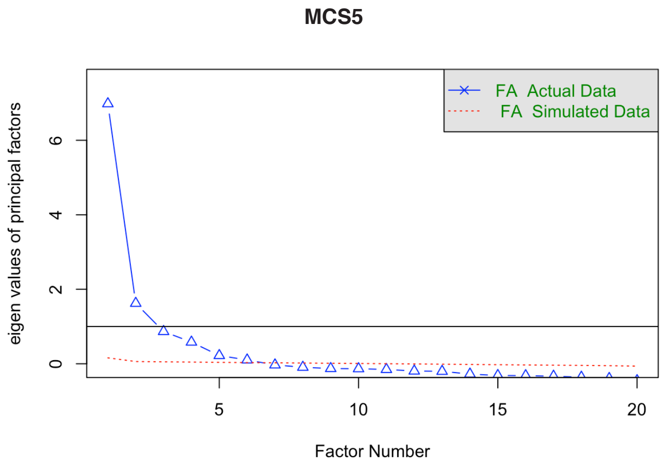
MCS7

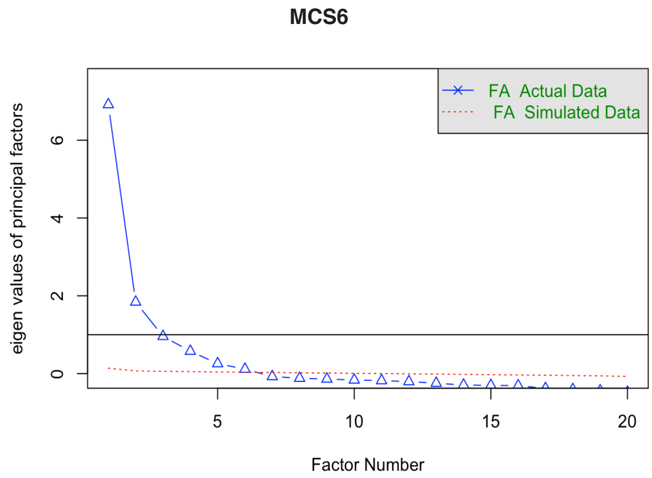


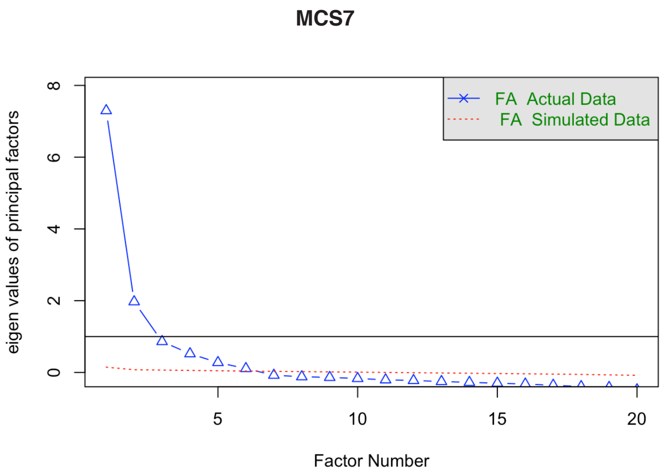
2. Factor analysis scree plots for all sweeps











3. ANOVA and post-hoc tests

A 2-way ANOVA analysis indicated significant differences in behavioural ratings between the five time points (time), between each of the six behavioural problems (factor), as well as between the factors across the five sweeps (time:factor).

	Effect	DFn	DFd	F	p	p < 0.5	ges
1	time	3.58	21834.64	3.947	5.00e-03	*	6.9e-05
2	factor	4.31	26224.25	36.605	1.09e-32	*	2.0e-03
3	time:factor	12.73	77516.76	14.476	1.76e-32	*	1.0e-03

Results from post-hoc t tests of the peer factor across time showed that peer problems were greatest at age 17 in terms of scores, followed roughly by ages 14, 7, and 5, and lowest at age 11.

Sweep (age)	Sweep (age)	t statistic	p-value (adjusted)	Significance	Interpretation (age)
1 (5)	3 (11)	4.578	4.79e-05	****	5 > 11
1 (5)	5 (17)	–3.479	0.005	**	17 > 5
2 (7)	3 (11)	4.078	4.6e-04	***	7 > 11
2 (7)	5 (17)	–4.688	2.82e-05	****	17 > 7
3 (11)	4 (14)	–6.849	8.19e-11	****	14 > 11
3 (11)	5 (17)	–8.937	5.22e-18	****	17 > 11
4 (14)	5 (17)	–2.984	0.028	*	17 > 14

4. UMAP parameters

UMAP was configured with a relatively high number of neighbours (n_neighbours = 100) to decrease the probability of producing fine-grained clusters that may result from noise rather than the actual clusters.

I also set a low minimum distance (min_dist = 0.001) to create denser clusters and cleaner separations between clusters.

The distance metric was set to Euclidean (McInnes et al., 2018).

