

A twin study exploring the association between childhood emotional and behaviour problems and specific psychotic experiences in a community sample of adolescents

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Appendix

Table S1: Phenotypic correlations

	Emotional and behaviour problems	
	Age-7	Age-12
	r (CI)	r (CI)
Psychotic experiences		
Paranoia	0.13 (0.10, 0.16)	0.17 (0.14, 0.20)
Hallucinations	0.10 (0.07, 0.14)	0.13 (0.10, 0.16)
Cognitive disorganisation	0.16 (0.13, 0.19)	0.22 (0.19, 0.25)
Grandiosity	0.04 (0.01, 0.07)	0.03 (-0.01, 0.06)
Anhedonia	0.06 (0.03, 0.09)	0.12 (0.08, 0.15)
Parent-rated negative symptoms	0.34 (0.31, 0.37)	0.42 (0.39, 0.45)

Note: Correlations were performed using one random member of each twin pair using standardised age and sex regressed residuals. r = Pearson's correlation, CI= confidence intervals.

Table S2: Proportion of psychotic experiences attributable to emotional and behaviour problems

	Prevalence N (%)			Population attributable fraction (95% CI)	
	Total	No	Yes	Age-7	Age-12
Psychotic experiences					
Paranoia	4,798	4,433 (92.39)	365 (7.61)	6% (2%-9%)	10% (6%-13%)
Hallucination	4,806	4,501 (93.65)	305 (6.35)	1% (-2%-4%)	5% (1%-8%)
Cognitive disorganisation	4,799	4,428 (92.27)	371 (7.73)	6% (3%-10%)	8% (4%-11%)
Grandiosity	4,802	4,512 (93.96)	290 (6.04)	1% (-2%-5%)	3% (0%-72%)
Anhedonia	4,802	4,480 (93.86)	340 (6.14)	1% (-3%-3%)	2% (-1%-5%)
Parent-rated negative symptoms	4,817	4,510 (93.63)	307 (6.37)	15% (10%-20%)	17% (12%-22%)
Emotional and behaviour problems: Parent report					
Age-7	5,537	5,197 (93.86)	340 (6.14)	-	-
Age -12	4,953	4,710 (95.09)	243 (4.91)	-	-

Note: Population attributable fraction presented as a proportion.

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Table S3: Sensitivity and specificity values, and positive and negative predictive values between emotional and behavioural problems at age 7 and 12 and psychotic experiences at age 16.

	Predictive values							
	Age 7				Age 12			
	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)
PEs								
Par	11% (8%-15%)	95% (94%-95%)	14% (10%-20%)	93% (92%- 94%)	14% (11%-19%)	96% (95%-97%)	22% (17%-29%)	93% (92%-94%)
Hal	7% (4%-11%)	94% (94%-95%)	8%(5%-12%)	94% (93%-,95%)	9% (6%-14%)	95% (95%-96%)	13% (8%-18%)	94% (93%-95%)
Cog Dis	12% (8%-16%)	95% (94%-95%)	16% (11%-21%)	93% (92%, 94%)	12% (9%-17%)	96% (95%-96%)	18% (13%-25%)	93% (92%-94%)
Gran	7% (4%-11%)	94% (94%-95%)	7% (4%-11%)	94% (94%-95%)	8% (5%-13%)	95% (95%-96%)	10% (6%-15%)	94% (94%-95%)
Anhe	6% (4%-10%)	94% (94%-95%)	7% (4%-11%)	94% (93%-94%)	7% (4%-11%)	95% (95%-96%)	10% (6%-15%)	93% (92%-94%)
Par neg sym	20% (15%-26%)	95% (94%-96%)	20% (15%-25%)	95% (94%-96%)	21% (16%-27%)	96% (96%-97%)	26% (20%-33%)	95% (94%-96%)

Note: PEs= Psychotic experiences, Par=paranoia, Hal=hallucinations, Cog Dis=cognitive disorganisation, Gran=grandiosity, Anhe= anhedonia, Par neg symp=parent-rated negative symptoms, PPV = positive predictive value, NPV =negative predictive value, CI= confidence intervals

