



Developing Executive Control, Obesity Risk, and Behavioral Health Problems: A Pilot fMRI Study



Timothy D. Nelson¹, Cary R. Savage¹, Maital Neta¹, Jennifer Mize Nelson¹, W. Alex Mason², and Kimberly Andrews Espy^{3,1}

¹University of Nebraska-Lincoln; ²Boys Town Child and Family Translational Research Center; ³University of Texas at San Antonio



PURPOSE

To conduct a pilot study to: 1) demonstrate the *feasibility* of specific fMRI paradigms with relevance for obesity and behavioral health; 2) collect data that will facilitate *substantive preliminary analyses* of links between executive control, neural mechanisms, and clinical outcomes.

BACKGROUND

- Obesity and behavioral health problems are among the most prevalent and costly conditions in the US today, with each posing critical challenges for the health and productivity of the nation.¹⁻⁴
- Deficits in **executive control (EC)**, a critical set of cognitive abilities for directing attention and behavior, have been proposed as modifiable contributors to *both* obesity risk and behavioral health problems;⁵⁻⁹ however, the role of EC deficits in the development of these problems is not well-understood.
- There is a critical need for studies that elucidate the EC-obesity and EC-behavioral health relationships within rigorous longitudinal designs incorporating neuroimaging techniques to explore brain-behavior mechanisms within a rich developmental and environmental context.
- Our research team has a unique opportunity to conduct such a study, leveraging our existing longitudinal sample (N=312), current NIH funding (R01DK116693, R01DA041738), and fMRI resources available through the UNL Center for Brain, Biology and Behavior.

CURRENT PROJECT

Existing longitudinal sample: Recruited in preschool, followed through elementary school, and funding in place to follow through adolescence, with repeated measures of EC, BMI, mental health, substance use, and obesity-relevant health behaviors (i.e., diet, physical activity sleep).
New pilot study: Will leverage existing data and add fMRI protocol.

AIMS

- Aim 1. Establish the feasibility of fMRI paradigms relevant to obesity and behavioral health**
- Aim 2. Explore preliminary associations between individual differences in brain function and EC development, weight status, obesity-relevant behaviors, mental health problems, and substance use**
- Aim 3. Explore preliminary associations between neural connectivity, EC, and clinical outcomes**

APPROACH

Participants (N=80 total) will complete the study within the 3T Siemens Skyra.

- New sample of 18 year-olds to pilot protocol (*n*=50)
- Subset of existing longitudinal sample at age 18 (*n*=30)



Previously Collected Data from Longitudinal Sample

Measures	Preschool	Elementary School	Adolescence
EC	X	X	X
BMI		X	X
Mental Health	X	X	X
Health Behaviors			X

Note: The new sample will complete assessments of EC, BMI, mental health, and key health behaviors that parallel adolescent measures in the existing sample to facilitate analysis of concurrent associations.

New Data to be Collected

Food Cognitive Reappraisal Task

- Adapted from Yokum & Stice¹⁰
- Present appetizing but unhealthy food images in scanner
- Instructions to either 1) imagine eating the food OR 2) regulate (decrease) appetitive response by thinking about the benefits of not eating the food.
- Behavioral ratings of desire to eat the food



Emotion Regulation Task

- Used in Neta R01MH111640
- Present aversive and arousing images from the IAPS
- Instructions to either 1) "Look" OR 2) "Decrease" negative emotional response
- Training session with strategies

Resting State fMRI

- 15 minutes
- Lie still and look at central fixation cross
- Graph theory for characterizing complex brain connectivity patterns