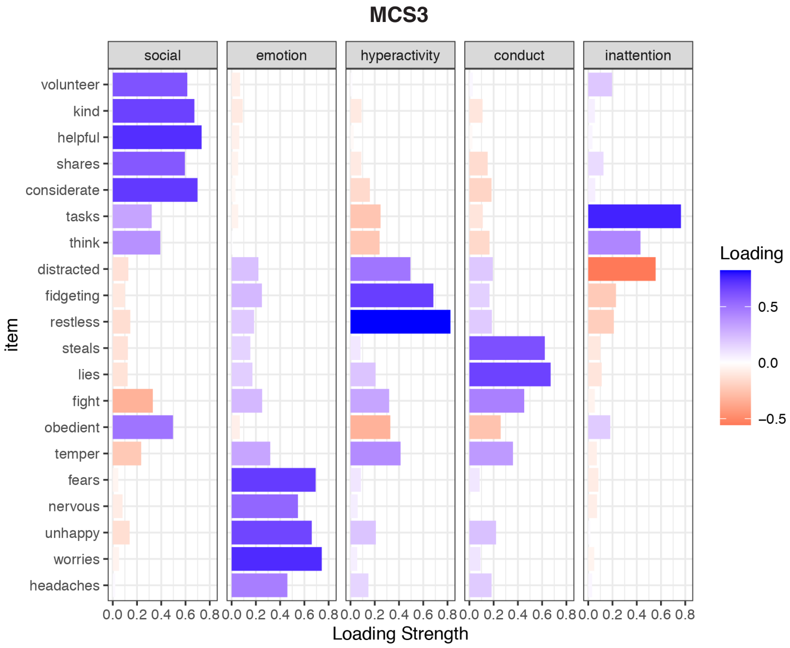
5. Table of risk factors with variable codes

	Sweep 3 (age 5)	Sweep 4 (age 7)	Sweep 5 (age 11)
Child cognition	Naming vocab [*CCNVABIL*] Pattern construction [*CCPCABIL*] Picture similarities [*CCPSABIL*]	Word reading [*DCWRAB00*] Pattern construction [*DCPCAB00*]	Verbal similarities [*EVSABIL*]
Child health	General level of health [*CPCGHE00*] Sports and exercise [*CPSEHO00*] Longstanding illness [*CPCLSI00*]	General level of health [*DPCGHE00*] Sports and exercise [*DPSEHO00*] Longstanding illness [*DPCLSI00*] Mental health [*DCSC0011*]	General level of health [*EPCGHE00*] Sports and exercise [*EPSEHO00*] Longstanding illness [*EPCLSI00*] Mental health [*ECQ11A00*]
Parental mental health & personality	Kessler K6 scale [*CDKESS00*] Life satisfaction [*CPWALI00*]	Word reading [*DDKESSLER*] Life satisfaction [*DPWALI00*] Neuroticism [*DDNEUROT*]	Kessler K6 scale [*EPPHDE00, EPPHHO00, EPPHRF00, EPPHEE00, EPPHWO00, EPPHNE00*] Life satisfaction [*EPWALI00*]
Parent-child relationship	Time spent with child [*CPCHTI00*] Parent-child relationship [*CPSCHC00*]	Time spent with child [*DPHCTI00*] Parent-child relationship [*DPSCHC00*]	Time spent with child [*EPCHTI00*] Parent-child relationship [*EPSCHC00*]
Family relationships	Marital status [*CPFCIN00*] Parent satisfaction with partner [*CPHARE00*] Use of force [*CPFORC00*] Number of siblings [*CDOTHS00*] Proximity of family/friends [*CPAFR00*]	Marital status [*DPFCIN00*] Parent satisfaction with partner [*DPHARE00*] Use of force [*DPFORC00*] Number of siblings [*DDOTHS00*] Proximity of family/friends [*DPAFR00*]	Marital status [*EPFCIN00*] Parent satisfaction with partner [*EPHARE00*] Use of force [*EPFORC00*] Number of siblings [*EOTHS00*] Proximity of family/friends [*EPAFR00*]
Demographics	Income OECD [*CDOEDE00*] Parent education NVQ [*CDDNVQ00*] Area of upbringing [*CPARGD00*]	Income OECD [*DDOEDE00*] Parent education NVQ [*DDDNVQ00*]	Income OECD [*EDOEDE00*] Parent education NVQ [*EACAQ00*] Area of upbringing [*EPARGD00*]

6. Table showing extracted factors and associated SDQ items

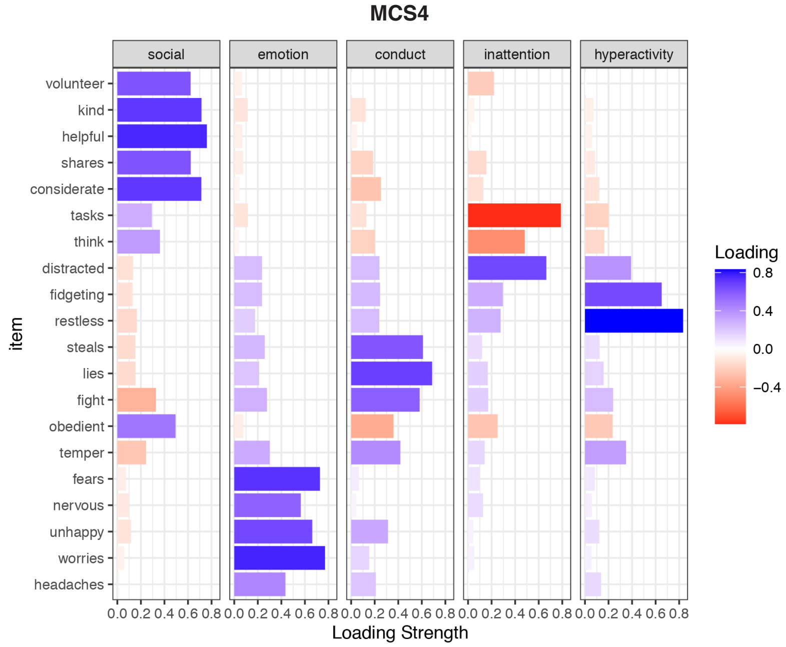
Prosocial	Emotion	Conduct	Hyperactivity	Inattention
Generally obedient	Often complains of headaches	Often has temper tantrums or hot tempers	Restless, overactive	Easily distracted, concentration wanders
Considerate of other people's feelings	Many worries	Often fights with other children	Constantly fidgeting or squirming	Thinks things out before acting
Shares readily with other children	Often unhappy, downhearted	Often lies or cheats		Sees tasks through to the end
Helpful if someone is hurt	Nervous or clingy in new situations	Steals from home, school or elsewhere		
Kind to younger children	Many fears, easily scared			
Often volunteers to help others				

