Biological Psychiatry: GOS

Investigative Approaches to Resilient Emotion Regulation Neurodevelopment in a South African Birth Cohort

Tristan Yates, Siphumelele Sigwebela, Soraya Seedat, Michael Milham, Stefan du Plessis, Lior Abramson, Erica Niemiec, Carol Worthman, Mary Jane Rotheram-Borus, Giovanni Salum, Alexandre Franco, Arianna Zuanazzi, Fatima Ahmed, Kelly Gemmell, Joan Christodoulou, Nomandla Mhlaba, Noluncedo Mqhele, Nomfusi Ngalimane, Akhona Sambudla, Nim Tottenham, and Mark Tomlinson

ABSTRACT

Understanding the neurobiology of resilient emotion regulation following adversities is critical for addressing mental health problems globally. However, the functional neurobiology of resilience has rarely been studied in low- and middle-income countries, which comprise 90% of the world's population and experience more consistent adversities. Here, we describe how we are investigating the neurodevelopment of resilient emotion regulation in adolescents (anticipated N = 525) from a South African birth cohort recruited from a low-income, high-adversity township. Across 2 longitudinal time points (13–14 and 15–16 years), magnetic resonance imaging, behavior, and self-report measures from adolescents and their caregivers are collected. These data are complemented by existing developmental histories (from the prenatal period to 8 years). The culturally adapted measures, protocols, and analytic plans for investigating resilient emotion regulation are presented. By characterizing neurodevelopmental correlates of adolescent resilience from an understudied low- and middle-income country, this research will provide deeper insights into mental health globally.

https://doi.org/10.1016/j.bpsgos.2025.100457

Early-life adversity is a leading environmental risk factor for mental illnesses (1–3). This robust link has accelerated the study of factors associated with successful development and coping despite adversity exposure—in other words, resilience (4). Emotion regulation, or the ability to modulate the intensity and duration of positive and negative emotions, is a key psychological process related to positive developmental outcomes following adversity (5). Although in an ideal world, no child would experience extreme adversity, understanding the protective factors that promote resilient emotion regulation and healthy developmental outcomes following adversity is critical for addressing mental health problems globally (6).

To date, most resilience research has focused on high-income countries (HICs), a phenomenon known as the 10/90 divide, wherein only 10% of scientific knowledge is produced by or in low- and middle-income countries (LMICs)[a] that comprise 90% of the world's population (i.e., the majority world) (7–12). However, children in LMICs are at high risk of failing to reach their developmental potential due to environmental and psychosocial risk factors (13–15). Therefore, studying diverse populations with a broad range of experiences is essential to advancing our understanding of resilience (16–19). Assuming that research conducted in HICs is universal can impede scientific progress and recapitulate a colonial narrative of assuming developmental norms (20). This is not to invalidate research in HICs but rather to highlight that a more complete understanding of resilience must include other lived experiences. There is a rich literature on resilience in children and adolescents from LMICs (21–26), but neurobiological research has lagged behind. Closing this research gap is an ethical imperative; characterizing flexible adaptation and neurodevelopmental change in children and adolescents from lower-resourced, high-adversity contexts will inform interventions that promote successful development in children and adolescents who are at the highest risk.

We have embarked on a longitudinal neurodevelopmental study of resilient emotion regulation in a low-income, high-adversity South African context (Figure 1) through a global research collaboration. We are re-enrolling 525 South African adolescents who have been tracked longitudinally from pregnancy (27,28). As detailed below, adolescents in this cohort were recruited from a township characterized by particularly high adversity. The cohort has experienced numerous adversities, starting with challenges faced by their mothers during

[a]There are many different terms that can be used to characterize the types of countries that have been included in the majority of scientific research and those that have been excluded [e.g., HICs vs. LMICs, Global North vs. Global South, minority world vs. majority world (167)].

ISSN: 2667-1743

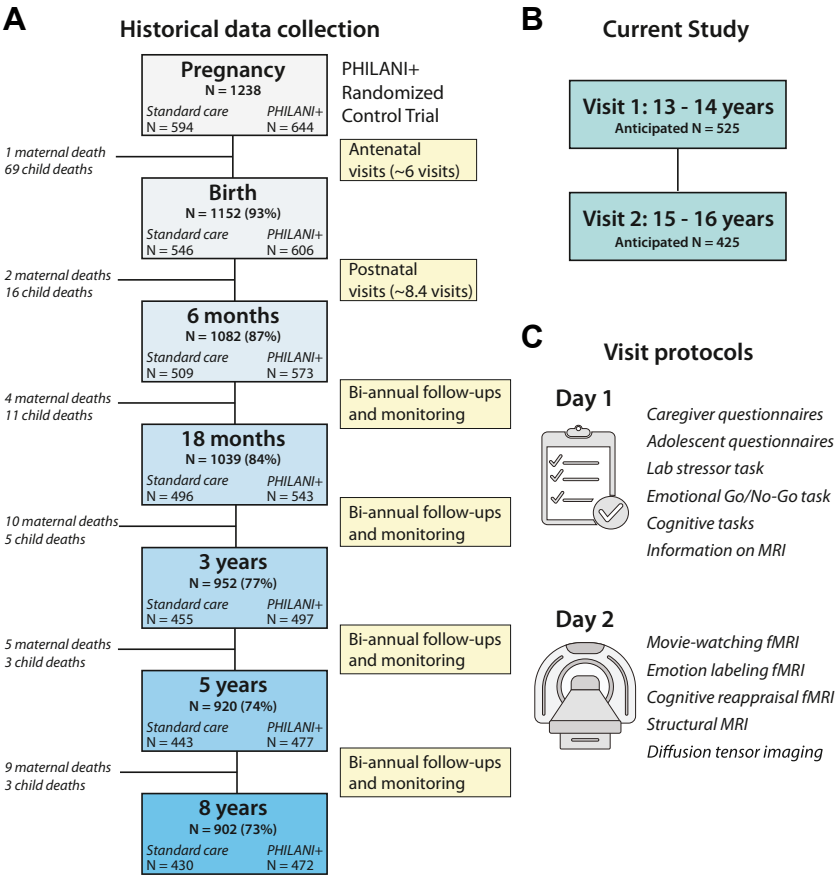

Figure 1. Study details. **(A)** Historical data collection timeline [modified from (28)]. Note that the numbers change according to loss to follow-up at various time points and subsequent return to the study. Thus, retention of the sample from the first time point is represented proportionally as percentages in parentheses. **(B)** Time points collected for the current study. **(C)** Protocol for data collection at both adolescent time points. fMRI, functional magnetic resonance imaging.

pregnancy (e.g., infectious disease, alcohol use, depression, partner violence, and the intergenerational impacts of racism) (27,29) and continuing into the children's own lives after birth. By definition, resilience is a phenomenon that can only be observed following exposure to adversity (16,18,19,30), meaning that the unfortunate, near-universal experience of adversity in the current sample may lead to important insights into the factors that contribute to positive developmental outcomes.

In this article, we outline an ongoing protocol for studying resilience and emotion regulation neurodevelopment in South African adolescents; our strategies for conducting methodologically robust, culturally relevant, and ethically sound research; the challenges and considerations in conducting this research; and the promise that this research holds both for the basic science of resilience and its clinical translation. We will make deidentified data from this project publicly available via the National Institute of Mental Health Data Archive. This article acts as a guide to the types of data being collected and provides context on the population and measures included.

Resilient Emotion Regulation

Definitions of resilience vary, but the current scientific consensus is that it is not merely the opposite of vulnerability/risk or a stable trait; rather, resilience consists of a myriad of dynamic, protective factors that contribute to successful developmental outcomes following exposure to adversity (4,19,31–33). Resilience can include both processes that are internal to the individual, such as self-regulation (33), and factors that are external to the individual, such as social support in the form of caregivers, teachers, mentors, and friends (34) and resources in the community (35). These factors are part of a reciprocal system in which protective factors operate dynamically at multiple proximal and distal levels (36–39). Systems of resilience have been investigated across various cultures, with caregivers playing a central role (22), particularly in establishing children's adaptive socioemotional skills (40–42) and influencing the neurobiology that underlies emotion regulation (43–45) and associated resilience (31,46).

We focus on resilient emotion regulation in this project. Despite differences in beliefs about and desires for certain emotions across cultures (47–52), having weak regulation over emotions is maladaptive (53–55). In South African adolescents, emotion dysregulation and poor coping strategies have been linked to internalizing symptoms and drug use (56,57). Cognitive reappraisal, in which a person thinks about a situation in a different way to change its emotional intensity or valence, is widely recognized as an adaptive emotion regulation strategy (58)—an effect that is seen across countries (59). Nonetheless, the paucity of research on emotion regulation in LMIC contexts means that questions remain about what

adaptive (or maladaptive) emotion regulation strategies look like, the factors that predict their emergence, and how they are related to positive outcomes (60).

