Functional connectivity in central executive network protects youth against cardiometabolic risks linked with neighborhood violence

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Abstract

There is considerable variability in how people respond to major stressors. Some remain healthy, whereas others deteriorate. Little is known about the brain networks that are involved in shaping these different outcomes, a problem we pursue here. Like previous studies, we find that youth living in neighborhoods with high levels of violence have worse cardiometabolic health than peers from safer communities. Extending this knowledge, we show this connection is absent for youth who display higher connectivity within the brain’s frontoparietal central executive network (CEN), which facilitates efforts of self-control as well as reinterpretation of threatening events and suppression of unwanted emotional imagery. These observations suggest that CEN connectivity may be a neurobiological contributor to resilience.

Significance

Results like this are ubiquitous in stress research: Even following severe trauma, a sizeable fraction of people remains healthy and competent (11). This observation raises a fundamental question for basic scientists studying adaption and for clinical researchers seeking application: In the midst of adversity, what enables some people to remain healthy, whereas others deteriorate (12–14)?

Recent insights into the brain’s intrinsic activity may help answer this question. “Intrinsic activity” refers to the spontaneous neural activity that is recorded from the brain when the subject is not engaged in any specific task. This activity, which is constitutively present in both awake and resting states, represents the intrinsic functional architecture of the brain— that is, the set of spontaneous patterns that emerge from the activity of the individual neuronal populations. This architecture has impor-

Over the past 25 y, rates of violent crime have declined sharply in the United States, particularly in large cities (1). However, in some urban neighborhoods violence remains a feature of daily life. Recent murder statistics in Chicago illustrate these trends vividly. The city is divided into 77 community areas with average populations of roughly 35,000 people. According to the city’s data portal, 10 of these areas recorded more than 26 murders in 2016, more than 2xmo on average. By contrast, nearly all the other community areas had fewer than five murders that year. Much is known about how murder and other violent crimes affect the friends and families of victims. Less well understood is what impact, if any, these events have on members of the surrounding community who are not touched personally by the violence (1).

Studies addressing this question have yielded some indications that community violence can adversely influence the health of youth. One study tracked sleep patterns and cortisol release over multiple days. During the monitoring, homicides or sexual assaults occurred in the neighborhoods of some of these youth; however, none was personally affected. Nonetheless, these youth lost more than 1 h of sleep on the night of the crime, relative to their usual amount, and also released more cortisol the next morning (2). Research on chronic health problems has yielded mixed findings (3–6). However, recent studies with richer data suggest that youth living in violent neighborhoods are more likely to develop asthma than peers in safer areas and to display cardiometabolic risk factors that include obesity, high blood pressure, altered sex, and short telomeres (7–10).

However, even in studies in which such associations are observed, there is marked heterogeneity in the response to neighborhood violence. For example, one prospective study reported that youth from high-violence communities developed asthma at twice the rate of peers from safer areas (7). However, even among youth living in high-violence areas, asthma incidence was only 25%, meaning that 75% of exposed youth showed what psychologists call “resilience.” Results like this are ubiquitous in stress research: Even following severe trauma, a sizeable fraction of people remains healthy and competent (11). This observation raises a fundamental question for basic scientists studying adaption and for clinical researchers seeking application: In the midst of adversity, what enables some people to remain healthy, whereas others deteriorate (12–14)?

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states that occur when a person is not engaged in a task. This resting-state activity is coordinated by a set of large-scale functional networks, each of which is comprised of anatomically distributed nodes that display correlated patterns of activity (15). This phenomenon is referred to as “resting-state functional connectivity” (rsFC). The degree of rsFC is a temporally stable characteristic of individuals that reflects person-to-person variation in both the anatomical structure and functional history of a network, i.e., how often its nodes have been coactivated (16, 17). By late childhood, individual differences in rsFC are apparent (18).

Although the functions that intrinsic networks support are still being clarified, mounting evidence indicates they are instrumental in helping us anticipate environmental changes and understand their significance (19). These observations suggest that individual differences in rsFC might facilitate understanding of the heterogeneity in adaptation we highlighted above. Indeed, violent neighborhoods are inherently unpredictable places to live, which people must navigate while balancing two competing demands on cognitive resources: purposefully going about daily activities versus remaining vigilant for threats to safety. In doing so, they are likely to engage the frontoparietal central executive network (CEN), which connects areas of the dorsolateral prefrontal cortex and the posterior parietal cortex. At a broad level, this network supports the cognitive regulation of emotion, behavior, and thought. More focially, the CEN is activated during efforts to exert self-control, reappraise threatening stimuli, and suppress intrusive, unpleasant thoughts (20-22). Neighborhood danger is also likely to engage the anterior salience network (aSN), whose nodes functionally connect the dorsal anterior cingulate cortex with regions involved in threat vigilance and salience processing. The aSN is involved in the detection of incoming stimuli, assigning those stimuli meaning, and initiating a biobehavioral response.