Table S4: Intraclass twin correlations

	MZ	DZ
	ICC (CI)	ICC (CI)
Univariate twin correlations		
Psychotic experiences		
Paranoia	0.52 (0.49, 0.56)	0.29 (0.24, 0.34)
Cognitive disorganisation	0.45 (0.41, 0.48)	0.23 (0.18, 0.28)
Parent-rated negative symptoms	0.82 (0.81, 0.84)	0.55 (0.52, 0.59)
Emotional and behaviour problems		
Age-7	0.74 (0.72, 0.76)	0.44 (0.40, 0.49)
Age-12	0.79 (0.77, 0.81)	0.56 (0.52, 0.60)
Cross-trait cross-twin correlation		
Psychotic experiences and Age-7 emotional and behaviour problems		
Paranoia	0.11 (0.06, 0.16)	0.09 (0.03, 0.14)
Cognitive disorganisation	0.10 (0.05, 0.15)	0.06 (0.01, 0.12)
Parent-rated negative symptoms	0.30 (0.25, 0.34)	0.24 (0.19, 0.29)
Psychotic experiences and Age-12 emotional and behaviour problems		
Paranoia	0.16 (0.11, 0.21)	0.10 (0.04, 0.15)
Cognitive disorganisation	0.20 (0.15, 0.25)	0.12 (0.07, 0.18)
Parent-rated negative symptoms	0.37 (0.32, 0.41)	0.29 (0.24, 0.34)

Note: Intraclass correlations using transformed standardised age and sex regressed scales. ICC= Intraclass correlations
CI= confidence intervals.

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Table S5: Fit statistics and parameter estimates for best fitting univariate models

	Model	Model Fit						Parameter estimates		
		-2LL	df	LRT	Δ df	BIC	p	A (CI)	C (CI)	E (CI)
Paranoia	Sat	23525.91	6527	-	-	-	-	-	-	-
	ACE	23529.68	6533	3.77	6	-29394.62	.71	.45 (.34, .54)	.07 (.00, .16)	.48 (.45, .52)
	CE	23598.74	6534	72.83	7	-29333.66	< 0.1	-	-	-
	*AE	23531.56	6534	5.64	7	-29400.84	0.58	.52 (.49, .55)	-	.48 (.45, .51)
Cognitive disorganisation	Sat	31571.04	6528	-	-	-	-	-	-	-
	ACE	31580.54	6534	9.50	6	-21351.86	.15	.44 (.32, .48)	.01 (.00, .11)	.55 (.52, .59)
	CE	31637.18	6535	66.14	7	-21303.32	< .01	-	-	-
	*AE	31580.58	6535	9.54	7	-21359.92	.22	.45 (.42, .48)	-	.55 (.52, .58)
Parent-rated negative symptoms	Sat	17410.51	6512	-	-	-	-	-	-	-
	*ACE	17416.10	6518	5.59	6	-35386.68	.47	.57 (.50, .64)	.26 (.19, .32)	.17 (.16, .18)
	CE	17810.00	6519	399.50	7	-35000.89	< .01	-	-	-
	AE	17465.87	6519	55.37	7	-35345.02	< .01	-	-	-
Emotional and behaviour problems: Age-7	Sat	12936.75	5614	-	-	-	-	-	-	-
	*ACE	12945.00	5620	8.25	6	-34620.33	.22	.63 (.55, .72)	.12 (.03, .20)	.25 (.23, .27)
	CE	13191.07	5621	254.33	7	-34382.72	< .01	-	-	-
	AE	12951.88	5621	15.14	7	-34621.91	< .01	-	-	-
Emotional and behaviour problems: Age-12	Sat	13282.75	5367	-	-	-	-	-	-	-
	*ACE	13288.95	5373	6.20	6	-32185.87	.40	.50 (.43, .58)	.30 (.23, .37)	.20 (.18, .22)
	CE	13515.26	5374	232.51	7	-31968.03	< .01	-	-	-
	AE	13342.70	5374	59.95	7	-32140.59	< .01	-	-	-

Note: Sat = saturated model; -2LL = negative 2 log likelihood; df = degrees of freedom; LRT = likelihood ratio X^2 test comparing the -2LL fit of each model to the -2LL fit of the saturated model; Δ df = difference in degrees of freedom comparing each model to the saturated model; BIC = Bayesian Information Criterion (lower values reflect a better fit); p = p-value. *Best fitting model.

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Table S6: Fit statistics for best fitting trivariate models