While it is unlikely that any one resilience factor is specific to one group, universal mechanisms of resilience (e.g., access to resources, social support, community affiliation, feelings of agency) will be informed by both culture and context (61,62). In other words, what makes an individual resilient in an HIC may not necessarily apply to an adolescent who is growing up in a peri-urban settlement in South Africa (35,63). For example, South African young people have described the cultural tradition of ubuntu—that is, showing "humanity to others"—as a key value important to developmental success (24). Ubuntu highlights community connectedness, spirituality, and cultural beliefs and has been identified as a source of resilience (26). Overall, it is important that resilience measures are culturally relevant and adapted before being used (64), as in the current research project.

In HICs, individual differences in emotion regulation are supported by brain networks that include the prefrontal cortex and limbic regions (i.e., amygdala) (65–68), with activity in these regions linked to resilience (69). However, the functional development of the brain mechanisms associated with resilient emotion regulation have not been studied in LMIC contexts. Whether the same neurobiology supports resilient emotion regulation universally is an open question.

Adolescence: A Neurobiological and Sociocultural Sensitive Period

Although emotion regulation is important across development, it is particularly salient during adolescence, an important transition period for emotion regulation and related neurobiology (70–73). Adolescents transition from intrapersonal to independent emotion regulation strategies to successfully adapt to the changes that mark this developmental period (74,75). At the same time that these emotion regulation strategies are maturing, adolescence is marked by heightened sensitivity to the extrafamilial social environment, emotional reactivity, impulsivity, and risk taking (71,73,76,77). Perhaps reflecting this, caregivers from South Africa were most likely to report that early adolescence (10–15 years) is the most important time for caregiver support and intervention, citing the need to develop morals, self-protection, and life skills (78). Theoretical and empirical work (in HIC contexts) has also shown that adolescence is a biological sensitive period for the structural and functional development of neural systems relevant for affective processing, including emotion regulation (71,73,79–83). In sum, changes in emotion regulation and related affective processes during adolescence make it a period during which people are especially vulnerable to the emergence of mental health issues (84,85) and important for examining neurobiological mechanisms of resilient emotion regulation.

The Current Project

The primary aim of this project is to identify pathways to resilient emotion regulation and its neurobiological correlates during adolescence following adversity in an established South African birth cohort. As a transdiagnostic predictor of psychopathology (86–88), emotion regulation may be particularly useful in capturing the heterogeneity of mental health problems related to adversity exposure (89). By employing an exploratory, data-driven, and multilevel dimensional approach (including historical data, caregiver-/self-reports, performance measures, and longitudinal changes in magnetic resonance imaging [MRI] structure, connectivity, and task-based functional activity) (see Figure 2), this research will overcome some of the known limitations of categorical diagnoses as defined in the DSM (90,91). Additionally, we aim to reveal whether existing models of resilient emotion regulation generalize to adolescents from LMICs such as South Africa. Importantly, the measures used in this study were culturally adapted to the South African context through the input of focus groups and community members who serve as data collectors and key members of the research team. By including neuroimaging as a key component, this research will characterize neurodevelopmental change profiles in South African adolescents, thereby contributing to the growing field of neuroscience in Africa (92–94). Finally, understanding how aspects of the social and physical environment can serve as protective factors in adolescents from LMICs will advance preventive efforts and interventions.

METHODS AND MATERIALS

Participants: The Philani Longitudinal Birth Cohort

Our study follows a longitudinal birth cohort of adolescents born in the Khayelitsha township in Cape Town, South Africa (27,95), an extremely low-income and high-adversity setting (see Supplemental Text). Pregnant women (N = 1238) were originally enrolled in a longitudinal randomized controlled trial to evaluate the effectiveness of a community-based home visiting program (see Figure 1A). Participants were divided into intervention groups based on the neighborhood that they lived in (n = 12 each), such that demographic factors were similar across groups. In the intervention group, local women, defined as peer influencers or mentor mothers, made home visits to support maternal and child nutrition in their geographic area. This original randomized controlled trial (from 2009–2011) was developed with Philani, a nongovernmental organization (96), to integrate the existing nutrition intervention with additional content and activities to address maternal health risks such as HIV, tuberculosis, nutrition, mental health, alcohol use, and healthy daily routines for mothers (27).

Results of the original randomized controlled trial and follow-ups have been published previously (28,29,95,97–99) (see Supplemental Text for a brief summary of the results). Given the effects of adversity observed in this sample, with or without the original intervention, there is value in following this cohort into adolescence to identify protective factors that promote individual differences in resilient emotion regulation and its neurobiology. This will be the first time that neuroimaging data have been collected with this cohort, meaning that the Philani sample will be the only LMIC birth cohort with a combination of high-density profiling of significant adversity/disparities (cataloged from the prenatal period to 8 years) together with neurobiological and behavioral phenotyping during adolescence.

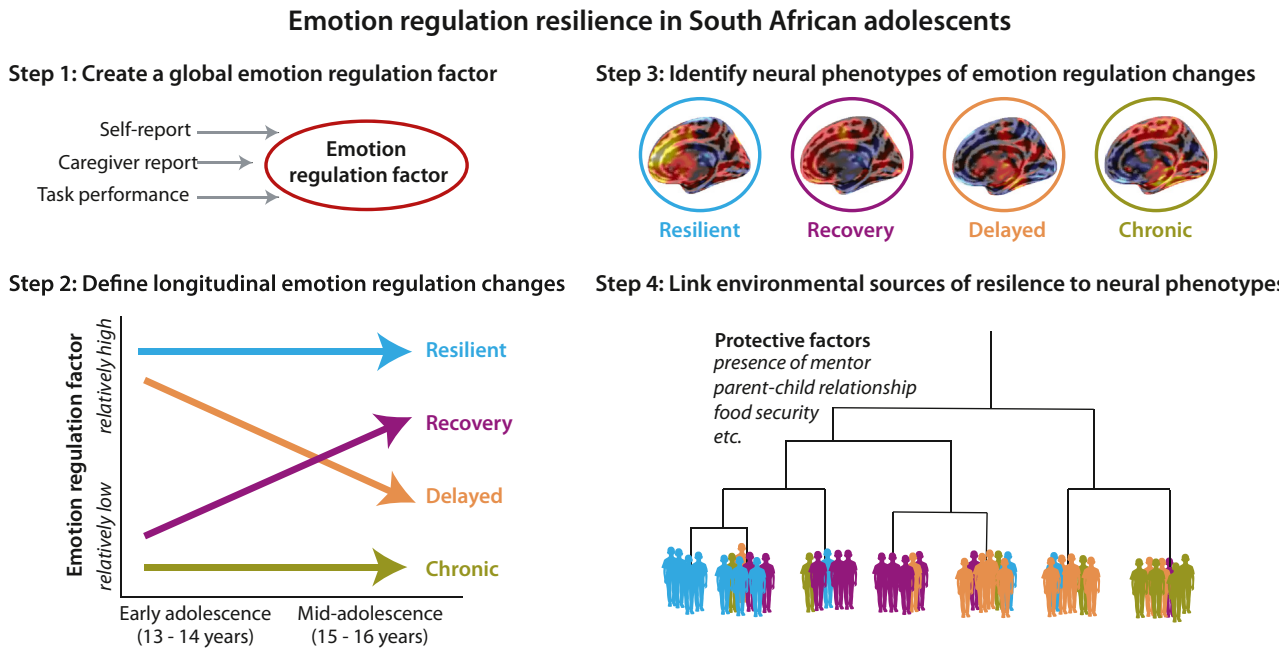

Figure 2. Analysis strategy for examining neurodevelopmental change profiles of resilient emotion regulation in South African adolescents. We take an exploratory, data-driven, and multilevel dimensional approach to overcome known limitations of single measures and to minimize assumptions made about resilient emotion regulation in adolescents from a low- and middle-income country (LMIC) context (see Table S6). There are 4 major parts to our analysis approach. First, we create a global emotion regulation factor informed by multiple methods (self-report, caregiver report, and task performance). Second, adolescents are identified as exhibiting resilient emotion regulation (or other developmental changes) based on their emotion regulation factor score across 2 time points. These canonical change profiles (resilient, recovery, delayed, and chronic) are informed by previous work that examined resilient change profiles following adversity. Third, neural phenotypes of resilient emotion regulation are identified using multiple sources of data (i.e., structural and functional). Finally, environmental sources of resilience (protective factors) are used to group participants and examine the link between protective factors and neural phenotypes of resilient emotion regulation. Caregiver-reported gender, age, and other covariates are considered across analyses, as are adversity profiles. Note that these images are for illustrative purposes only and do not reflect the data.