Collectively, these observations suggest that variations in the functional connectivity within intrinsic networks might constitute a neurobiological source of resilience or vulnerability. However, to our knowledge, this hypothesis has yet to be evaluated. We do so here in a sample of urban youth exposed to varying amounts of community violence, as reflected in their neighborhood murder rate. The health outcomes included multiple dimensions of cardiometabolic risk, including signs of metabolic syndrome (MetS) and insulin resistance. These signs of risk begin to emerge in early adolescence, and they generally track across the life course (23), so that youth with unfavorable profiles have increased susceptibility to later-life conditions that can include diabetes, heart disease, and stroke.

We hypothesized that individual differences in network functional connectivity would serve as moderators of the relationship between the neighborhood murder rate and cardiometabolic risk. The nature of our predictions varied across networks. As noted, the CEN supports self-control, reappraisal of threats, and suppression of unpleasant thoughts. As such, we reasoned that youth with greater connectivity in this network would be resilient, not manifesting cardiometabolic risk under high-violence conditions. By contrast, the aSN detects incoming stimuli, assigns them meaning, and initiates biobehavioral responses. Therefore, greater connectivity among its nodes should theoretically constitute a source of vulnerability that amplifies a youth’s behavioral and biological responses to threats in the environment. Finally, as a check on specificity, we considered the rsFC of the most widely studied intrinsic network, the default mode network (DMN). Anchored in the posterior cingulate cortex and medial prefrontal cortex, the DMN is implicated in self-referential processes, including autobiographical memory and self-monitoring (24). It was not apparent to us how variations in such processes would bear upon youth responses to neighborhood violence, and so we made a null prediction for the DMN, reasoning that it would not operate as a moderator.

Results
Overview. Data are from a study of eighth-graders from the Chicago area, all of whom were without a history of serious medical or psychiatric illnesses. Following an overnight fast, youth attended an assessment session during which cardiometabolic risk was assessed. Sessions were held between 8:00 and 10:00 AM to minimize circadian variations. The principal health outcome was MetS, a cluster of interrelated signs whose presence forecasts higher risks of later diabetes, heart disease, and stroke. For youth, a MetS diagnosis requires three or more of these signs: abdominal adiposity, raised blood pressure, elevated glucose, raised triglycerides, and lowered high-density lipoproteins (25). Thus, we measured each youth’s waist, recorded his/her heart rate and systolic blood pressure continuously for 10 min using a CNAP Monitor 500 (CSNSystems), and drew antecubital blood from which fasting lipids and glucose were assayed. Because only seven youth met diagnostic criteria, we considered two alternative definitions of metabolic risk (26); the number of signs for which a youth scored above the International Diabetes Federation threshold and a composite formed by averaging z-scored values of each sign. The latter variable addresses concerns that the MetS diagnosis loses useful information by applying binary thresholds to continuously distributed variables (27).

MetS guidelines also have been criticized for omitting signs with prognostic value (28). For example, the MetS definition considers fat in the abdomen but not elsewhere in the body, despite evidence that total adiposity independently forecasts heart disease (29). Also, the MetS definition considers glucose the sole indicator of insulin resistance, while reflecting insulin resistance yields greater sensitivity (30). Thus, we supplemented MetS with indicators of total adiposity [body mass index (BMI) measured in kilograms per square meter], body fatness (measured via bioimpedance using a Tanita BF-350 total body composition analyzer), and insulin resistance [estimated from fasting insulin and glucose using the homeostatic model assessment of insulin resistance (HOMA-IR) equation]. Finally, we considered leptin, a hormone that regulates appetite by mediating cross-talk between adipose tissue and brain regions involved in hunger and feeding. Leptin also regulates a host of cardiometabolic processes, including insulin resistance, blood pressure, and vascular tone (31).

