Supplemental materials for "Exploring neural correlates of behavioral and academic resilience among children in poverty"

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Table of Contents

Longitudinal network development: interactions with test performance

Developmental trajectories of networks as a function of poverty status and test performance

As exploratory analyses, we investigated whether trajectories of network connectivity differ as a function of children's cognitive test scores and their poverty status. To this end, we conducted three separate linear mixed effects models associating (1) LFPN-DMN connectivity at T2, (2) CON-DMN connectivity at T2, and (3) CON-LFPN connectivity at T2, respectively, with a three-way interaction between connectivity at T0, poverty status, and T0 cognitive test performance.

LFPN-DMN trajectories and test scores. LFPN-DMN connectivity at T0 was predictive of connectivity two years later, B = 0.29, SD = 0.164, χ^2 (4) = 334.78, p < .001. There were no significant interactions.

CON-DMN trajectories and test scores. CON-DMN connectivity at T0 was predictive of CON-DMN connectivity two years later, B = 0.08, SD = 0.156, χ^2 (4) = 306.13, p < .001. There were no significant interactions.

CON-LFPN trajectories and test scores. CON-LFPN connectivity at T0 was predictive of CON-LFPN connectivity two years later, B = 0.01, SD = 0.158, χ^2 (4) = 269.55, p < .001. There was also a significant interaction of CON-LFPN network connectivity at T0 by poverty status, B = 0.04, SD = 0.355, χ^2 (4) = 24.86, p < .001. The relation was significant for both children below and above poverty, though it was in opposite directions (below poverty: B = -0.035, SD = 0.319, χ^2 (2) = 8.87, p = 0.012; above poverty: B = 0.015, SD = 0.158, χ^2 (2) = 262.85, p < .001). Thus, children below poverty who started out with higher CON-LFPN connectivity at T0 showed lower CON-LFPN connectivity at T2, while children above poverty who had higher CON-LFPN connectivity at T0 also showed higher CON-LFPN connectivity at T2.

Thus, across all networks, children's test scores at T0 were not associated with the rate of change in their connectivity metrics over the next two years, regardless of children's poverty status.

Testing the contribution of CON connectivity to attention problems

Attention	*B*	SD	χ^2	*p*
LFPN-DMN	3.47	1.31	2.82	0.093
CON-DMN	3.48	1.15	20.86	< 0.001 ***
CON-LFPN	-0.48	1.33	0.051	0.821
Poverty level	2.47	0.38	40.27	< 0.001 ***
Motion	1.71	0.39	19.40	< 0.001 ***
Sex(M)	0.36	0.13	7.62	0.006 **
LFPN-DMN*poverty level	-8.26	3.07	7.24	0.007 **
CON-DMN*poverty level	7.51	2.68	7.85	0.005 **
CON-LFPN*poverty level	4.08	3.07	1.77	0.184

Supplementary Table 1. Results of linear mixed effects model associating attention problems at T0 with an interaction between each of the three brain networks of interest (LFPN-DMN, CON-DMN, and CON-LFPN), separately, and poverty status. Chi-squared and significance values from Type II anova, using the Anova package in *car* (Fox & Weisberg, 2019).

Substituting matrix reasoning for the NIH composite

In our previous study, Matrix Reasoning had shown the strongest group interaction in the link between LFPN-DMN connectivity and cognition. Therefore, we performed each analysis reported that tested associations with NIH cognitive test performance, substituting NIH composite with Matrix Reasoning.

Children's performance was measured on the Matrix Reasoning Task from the Wechsler Intelligence Test for Children-V (WISC-V), a measure of abstract reasoning (Wechsler, 2014). We used the total score for each child, at T0. Matrix Reasoning is a widely used test of higher-level cognition that was not included in the NIH composite score.

Relations between academic performance and matrix reasoning. On average, higher matrix reasoning was related to higher grades concurrently, B = -0.24, SD = 0.01, χ^2 (2) = 614.95, p < .001, though this relation differed as a function of poverty status, B = 0.06, SD = 0.02, χ^2 (1) = 5.71, p = .017. For both children above and below poverty, higher reasoning scores were related to higher grades, though the relation was stronger for children above poverty (above poverty: B = -0.25, SD = 0.012, χ^2 (1) = 539.04, p = .001; below poverty: B = -0.18, SD = 0.02, χ^2 (1) = 74.77, p = .001). These results mirror the primary results found between children's performance on cognitive tests and grades in school.