	Model Fit						
		Compared to saturated model					
	Model	-2LL	df	LRT	Δ df	BIC	p
Paranoia	Sat	43206.28	17526	-	-	-	-
	ACE	43230.33	17559	24.04	33	-105381.70	.87
	CE	43716.86	17565	510.58	39	-104945.95	<. 01
	AE	43295.45	17565	89.16	39	-105367.36	<. 01
	ACE dropped cov _a with Para	43305.56	17562	99.27	36	-105331.86	<. 01
	*ACE dropped cov _c with Para	43236.48	17562	30.20	36	-105400.94	. 74
Cognitive disorganisation	Sat	43050.66	17527	-	-	-	-
	ACE	43085.40	17560	34.74	33	-105535.09	.39
	CE	43561.22	17566	510.56	39	-105110.05	<. 01
	AE	43148.26	17566	97.60	39	-105523.01	<. 01
	ACE dropped cov _a with Cog	43150.34	17563	99.68	36	-105495.54	<. 01
	*ACE dropped cov _c with Cog	43092.20	17563	41.54	36	-105553.68	.24
Parent-rated negative symptoms	Sat	40397.10	17513	-	-	-	-
	*ACE	40440.52	17546	43.42	33	-108061.48	.11
	CE	41250.76	17552	853.66	39	-107302.02	<. 01
	AE	40578.19	17552	181.09	39	-107974.59	<. 01
	ACE dropped cov _a with Neg	40834.58	17549	437.48	36	-107692.81	<. 01
	ACE dropped cov _c with Neg	40548.83	17549	151.73	36	-107978.56	<. 01

Note: Sat= Saturated model; ACE= Full model testing genetic, common and unique environmental influences; CE = Model testing common and unique environmental influences; AE = Model testing genetic and unique environment influences; ACE dropped cov_a = Model testing genetic, common and unique environmental influences with genetic covariances between all phenotypes dropped. ACE dropped cov_c = Model testing genetic, common and unique environmental influences with common environmental covariances between all phenotypes dropped. The same is applied to paranoia, cognitive disorganisation, and parent-rated negative symptoms. Para = paranoia, Cog = cognitive disorganisation, Neg = parent-rated negative symptoms. -2LL = negative 2 log likelihood; df = degrees of freedom; LRT = likelihood ratio X² test comparing the -2LL fit of each model to the -2LL fit of the saturated model; Δ df = difference in degrees of freedom comparing each model to the saturated model; BIC = Bayesian Information Criterion (lower values reflect a better fit); p = p-value. *Best fitting model.

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Table S7. Interscale correlations between the subscales of emotional and behaviour problems

	Paranoia r (CI)	Hallucinations r (CI)	Cognitive disorganisation r (CI)	Grandiosity and delusion r (CI)	Anhedonia r (CI)	Parent-rated negative symptoms r (CI)
Age 7						
Emotional and behaviour problems	0.13 (0.10, 0.16)	0.10 (0.07, 0.14)	0.16 (0.13, 0.19)	0.04 (0.01, 0.07)	0.06 (0.03, 0.09)	0.34 (0.31, 0.37)
Hyperactivity	0.06 (0.03, 0.09)	0.06 (0.03, 0.09)	0.12 (0.09, 0.15)	0.05 (0.02, 0.08)	0.03 (-0.01, 0.06)	0.25 (0.22, 0.28)
Conduct problems	0.10 (0.06, 0.13)	0.06 (0.03, 0.09)	0.10 (0.07, 0.13)	0.03 (-0.03, 0.06)	0.06 (0.03, 0.09)	0.23 (0.20, 0.26)
Peer problem	0.12 (0.09, 0.15)	0.08 (0.04, 0.11)	0.08 (0.05, 0.11)	0.02 (-0.01, 0.05)	0.09 (0.06, 0.12)	0.23 (0.20, 0.26)
Emotional problems	0.09 (0.06, 0.12)	0.07 (0.04, 0.10)	0.13 (0.10, 0.16)	0.01 (-0.03, 0.04)	0.01 (-0.03, 0.04)	0.20 (0.17, 0.23)
Age12						
Emotional and behaviour problems	0.17 (0.14, 0.20)	0.13 (0.10, 0.16)	0.22 (0.19, 0.25)	0.03 (-0.01, 0.06)	0.12 (0.08, 0.15)	0.42 (0.39, 0.45)
Hyperactivity	0.09 (0.06, 0.12)	0.08 (0.05, 0.11)	0.15 (0.11, 0.18)	0.05 (0.02, 0.08)	0.09 (0.06, 0.12)	0.34 (0.31, 0.37)
Conduct problem	0.12 (0.09, 0.15)	0.09 (0.05, 0.12)	0.12 (0.09, 0.15)	0.02 (-0.01, 0.05)	0.07 (0.04, 0.10)	0.26 (0.24, 0.30)
Peer problems	0.18 (0.14, 0.21)	0.12 (0.09, 0.15)	0.13 (0.09, 0.16)	0.04 (0.01, 0.07)	0.11 (0.09, 0.15)	0.28 (0.25, 0.31)
Emotional problems	0.11 (0.08, 0.15)	0.11 (0.07, 0.14)	0.20 (0.17, 0.23)	-0.02 (-0.06, 0.01)	0.06 (0.03, 0.09)	0.28 (0.25, 0.31)

Note: Emotional and behaviour problems: Total score of SDQ scales