7. Factor analysis correlation plots and loading matrices for all sweeps except MCS7

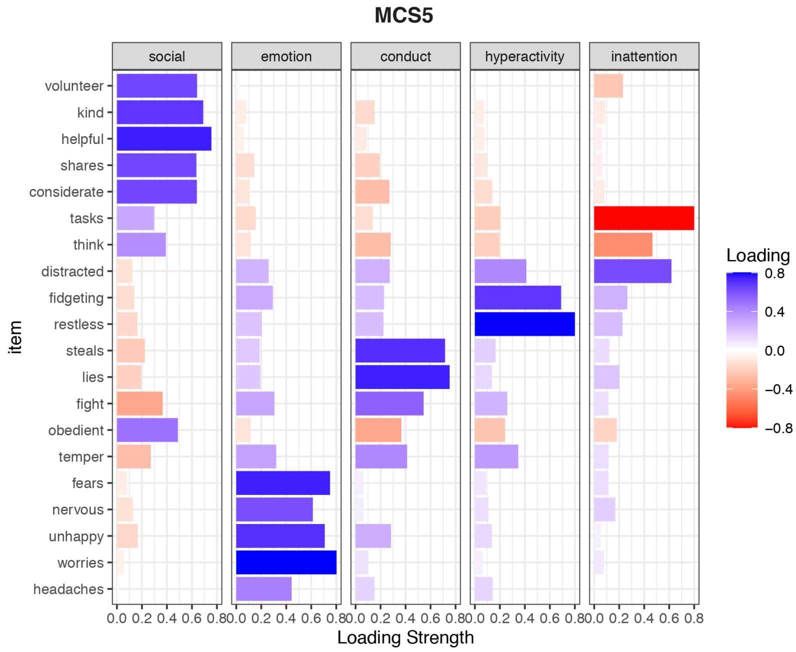


	Social	Emotion	Conduct	Hyperactivity	Inattention
SS loadings	2.986	2.372	2.060	1.543	1.317
Proportion variance	0.149	0.119	0.103	0.077	0.066
Cumulative variance	0.149	0.268	0.371	0.448	**0.514**

7. Factor analysis correlation plots and loading matrices for all sweeps except MCS7 (cont'd)



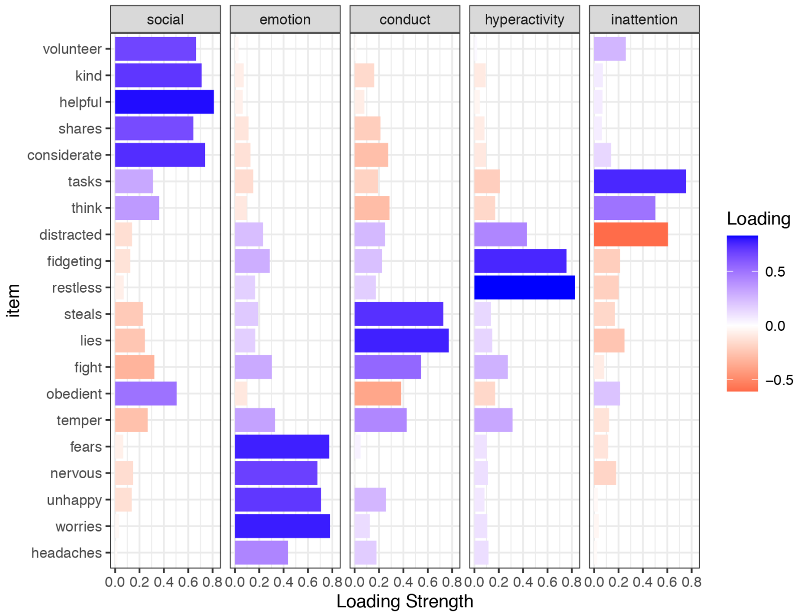
	Social	Emotion	Conduct	Hyperactivity	Inattention
SS loadings	3.141	2.544	2.008	1.736	1.692
Proportion variance	0.157	0.127	0.100	0.087	0.085
Cumulative variance	0.157	0.284	0.385	0.471	**0.556**



	Social	Emotion	Conduct	Hyperactivity	Inattention
SS loadings	3.163	2.837	2.217	1.762	1.604
Proportion variance	0.158	0.142	0.111	0.088	0.080
Cumulative variance	0.158	0.300	0.411	0.499	**0.579**