We are recruiting 525 participants with the aim of retaining 425 adolescents across 2 visits occurring at 13 to 14 years of age (early adolescence) and 15 to 16 years of age (mid-adolescence) (Figure 1B). The pacing of the visits across 2 years was chosen to permit observation of developmental change while also being short enough to retain the sample. Our anticipated retention rate of 81% over 2 time points is a conservative estimate given the high rates of retention of this sample over the past decade (which ranges from 92%–98% across subsequent visits) (see Figure 1A). Recruitment is conducted by data collectors from the community who have longstanding relationships with the participants. To maintain a tight age range, participants >15 years of age at the time of the first visit are not enrolled. Because some participants might have migrated between the Western and Eastern Cape provinces (100), recruitment targets both locations. Exclusion criteria include significant neonatal medical complications, autism or significant intellectual disabilities, and MRI contraindications. Maternal HIV+ status during pregnancy is not considered an exclusion criterion given that vertical transmission rates have decreased considerably in South Africa due to improved access to antiretroviral therapy (101), which is reflected in the low incidence rates found in this cohort (2.4% of children with HIV at age 3 years) (102). Moreover, including adolescents born to mothers who are HIV+ is important to ensure the generalizability of our results to the study population. Nonetheless, maternal HIV status and known adolescent HIV status will be considered as covariates in follow-up robustness analyses to assess whether this adds additional variance to our results.

All participants are supported with fair compensation including meals and travel to and from study sites. We have a detailed neuroimaging incidental findings protocol and a referral system in place for participants who are in active distress or who need additional mental or physical health evaluation. Finally, the research is conducted by trained data collectors from the community who are fluent in isiXhosa and skilled in communicating with participants. This study was approved by the ethics committees at Stellenbosch University (HREC # N23/03/012) and Columbia University (IRB #AAAU5623).

Aiming for Cultural Relevance

Cultural adaptation is an essential practice in adapting psychosocial measures across diverse settings (64). Key to this is an understanding of the context of the target population. This includes community views, beliefs, values, and practices related to specific research questions (e.g., stress, coping mechanisms, child development) (103,104). The process of cultural adaptation used in the current study was guided by input from adolescent and adult community advisory boards

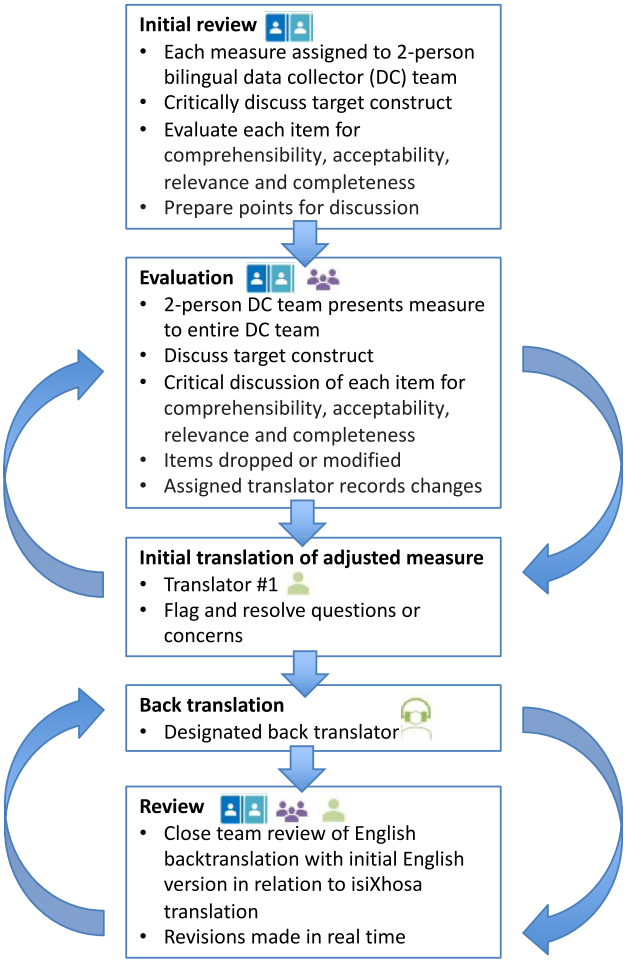

Figure 3. Cultural adaptation process for assessments used in the study. The procedure for cultural adaptation was iterative and consisted of translation, comprehension checks, back translation, and review.

and conducted by members of the research team who have expertise in cultural adaptation and/or have lived and worked in the community (see Positionality Statement) (78,105–108). Adaptation was a rigorous and iterative process of translation, consultation, review, and back translation (outlined in Figure 3). The Supplemental Text summarizes the cultural adaptation process for this study; the outcomes of this process, including community perceptions and guidance, will be detailed in a forthcoming article.

Behavioral and Neuroimaging Measures

Adolescents and their caregivers participate in a 2 day study visit twice across 2 years. On day 1, adolescents and their caregivers complete questionnaires and assessments at a research site in Khayelitsha. During this visit, prior to giving consent/assent, caregivers also receive MRI education through slideshows and videos presented in a standardized format and are given the opportunity to ask any questions. On day 2, adolescents receive the same MRI education and practice the MRI tasks prior to the MRI session (Figure 1C), which takes place at a nearby Cape Town hospital with a dedicated 3T research scanner. The MRI session lasts approximately 60 minutes, during which time data collectors from the community are in constant communication with adolescents to ensure participant comfort. The follow-up visit 2 years later follows the same behavioral and neuroimaging protocol to assess neurodevelopmental change profiles: resilient (high emotion regulation over time), recovery (initially low emotion regulation that increases), delayed (initially high or moderate emotion regulation that decreases), and chronic (low emotion regulation over time) (109,110). The assessment battery is summarized in Tables S1–S5 and detailed below. Assessments were chosen based on their strong psychometric properties, appropriateness for this sample given their previous use in the sample, and the outcomes of the cultural adaptation process.

Our primary aim is to examine emotion regulation. Previous work has found that emotion regulation during adolescence can be related to physical health and cognitive abilities (111,112). Therefore, we are collecting additional physical health and cognitive measures that have been validated in adolescent populations [e.g., (113)] to be used as covariates in our analyses (Table S1).

Measures of Adverse Experiences and Protective Factors. Adverse experiences from across the adolescents' lifespan are measured through adolescent and caregiver reports (Table S2), as well as previously collected longitudinal data. Briefly, using standardized questionnaires and additional assessments, caregivers and adolescents report on their physical environment (e.g., where they live, neighborhood characteristics, access to food, predictability in the environment, access to the internet), negative life experiences (e.g., trauma, relationship violence, abuse and neglect, racial discrimination), and mental health (e.g., depression, anxiety, posttraumatic stress disorder, substance use). Measures were selected to complement historical data on adversity exposure in this sample. Additional assessments measure potential protective factors that may contribute to adolescent resilience (Table S3). Given that protective factors that contribute to adolescent resilience have not yet been characterized in this sample, we are assessing multiple possible sources of resilience including those raised in focus groups. Caregivers and adolescents are asked about the caregiver-child relationship, extrafamilial relationships (friendships, relationships with teachers, mentors), spiritual beliefs, feelings of connectedness to family and culture, daily activities and routines, goals and future-oriented thinking, and perceived social support. Condition in the previous randomized controlled trial (i.e., intervention or standard care group) is also considered as a potential protective factor.

Measures of Emotion Regulation and Resilience. Our primary outcome of adolescent resilient emotion regulation comprises multiple behavioral, caregiver, and self-report measures (Table S4). The rationale for assessing emotion regulation using a multilevel dimensional approach is to find a common higher-order factor of emotion regulation that is then related to neural phenotypes and protective factors. Caregivers and adolescents are asked about adolescents' emotion

reactivity and regulation, coping, social behavior, impulse control, goal-directed behavior, and motivation to regulate emotions. Adolescents' physiological (i.e., skin conductance) and behavioral ratings of the intensity and valence of looming auditory stimuli (114) are measured to assess responses to stressors. An emotional faces Go/NoGo task (115) is used to assess cognitive control in the context of emotional information.

Implicit and explicit emotion regulation abilities are assessed using behavioral tasks acquired during functional MRI (fMRI). These tasks were chosen based on their previous use in behavioral and neuroimaging studies of emotion regulation. Although task-based fMRI has recently been shown to exhibit moderate to low test-retest reliability (116,117), including for measures of emotion processing (118–120), task-based fMRI provides high validity for our aim of investigating neurobiology relevant to emotion regulation and thus is an essential aspect of the research (121). An affect labeling task (122) is used to assess implicit emotion regulation, requiring participants either to choose the word that describes a facial expression (affect labeling condition) or a face of another person that matches the facial expression (affect matching condition). Behavioral (i.e., accuracy and response time) and neural differences between these conditions suggest differences due to the process of "putting emotions into words," which is considered an implicit form of emotion regulation (123). To control for emotion reactivity, adolescents also perform a nonaffective matching condition (shape matching condition). All facial images shown are of Black people from the NimStim (124), following previous South African research (125). For explicit emotion regulation, adolescents perform a task used to assess the regulation of negative emotions via cognitive reappraisal, which in research in HICs is considered an adaptive regulation strategy (126). While viewing negative pictures from the International Affective Picture System (127) and the South African Affective Picture System (128), adolescents are instructed to try either to reduce their negative emotion by reappraising the picture's content (reappraisal condition) or to look at the picture without trying to reduce negative feelings (attend-to-negative condition). Adolescents are also instructed to look at neutral pictures (attend-to-neutral condition). Neural differences between the attend-to-neutral and attend-to-negative conditions reflect emotional reactivity, while differences between the reappraisal and attend-to-negative conditions reflect the exertion of emotion regulation strategies via cognitive reappraisal. Adolescents undergo prescan training on cognitive reappraisal strategies to ensure that they understand the instructions and also answer postscan questions to assess the specific strategies that they used during scanning.

