Thinking about effects of the environment on the developing mind and brain: the ABCD Study

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I. EXTENDED ABSTRACT

In late 2015, eight institutes and centers of the National Institutes of Health awarded funding to support a landmark nationwide study of the adolescent mind and brain called the Adolescent Brain Cognitive Development (ABCD) study. A national consortium of over 50 lead investigators and over 150 research staff members are collaborating to conduct this study. The Coordinating Center and the Data Analysis and Informatics Center are based at UC San Diego, and 19 institutions across the US will host research sites where participants will be studied. The ABCD Consortium aims to study 10,000 youth, enrolling them at age 9-10 and following them for 10 years, creating an unprecedented data resource for scientists to share for studies of the adolescent brain. Methods the study will employ include:

- School-based recruitment (at 19 sites) of a demographically representative national sample
- Multimodal neuroimaging
- Extensive health and behavioral assessment
- Additional assessments of activities and environmental factors.
- Sampling and storage of biospecimens for: genetics, epigenetics, hormones, substance use
- Novel wireless, web based, and nanoengineered assessment technologies

Some of the primary objectives of the study are to:

- Identify individual developmental trajectories (e.g., of brain, cognitive, and emotional development, academic progress), and the factors that can impact them.
- Develop national standards of normal brain development in youth.
- Examine the roles of genetic vs. environmental factors on development, (e.g., by analysis of data from 800 twin pairs who will be recruited as part of the cohort).
- Study the effects of physical activity, sleep, as well as sports and other injuries on brain development and other outcomes.
- Study the onset and progression of mental disorders, factors that influence course or severity; and the relationship between mental disorders and substance use.
- Determine how exposure to various levels and patterns of alcohol, nicotine, caffeine, cannabis, and other substances affect developmental outcomes and vice versa.

Neuroimaging reveals ongoing biological development of the human brain throughout childhood into early adulthood. Adolescence is also a time of significant ongoing development of cognitive/intellectual and social/emotional functions. This is an important, and often pivotal, time in the lives of young people. For many it is a time of dramatically increasing knowledge and skill - a time when youth find their intellectual and creative voices, if you will, and form strong bonds with friends and family that will support them throughout their lives. In other words, many emerge from adolescence engaged, independent, and resilient to life's challenges. Unfortunately, though, this is also a period during which the first symptoms of many serious problems appear, such as depression, anxiety, and psychosis – and some youth become disengaged, academically and socially. It is also a time of heightened vulnerability because, though it is typical, and healthy, for adolescents to begin to take more risks at this time in life, and to become more exploratory and curious, risky behavior can lead to problems for some youth – including serious injuries and growing dependence on self-destructive activities and substances. Previous studies have documented genetic, environmental, and behavioral factors that are correlated with positive or negative outcomes in adolescents. However, there is continuing uncertainty about the degree to which these correlations reflect causal effects of genes or specific environmental factors on these outcomes. The development of effective and personalized interventions to prevent or reduce adverse behavioral-health and neuropsychiatric conditions will rely upon accurate models of the effects of genetic and environmental factors, and interactions between these, in the emergence of these conditions. Unfortunately most previous studies focusing on these questions have been limited in scope, lacked statistical power to estimate multiple parameters in complex dynamic models, and have employed diverse methods that make it difficult to compare results across studies. The ABCD initiative hopes to overcome some of these limitations.

Advantages, Opportunities, and Challenges for ABCD:

- The large cohort size (10,000), duration (10 years), and high-dimensional datasets (petabytes of imaging, genome sequencing, behavioral-health data, etc) of ABCD create unique technical, informatics, and data science challenges but also great opportunities for discovery science.
- ABCD provides the resources to create a virtually unique, big-data infrastructure that can be leveraged in the future for large, multi-site behavioral/health, imaging, and genomics studies.
- ABCD could be dramatically enhanced by the addition of novel wireless technologies for passive, more ecologically valid, assessments of biomarkers, behavior, and environments.
- ABCD provides an opportunity to pilot and quickly validate novel assessment methods through academic collaborations and academic-industry partnerships within this high-profile study.

Focus on Environmental Effects:

ABCD represents a transformational approach, akin to the precision medicine approach, sometimes referred to as "population neuroscience". Here a carefully constructed and well curated, high-dimensional dataset is collected using an open-science model. This means that participants agree to broad data-sharing across the scientific community and including industry partners. One of the greatest challenges of a study like ABCD, however, is to decide what kinds of data to collect. From the ever growing biomedical toolkit, a feasible set of biomarkers has to be selected, and decisions have to be made about the best way to sample an even larger and more complex domain: human behavior. But probably the most difficult decision is to decide which aspects of the environments of our participants are impacting their development, for better or worse, and to measure them. In this talk I will describe the ABCD Study and the paradigm that it represents, and discuss the focus on environmental factors. I hope to learn from the attendees how they think learning and brain development might be impacted by the built environment, and how we might better define such effects – and the mechanisms by which they may be mediated - in our models.

2. AUTHOR BIOS

Dr. Jernigan is Co-Director of the Coordinating Center for the ABCD Study, and Professor of Cognitive Science, Psychiatry, and Radiology at the University of California, San Diego. For over 30 years, she has studied the human brain using noninvasive imaging. This work has focused on brain development and agining, neurodevelopmental disorders, neuropsychiatric and substance use disorders, and neurodegenerative disorders. For the last decade, her central research interest has been the developing human mind and brain, with a focus on the dynamic neurodevelopmental processes that give rise to human individuality - and on how these processes are impacted by experience, substance exposure, prenatal factors, and other risks. She has pursued this interest in collaboration with an interdisciplinary team as Director of the Center for Human Development at the University of California, San Diego. She also directs the Coordinating Center for the Pediatric Imaging Neurocognition, and Genetics (PING) Project - a publicly shared imaging genomics data resource with imaging, neurocognition, and whole genome genotyping data from over 1500 children aged 3 to 20 years. She is a member of the Council of Councils for the National Institutes of Health, and serves on the scientific advisory boards of sevveral research organizations in the United States and Europe.