Longitudinal associations between positive attributes and psychopathology and their interactive effects on educational outcomes

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Supplementary Information

Details on the study methods

Confirmatory factor analysis for YSI, SDQ and literacy modelling

All confirmatory factor analysis (CFA) were performed in R using the *lavaan* package [1]. The CFA of TDE (literacy), SDQ (multidimensional psychopathology) and YSI (positive attributes) in a longitudinal dataset, we used items from the two time points and defined the subjects as a cluster, applying pairwise method to deal with missing data. We used delta parameterization and weighted least square with diagonal weight matrix with

standard errors and mean- and variance- adjusted chi-square test statistics (WLSMV) estimator and pairwise deletion of missing data. Model fit was tested by root mean square error of approximation (RMSEA), comparative fit index (CFI), and Tucker–Lewis index (TLI). RMSEA near or below 0.080 represent acceptable model fit, and values lower than 0.060 represent good-to-excellent model fit CFI and TLI values near or above 0.900 represent acceptable model fit, while values higher than 0.950 represent a good-to-excellent model fit [2]. Omega (ω), hierarchical omega (ωH) and Cronbach's α coefficient were calculated to estimate factor reliability. ω computes the proportion of variance in the observed total score attributable to all sources of common variance, which takes factor loadings to account the variance computation. ωH calculate the unique variance associated with each specific/subscale factor once controlling for the variance due to the general factor [3]. All factor scores were extracted using Empirical Bayes Modal method, and further saved to be used in the cross-lagged and regression models.

YSI was modelled as a one-factor model. Items were allowed to correlate if indicated by high correlation (>50.0) in the modification indices. The one-factor solution was conducted and indicated an adequate fit index (RMSEA=0.051 [90% CI = 0.049, 0.053]; CFI = 0.987; TLI = 0.985). Factor loadings, reliability and item correlations are displayed in supplementary table A1.

To access psychopathology (general and specific) in present study, we used emotional, inattention/hyperactivity and conduct subscales (15 items) of the Strength and Difficulties Questionnaire (SDQ). It was modelled with CFA using a bi-factor structure [4], in which all 15 items loaded in the general psychopathology factor (SDQ-general) and each specific subscale items loaded in their specific factor. All factors were orthogonal. This model indicated an adequate fit index (RMSEA=0.055 [90% CI = 0.052, 0.058]; CFI=0.980, TLI=0.972).

Literacy comprised reading and writing skills measured by the School Performance Test ("Teste de Desempenho Escolar" - TDE) [5]. It is composed of two right/wrong subtests of reading and writing tests. We used 12 items of reading and 61 items assessing writing ability from the two time-points. Reading and writing items were modelled with CFA to be loaded by one common literacy. CFA demonstrated excellent model fit and reliability indices [2,6] for this latent variable (RMSEA = 0.019 [90% CI = 0.018, 0.020]; CFI 0.999; TLI 0.999; $\alpha = 0.995$; $\omega = 0.984$). Literacy factor scores were mean-centred and standardized and extracted to be used in main analysis.

Covariates

Social class. "Associação Brasileira de Empresas de Pesquisa" [7] is a Brazilian standardized instrument that is an indicator of family social class. Classification is made through a composite score comprising the main caregiver's educational level and household assets and conditions. A/B represent the high/comfortable class; C is considered a medium class; and D/E the lowest social class.

Maternal education: Maternal education was reported at baseline and, for this study, was categorized in four blocks: (1) no formal education or less than lower secondary school (incomplete former 8th grade); (2) complete lower secondary school or uncomplete upper-secondary school; (3) complete upper-secondary or incomplete tertiary education and (4) complete tertiary education. This categorization was done due to the importance of having a complete degree of education for the job marketing in Brazil(Amorim, Lecrubier, Weiller, Hergueta, & Sheehan, 1998) [8].

Maternal psychopathology: We used the Mini International Psychiatric Interview (MINI) and the MINI Plus [9,10] to assess the presence of any maternal history of psychiatric

disorders namely: depressive episode, manic episode, panic disorder, agoraphobia, social anxiety disorder, alcohol abuse and dependence, drug abuse and dependence, psychotic conditions, generalized anxiety disorder and attention deficit hyperactivity disorder.