Finally, we collect structural and functional neuroimaging measures (Table S5) to identify neural phenotypes of resilient emotion regulation. Neuroimaging data can reveal whether the same neural circuits that underlie resilient emotion regulation in HIC contexts apply to this sample. The neuroimaging procedures and scanning parameters were chosen to yield valid neuroimaging variables previously connected to emotion regulation, minimize participant burden, and roughly harmonize with imaging acquisition from a large longitudinal study of adolescents in the United States [the Adolescent Brain Cognitive Development (ABCD) Study (129)]. The use of multiband fMRI acquisitions enables higher spatial resolution for imaging subcortical structures (e.g., amygdala), examining fine-grain representations, and conducting surface-based analyses for functional connectivity (130). Task-based fMRI during implicit and explicit emotion regulation tasks (described above) are collected to examine functional neural activity during emotion regulation processes. Structural scans (T1-weighted) are collected to measure cortical volume and thickness across the brain and in particular regions of interest (e.g., the prefrontal cortex) (131). Diffusion tensor imaging scans are collected to measure structural connectivity between brain regions, such as between the prefrontal cortex and the amygdala (132), and to investigate the maturation of white matter microstructure, which exhibits well-documented changes during adolescence (133,134). To measure functional connectivity between regions, adolescents watch 2 short movie clips ("The Present" and "Homeward Bound") during a resting-state fMRI scan (135,136). Both movies are narratives that have been used in previous developmental neuroimaging research and include socioemotional content but differ in the extent to which caregiver attachment relations are evoked, enabling exploratory analyses of naturalistic socioemotional stimulus processing (137). The movie-watching resting state occurs at the start of the MRI session, following the structural scan, to reduce the impact of posttask effects on functional connectivity (138). Next, participants complete the emotion regulation fMRI tasks and the diffusion tensor imaging scan. Finally, an additional functional scan is collected at the end of the session to infer eye gaze during neuroimaging data collection using a predictive modeling approach (139).

Considerations for Analyses

The rich, multimodal, and longitudinal nature of this project creates the opportunity for us to answer a number of research questions about resilient emotion regulation neurodevelopment in an LMIC context. Moreover, because we plan to make this data publicly available, it is important to provide context and considerations for future data analyses. We have specifically chosen not to collect data from a comparison group outside of this context. Cross-cultural comparisons, if not done properly, can inadvertently lead to further marginalization of at-risk and minority groups (140). Thus, it is important to maintain the cultural context in which this research is being conducted. As we mentioned previously, adversity is nearly universal in the community in which the participants live, meaning that there would be no suitable no-adversity comparison group within the cultural context of this research. Instead, our primary aim in this study is to examine individual differences and pathways to emotion regulation resilience within the Philani longitudinal birth cohort; doing so allows us to move away from a deficit-only perspective of adversity and toward research that promotes resilience in this population (141).

We also had to consider whether theories and constructs derived from HICs would be appropriate to the context of this study. Much of our understanding of resilience following adversity derives from populations that have experienced different types and magnitudes of adversity than the adolescents in the current study. Thus, we opted to use data-driven approaches to characterize adversity and emotion regulation resilience in this population (89) (Figure 2). For example, rather

than grouping adolescents by hypothesized dimensions of adversity [e.g., threat and deprivation, harshness and unpredictability (142,143)], we will use a clustering approach to create adversity subgroups specific to this population (see Table S6 for the analytic plan). Additionally, rather than relying on a single measure of emotion regulation, we opted to aggregate multiple types of data (i.e., survey responses, task behaviors) into a global emotion regulation factor that we will then relate to different protective factors. Data-driven analyses have been successfully used in previous neurobiological and behavioral phenotyping research (144–147). For neural measures, while we will consider regions of interest that have previously been shown to be related to resilience in HIC contexts (e.g., the prefrontal cortex, amygdala), our primary analysis approach will be to characterize whole-brain neural phenotypes for resilience. From this methodology, we will uncover region and network contributions to resilient emotion regulation that may answer questions about the localization and laterality of emotion processing (148,149). This neural phenotyping approach has the additional advantage of mitigating concerns over signal to noise for any given region/task that may be due to task reliability (116,117) or the use of multiband acquisitions for fMRI (150,151). All analyses will consider relative differences across measures within the study population, rather than using external benchmarks, to again maintain the cultural context and minimize assumptions.

DISCUSSION

Many children and adolescents in LMICs experience profound adversities, but these samples have been underrepresented in research on neurobiological mechanisms of resilience. Here, we described our strategies for investigating the neurodevelopmental mechanisms that underlie resilient emotion regulation in a South African cohort. We have emphasized the need to understand resilience and neurodevelopmental change profiles in the context and culture of this sample to reduce the 10/90 research divide (7,8,10) and provide insights into resilience, emotion regulation, and neurodevelopment in adolescents from an LMIC.

The current work has limitations that should be considered. First, although we are leveraging dense historical data from across adolescents' lives, the original study was not designed to characterize resilience. Thus, we do not have the ability to consider how early protective factors (i.e., during infancy and childhood) are related to current resilient emotion regulation. Future work is needed to advance our understanding of sensitive periods for resilience (152). Second, the final planned sample size for neuroimaging data collection will be moderate compared with other large-scale consortium studies (anticipated N = 525 at time point 1 and n = 425 at time point 2). There have been several recent debates over the appropriate sample size for relating brain and behavior, with some analyses requiring thousands of individuals (153–157). Our approach of collecting rich, phenotypic data from individual participants; using high signal-to-noise, task-based fMRI; and using machine learning methods with cross-validation techniques mitigates some of these concerns. Another strength of our approach is going beyond cross-sectional individual differences to examine how protective factors predict change profiles over 2 time points within the early adolescence to mid-adolescence period. Previous research has shown that measurable change can be acquired with few time points in the adolescent age range (158,159) and that this approach is statistically valid over longer study durations (160). However, it is possible that not all of the canonical change profiles (resilient, recovery, delayed, chronic) (Figure 2) are observable in this sample. In this event, we will adopt machine learning–based clustering methods to uncover change profiles in a data-driven way (see Table S6). Additionally, although we anticipate high retention given historical success, attrition is always a challenge, and we will employ appropriate statistical measures if necessary to account for possible biases (161,162).

No child should have to bear the burden of developing resilience as a response to familial, structural, and/or health inequities. However, identifying modifiable sources of resilient emotion regulation that mitigate risk factors offers promise for promoting positive neurodevelopmental and mental health outcomes in individuals who are growing up with considerable adversity. By focusing on South African adolescents with extreme adversity, this research can inform new models of risk and resilience for adolescents from LMICs. Ultimately, our hope is that findings from this research will inform models for mental health around the world.

Positionality Statement

We have prioritized a research approach that reflects a diverse set of voices and avoids replicating historical power hierarchies between countries. There is an unfortunate history of science being conducted by researchers from HICs on participants from low-income countries [sometimes referred to as helicopter or parachute research (10,163–165)]. Our approach has been to instead echo the principles of interconnectedness, collaboration, and mutual respect that are central to the ubuntu philosophy (166) and to conduct collaborative work that is both inclusive and culturally competent. From the outset, community members have participated in the research, not just as temporary consultants, but also as leading, valuable members of the research team (see Aiming for Cultural Relevance). We aim for an equitable global collaboration where information transfer is bidirectional and considers the expertise and perspectives of all team members. In line with these goals, the project researchers continuously learn from team members of various disciplines, both through formal training and knowledge sharing. In the current paper, 57.1% of the authors are working in the United States, and 42.9% of the authors are working in South Africa; 28.6% of authors have worked with the Philani longitudinal birth cohort since its inception in 2009. The authors include experts in psychology, developmental science, neuroscience, psychiatry, medicine, public health, anthropology, informatics, open science, and community-based research. Seventeen of the authors self-reported additional demographic information: 5.9% identify as Asian/White, 29.4% identify as Black African, 5.9% identify as Indian, 5.9% identify as Latin/White, 5.9% identify as Middle East/North African, and 47.1% identify as White/Caucasian[b]; 29.4% of

[b]Note that self-identified race/ethnicity categories can vary by country.

authors speak isiXhosa, and 11.8% of authors speak another common South African language (e.g., Afrikaans).

ACKNOWLEDGMENTS AND DISCLOSURES

This work was supported by the National Institute of Mental Health (Grant No. R01 MH130578 [to NT, SSe, and MT]).