7. Factor analysis correlation plots and loading matrices for all sweeps except MCS7(cont'd)

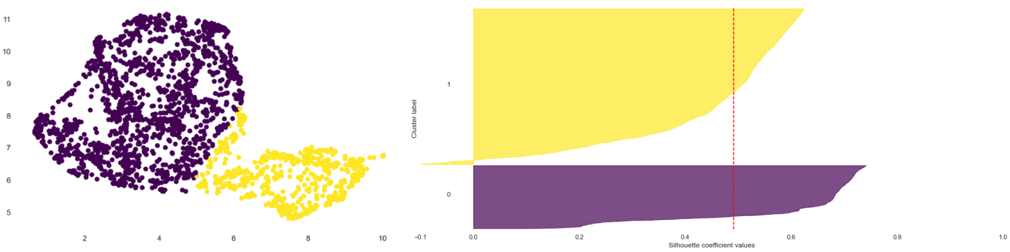
MCS6



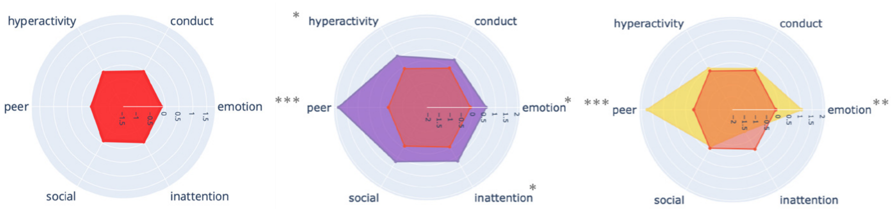
	Social	Emotion	Conduct	Hyperactivity	Inattention
SS loadings	3.410	2.868	2.279	1.837	1.582
Proportion variance	0.170	0.143	0.114	0.092	0.079
Cumulative variance	0.170	0.314	0.428	0.520	**0.599**

8. Visualisation of MCS3 to MCS6 (projection with KMeans clustering in UMAP space, silhouette plot, C-H plot, radar plots, table of cluster characteristics)

MCS3 (age 5)



n_clusters	Average silhouette score
2	0.49
3	0.46
4	0.44
5	0.43
6	0.41
7	0.41
8	0.39
9	0.41

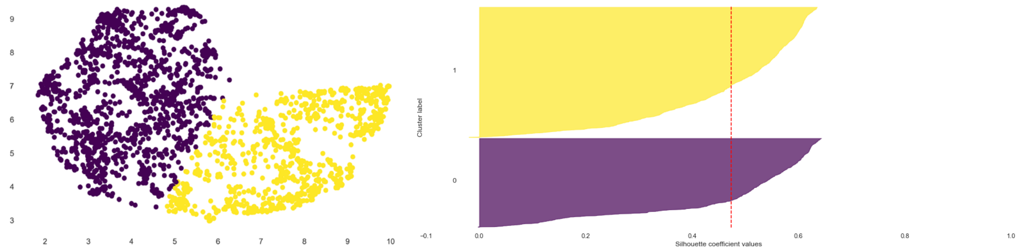


Non-peer   Peer & emotion   **Peer**

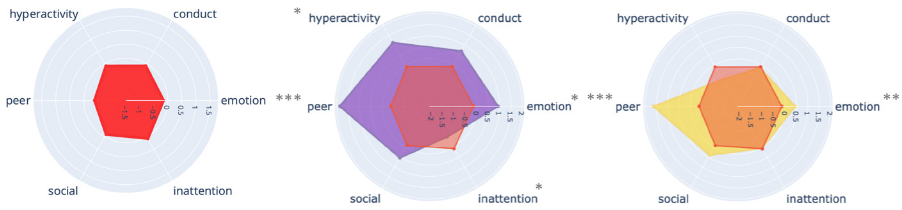
Cluster	Cluster label	Size	% of total sample	No. of females	No. of females (% of total sample)
A0	Non-peer	11,657	83.58	5,813	84.96
A1	Peer & emotion	663	4.75	351	5.13
A2	Peer	1,627	11.67	678	9.91
Total	Total	13,947	100.00	6,842	100.00

8. Visualisation of MCS3 to MCS6 (projection with KMeans clustering in UMAP space, silhouette plot, C-H plot, radar plots, table of cluster characteristics) (cont'd)

MCS4 (age 7)



n_clusters	Average silhouette score
2	0.47
3	0.44
4	0.41
5	0.42
6	0.42
7	0.42
8	0.42
9	0.43



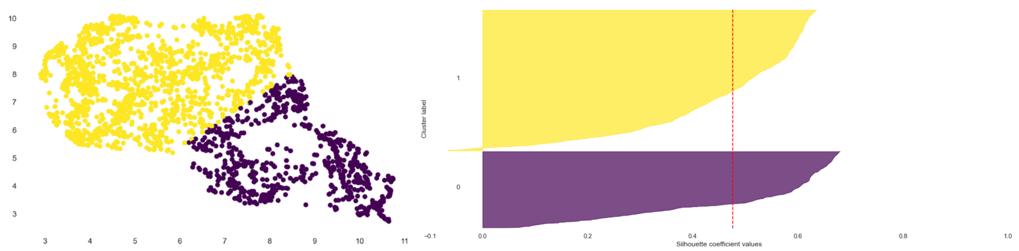
Non-peer | **Peer, hyperactivity & emotion** | Peer

Cluster	Cluster label	Size	% of total sample	No. of females	No. of females (% of total sample)	Wellbeing*
B0	Non-peer	10,393	82.15	5,273	84.35	1.637
B1	Peer, hyperactivity, & emotion	1,341	10.60	518	8.29	1.652
B2	Peer	917	7.25	460	7.36	1.711
Total	Total	12,651	100.00	6,251	100.00	1.642

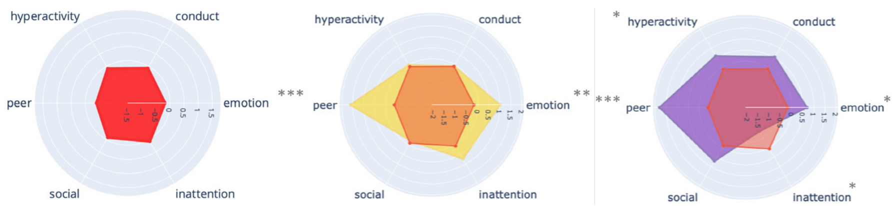
* "How often do you feel happy"?