Inverse probability weight (IPW) and sampling weights

IPW was calculated from regressing the likelihood of being in the sample at follow-up on maternal education, any anxiety disorder, study site, and social class, which was previously associated with attrition in our sample [11]. The predicted probability of this regression was inversed to generate IPW [12]. Sampling weights were calculated to adjust for the high-risk procedure used in this cohort, in a way that the rate of mental health conditions was equal among random and high-risk sample, as described previously [13]. IPW and sampling weights were multiplied and used as the final weight.

Details on the study results

Regression models with complete predictors

Regression models are described in the main text. Here, they are described in full in the supplementary tables A5 (literacy as outcome) and A6 (dropout as outcome) considering YSI and SDQ-general factor, emotional factor, conduct factor and inattention/hyperactivity factor as predictors.

References

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Table A1. Factor loadings from confirmatory factor analysis of Youth Strengths Inventory in both waves

YSI item	
Generous	0.587
Lively	0.613
Keen to learn	0.671
Affectionate	0.720
Reliable and responsible	0.741
Easy going	0.749
Good fun, good sense of humour	0.686
Interested in many things	0.739
Caring, kind-hearted	0.763
Bounces back quickly after setbacks	0.653
Grateful, appreciative of what he gets	0.770
Independent	0.539
Helps around the home	0.444
Gets on well with the rest of the family	0.738
Does homework without needing to be reminded	0.510
Creative activities: art, acting, music, making things	0.506
Likes to be involved in family activities	0.713
Takes care of his appearance	0.547
Good at school work	0.615
Polite	0.760
Good at sport	0.447
Keep his bedroom tidy	0.509
Good with friends	0.748
Well behaved	0.747

Note: Errors of the following item were correlated in the model: *Good at School* with *Keen to Learn* (r=0.278), *Does homework without need to be reminded* (r=0.399) and *Creative activities* (r=0.212). *Good fun/humour* with *Lively* (r=0.353). *Interested in many things* with *Keen to learn* (r=0.251). *Caring/Kind-hearted* with *Affectionate* (r=0.215) and *Generous* (r=0.204). *Keep his/her bedroom tidy* with *Helps around*(r=0.272) and *Does homework without need to be reminded* (r=0.208). *Well behaved* with *Polite* (r=0.178). *Affectionate* with *Generous* (r=0.223). *Creative activities* with *Does homework without need to be reminded* (r=0.249). YSI, Youth Strengths Inventory.

Table A2. Factor loadings from confirmatory factor analysis of parent-report Strength and Difficulties Questionnaire in both waves

SDQ Item	General factor	Emotional	Conduct	Inattention/ Hyperactivity
Often complains of headaches, stomach-aches or sickness	0.427	0.394		
Many worries or often seems worried	0.223	0.642		
Often unhappy, depressed or tearful	0.543	0.442		
Nervous in new situations, easily loses confidence	0.495	0.357		
Many fears, easily scared	0.456	0.506		
Often loses temper	0.684		0.207	
Generally well behaved, usually does what adults request (R)	0.539		0.279	
Often fights with other children/youth or bullies them	0.600		0.322	
Often lies or cheats	0.575		0.529	
Steals from home, school or elsewhere	0.401		0.654	
Restless, overactive, cannot stay still for long	0.749			0.277
Constantly fidgeting or squirming	0.769			0.415
Easily distracted, concentration wanders	0.787			-0.170
Thinks things out before acting (R)	0.594			-0.232
Good attention span, sees chores or homework through to the end (R)	0.707			-0.370

Note: SDQ, Strength and Difficulties Questionnaire. R, reverse code.