We thank the adolescents and their caregivers participating in this research.

The authors report no biomedical financial interests or potential conflicts of interest.

ARTICLE INFORMATION

From the Department of Psychology, Columbia University, New York, New York (TY, LA, EN, NT); Institute for Life Course Health Research, Department of Global Health, Stellenbosch University, Cape Town, South Africa (SSi, KG, NMh, NMq, NN, AS, MT); Department of Psychiatry, Faculty of Medicine and Health Sciences, Stellenbosch University, Cape Town, South Africa (SSe, SdP, FA); Center for the Developing Brain, Child Mind Institute, New York, New York (MM, GS, AF, AZ); School of Psychological Sciences, Tel Aviv University, Tel Aviv, Israel (LA); Department of Anthropology, Emory University, Atlanta, Georgia (CW); Semel Institute, Department of Psychiatry and Biobehavioral Sciences, University of California at Los Angeles, Los Angeles, California (MJR-B); Department of Psychology, Palo Alto University, Palo Alto, California (JC); and School of Nursing and Midwifery, Queens University, Belfast, Northern Ireland, United Kingdom (MT).

TY and SSi equally contributed as co-first authors.

NT and MT equally contributed co-senior authors.

Address correspondence to Mark Tomlinson, Ph.D., at markt@sun.ac.za.

Received Aug 18, 2024; revised Jan 8, 2025; accepted Jan 24, 2025.

Supplementary material cited in this article is available online at https://doi.org/10.1016/j.bpsgos.2025.100457.

REFERENCES

1. Green JG, McLaughlin KA, Berglund PA, Gruber MJ, Sampson NA, Zaslavsky AM, Kessler RC (2010): Childhood adversities and adult psychiatric disorders in the National comorbidity survey replication I: Associations with first onset of DSM-IV disorders. Arch Gen Psychiatry 67:113–123.
2. Kessler RC, McLaughlin KA, Green JG, Gruber MJ, Sampson NA, Zaslavsky AM, *et al.* (2010): Childhood adversities and adult psychopathology in the WHO World Mental Health Surveys. Br J Psychiatry 197:378–385.
3. McLaughlin KA, Green JG, Gruber MJ, Sampson NA, Zaslavsky AM, Kessler RC (2010): Childhood adversities and adult psychiatric disorders in the National comorbidity survey replication II: Associations with persistence of DSM-IV disorders. Arch Gen Psychiatry 67:124–132.
4. Kalisch R, Baker DG, Basten U, Boks MP, Bonanno GA, Brummelman E, *et al.* (2017): The resilience framework as a strategy to combat stress-related disorders. Nat Hum Behav 1:784–790.
5. Gross JJ (2015): Emotion regulation: Current status and future prospects. Psychol Inq 26:1–26.
6. Kieling C, Baker-Henningham H, Belfer M, Conti G, Ertem I, Omigbodun O, *et al.* (2011): Child and adolescent mental health worldwide: Evidence for action. Lancet 378:1515–1525.
7. Paraje G, Sadana R, Karam G (2005): Public health. Increasing international gaps in health-related publications. Science 308:959–960.
8. Saxena S, Paraje G, Sharan P, Karam G, Sadana R (2006): The 10/90 divide in mental health research: Trends over a 10-year period. Br J Psychiatry 188:81–82.
9. Abubakar A, Brandelli Costa A, Cui L, Koller SH, Nwafor CE, Raval VV (2024): Towards a decolonial developmental science: Adolescent development in the Majority World taking center stage. J Res Adolesc 34:246–256.
10. Draper CE, Barnett LM, Cook CJ, Cuartas JA, Howard SJ, McCoy DC, *et al.* (2023): Publishing child development research from around the world: An unfair playing field resulting in most of the world's child population under-represented in research. Infant Child Dev 32:e2375.
11. Tomlinson M, Bornstein MH, Marlow M, Swartz L (2014): Imbalances in the knowledge about infant mental health in rich and poor countries: Too little progress in bridging the gap. Infant Ment Health J 35:624–629.
12. Tomlinson M, Swartz L (2003): Imbalances in the knowledge about infancy: The divide between rich and poor countries. Infant Ment Health J 24:547–556.
13. Engle PL, Black MM, Behrman JR, de Cabral de Mello MC, Gertler PJ, Kapiriri L, *et al.* (2007): Strategies to avoid the loss of developmental potential in more than 200 million children in the developing world. Lancet 369:229–242.
14. Grantham-McGregor S, Cheung YB, Cueto S, Glewwe P, Richter L, Strupp B, International Child Development Steering Group (2007): Developmental potential in the first 5 years for children in developing countries. Lancet 369:60–70.
15. Walker SP, Wachs TD, Gardner JM, Lozoff B, Wasserman GA, Pollitt E, *et al.* (2007): Child development: Risk factors for adverse outcomes in developing countries. Lancet 369:145–157.
16. Masten AS (2001): Ordinary magic. Resilience processes in development. Am Psychol 56:227–238.
17. Masten AS (2014): Global perspectives on resilience in children and youth. Child Dev 85:6–20.
18. Rutter M (2012): Resilience as a dynamic concept. Dev Psychopathol 24:335–344.
19. Southwick SM, Bonanno GA, Masten AS, Panter-Brick C, Yehuda R (2014): Resilience definitions, theory, and challenges: Interdisciplinary perspectives. Eur J Psychotraumatol 5:25338.
20. Oppong S (2016): A critique of early childhood development research and practice in Africa. Africanus 45:23–41.
21. Du Toit S, Haag K, Skeen S, Sherr L, Orkin M, Rudgard WE, *et al.* (2022): Accelerating progress towards improved mental health and healthy behaviours in adolescents living in adversity: Findings from a longitudinal study in South Africa. Psychol Health Med 27(suppl 1):14–26.
22. Höltge J, Theron L, Cowden RG, Govender K, Maximo SI, Carranza JS, *et al.* (2021): A cross-country network analysis of adolescent resilience. J Adolesc Health 68:580–588.
23. Mebrahtu H, Skeen S, Rudgard WE, Du Toit S, Haag K, Roberts KJ, *et al.* (2022): Can a combination of interventions accelerate outcomes to deliver on the Sustainable Development Goals for young children? Evidence from a longitudinal study in South Africa and Malawi. Child Care Health Dev 48:474–485.
24. Theron LC (2007): Uphenyo ngokwazi kwentsha yasemalokishini ukumelana nesimo esinzima: A South African study of resilience among township youth. Child Adolesc Psychiatr Clin N Am 16:357–375.
25. Theron LC (2016): Toward a culturally and contextually sensitive understanding of resilience: Privileging the voices of Black, South African young people. J Adolesc Res 31:635–670.
26. Van Breda AD, Theron LC (2018): A critical review of South African child and youth resilience studies, 2009-2017. Child Youth Serv Rev 91:237–247.
27. Rotheram-Borus MJ, le Roux IM, Tomlinson M, Mbewu N, Comulada WS, le Roux K, *et al.* (2011): Philani plus (+): A mentor Mother community health worker home visiting program to improve maternal and infants' outcomes. Prev Sci 12:372–388.
28. Rotheram-Borus MJ, Tomlinson M, Worthman CM, Norwood P, le Roux I, O'Connor MJ (2023): Maternal depression, alcohol use, and transient effects of perinatal paraprofessional home visiting in South Africa: Eight-year follow-up of a cluster randomized controlled trial. Soc Sci Med 324:115853.
29. Rotheram-Borus MJ, Tomlinson M, Roux IL, Stein JA (2015): Alcohol use, partner violence, and depression: A cluster randomized controlled trial among urban South African Mothers Over 3 years. Am J Prev Med 49:715–725.
30. Bonanno GA, Westphal M, Mancini AD (2011): Resilience to loss and potential trauma. Annu Rev Clin Psychol 7:511–535.
31. Gee DG (2021): Early adversity and development: Parsing heterogeneity and identifying pathways of risk and resilience. Am J Psychiatry 178:998–1013.