1 - never
2 - some of the time
3 - all of the time

MCS5 (age 11)



n_clusters	Average silhouette score
2	0.48
3	0.43
4	0.43
5	0.42
6	0.43
7	0.44
8	0.45
9	0.46



Non-peer | Peer & emotion | **Peer**

Cluster	Cluster label	Size	% of total sample	No. of females	No. of females (% of total sample)	Wellbeing*
C0	Non-peer	10,398	81.34	5,252	82.75	1.84
C1	Peer & emotion	838	6.56	476	7.50	2.33
C2	Peer	1,547	12.10	619	9.75	2.12
Total	Total	12,783	100.00	6,347	100.00	1.92

* Happiness with life as a whole

1 - not at all happy
7 - completely happy

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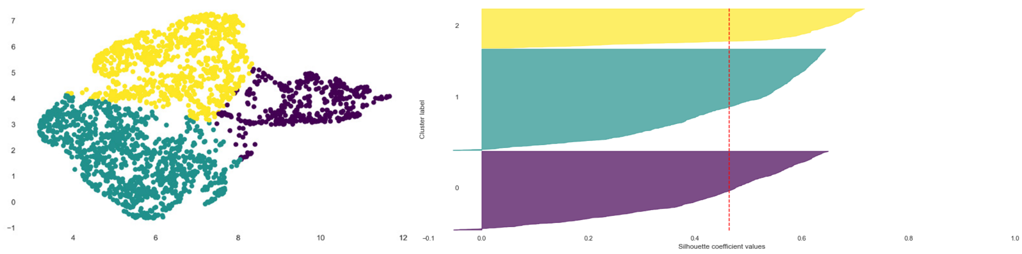
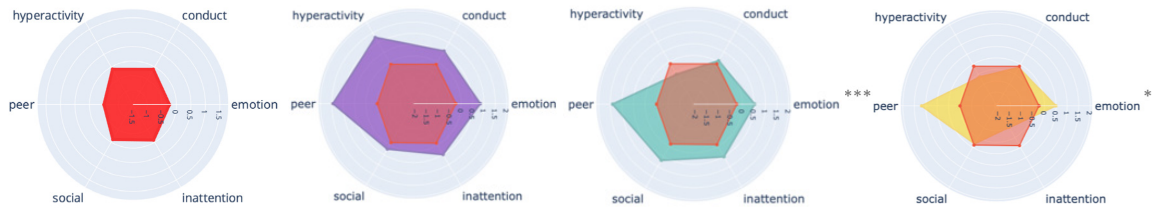
8. Visualisation of MCS3 to MCS6 (projection with KMeans clustering in UMAP space, silhouette plot, C-H plot, radar plots, table of cluster characteristics) (cont'd)

MCS6 (age 14)



n_clusters	Average silhouette score
2	0.48
3	0.43
4	0.43
5	0.42
6	0.43
7	0.44
8	0.45
9	0.46



Non-peer | **Peer, hyperactivity & emotion** | Peer | Peer

Cluster	Cluster label	Size	% of total sample	No. of females	No. of females (% of total sample)	Wellbeing*
C0	Non-peer	10,398	81.34	5,252	82.75	1.84
C1	Peer & emotion	838	6.56	476	7.50	2.33
C2	Peer	1,547	12.10	619	9.75	2.12
Total	Total	12,783	100.00	6,347	100.00	1.92

* Wellbeing Grid - happiness with school work, the way they look, family, friends and school - happiness with life as a whole
1 - not at all happy
7 - completely happy

9. Tables showing transitions from MCS3 through MCS7

MCS3 \ MCS4	B1 Peer, Hyperactivity, Emotion, (Conduct,& Antisocial)	B2 Peer (& Emotion)	B0 Non-peer
A1 Peer & Emotion	**0.197133**	**0.195341**	**0.607527**
A2 Peer, (Antisocial, Inattention, Emotion & Hyperactivity)	**0.371118**	**0.172360**	**0.456522**
A0 Non-peer	**0.058377**	**0.052179**	**0.889444**

MCS4 \ MCS5	C1 Peer, Emotion (& Inattention)	C2 Peer, (Antisocial, Emotion, Hyperactivity & Conduct)	C0 Non-peer
B1 Peer, Hyperactivity, Emotion, (Conduct & Antisocial)	**0.124424**	**0.403687**	**0.471889**
B2 Peer (& Emotion)	**0.168407**	**0.203655**	**0.627937**
B0 Non-peer	**0.045703**	**0.071740**	**0.882557**

MCS5 \ MCS6	D1 Peer, Hyperactivity, Emotion, (Conduct & Inattention)	D2 Peer, (Antisocial, Emotion & Inattention)	D3 Peer (& Emotion)	D0 Non-peer
C1 Peer, Emotion (& Inattention)	**0.197092**	**0.164782**	**0.166397**	**0.471729**
C2 Peer, (Antisocial, Emotion, Hyperactivity & Conduct)	**0.373460**	**0.056872**	0.239810	**0.329858**
C0 Non-peer	**0.077655**	**0.038185**	**0.067112**	**0.817048**