During a separate session, youth underwent functional MRI (fMRI) to quantify rsFC of the aSN, CEN, and DMN. The scan consisted of a 10-min run during which youth were instructed to sit quietly with their eyes open. We selected the regions of interest (ROIs) a priori for each network from meta-analytic research and publicly available atlases (32-34). ROIs for each network are shown in SI Appendix, Fig. S1 and Table S1. Functional connectivity within each network was quantified by correlating the average time series in an ROI with the average time series in all other ROIs within the network.

Preliminary Analyses. Table 1 describes the 218 youth in the analytic sample. They ranged from 12 to 14 y old, and most were at least midway through puberty. The sample was highly diverse, with roughly equal numbers of youth identifying as Hispanic, white, and black. Based on their family’s income-to-needs ratio, 18% of youth met the federal poverty threshold, and another 22% were low income.

Using crime data that local police departments supply to the Federal Bureau of Investigation, Applied Geographic Solutions computes a neighborhood murder index (NMI). This index is given at the block-group level of resolution, which corresponds to neighborhoods of 600–3,000 people. The NMI’s validity has been illustrated in large-scale studies of violence and health in adults (8). Fig. 1 shows the spatial distribution of NMIs in the Chicago area using values for the 5-y window from 2010 to 2014. As is evident, there is considerable variability across the 192 different block groups in our sample. The NMI is scaled so that a value of 100 represents a block group with murder rates at the national average. The mean value in our sample was 242 (SD = 257, range 3–986), meaning that, on average, murder was 142% more common in study block groups than in the United States as a whole. However, the sample’s distribution was skewed to the right, so its median (159) is a better indicator of central tendency.
Hypothesis Testing. This dataset has a nested structure in which youth live within block groups. Thus, we tested hypotheses using generalized estimating equations (GEE), specifying block group as a nesting variable and an exchangeable covariance matrix with robust estimation. Each model included terms for the NMI and the rsFC network of interest, a product variable representing their interaction, and a panel of covariates that included age, gender, self-identified racial (white vs. non-white) and ethnic (Hispanic vs. non-Hispanic) category, family income and savings, and pubertal status using a well-validated instrument, the Peterson Pubertal Development Scale (35). SI Appendix, Table S2 shows zero-order correlations between these covariates and predictors and outcomes. Reflecting long-term disparities in the Chicago area, lower-income and black youth tended to reside in areas with higher NMI values and show worse cardiometabolic health. SI Appendix, Fig. S2 illustrates the strength of the multivariate associations between covariates and outcomes from the GEE models. In both cases, the covariates were occasionally, but not consistently, related to study predictors and outcomes. Because the cardiometabolic outcomes had positive values and were right-skewed, we specified gamma probability distributions with log-links. Relative to more conventional strategies for normalizing skewed data, e.g., trimming and transforming, this approach utilizes all available values, yields more interpretable results, and generally has greater power (36).

CEN. Table 2 summarizes GEEs relating the neighborhood murder rate and CEN rsFC to cardiometabolic health (SI Appendix, Table S3). Consistent with hypotheses, significant interactions emerged for all six outcomes considered, including BMI, percent body fat, leptin, insulin resistance, and both MetS indicators (Ps from <0.0001-0.03). Because multiple outcomes were examined, we applied Benjamini and Hochberg’s (37) step-up procedure to control the proportion of false discoveries. As SI Appendix, Table S4 shows, with the false-discovery rate controlled at 5%, all the observed interactions remained significant.

To decipher the interactions, we used standard procedures (38) to plot cardiometabolic outcomes at lower (−1 SD) and higher (+1 SD) values of the NMI and CEN distributions (Fig. 2). Across outcomes, the neighborhood murder rate and cardiometabolic risk were positively associated but only among youth who displayed lower rsFC within the CEN. To confirm this interpretation, we next estimated the simple slopes relating the neighborhood murder rate to cardiometabolic risk separately for youth at lower (−1 SD) and higher (+1 SD) values of the CEN rsFC distribution (38). As Table 3 shows, these simple slopes were significantly greater than zero for all outcomes at lower values of CEN rsFC. The exception was the MetS composite, for which the slope value was marginal. By contrast, at higher levels of CEN rsFC, the link between the neighborhood murder rate and cardiometabolic health was not apparent, as reflected in the simple slopes being statistically equivalent to zero. Insulin resistance was an exception to this pattern: At higher rsFC the neighborhood murder rate and HOMA were inversely associated. (For some outcomes, main effects were observed for NMI and/or CEN. However, all these main effects were qualified by interactions, so we did not interpret them further.)

aSN. Consistent with aSN predictions, we observed significant interactions for two indicators of adiposity: BMI and percent body fat (Table 2 and SI Appendix, Table S5). However, neither of these interactions survived 5% false-discovery controls, so we did not interpret them further. No other significant interactions were apparent (Ps 0.06–0.92) (SI Appendix, Table S5), although several main effects of NMI emerged: Youth from neighborhoods with higher murder rates had more adiposity, leptin, and MetS signs.