Table A3 - Cross-lagged panel models of positive attributes (YSI) and psychopathology (all SDQ-derived factors) in a 3-year follow-up

Model	Outcome	Predictor				
	Follow-up	Baseline	β	S.E.	95% CI	p-value
YSI and SDQ - General						
	YSI	YSI	0.305	0.023	0.259 - 0.351	0.000
		SDQ - General	-0.242	0.027	-0.295 - -0.190	0.000
	SDQ - General	YSI	-0.085	0.020	-0.124 - -0.045	0.000
		SDQ - General	0.504	0.023	0.459 - 0.549	0.000
YSI and SDQ - Emotional						
	YSI	YSI	0.423	0.020	0.384 - 0.462	0.000
		SDQ - Emotional	0.006	0.027	-0.047 - 0.058	0.828
	SDQ - Emotional	YSI	0.029	0.015	0.000 - 0.057	0.050
		SDQ - Emotional	0.388	0.020	0.350 - 0.427	0.000
YSI and SDQ - Conduct						
	YSI	YSI	0.397	0.021	0.357 - 0.437	0.000
		SDQ - Conduct	-0.145	0.033	-0.208 - -0.081	0.000
	SDQ - Conduct	YSI	-0.047	0.013	-0.072 - -0.021	0.000
		SDQ - Conduct	0.244	0.020	0.204 - 0.284	0.000
YSI and SDQ - Inattention/hyperactivity						
	YSI	YSI	0.420	0.020	0.381 - 0.459	0.000
		SDQ - Inattention/hyperactivity	0.030	0.032	-0.033 - 0.092	0.349
	SDQ - Inattention/hyperactivity	YSI	0.065	0.013	0.038 - 0.091	0.000
		SDQ - Inattention/hyperactivity	0.258	0.021	0.216 - 0.300	0.000

Note: β, standardized regression coefficient; S.E., standardized error; CI, 95% confidence interval; YSI, youth strength inventory z-score derived from confirmatory factor analysis at baseline; SDQ, strengths and difficulties questionnaire general factor (z-score) extracted from confirmatory factor analysis at baseline.

Table A4 - Marginal effects of positive attributes for fixed values of the general factor of psychopathology on the probability of school dropout

Fixed z-score	Positive attributes (YSI)			
		95% CI		
SDQ-general factor	School dropout (OR)	LB	UB	p-value
-2.0	0.23	0.08	0.62	0.004
-1.5	0.31	0.14	0.68	0.004
-1.0	0.42	0.23	0.77	0.005
-0.5	0.57	0.36	0.90	0.015
0.0	0.78	0.53	1.15	0.204
0.5	1.06	0.67	1.66	0.817
1.0	1.43	0.78	2.63	0.245
1.5	1.95	0.88	4.33	0.101
2.0	2.65	0.97	7.25	0.058

Note: Marginal effects derived from adjusted model predicting school dropout with interactions of YSI with all SDQ factors (general, emotional, conduct and inattention/hyperactivity). All regressions are weighted for follow-up response and oversampling for high-risk of family psychopathology. Covariates included but not shown in the table are age, sex, race/ethnicity, intelligence, baseline social class, baseline maternal education and psychiatric diagnosis, and baseline school dropout level. UB, 95% confidence interval upper bound; LB, 95% confidence interval lower bound.

Table A5 - Complete weighted mixed regression models of YSI, SDQ factors and covariates predicting literacy ability at follow-up