32. Gee DG, Cohodes EM (2021): Caregiving influences on development: A sensitive period for biological embedding of predictability and safety cues. Curr Dir Psychol Sci 30:376–383.
33. Méndez Leal AS, Silvers JA (2021): Neurobiological markers of resilience to early-life adversity during adolescence. Biol Psychiatry Cogn Neurosci Neuroimaging 6:238–247.
34. Ozbay F, Johnson DC, Dimoulas E, Morgan CA, Charney D, Southwick S (2007): Social support and resilience to stress: From neurobiology to clinical practice. Psychiatry (Edgmont) 4:35–40.
35. Ungar M, Ghazinour M, Richter J (2013): Annual Research Review: What is resilience within the social ecology of human development? J Child Psychol Psychiatry 54:348–366.
36. Bronfenbrenner U (1979): The Ecology of Human Development: Experiments by Nature and Design. Cambridge, England: Harvard University Press.
37. Masten AS, Lucke CM, Nelson KM, Stallworthy IC (2021): Resilience in development and psychopathology: Multisystem perspectives. Annu Rev Clin Psychol 17:521–549.
38. Theron L, Murphy K, Ungar M (2022): Multisystemic resilience: Learning from youth in stressed environments. Youth Soc 54:1000–1022.
39. Ungar M, Theron L (2020): Resilience and mental health: How multisystemic processes contribute to positive outcomes. Lancet Psychiatry 7:441–448.
40. Bornstein MH, Putnick DL (2012): Cognitive and socioemotional caregiving in developing countries. Child Dev 83:46–61.
41. Collins WA, Maccoby EE, Steinberg L, Hetherington EM, Bornstein MH (2000): Contemporary Research on parenting. The case for nature and nurture. Am Psychol 55:218–232.
42. Silvers JA (2022): Adolescence as a pivotal period for emotion regulation development. Curr Opin Psychol 44:258–263.
43. Callaghan BL, Tottenham N (2016): The Stress Acceleration Hypothesis: Effects of early-life adversity on emotion circuits and behavior. Curr Opin Behav Sci 7:76–81.
44. Tottenham N (2020): Early adversity and the neotenous human brain. Biol Psychiatry 87:350–358.
45. Vannucci A, Fields A, Hansen E, Katz A, Kerwin J, Tachida A, *et al.* (2023): Interpersonal early adversity demonstrates dissimilarity from early socioeconomic disadvantage in the course of human brain development: A meta-analysis. Neurosci Biobehav Rev 150:105210.
46. Gee DG, Cohodes EM (2023): Leveraging the developmental neuroscience of caregiving to promote resilience among youth exposed to adversity. Dev Psychopathol 35:2168–2185.
47. Ford BQ, Gross JJ (2019): Why beliefs about emotion matter: An emotion-regulation perspective. Curr Dir Psychol Sci 28:74–81.
48. Tamir M, Schwartz SH, Cieciuch J, Riediger M, Torres C, Scollon C, *et al.* (2016): Desired emotions across cultures: A value-based account. J Pers Soc Psychol 111:67–82.
49. Tsai JL (2007): Ideal affect: Cultural causes and behavioral consequences. Perspect Psychol Sci 2:242–259.
50. Tamir M, Ito A, Miyamoto Y, Chentsova-Dutton Y, Choi JH, Cieciuch J, *et al.* (2024): Emotion regulation strategies and psychological health across cultures. Am Psychol 79:748–764.
51. Bozicevic L, De Pascalis L, Schuitmaker N, Tomlinson M, Cooper PJ, Murray L (2016): Longitudinal association between child emotion regulation and aggression, and the role of parenting: A comparison of three cultures. Psychopathology 49:228–235.
52. Yang Y, Wang Q (2019): Culture in emotional development. In: LoBue V, Pérez-Edgar K, Buss KA, editors. Handbook of Emotional Development. Cham, Germany: Springer International Publishing, 569–593.
53. Berking M, Wupperman P (2012): Emotion regulation and mental health: Recent findings, current challenges, and future directions. Curr Opin Psychiatry 25:128–134.
54. Gross JJ, Muñoz RF (1995): Emotion regulation and mental health. Clin Psychol Sci Pract 2:151–164.
55. McLaughlin KA, Hatzenbuehler ML, Mennin DS, Nolen-Hoeksema S (2011): Emotion dysregulation and adolescent psychopathology: A prospective study. Behav Res Ther 49:544–554.
56. Kliewer W, Pillay BJ, Swain K, Rawatlal N, Borre A, Naidu T, *et al.* (2017): Cumulative risk, emotion dysregulation, and adjustment in South African youth. J Child Fam Stud 26:1768–1779.
57. Ward-Smith C, Sorsdahl K, van der Westhuizen C (2024): An investigation into symptoms of depression and anxiety and emotion regulation among older adolescents from low-income settings in South Africa. Compr Psychiatry 132:152476.
58. Troy AS, Shallcross AJ, Brunner A, Friedman R, Jones MC (2018): Cognitive reappraisal and acceptance: Effects on emotion, physiology, and perceived cognitive costs. Emotion 18:58–74.
59. Wang K, Goldenberg A, Dorison CA, Miller JK, Uusberg A, Lerner JS, *et al.* (2021): A multi-country test of brief reappraisal interventions on emotions during the COVID-19 pandemic. Nat Hum Behav 5:1089–1110.
60. Haslam D, Mejia A, Thomson D, Betancourt T (2019): Self-regulation in low- and middle-income countries: Challenges and future directions. Clin Child Fam Psychol Rev 22:104–117.
61. Masten AS, Wright MO (2010): Resilience over the lifespan: Developmental perspectives on resistance, recovery, and transformation. In: Handbook of Adult Resilience. New York, NY: The Guilford Press, 213–237.
62. Ungar M, Brown M, Liebenberg L, Othman R, Kwong WM, Armstrong M, Gilgun J (2007): Unique pathways to resilience across cultures. Adolescence 42:287–310.
63. Bhana A, Bachoo S (2011): The determinants of family resilience among families in low- and middle-income contexts: A systematic literature review. S Afr J Psychol 41:131–139.
64. Hall GCN, Ibaraki AY, Huang ER, Marti CN, Stice E (2016): A meta-analysis of cultural adaptations of psychological interventions. Behav Ther 47:993–1014.
65. Barrett LF, Satpute AB (2013): Large-scale brain networks in affective and social neuroscience: Towards an integrative functional architecture of the brain. Curr Opin Neurobiol 23:361–372.
66. Morawetz C, Riedel MC, Salo T, Berboth S, Eickhoff SB, Laird AR, Kohn N (2020): Multiple large-scale neural networks underlying emotion regulation. Neurosci Biobehav Rev 116:382–395.
67. Morawetz C, Basten U (2024): Neural underpinnings of individual differences in emotion regulation: A systematic review. Neurosci Biobehav Rev 162:105727.
68. Ochsner KN, Silvers JA, Buhle JT (2012): Functional imaging studies of emotion regulation: A synthetic review and evolving model of the cognitive control of emotion. Ann N Y Acad Sci 1251:E1–E24.
69. Norbury A, Seeley SH, Perez-Rodriguez MM, Feder A (2023): Functional neuroimaging of resilience to trauma: Convergent evidence and challenges for future research. Psychol Med 53:3293–3305.
70. Blakemore S-J, Burnett S, Dahl RE (2010): The role of puberty in the developing adolescent brain. Hum Brain Mapp 31:926–933.
71. Casey BJ, Getz S, Galvan A (2008): The adolescent brain. Dev Rev 28:62–77.
72. Crone EA, Dahl RE (2012): Understanding adolescence as a period of social–affective engagement and goal flexibility. Nat Rev Neurosci 13:636–650.
73. Somerville LH, Jones RM, Casey BJ (2010): A time of change: Behavioral and neural correlates of adolescent sensitivity to appetitive and aversive environmental cues. Brain Cogn 72:124–133.
74. Cracco E, Goossens L, Braet C (2017): Emotion regulation across childhood and adolescence: Evidence for a maladaptive shift in adolescence. Eur Child Adolesc Psychiatry 26:909–921.
75. Zimmermann P, Iwanski A (2014): Emotion regulation from early adolescence to emerging adulthood and middle adulthood: Age differences, gender differences, and emotion-specific developmental variations. Int J Behav Dev 38:182–194.
76. Blakemore S-J, Mills KL (2014): Is adolescence a sensitive period for sociocultural processing? Annu Rev Psychol 65:187–207.
77. Fuhrmann D, Knoll LJ, Blakemore S-J (2015): Adolescence as a sensitive period of brain development. Trends Cogn Sci 19:558–566.
78. Worthman CM, Tomlinson M, Rotheram-Borus MJ (2016): When can parents most influence their child's development? Expert knowledge and perceived local realities. Soc Sci Med 154:62–69.
79. Casey BJ, Jones RM, Somerville LH (2011): Braking and accelerating of the adolescent brain. J Res Adolesc 21:21–33.
80. Casey BJ, Tottenham N, Liston C, Durston S (2005): Imaging the developing brain: What have we learned about cognitive development? Trends Cogn Sci 9:104–110.