DMN. Consistent with hypotheses, there was minimal evidence of moderation by the DMN (SI Appendix, Table S6). For four of the six outcomes, no significant interaction was observed. The exceptions were MetS signs (Ps 0.05) and insulin resistance (P = 0.005), but only the latter survived 5% false-discovery rate controls. As SI Appendix, Fig. S3 shows, for youth with lower DMN rsFC, the neighborhood murder rate was positively associated with insulin resistance (simple slope = 0.18; SE = 0.08; P = 0.03). By contrast, among youth with higher rsFC in this network, this...
association was inverse (simple slope = −0.22; SE = 0.09; P = 0.01). For other outcomes, no main effects of DMN rsFC were apparent (Ps 0.07–0.84).

**Personal Victimization.** Youth from high-violence neighborhoods are more likely to have personal histories of victimization, raising questions about whether the findings above truly reflect vicarious exposure to violence. With that said, few youth in our sample had a history of serious victimization (four had been attacked with a knife and three with a gun), so this is unlikely to account for our findings. When we considered a broader definition of violence, e.g., being shoved, hit, or kicked plus gun and knife attacks, a larger proportion (39.0%) endorsed being victimized. However, when the GEEs were recomputed with this broad index as a covariate, the magnitude and significance of the NMI × CEN rsFC interactions were virtually unchanged: BMI (P = 0.03); body fat (P = 0.02); leptin (P = 0.03); insulin resistance (P = 0.003); count of MetS signs (P < 0.0001); MetS composite (P = 0.04).

**Other Neighborhood Risks.** Neighborhoods with high violence are likely to have other features that undermine youth’s health. Thus, to evaluate the specificity of the findings, we reestimated the GEEs with additional neighborhood-level covariates that could have plausibly contributed to the CEN × NMI interactions. These covariates included the neighborhood’s level of environmental hazard, median household income, and racial/ethnic composition.

To capture the availability of nutritious food, we also calculated the distance from each youth’s home to the nearest full-service grocery store. **SI Appendix, Table S7** shows that the magnitude and significance of the interactions were virtually unchanged with these covariates in the models.

**Psychological Distress.** We also considered the possibility that the interactions were simply a reflection of underlying psychological distress, which covaries with the major constructs explored here (39, 40). Accordingly, we recomputed the GEEs after including covariates that reflected symptoms of depression and anxiety, as measured by youth’s self-reports on the Revised Child Anxiety and Depression Scale-25 (41). **SI Appendix, Table S8** shows that including these covariates did not change the magnitude or significance of the NMI × CEN interactions.

**CEN Behavioral Correlates.** Our CEN hypotheses were based on evidence that it supports the cognitive regulation of thought, behavior, and emotion. However, this evidence mostly comes from task-based fMRI studies rather than rsFC (20–22). Thus, to clarify the meaning of CEN in the resting-state context, we examined its association with the self-regulation of eating behavior, a trait likely to be of importance to cardiometabolic health. As part of their initial session, youth engaged in a standard laboratory protocol, Palestinian territory.
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There is increasing recognition that neighborhood violence has a practically relevant processes supported by the CEN, e.g., threat ap-
proximation and savings, and pubertal status were included, identified an
analysis, in which age, sex, racial and ethnic identity, family in-
scribed the task as a measure of sensory perception.) Regression
(out of grams) from the presession weight. (As a cover story, we de-
each youth ate by subtracting the postsession weight of the bowls
the end of the session, we calculated the total amount of candy
bowls of candy out and invited youth to snack as they wished. At
accurate ratings. After the ratings had been made, we left the
task (42) in which they were asked to taste three types of candy,
and evaluate the taste, texture, and freshness of each. Youth were
told they could eat as many pieces of candy as needed to make
accurate ratings. After the ratings had been made, we left the
bowls of candy out and invited youth to snack as they wished. At
the end of the session, we calculated the total amount of candy
each youth ate by subtracting the postsession weight of the bowls
(in grams) from the presession weight. (As a cover story, we de-
scribed the task as a measure of sensory perception.) Regression
analyses, in which age, sex, racial and ethnic identity, family in-
come and savings, and pubertal status were included, identified an
inverse association, such that youth with lower CEN rsFC ate
more candy ($b = -0.37, SE = 0.17, P = 0.03$). Unfortunately, our
protocol did not include behavioral indicators of other conceptu-
ally relevant processes supported by the CEN, e.g., threat ap-
praisal or intrusive thoughts.