9. Tables showing transitions from MCS3 through MCS7 (cont'd)

MCS6 \ MCS7	E1 Peer	E2 Peer, Emotion, (Hyperactivity & Inattention)	E3 Peer (& Antisocial)	E0 Non-peer
D1 Peer, Hyperactivity, Emotion, (Conduct & Inattention)	**0.471646**	**0.121715**	**0.001383**	**0.405256**
D2 Peer, (Antisocial, Emotion & Inattention)	**0.146974**	0.270893	0.023055	**0.559078**
D3 Peer (& Emotion)	**0.391036**	**0.217929**	**0.001546**	**0.389490**
D0 Non-peer	**0.084287**	**0.070038**	**0.003412**	**0.842264**

Interdisciplinary Commentary

SOCIAL ANTHROPOLOGY

Ethnographic engagements with the risks and troubles of growing up

Inika Murkumbi
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Both psychology and social anthropology are fascinated by a shared field of questions on how infants are fashioned into complete persons. Both are also fascinated with the risks and troubles this transformation may entail. The robustness and wide range of the Millennium Cohort Study and the intimacy and flexibility of social anthropology's ethnographic method can be reimagined as excitingly complementary (rather than in conflict). Ethnography might challenge assumptions that certain developmental stages are inevitably laden with certain profiles of problems, widen our mental landscape of culturally salient peer/behavioural problems, and provide a holistic view of how peer/behavioural problems that are troublesome in their immediate context might be understood as valuable and generative in the larger context of a community's value-system.

Bringing a social anthropology lens to "peer problems and co-occurring behavioural problems" often collapses the distinction between more relational "peer problems" and more individualised "behavioural problems". In this framing, they are not just co-occurring and inter-related but mutually forged by cultural factors and jointly infused with the social. Overall, addressing peer/behavioural problems through social anthropology can be uniquely productive as it calls into play a broader disciplinary tension between attending to cultural specificities in their own context (e.g., culturally specific idioms of behavioural problems) and dialoguing with broader, more universal questions about the human condition (e.g., addressing how we grow into persons). Additionally, ethnography across different global contexts helps to problematize and unsettle the taken-for-granted assumptions underlying flat psychological constructs such as 'peer problems' and/or 'behavioural problems'.

Overturning a doxic assumption, Mead's ethnographic study of Samoan youth illustrated how adolescence as a developmental stage need not necessarily be accompanied by the emotional and social problems that Global Northern discourse paints as 'biologically' inevitable (Mead, 1928). In his foreword to her book Coming of Age in Samoa, Mead's mentor Franz Boas cites how 'When we [Westerners] speak about the difficulties of childhood and of adolescence, we are thinking of them as unavoidable periods of adjustment through which everyone has to pass… The anthropologist doubts the correctness of these views' (ibid, p. 6). Why Samoan girls seem to have a significantly less turbulent adolescence than American girls is a central concern of the book, and a question for which Mead draws out several possible explanations. These explanations include the observation that Samoan culture is more homogenous in terms of ideology and standards of behaviour (such that the adolescent girl is less beset with conflicting choices); the observation that Samoan culture mediates out intensities of ambition and emotional attachment to specific persons (such that the adolescent girl is less likely to experience acute disappointment or heartache); and the observation that the daily routine of the Samoan girl actually becomes far less cumbersome as she approaches adolescence (younger girls not yet strong enough to lift heavy loads are left in charge of minding irritating toddlers and other young relatives). While some of Mead's analysis seems influenced by a dated tendency to paint many non-Western peoples as 'simpler' or 'primitive', her underlying observation about how adolescence is not universally or inevitably beset by problems holds water and has powerful implications. In the context of this article, it suggests we remain critical and vigilant about the cross-cultural generalizability of behavioural/peer problem co-occurrences and configurations across developmental stages.

Ethnographic examples also widen our mental landscape of what peer/behavioural problems might look like in different settings and how cultural factors might shape which 'problems' are interpreted as the most striking. Gow's discussion of the transgressive social significance of earth-eating by indigenous children living in Bajo Urubamba (Peru) is particularly salient here (Gow, 1989). Amongst Bajo Urubamba people, the acquisition and production of food are deeply embedded in gendered social relations—personhood itself is constituted by the consumption of particular foods. Complex metaphoric relationships between food and sex situate them both in a common field of oral desire and the satisfaction of bodily desires is not 'baser' or 'below the social'—it is inherently and simultaneously the creation of social relations. In this context, children that eat earth are seen as strikingly perverse, becoming the recipients of anxiety, anger, and parental attempts to make them vomit up the earth they have eaten. While Gow as a Westerner reflected on how he had initially perceived earth-eating by children as a relatively benign behaviour, his interlocutors perceived it as profoundly anti-social and disruptive to the collaborative order. Because earth is seen as the antithesis of 'real food', eating it is perceived as threatening the very foundations of sociality. As earth is disembedded from social relations and undifferentiated by gender, the behaviour of earth-eating signals simultaneously a profound problem with one's social enmeshment (i.e., a 'peer problem', using the article's terminology) and a profound problem with one's 'perverse' behaviour (i.e., a 'behavioural problem', using the article's terminology). To state the obvious: a Millennium Cohort Study designed in the UK is unlikely to collect data on earth-eating as an alarming and salient form of social-behavioural problem facing children. However, earth-eating might be an important, even defining idiom of interpreting developmental 'trouble' in other sociocultural contexts. This is not a call to include earth-eating in Millenium Cohort Study questionnaires, but a call to attend to how reactions to developmental 'troubles' may be deeply and heavily shaped by varying cultural narratives.