	Literacy (baseline)		YSI		SDQ (all)		YSI+ SDQ (all)		Covariates		YSI + covariates		SDQ (all) + covariates		YSI * SDQ (all) + covariates	
Predictors	β	95% CI	β	95% CI	β	95% CI	β	95% CI	β	95% CI	β	95% CI	β	95% CI	β	95% CI
Baseline literacy ability	0.47 ***	0.44 – 0.50	0.47 ***	0.44 – 0.50	0.46 ***	0.43 – 0.49	0.46 ***	0.43 – 0.49	0.50 ***	0.46 – 0.53	0.50 ***	0.46 – 0.53	0.49 ***	0.46 – 0.52	0.49 ***	0.46 – 0.52
YSI			0.03 *	0.01 – 0.06			-0.01	-0.04 – 0.02			0.03	-0.00 – 0.05			-0.01	-0.04 – 0.02
SDQ-General					-0.08 ***	-0.11 – -0.05	-0.09 ***	-0.12 – -0.05					-0.07 ***	-0.10 – -0.04	-0.07 ***	-0.11 – -0.04
SDQ-Conduct					-0.01	-0.05 – 0.03	-0.02	-0.06 – 0.03					0.00	-0.04 – 0.04	0.00	-0.04 – 0.04
SDQ-Emotional					-0.01	-0.04 – 0.03	-0.01	-0.04 – 0.03					0.01	-0.03 – 0.04	0.01	-0.03 – 0.04
SDQ-Inattention/Hyperactivity					-0.01	-0.05 – 0.03	-0.01	-0.05 – 0.03					-0.00	-0.04 – 0.04	0.00	-0.04 – 0.04
Interaction of YSI and SDQ-General															-0.01	-0.04 – 0.02
Interaction of YSI and SDQ-Conduct															0.01	-0.03 – 0.06
Interaction of YSI and SDQ-Emotional															-0.00	-0.04 – 0.03
Interaction of YSI and SDQ-Inattention/Hyperactivity															-0.00	-0.04 – 0.04
Age									-0.05 ***	-0.07 – -0.04	-0.05 ***	-0.07 – -0.04	-0.05 ***	-0.07 – -0.04	-0.05 ***	-0.07 – -0.04
Sex (ref:male)									0.09 ***	0.05 – 0.14	0.09 ***	0.05 – 0.14	0.08 ***	0.04 – 0.13	0.08 ***	0.04 – 0.13
Skin colour (ref: White)									-0.07 **	-0.12 – -0.02	-0.07 **	-0.12 – -0.02	-0.06 **	-0.11 – -0.02	-0.06 *	-0.11 – -0.02
Social class (ref: E/D)									-0.06 **	-0.11 – -0.02	-0.07 **	-0.12 – -0.03	-0.07 **	-0.12 – -0.03	-0.07 **	-0.12 – -0.03
Maternal education (ref: Incomplete primary school)									0.01	-0.02 – 0.04	0.02	-0.01 – 0.04	0.01	-0.01 – 0.04	0.01	-0.02 – 0.04
Maternal psychiatric diagnosis (ref: No)									-0.06 *	-0.12 – -0.01	-0.06 *	-0.11 – -0.00	-0.04	-0.10 – 0.01	-0.04	-0.10 – 0.01
IQ (standardized)									0.07 ***	0.05 – 0.10	0.08 ***	0.05 – 0.10	0.07 ***	0.05 – 0.10	0.07 ***	0.05 – 0.10
Observations	1566		1566		1566		1566		1455		1455		1455		1455	

Marginal R^2 / Conditional R^2	0.438 / 0.487	0.440 / 0.488	0.448 / 0.495	0.447 / 0.495	0.484 / 0.524	0.484 / 0.533	0.490 / 0.537	0.490 / 0.536

Note: Literacy ability are standardized factor scores derived from reading and writing test (Teste de Desempenho Escolar). All regression models were weighted for follow-up attrition and for random sample. Subjects were clustered in their schools at baseline (random intercept mixed effect regression models). β, standardized regression coefficient; CI, 95% confidence interval; YSI, youth strenght inventory z-score derived from confirmatory factor analysis at baseline; SDQ, strenght and difficulties quesstionaire general factor (z-score) exctracted from confirmatory factor analysis at baseline; Social class measured at baseline by the Associação Brasileira de Empresas de Pesquisa (ABEP) criteria, in which E is the lowest social class and A the highest, combined in E/D, C and A/B strata; IQ, intelligence quotient measured by Weschler Intelligence scale for children using cubes and vocabulary tests and transformed in z-scores. *, $p<0.05$; **, $p<0.01$; ***, $p<0.001$.