**Discussion**

There is increasing recognition that neighborhood violence has a
long reach. As Sharkey explains, “violence happens to people,
but it also happens to places” (1). Consistent with this observa-
tion and with accumulating literature (2–4, 7–9), we found evi-
dence linking neighborhood violence with cardiometabolic risk
in urban youth. Extending this knowledge, we identified rsFC of
the CEN as a neurobiological moderator of this association,
which differentiated the health of youth living in high-violence
neighborhoods. Among youth with lower CEN rsFC, the neigh-
borhood murder rate was associated with greater adiposity, more
serum leptin and insulin resistance, and higher scores on two
MetS indicators. By contrast, no such associations were apparent
among youth showing higher CEN connectivity.

This pattern was not attributable to variations in racial or
ethnic background, pubertal stage, financial security, psycho-
logical distress, or victimization history. It also was not attrib-
utable to the degree of environmental pollution, economic
disadvantage, or residential segregation in youth’s neighbor-
hoods or to the availability of nutritious food. Instead, the
findings appear to reflect a scenario in which CEN connectivity
moderates how youth respond to the challenges of living in a
neighborhood where the threat of violence is ongoing. In such an
environment, high CEN rsFC would presumably be salutary
because it supports the reappraisal of threatening stimuli and
suppression of intrusive thoughts (21, 22). In a variety of stressful
conditions, these strategies have been shown to reduce the
magnitude of cardiovascular and neurohumoral reactivity and
to protect against worsening health (43, 44). For youth in violent
neighborhoods, high CEN rsFC would also likely facilitate
adaptive self-regulation, reducing the frequency of unhealthy
behaviors that people sometimes use to cope with unpredictable
stress (e.g., comfort eating, cigarette use). The results from our
eating task, in which youth with low CEN rsFC consumed more
candy, provide initial support for this self-control scenario.
However, further research is needed to substantiate this finding
and to delineate what role the other CEN-supported processes
we speculate about play.

Relative to the CEN, the other intrinsic networks we consid-
ered showed limited evidence of operating as moderators. There
were some indications that higher connectivity within the aSN
functions as a vulnerability factor, strengthening the association
between the neighborhood murder rate and childhood adiposity.
However, these patterns did not survive false-discovery controls
and were not observed with other cardiometabolic outcomes.
These results could indicate the aSN plays a modest role in be-
havior relevant to energy balance (e.g., dietary intake or physical
activity) but that, unlike the CEN, it has limited influence on pro-
cesses that are clinically downstream of obesity. Another possibility
is that, as a consequence of modern digital culture, variations in
youths’ aSN connectivity are of negligible importance for the phe-
nomena considered here. In today’s world, youth are likely to learn
about neighborhood violence within minutes of its occurrence and
to be saturated with details and imagery of the event via cellphone
calls, text messages, and social media. With such large quantities
of graphic information so readily available, variations in the kinds of
bottom-up threat-detection processes the aSN subserves may have
limited functional significance.

Consistent with predictions, we observed minimal evidence
that DMN rsFC operated as a moderator of neighborhood vio-
lence or had bivariate associations with cardiometabolic risk. As
explained in the Introduction, we do not have strong conceptual
reasons to hypothesize that such associations exist. However, it is
conceivable that our restrictive eligibility criteria precluded such
associations from emerging. DMN abnormalities are common in
neuropsychiatric disorders such as depression (39). Because
youth with any psychiatric history were excluded from the study,
we may have insufficient variation in DMN rsFC to definitely
evaluate its role.