Lastly, in-depth ethnographic study might illustrate how peer/behavioural problems (when enmeshed in certain value systems) can enhance a child's social status and development rather than impeding it. Abu-Lughod's study of an Awlad 'Ali Bedouin community illuminates one such complicating case where an adolescent girl is constituted as the community's most exemplar young person precisely because she expresses certain peer/behavioural problems (Abu-Lughod, 1986). Sketching out the community's value system, Abu-Lughod outlines the dual, somewhat contradictory importance afforded to basham (modesty/deference) as well as to autonomy and strength. This contradiction is particularly generative and relevant amongst women. Displays of basham amongst women are considered appropriate due to their status as dependents. At the same time, basham is prized the most when it is perceived as given willingly– deference offered by a woman who is docile has no real value as it is perceived as coerced from the weak rather than freely given by the wilful and strong to their social superiors, acknowledging their greater wisdom and rightful authority. Abu-Lughod shares how the young girl, considered 'most outstanding in the camp' (ibid., p. 252), was extremely modest and proper (even hostile) towards males. However, the girl's modesty was considered most exemplary precisely because she was wilful, strong, and troublesome in other qualities: 'she was tough and difficult, always yelling back at her mother, refusing to do what she was told, and bossing her brothers around' (ibid.). Her display of peer/behavioural problems thus served to affirm the power of her modesty in a significant way—her displays of basham were signs of exemplary character and honour precisely because her toughness and troublesome-ness in other areas accentuated how this deference was willingly given. This intimate ethnographic example thus affirms the importance of understanding peer/behavioural problems as embedded in dense systems of meaning. Certain peer/behavioural problems might be experienced as striking and troublesome in their immediate context (e.g., the girl's mother was irritated when she refused commands) but also be experienced as valuable and constitutive in a more long-term, character-building context (the girl's mother was overall quite proud of her toughness, aware that it reflected well on her character and prospects). The ambivalence and contradiction at the heart of our social lives, which is somewhat obscured by population-level psychology studies, may thus grow excitingly revitalised through intimate, in-depth ethnographic study.

To conclude, the robustness and wide range of the Millennium Cohort Study and the intimacy and flexibility of social anthropology's ethnographic method can be reimagined as excitingly complementary (rather than in conflict). The ethnographic method does not dispute valuable findings from big data, but deepens their relative flatness, unsettles some stable assumptions, complicates leanly designed constructs, and overall provides a particularly grounded view of how technically defined constructs play out in the human messiness of everyday life-worlds. As discussed in this commentary, ethnography might challenge assumptions that certain developmental stages are inevitably laden with certain profiles of problems, widen our mental landscape of culturally salient peer/behavioural problems, and provide a holistic view of how peer/behavioural problems that are troublesome in their immediate context might be understood as valuable and generative in the larger context of a community's value-system. Overall, the development and constitution of persons from birth to adulthood is an area of incredible fascination in both psychology and social anthropology. Bridges built between these two disciplines are in many ways built over a common stream of tantalising questions about how we grow into personhood.

NATURAL SCIENCES

A brief comment on the molecular genetics of hyperactivity and its associated disorders

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Lee describes hyperactivity as a substantial co-occurrence with peer relationships. To provide further depth, this commentary aims to provide brief contextual information on the available evidence on the genetic basis of hyperactivity or attention-deficit hyperactivity disorder at large. Greater emphasis is placed onto genome-wide and transcriptome-wide association studies (GWAS and TWAS respectively), which aim to study the many common genetic variants that have small but additive effect on ADHD severity, with brief descriptions of rarer mutations with more significant associations with ADHD.

Behavioural developments are generally agreed upon as the outcome of genetic and environmental factors; importantly, however, both factors have profound and complex interactions with each other that is critical in influencing human behaviour (Vrieze et al., 2012). While Lee aims to elucidate the interplay between peer problems and the development of behavioural problems, as well as the roles that other environmental risk factors play in both, this commentary seeks to describe recent evidence for the genetic factors that are linked to hyperactivity, which were identified in the above article as a significant co-occurrence with peer relationship problems.

For the purposes of this commentary, hyperactivity will be considered under the broader umbrella of attention-deficit hyperactivity disorder (ADHD). ADHD is now considered to be a neurodevelopmental disorder with a multifactorial aetiology, in line with the current paradigm of most other neurodevelopmental disorders (Scandurra et al., 2019). Genetic factors appear to play a significant role in the development of ADHD, with twin studies estimating ADHD heritability (a measure of phenotypic variation that can be attributed to genetic variation) at between 77 to 88 percent (Faraone & Larsson, 2019). Aside from rare mutations with outsized impacts, ADHD is more commonly *polygenic* in its genetic basis, such that a collection of genetic variants interacts additively to give rise to a continuous phenotype, such as the severity of ADHD manifested. This commentary will address both, with emphasis and priority on the latter.

The polygenic basis of ADHD

Genome-wide association studies (GWASs) are typically used to study complex disorders with severity continuums. These efforts are usually prospective studies to identify alleles (commonly single nucleotide polymorphisms or SNPs) at different loci associated with a trait of interest, albeit those with a small relative effect; these are also known as 'hits' (Uffelmann et al., 2021). Polygenic risk scores can then be calculated as a weighted sum of the alleles identified; these act as a measure of heritable risk of, or genetic predisposition to, the trait or disorder (ibid.). The genes nearest to the identified loci of interest can then be further analysed to find potential causal relationships or models, since GWASs only find alleles *correlated* to a polygenic trait.