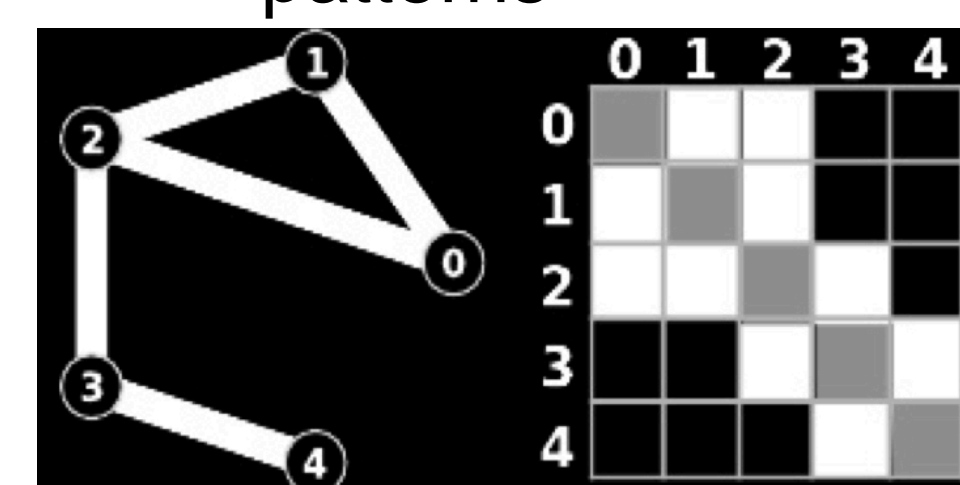


Figure: A graph theory model showing 5 brain regions, their connections, and a matrix representing connectivity.

NEXT STEPS

The pilot data collected in this study will provide evidence of feasibility for fMRI paradigms and preliminary associations with key constructs of interest (i.e., EC, clinical outcomes).

These data will serve as critical preliminary studies for multiple NIH R01 proposals using the *entire existing longitudinal sample*.

- **NIDDK R01 proposal:** Neural mechanisms linking EC development and obesity risk/obesogenic behavior.
- **NIMH/NIDA R01 proposal:** Neural mechanisms linking EC development and behavioral health problems.

Potential Implications for Intervention:

- Identify the most relevant neural targets for intervention and inform development of treatments to address these issues.
- Identify neural biomarkers of health risk leading to personalized medicine interventions.

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References

1. Ogden CL, Carroll MD, Lawman HG, Fryar CD, Kruszon-Moran D, Kit BK, Flegal KM. Trends in Obesity Prevalence Among Children and Adolescents in the United States, 1988-1994 Through 2013-2014. *JAMA*. 2016;315(21):2292-2299. doi:10.1001/jama.2016.6361.
2. Flegal KM, Kruszon-Moran D, Carroll MD, Fryar CD, Ogden CL. Trends in Obesity Among Adults in the United States, 2005 to 2014. *JAMA*. 2016;315(21):2284-2291. doi:10.1001/jama.2016.6458.
3. National Institute of Mental Health (NIMH). Any Mental Illness (AMI) Among U.S. Adults. <https://www.nimh.nih.gov/health/statistics/prevalence/any-mental-illness-ami-among-us-adults.shtml>. Accessed January 11, 2018.
4. National Institute on Drug Abuse (NIDA). Monitoring the Future 2017 Survey Results. <https://www.drugabuse.gov/related-topics/trends-statistics/infographics/monitoring-future-2017-survey-results>. Published December 12, 2017. Accessed January 11, 2018.
5. Espy, KA. Monographs of the Society for Research in Child Development - Volume 81 The Changing Nature of Executive Control in Preschool; by Kimberly Andrews Espy - December 2016 - Wiley Online Library. <http://onlinelibrary.wiley.com/doi/10.1111/mono.v81.4/issuetoc>. Accessed May 12, 2017.
6. Hall PA, Marteau TM. Executive function in the context of chronic disease prevention: Theory, research and practice. *Prev Med*. 2014;68:44-50. doi:10.1016/j.ypmed.2014.07.008.
7. Nelson TD, James TD, Hankey M, Nelson JM, Lundahl A, Espy KA. Early executive control and risk for overweight and obesity in elementary school. *Child Neuropsychol J Norm Abnorm Dev Child Adolesc*. 2017;23(8):994-1002. doi:10.1080/09297049.2016.1183606.
8. Nelson, TD, Nelson, JM, Mason, WA, Kozikowski, CB, Tomaso, CC, Espy, KA. Executive control and pediatric health: Toward a conceptual framework. *J Pediatr Psychol*. under review.
9. Nelson TD, Kidwell KM, Nelson JM, Tomaso CC, Hankey M, Espy KA. Preschool executive control and internalizing symptoms in elementary school. *J Abnorm Child Psychol*. in press.
10. Yokum S, Stice E. Cognitive regulation of food craving: Effects of three cognitive reappraisal strategies on neural response to palatable foods. *Int J Obes*. 2013;37(12):1565-1570. doi:10.1038/ijo.2013.39.