This study’s results should be interpreted in the context of its
limitations. Most importantly, the cross-sectional, observational
nature of its design precludes inferences about causality. Because
of collatral evidence from earlier studies, which used within-
person contrasts (2) and threat salience manipulations (45) to
facilitate causal inference, we are persuaded that neighborhood
violence can, in principle, affect youth health. The causal status of
functional connectivity is less certain. A reverse-causation
scenario is certainly plausible here, although it would not par-
simoniously explain the interactions we observed; in other words,
if cardiometabolic health were affecting functional connectivity, why
would this be evident only among youth in high-violence areas? This
study is also subject to omitted-variable biases: CEN rsFC could be
a proxy for other experiences (e.g., early caregiving) or character-
istics (e.g., allelic variation, cognitive ability) that are more centrally
involved with adaptation. Differential selection could also have
played a role if families with hardy, healthy youth preferentially
located themselves in more dangerous neighborhoods. Also, al-
though we tested multiple alternative explanations at the individual
and neighborhood level, follow-up research with more thorough

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Lower rsFC slope (SEM)</th>
<th>Higher rsFC slope (SEM)</th>
<th>P</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>MetS count of signs</td>
<td>0.51 (0.12)</td>
<td>0.0001 (0.19)</td>
<td>0.30</td>
<td></td>
</tr>
<tr>
<td>MetS composite</td>
<td>0.18 (0.10)</td>
<td>0.08 (0.12)</td>
<td>0.19</td>
<td></td>
</tr>
<tr>
<td>BMI</td>
<td>0.07 (0.03)</td>
<td>0.01 (0.02)</td>
<td>0.70</td>
<td></td>
</tr>
<tr>
<td>Percent body fat</td>
<td>0.09 (0.03)</td>
<td>0.007 (0.04)</td>
<td>0.55</td>
<td></td>
</tr>
<tr>
<td>Insulin resistance</td>
<td>0.24 (0.12)</td>
<td>0.04 (0.06)</td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td>Serum leptin</td>
<td>0.04 (0.01)</td>
<td>0.0005 (0.01)</td>
<td>0.57</td>
<td></td>
</tr>
</tbody>
</table>

Slope parameters represent the association between the neighborhood violence and cardiometabolic health, estimated at lower (−1.5 SD) and higher (+1.5 SD) values of the sample distribution for CEN rsFC. These associations are net of covariates reflecting the child’s age and sex, whether s/he self-identifies as white and/or Hispanic, family income and savings, and pubertal stage.
covariate assortments would bolster confidence in the specificity and robustness of these findings. Finally, because some youth moved homes during the 5-y window of the murder index, we are likely to have estimated exposure neighborhood violence imprecisely. Although not ideal, the consequence of this misestimation would be to introduce measurement error, biasing models toward null results.

To address these limitations, a multiwave longitudinal study is needed that tracks neighborhood conditions, brain development, and cardiometabolic risk across childhood. Such a study could also help answer mechanistic questions we are unable to address here regarding the role of youth’s subjective perceptions of violence, how individual differences in rsFC arise, and the pathways by which they shape resilience vs. vulnerability to adversity. Along these lines, preliminary evidence suggests that individual differences in functional connectivity reflect developmental histories of coactivation (17). To the extent this account is accurate, it suggests that youth in our study with high CEN rsFC have a history of using self-control, threat reappraisal, and thought suppression to mitigate biobehavioral responses to neighborhood violence. Formally testing this developmental scenario should be a priority in subsequent research. Another priority should be to consider more fully histories of personal victimization and to determine whether their impact is moderated by functional connectivity in a manner similar to the NML. We hypothesize the same patterns will be apparent with personal victimization, but we could not definitively test that possibility here because few youth had been victims of severe assaults.

Meanwhile, the observations here advance knowledge about differential adaptation to adversity, highlighting the CEN’s intrinsic activity as a potential neurobiological contributor to resilience. For basic scientists, these findings provide clues about the neural circuits that facilitate or undermine adaptation. Should these observations be substantiated, they could also have implications for intervention strategies. In this regard, preliminary evidence suggests that “network training” programs, which seek to modulate the CEN’s functional connectivity, can alter patterns of food choice, drug use, and stress reactivity (46).

Methods
The study consisted of two sessions. At the first, youth completed psychosocial measures and had cardiometabolic health assessed while sociodemographic data were collected from a parent. At the second, youth had structural and functional MRI scans. All youth gave written assent to participate, and a parent gave written consent. Northwestern University’s IRB approved the protocol. Additional details are in SI Appendix.

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