Early attempts with GWASs with regards to ADHD did not manage to find any significant loci, owing to small sample sizes (Neale et al., 2010). Only recently did Demontis and colleagues (2019) manage to find genome-wide significant loci using sufficiently large datasets. Some of these loci are associated with genes not previously associated with ADHD, but are important in neural development. These include *FOXP2*, which encodes an important transcription factor for neural development, speech development, and learning (Vargha-Khadem et al., 2005), as well as *SEMA6D*, encoding a putative semaphorin—signalling molecules important in axonal growth cone guidance and hence neural development (Hu & Zhu, 2018). These genes, along with most of the other identified genes, have alleles that are linked to other neurodevelopmental and internalising disorders (such as intellectual disability, schizophrenia and depression) or co-occurrences associated with ADHD (such as lower educational attainment) (Demontis et al., 2019).

However, assigning any further biological significance to the identified loci has been difficult for a few reasons. For example, variation at a given locus does not necessarily lead to changes in expression of the nearest gene(s); indeed, most SNPs identified sit in nucleosome-free regions of the genome containing *cis*-regulatory elements (Maurano et al., 2012), including enhancers which effect transcription activation of genes kilobases up- or down-stream. Moreover, gene identification in GWASs bias against smaller genes and cannot give any indication on whether any putative genes of interest are expressed in relevant tissue, such as the brain in the case of ADHD. These issues can be partially addressed using transcriptome-wide association studies (TWASs).

TWASs use data derived from GWASs and transcriptomic analysis of representative, healthy tissue samples, namely in the form of expression quantitative trait loci (eQTLs). eQTLs account for the genetic variation of the *expression of a certain gene*, rather than *phenotypic trait* (Nica & Dermitzakis, 2013). Machine learning methods have further allowed the assignment of tissue-specific expression patterns based on eQTLs in a process known as *transcriptomic imputation* (Beretta & Santaniello, 2016; Song et al., 2020). By integrating information from GWAS studies on ADHD and imputed transcriptomic data, TWAS can aid in identifying the variations in tissue-relevant gene expression arising from variations in putative loci of interest that are linked to ADHD.

Shortly after Demontis and colleagues' (2019) study, Liao and colleagues (2019) conducted an ADHD TWAS with the European sub-population from the former's dataset. The study identified other genes whose expression signals account for significant proportions of GWAS signals at their loci, including a small gene that was ignored in the 'traditional' GWAS meta-analysis framework. Potentially causative gene sets were also identified by fine-mapping of TWAS hits. These include *KAT2B* in the dorsolateral prefrontal cortex (Liao et al., 2019), which encodes a lysine acetyltransferase, the enzymatic process of which is critical in brain development (Tapias & Wang, 2017). The identified genes were also implicated in dopaminergic and noradrenergic signalling networks by pathway enrichment analysis, while also expressed in brain tissue that is considered relevant in ADHD aetiology, namely those involved in deficits in noradrenergic and dopaminergic signalling (Arnsten, 2009; del Campo et al., 2011; Plessen et al., 2006).

Rare mutations and ADHD

Broadly speaking, there are two classes of rare mutations that appear to have significant associations with ADHD: protein-truncating variants (PTVs) and *de novo* copy number variants (CNVs). The former refers to nonsense, frameshift, and splice-site mutations in coding genes, resulting in truncated gene products. One of the largest exome sequencing studies on ADHD used archived bloodspots from persons diagnosed with ADHD or autism spectrum disorder (ASD) to identify rare PTVs. The study found that the burden of such PTVs was higher among people with ADHD and those with ASD (relative to the control group), but the burden was also similar in size and gene sets between both groups with neuropsychiatric disorders (Satterstrom et al., 2019). *MAP1A* and its PTVs were identified as significantly associated with both neurodevelopmental disorders in this study (ibid.); previous studies have implicated its gene product in maintaining neuronal microtubule networks, and that associated rare missense *MAP1A* alleles with ASD and schizophrenia (Liu et al., 2015).

De novo CNVs involve chromosomal segments that are duplicated or deleted, such that the number of copies of a gene are changed as a result, and they have been linked to other neurodevelopmental disorders (Takumi & Tamada, 2018). By studying mutations among parent-offspring trios whereby the offspring is diagnosed with ADHD, Martin and colleagues (2020) found a mutation rate over four times higher among people with ADHD compared to a previous control trio, with some CNVs also implicated previously in other neurodevelopmental disorders (some of which co-occur with ADHD). No genes within the CNVs were highlighted by previous GWAS/TWAS studies, however (Martin et al., 2020).

Conclusions and perspectives

While TWAS has provided indirect links that implicate dopamine and noradrenaline signalling impairment, as is the prevailing paradigm regarding the contemporary pathophysiology of, and treatments against, ADHD, much remains unanswered on the specific mechanistic details that contributes to ADHD development. The sample sizes used in the GWAS and TWAS studies mentioned are still relatively small despite significant improvements. This could explain why candidate genes that were previously associated with ADHD prior to GWAS studies were not identified as direct hits, such as those involved in dopaminergic (and sometimes serotonin) signalling, from synaptic vesicle trafficking to signal transduction (Hawi et al., 2015). As such, future GWAS/TWAS studies with larger datasets could then identify these candidate genes as direct hits.

Despite the shortcomings with our current understanding so far, the available data still provides pertinent information that have, and will continue to, inform future research directions. For example, the studies mentioned find that ADHD has significant genetic overlap for other neuropsychiatric disorders, which are also observed to co-occur with ADHD. Therefore, recent research efforts into ADHD genetics have also included datasets from conditions known to co-occur with ADHD, such as ASD and disruptive behaviour disorders (Satterstrom et al., 2019). Indeed, the same researchers that produced the earlier GWAS study have conducted a GWAS meta-analysis of ADHD comorbid with disruptive behaviour disorders, and found a higher SNP heritability for that relative to ADHD alone (Demontis et al., 2021).

PSYCHOLOGY

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