Table A6 - Complete weighted mixed regression models of YSI and SDQ general factor predicting school dropout at follow-up

	School dropout (baseline)		YSI		SDQ (all)		YSI+ SDQ (all)		Covariates		YSI + covariates		SDQ (all) + covariates		YSI * SDQ (all) + covariates	
Predictors	*OR*	95% CI	*OR*	95% CI			*OR*	95% CI	*OR*	95% CI	*OR*	95% CI	*OR*	95% CI	*OR*	95% CI
Baseline school dropout (ref: No)	4.10 *	1.19 – 14.15	3.81 *	1.10 – 13.17	3.34	0.93 – 12.02	3.41	0.95 – 12.23	4.19 *	1.05 – 16.74	3.89	0.96 – 15.81	4.07	0.98 – 16.87	3.82	0.90 – 16.18
YSI			0.57 ***	0.44 – 0.73			0.69 *	0.51 – 0.94			0.69 *	0.50 – 0.93			0.81	0.54 – 1.23
SDQ-General					1.35 *	1.00 – 1.82	1.08	0.76 – 1.53					0.96	0.66 – 1.39	0.97	0.62 – 1.53
SDQ-Conduct					2.12 ***	1.48 – 3.05	1.89 ***	1.29 – 2.75					2.82 ***	1.78 – 4.46	2.55 ***	1.54 – 4.21
SDQ-Emotional					1.08	0.78 – 1.51	1.09	0.78 – 1.52					0.94	0.62 – 1.42	0.91	0.59 – 1.40
SDQ-Inattention/Hyperactivity					0.80	0.55 – 1.18	0.85	0.57 – 1.26					1.01	0.62 – 1.67	0.94	0.56 – 1.57
Interaction of YSI and SDQ-General															1.98 **	1.22 – 3.19
Interaction of YSI and SDQ-Conduct															0.86	0.50 – 1.48
Interaction of YSI and SDQ-Emotional															0.93	0.58 – 1.48
Interaction of YSI and SDQ-Inattention/Hyperactivity															0.73	0.40 – 1.34
Age									1.78 ***	1.51 – 2.11	1.77 ***	1.49 – 2.09	1.78 ***	1.50 – 2.12	1.76 ***	1.47 – 2.10
Sex (ref:male)									0.73	0.41 – 1.28	0.77	0.44 – 1.36	0.71	0.40 – 1.27	0.75	0.41 – 1.37
Skin colour (ref: White)									0.70	0.39 – 1.25	0.70	0.39 – 1.26	0.55	0.30 – 1.02	0.59	0.32 – 1.11
Social class (ref: E/D)									1.18	0.68 – 2.06	1.27	0.72 – 2.24	1.37	0.77 – 2.43	1.44	0.80 – 2.61
Maternal education (ref: Incomplete primary school)									0.75	0.53 – 1.07	0.74	0.52 – 1.06	0.73	0.51 – 1.04	0.71	0.49 – 1.02
Maternal psychiatric diagnosis (ref: No)									2.72 ***	1.55 – 4.77	2.32 **	1.30 – 4.16	2.45 **	1.33 – 4.51	2.28 *	1.21 – 4.30

IQ (z-score)					0.95	0.71 – 1.28	0.99	0.73 – 1.33	0.95	0.70 – 1.30	1.01	0.73 – 1.39
Observations	2001	2000	2001	2000	1796		1795		1796		1795	
Marginal R^2 / Conditional R^2	0.010 / 0.227	0.076 / 0.276	0.081 / 0.276	0.097 / 0.283	0.300 / 0.418		0.312 / 0.435		0.350 / 0.456		0.363 / 0.476	

Note: School dropout included dropout and expulsion. All regression models were weighted for follow-up attrition and for random sample. Subjects were clustered in their schools at baseline (random intercept mixed effect regression models). OR, odds ratio; CI, 95% confidence interval; YSI, youth strenght inventory z-score derived from confirmatory factor analysis at baseline; SDQ, strenght and difficulties quesstionaire general factor (z-score) exctracted from confirmatory factor analysis at baseline; Social class measured at baseline by the Associação Brasileira de Empresas de Pesquisa (ABEP) criteria, in which E is the lowest social class and A the highest, combined in E/D, C and A/B strata; IQ, intelligence quotient measured by Weschler Intelligence scale for children using cubes and vocabulary tests and transformed in z-scores. *, $p<0.05$; **, $p<0.01$; ***, $p<0.001$.