81. Gee DG, Hanson C, Caglar LR, Fareri DS, Gabard-Durnam LJ, Mills-Finnerty C, *et al.* (2022): Experimental evidence for a child-to-adolescent switch in human amygdala-prefrontal cortex communication: A cross-sectional pilot study. Dev Sci 25:e13238.
82. Pfeifer JH, Allen NB (2012): Arrested development? Reconsidering dual-systems models of brain function in adolescence and disorders. Trends Cogn Sci 16:322–329.
83. Shulman EP, Smith AR, Silva K, Icenogle G, Duell N, Chein J, Steinberg L (2016): The dual systems model: Review, reappraisal, and reaffirmation. Dev Cogn Neurosci 17:103–117.
84. Kessler RC, Berglund P, Demler O, Jin R, Merikangas KR, Walters EE (2005): Lifetime prevalence and age-of-onset distributions of DSM-IV disorders in the National comorbidity survey replication. Arch Gen Psychiatry 62:593–602.
85. Lee FS, Heimer H, Giedd JN, Lein ES, Šestan N, Weinberger DR, Casey BJ (2014): Mental health. Adolescent mental health–Opportunity and obligation. Science 346:547–549.
86. Aldao A, Gee DG, De Los Reyes ADL, Seager I (2016): Emotion regulation as a transdiagnostic factor in the development of internalizing and externalizing psychopathology: Current and future directions. Dev Psychopathol 28:927–946.
87. Cludius B, Mennin D, Ehring T (2020): Emotion regulation as a transdiagnostic process. Emotion 20:37–42.
88. Cole PM, Hall SE, Hajal NJ (2017): Emotion dysregulation as a vulnerability to psychopathology. In: Beauchaine TP, Hinshaw SP, editors. Child and Adolescent Psychopathology, 3rd ed.. (346–386). Chichester, UK: John Wiley & Sons, Limited, 346–386.
89. Nikolaidis A, Heleniak C, Fields A, Bloom PA, VanTieghem M, Vannucci A, *et al.* (2022): Heterogeneity in caregiving-related early adversity: Creating stable dimensions and subtypes. Dev Psychopathol 34:621–634.
90. Cuthbert BN (2014): The RDoC framework: Facilitating transition from ICD/DSM to dimensional approaches that integrate neuroscience and psychopathology. World Psychiatry 13:28–35.
91. Cuthbert BN, Insel TR (2013): Toward the future of psychiatric diagnosis: The seven pillars of RDoC. BMC Med 11:126.
92. Besharati S, Akinyemi R (2023): Accelerating African neuroscience to provide an equitable framework using perspectives from West and Southern Africa. Nat Commun 14:8107.
93. Kwikima U (2024): Looking towards the future of MRI in Africa. Nat Commun 15:2260.
94. Maina MB, Ahmad U, Ibrahim HA, Hamidu SK, Nasr FE, Salihu AT, *et al.* (2021): Two decades of neuroscience publication trends in Africa. Nat Commun 12:3429.
95. Tomlinson M, Hartley M, Le Roux IM, Rotheram-Borus MJ (2016): The Philani Mentor Mothers Intervention: Neighbourhood wide impact on child growth in Cape Town's peri-urban settlements. Vulnerable Child Youth Stud 11:221–222.
96. Maternal Philani: Child Health and Nutrition Trust (2024): Philani. Available at: http://www.philani.org.za/. Accessed May 22, 2024.
97. Le Roux IM, Tomlinson M, Harwood JM, O'Connor MJ, Worthman CM, Mbewu N, *et al.* (2013): Outcomes of home visits for pregnant mothers and their infants: A cluster randomized controlled trial. AIDS 27:1461–1471.
98. Le Roux IM, Rotheram-Borus MJ, Stein J, Tomlinson M (2014): The impact of paraprofessional home visitors on infants' growth and health at 18 months. Vulnerable Child Youth Stud 9:291–304.
99. Tomlinson M, Rotheram-Borus MJ, Harwood J, Le Roux IM, O'Connor M, Worthman C (2015): Community health workers can improve child growth of antenatally-depressed, South African mothers: A cluster randomized controlled trial. BMC Psychiatry 15:225.
100. Gordon S, Rotheram-Fuller E, Rezvan P, Stewart J, Christodoulou J, Tomlinson M (2021): Maternal depressed mood and child development over the first five years of life in South Africa. J Affect Disord 294:346–356.
101. Wessels J, Sherman G, Bamford L, Makua M, Ntloana M, Nuttall J, *et al.* (2020): The updated South African National Guideline for the Prevention of Mother to Child Transmission of Communicable Infections (2019). South Afr J HIV Med 21:1079.
102. Tomlinson M, Rotheram-Borus MJ, Le Roux IM, Youssef M, Nelson SH, Scheffler A, *et al.* (2016): Thirty-six-month outcomes of a generalist paraprofessional perinatal home visiting intervention in South Africa on maternal health and child health and development. Prev Sci 17:937–948.
103. Chun Tie Y, Birks M, Francis K (2019): Grounded theory research: A design framework for novice researchers. SAGE Open Med 7: 205031211882292.
104. Greene MC, Ventevogel P, Likindikoki SL, Bonz AG, Turner R, Rees S, *et al.* (2023): Why local concepts matter: Using cultural expressions of distress to explore the construct validity of research instruments to measure mental health problems among Congolese women in Nyarugusu refugee camp. Transcult Psychiatry 60:496–507.
105. De Bruin GP, Swartz L, Tomlinson M, Cooper PJ, Molteno C (2004): The factor structure of the Edinburgh Postnatal Depression Scale in a South African peri-urban settlement. S Afr J Psychol 34:113–121.
106. Rochat TJ, Tomlinson M, Newell M-L, Stein A (2013): Detection of antenatal depression in rural HIV-affected populations with short and ultrashort versions of the Edinburgh Postnatal Depression Scale (EPDS). Arch Womens Ment Health 16:401–410.
107. Seedat S, Stein DJ, Emsley RA (2000): Open trial of citalopram in adults with post-traumatic stress disorder. Int J Neuropsychopharmacol 3:135–140.
108. Tomlinson M, Hunt X, Rotheram-Borus MJ (2018): Diffusing and scaling evidence-based interventions: Eight lessons for early child development from the implementation of perinatal home visiting in South Africa. Ann N Y Acad Sci 1419:218–229.
109. Galatzer-Levy IR, Huang SH, Bonanno GA (2018): Trajectories of resilience and dysfunction following potential trauma: A review and statistical evaluation. Clin Psychol Rev 63:41–55.
110. Norris FH, Tracy M, Galea S (2009): Looking for resilience: Understanding the longitudinal trajectories of responses to stress. Soc Sci Med 68:2190–2198.
111. Halse M, Steinsbekk S, Bjørklund O, Hammar Å, Wichstrøm L (2024): Emotions or cognitions first? Longitudinal relations between executive functions and emotion regulation in childhood. Child Dev 95:1508–1521.
112. Lantrip C, Isquith PK, Koven NS, Welsh K, Roth RM (2016): Executive function and emotion regulation strategy use in adolescents. Appl Neuropsychol Child 5:50–55.
113. Simioni AR, Pine DS, Sato JR, Pan PM, Fonseca RP, Schafer J, *et al.* (2019): A cognitive development chart for school-age children and adolescents. medRxiv. https://doi.org/10.1101/19012963.
114. Bach DR, Schächinger H, Neuhoff JG, Esposito F, Di Salle FD, Lehmann C, *et al.* (2008): Rising sound intensity: An intrinsic warning cue activating the amygdala. Cereb Cortex 18:145–150.
115. Tottenham N, Hare TA, Casey BJ (2011): Behavioral assessment of emotion discrimination, emotion regulation, and cognitive control in childhood, adolescence, and adulthood. Front Psychol 2:39.
116. Elliott ML, Knodt AR, Ireland D, Morris ML, Poulton R, Ramrakha S, *et al.* (2020): What is the test–retest reliability of common task-functional MRI measures? New empirical evidence and a meta-analysis. Psychol Sci 31:792–806.
117. Kennedy JT, Harms MP, Korucuoglu O, Astafiev SV, Barch DM, Thompson WK, *et al.* (2022): Reliability and stability challenges in ABCD task fMRI data. Neuroimage 252:119046.
118. Sauder CL, Hajcak G, Angstadt M, Phan KL (2013): Test–retest reliability of amygdala response to emotional faces. Psychophysiology 50:1147–1156.
119. Gee DG, McEwen SC, Forsyth JK, Haut KM, Bearden CE, Addington J, *et al.* (2015): Reliability of an fMRI paradigm for emotional processing in a multisite longitudinal study. Hum Brain Mapp 36:2558–2579.
120. Cannon TD, Cao H, Mathalon DH, Gee DG, NAPLS consortium (2018): Reliability of an fMRI paradigm for emotional processing in a multisite longitudinal study: Clarification and implications for statistical power. Hum Brain Mapp 39:599–601.
121. Noble S, Scheinost D, Constable RT (2021): A guide to the measurement and interpretation of fMRI test–retest reliability. Curr Opin Behav Sci 40:27–32.
122. Lieberman MD, Eisenberger NI, Crockett MJ, Tom SM, Pfeifer JH, Way BM (2007): Putting feelings into words: Affect labeling disrupts