We also conducted these analyses longitudinally. The same pattern was found at T1, such that higher matrix reasoning was related to higher grades, controlling for grades at T0, B = -0.14, SD = 0.01, χ^2 (2) = 121.46, p < .001. However, this relation differed significantly as a function of poverty status, just as with the NIH toolbox composite, interaction: B = 0.07, SD = 0.03, χ^2 (1) = 6.73, p = 0.009. At T2, higher matrix reasoning was again related to higher grades, controlling for grades at T0, B = -0.14, SD = 0.02, χ^2 (2) = 84.02, p < .001, however, this relation did not differ as a function of poverty status, interaction: B = 0.05, SD = 0.04, χ^2 (1) = 2.07, p = 0.150.

Relations between attention problems and matrix reasoning. On average, children with higher matrix reasoning scores had fewer attention problems, B = -0.04, SD = 0.01, χ^2 (2) = 47.27, p < .001. This relation did not differ significantly as a function of poverty status, B = 0.01, SD = 0.01, χ^2 (1) = 0.72, p = 0.396.

Interaction between changes in connectivity, poverty status, and matrix reasoning.

LFPN-DMN trajectories and matrix reasoning. LFPN-DMN connectivity at T0 was predictive of connectivity two years later, B = 0.25, SD = 0.063, χ^2 (4) = 331.12, p < .001. There were no significant interactions with poverty or matrix reasoning.

CON-DMN trajectories and matrix reasoning. CON-DMN connectivity at T0 was predictive of connectivity two years later, B = 0.28, SD = 0.061, χ^2 (4) = 301.08, p < .001. There were no significant interactions with poverty or matrix reasoning.

CON-LFPN trajectories and matrix reasoning. There were several significant main effects and interactions, including a significant three-way interaction between

CON-LFPN, poverty status, and matrix reasoning. Model parameters and significance are displayed in Supplementary Table 2.

CON-LFPN T2	***B***	**SD**	χ^2	***p***
CON-LFPN T0	0.30	0.06	258.67	< 0.001 ***
Poverty level	-0.01	0.01	3.64	0.057
Matrix reasoning	-0.00	0.00	0.95	0.331
Motion T2	0.05	0.01	70.49	< 0.001 ***
Motion T0	0.01	0.01	4.23	0.040 *
Sex(M)	0.01	0.00	17.55	< 0.001 ***
CON-LFPN T0 * poverty status	-0.52	0.13	17.12	< 0.001 ***
CON-LFPN T0 * matrix reasoning	-0.00	0.01	0.65	0.422
Poverty level T0 * matrix reasoning	0.00	0.00	0.11	0.743
CON-LFPN T0 * poverty status * matrix reasoning	0.04	0.01	8.05	0.005 **

Supplementary Table 2. Results of linear mixed effects model associating CON-LFPN T2 network connectivity with a three-way interaction between connectivity at T1, poverty status, and matrix reasoning scores. Chi-squared and significance values from Type II anova, using the Anova function in *car* (Fox & Weisberg, 2019).

Deviations from pre-registration.

Vigilance. We had initially intended to look at vigilance as a potential mechanism of resilience for children below poverty, as specified in our preregistration. More specifically, we sought to explore whether vigilance could explain why higher LFPN-DMN connectivity is related to higher cognitive test scores for these children. However, the only measure of vigilance available in the ABCD dataset was in the KSADS-5 Diagnostic Interview at T0, with two questions about past and present hypervigilance (1 = yes, 0 = no). This measure did not fully capture our definition of vigilance and the number of children who endorsed the two items was very low; therefore, we do not report any analyses involving vigilance.

Grades. We also pre-registered that we would use the mean of parent-reported grades from the CBCL for academic performance. Instead, we used parent-reported grades in the ABCD Longitudinal Parent Diagnostic Interview for DSM-5 Background Items Full (KSAD) because there was no CBCL question on grades in the ABCD dataset that was available.

In addition, we preregistered an analysis plan using linear mixed effects models to test these relations. However, because grades are a categorical ordered variable, cumulative link mixed models are more appropriate. Thus, as noted in the main text, we report the latter analyses for all tests including grades as an outcome variable. Results are not meaningfully different when performing the pre-registered linear mixed effects models.

Longitudinal associations. Our pre-registration focused on longitudinal associations between T0 and T2. Given that more data was available for T1 than T2 for many of our measures of interest, we also performed analyses testing associations with T1.