amygdala activity in response to affective stimuli. Psychol Sci 18:421–428.
123. Torre JB, Lieberman MD (2018): Putting feelings into words: Affect labeling as implicit emotion regulation. Emot Rev 10:116–124.
124. Tottenham N, Tanaka JW, Leon AC, McCarry T, Nurse M, Hare TA, *et al.* (2009): The NimStim set of facial expressions: Judgments from untrained research participants. Psychiatry Res 168:242–249.
125. Rowe K, Duta M, Demeyere N, Wagner RG, Pettifor A, Kahn K, *et al.* (2021): Validation of Oxford Cognitive Screen: Executive Function (OCS-EF), a tablet-based executive function assessment tool amongst adolescent females in rural South Africa. Int J Psychol 56:895–907.
126. Ochsner KN, Bunge SA, Gross JJ, Gabrieli JDE (2002): Rethinking feelings: An fMRI study of the cognitive regulation of emotion. J Cogn Neurosci 14:1215–1229.
127. Lang PJ, Bradley MM (2008): International Affective Picture System (IAPS): Affective Ratings of Pictures and Instruction Manual. Gainesville, FL: University of Florida.
128. Nestadt AE, Kantor K, Thomas KGF, Lipinska G (2023): A South African adaptation of the international affective picture system: The influence of socioeconomic status and education level on picture ratings. Behav Res Methods 55:3855–3871.
129. Casey BJ, Cannonier T, Conley MI, Cohen AO, Barch DM, Heitzeg MM, *et al.* (2018): The Adolescent Brain Cognitive Development (ABCD) study: Imaging acquisition across 21 sites. Dev Cogn Neurosci 32:43–54.
130. Smith SM, Beckmann CF, Andersson J, Auerbach EJ, Bijsterbosch J, Douaud G, *et al.* (2013): Resting-state fMRI in the human connectome project. Neuroimage 80:144–168.
131. Vijayakumar N, Whittle S, Yücel M, Dennison M, Simmons J, Allen NB (2014): Thinning of the lateral prefrontal cortex during adolescence predicts emotion regulation in females. Soc Cogn Affect Neurosci 9:1845–1854.
132. Ray RD, Zald DH (2012): Anatomical insights into the interaction of emotion and cognition in the prefrontal cortex. Neurosci Biobehav Rev 36:479–501.
133. Paus T (2010): Growth of white matter in the adolescent brain: Myelin or axon? Brain Cogn 72:26–35.
134. Lebel C, Deoni S (2018): The development of brain white matter microstructure. Neuroimage 182:207–218.
135. Alexander LM, Escalera J, Ai L, Andreotti C, Febre K, Mangone A, *et al.* (2017): An open resource for transdiagnostic research in pediatric mental health and learning disorders. Sci Data 4:170181.
136. Lee CS, Cohen SS, Hutchinson S, Tottenham N, Baldassano C (2024): Neural and verbal responses to attachment-schema narratives differ based on past and current caregiving experiences. bioRxiv https://doi.org/10.1101/2024.09.13.612953.
137. Vanderwal T, Eilbott J, Castellanos FX (2019): Movies in the magnet: Naturalistic paradigms in developmental functional neuroimaging. Dev Cogn Neurosci 36:100600.
138. Waites AB, Stanislavsky A, Abbott DF, Jackson GD (2005): Effect of prior cognitive state on resting state networks measured with functional connectivity. Hum Brain Mapp 24:59–68.
139. Son J, Ai L, Lim R, Xu T, Colcombe S, Franco AR, *et al.* (2020): Evaluating fMRI-based estimation of eye gaze during naturalistic viewing. Cereb Cortex 30:1171–1184.
140. White EJ, Demuth MJ, Wiglesworth A, Coser AD, Garrett BA, Kominsky TK, *et al.* (2023): Five recommendations for using large-scale publicly available data to advance health among American Indian peoples: The Adolescent Brain and Cognitive Development (ABCD) StudySM as an illustrative case. Neuropsychopharmacology 48:263–269.
141. Ellis BJ, Abrams LS, Masten AS, Sternberg RJ, Tottenham N, Frankenhuis WE (2022): Hidden talents in harsh environments. Dev Psychopathol 34:95–113.
142. Belsky J, Schlomer GL, Ellis BJ (2012): Beyond cumulative risk: Distinguishing harshness and unpredictability as determinants of parenting and early life history strategy. Dev Psychol 48:662–673.
143. McLaughlin KA, Sheridan MA, Lambert HK (2014): Childhood adversity and neural development: Deprivation and threat as distinct dimensions of early experience. Neurosci Biobehav Rev 47:578–591.
144. Van Dam NT, O'Connor D, Marcelle ET, Ho EJ, Cameron Craddock R, Tobe RH, *et al.* (2017): Data-driven phenotypic categorization for neurobiological analyses: Beyond DSM-5 labels. Biol Psychiatry 81:484–494.
145. Drysdale AT, Grosenick L, Downar J, Dunlop K, Mansouri F, Meng Y, *et al.* (2017): Resting-state connectivity biomarkers define neurophysiological subtypes of depression. Nat Med 23:28–38.
146. Hong S-J, Vogelstein JT, Gozzi A, Bernhardt BC, Yeo BTT, Milham MP, Di Martino A (2020): Toward neurosubtypes in autism. Biol Psychiatry 88:111–128.
147. Tang S, Sun N, Floris DL, Zhang X, Di Martino AD, Yeo BTT (2020): Reconciling dimensional and categorical models of autism heterogeneity: A brain connectomics and behavioral study. Biol Psychiatry 87:1071–1082.
148. Davidson RJ, Jackson DC, Kalin NH (2000): Emotion, plasticity, context, and regulation: Perspectives from affective neuroscience. Psychol Bull 126:890–909.
149. Lindquist KA, Wager TD, Kober H, Bliss-Moreau E, Barrett LF (2012): The brain basis of emotion: A meta-analytic review. Behav Brain Sci 35:121–143.
150. Risk BB, Murden RJ, Wu J, Nebel MB, Venkataraman A, Zhang Z, Qiu D (2021): Which multiband factor should you choose for your resting-state fMRI study? Neuroimage 234:117965.
151. Wall MB (2023): Multiband acquisition sequences for fMRI: Proceed with caution. Aperture Neuro 3.
152. Donald KA, Hoogenhout M, du Plooy CP, Wedderburn CJ, Nhapi RT, Barnett W, *et al.* (2018): Drakenstein Child Health Study (DCHS): Investigating determinants of early child development and cognition. BMJ Paediatr Open 2:e000282.
153. Gratton C, Nelson SM, Gordon EM (2022): Brain-behavior correlations: Two paths toward reliability. Neuron 110:1446–1449.
154. Marek S, Tervo-Clemmens B, Calabro FJ, Montez DF, Kay BP, Hatoum AS, *et al.* (2022): Reproducible brain-wide association studies require thousands of individuals. Nature 603:654–660.
155. Rosenberg MD, Finn ES (2022): How to establish robust brain–behavior relationships without thousands of individuals. Nat Neurosci 25:835–837.
156. Spisak T, Bingel U, Wager TD (2023): Multivariate BWAS can be replicable with moderate sample sizes. Nature 615:E4–E7.
157. Tervo-Clemmens B, Marek S, Chauvin RJ, Van AN, Kay BP, Laumann TO, *et al.* (2023): Reply to: Multivariate BWAS can be replicable with moderate sample sizes. Nature 615:E8–E12.
158. Swartz JR, Williamson DE, Hariri AR (2015): Developmental change in amygdala reactivity during adolescence: Effects of family history of depression and stressful life events. Am J Psychiatry 172:276–283.
159. VanTieghem M, Korom M, Flannery J, Choy T, Caldera C, Humphreys KL, *et al.* (2021): Longitudinal changes in amygdala, hippocampus and cortisol development following early caregiving adversity. Dev Cogn Neurosci 48:100916.
160. Brandmaier AM, Lindenberger U, McCormick EM (2024): Optimal two-time point longitudinal models for estimating individual-level change: Asymptotic insights and practical implications. Dev Cogn Neurosci 70:101450.
161. Diggle P, Kenward MG (1994): Informative Drop-Out in longitudinal data analysis. J R Stat Soc C 43:49–73.
162. Daniels MJ, Hogan JW (2008): Missing Data in Longitudinal Studies: Strategies for Bayesian Modeling and Sensitivity Analysis. New York, NY: Chapman & Hall/CRC.
163. Haelewaters D, Hofmann TA, Romero-Olivares AL (2021): Ten simple rules for Global North researchers to stop perpetuating helicopter research in the Global South. PLoS Comput Biol 17:e1009277.
164. Morton B, Vercueil A, Masekela R, Heinz E, Reimer L, Saleh S, *et al.* (2022): Consensus statement on measures to promote equitable authorship in the publication of research from international partnerships. Anaesthesia 77:264–276.
165. Tomlinson M, Swartz L, Fitzgerald HE (2006): International collaboration in infant mental health: Pitfalls, challenge, and a way forward. Infant Ment Health J 27:529–531.
166. Marovah T, Mutanga O (2024): Decolonising participatory research: Can Ubuntu philosophy contribute something? Int J Soc Res Methodol 27:501–516.
167. Khan T, Abimbola S, Kyobutungi C, Pai M (2022): How we classify countries and people-and why it matters. BMJ Glob Health 7:e009704.