ENVIRONMENTAL-RISK (E-RISK) LONGITUDINAL TWIN STUDY
CONCEPT PAPER FORM

Proposing Author: Aaron Reuben

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Sponsoring Investigator (if the proposing author is a student, a post-doc or a colleague): Candice Odgers, Temi Moffitt, Avshalom Caspi

Proposed co-authors: Candice Odgers, Terrie Moffitt, Avshalom Caspi, Dan Belsky, Helen Fisher, Louise Arseneault

Provisional Paper Title: Exposure to green space and children's physical, psychological and cognitive health

Date: 25/05/17

Objective of the study and its significance:

E.O. Wilson's biophilia hypothesis (Wilson, 1984) posits that humans have an innate "urge to affiliate" with nature and that exposure to green, vegetated spaces will promote human health and well-being. Following a report in *Science* that hospital patients recover more quickly when placed in a room with a view of trees rather than a view of a brick wall (Ulrich, 1984), researchers in a variety of disciplines have evaluated the influence of exposure to nature on health and well-being. Recent experimental studies suggest that exposure to nature may reduce stress, attentional fatigue, anger, and anxiety in healthy individuals (Richardson et al., 2012) and improve affect and cognitive performance in clinical populations, including children with attention deficits (Taylor & Kuo, 2009; Taylor & Kuo, 2011; Van den Berg & van den Berg, 2010), adults with depression (Berman et al., 2012), and adults with profound mental retardation (Cuvo, May, & Post, 2001).

In particular, such evidence from experimental studies suggests that exposure to green space and ambient greenery may promote physical health and psychological and cognitive maturation in developing children. Findings from one recent yearlong observational study of Spanish school children, published in *PNAS*, has added evidence to this suggestion. The study authors report that children exposed to more greenery at home and school developed stronger working memory and attentional abilities than their less exposed peers (Dadvand et al., 2015). The link between childhood exposure to greenery and physical, psychological, and cognitive outcomes has not yet been fully epidemiologically evaluated, and there is a need for additional, well-designed observational studies of this relationship (Bowler et al., 2010; Collado & Staats, 2016). We propose to use recently-derived measures of green space and

greenery surrounding E-Risk Study children's homes and schools to evaluate the relationship between children's exposure to greenery and physical, psychological, and cognitive outcomes. We will describe the Study children's green space exposure using: 1) a novel Google Maps-based count of green spaces near Study member's homes, and 2) a well-validated satellite-derived measure of the density of green vegetation surrounding Study member homes and schools, the normalized difference vegetation index (NDVI), which provides 5x5m resolution information on ambient "greenness" based on land-surface reflectance of visible and near-infrared light. We will then relate these measures to physical, psychological, and cognitive outcomes and use careful multivariate controls to determine whether greenery is independently associated with child outcomes after considering possible confounding factors. If robust associations are found, then we will test models that evaluate the potential mechanisms of effect using data on air pollution exposures, Study member physical activity, and reports on neighborhood quality.*

*Note on mechanisms of effect: The mechanism for greenspace physical, psychological, and cognitive influence are not yet conclusively determined. Three plausible mechanisms have been proposed (Groenewegen et al., 2006): 1) Stressor Reduction, whereby green spaces reduce known stressors, such as air and noise pollution; 2) Cognitive Restoration, whereby natural spaces depress physiological arousal and allow for restoration of attentional resources through evolutionarily-determined reactions (similar to, but in the opposite direction from, innate reactions to snakes or spiders, for example); and 3) Unique Behaviors, whereby green spaces allow and encourage activities that reduce stress and promote physical health, including social interactions, self-regulatory behavior, and physical activity.

Significance of the Study (for theory, research methods or clinical practice):

The results of this research will advance our understanding of whether key environmental factors influence child mental health and development. Green space represents a potentially cost-effective intervention for improving poor quality environments and for simultaneously fostering improved physical, cognitive, and emotional health in children. Better knowledge of developmental opportunity windows and potential benefits could inform policy decisions about school citing, school programing, and the provision of public environmental goods. Many school districts are currently debating the benefits of increased outdoor education, for example, with other communities deciding whether to allocate resources to the development or maintenance of public parks.

Statistical analyses:

Our primary data analysis will follow the following sequence:

1. Produce a composite "childhood exposure to greenery" score by averaging normalized difference vegetation index (NDVI) scores measured at age 5, 7, 10 and 12 to provide a description of E-Risk children's average exposure to green vegetation up to age 12.

2. Determine the relationship between greenery measures (childhood NDVI and the number of green

spaces around Study member homes at age 12) and physical, psychological, and cognitive outcomes using bivariate correlation.

3. Determine the relationship between greenery measures and neighborhood factors (the four d's: deprived, dilapidated, dirty, and disconnected) using bivariate correlation.

4. Determine whether greenery is independently associated with physical, psychological, and cognitive outcomes by regressing greenery measures on our outcomes while controlling for correlated neighborhood and family factors using multivariate linear regression.

5. Determine whether: (1) found associations are particularly pronounced for urban-dwelling children and (2) whether ambient air pollution, Study member physical activity, or specific neighborhood features mediate any of the identified associations. For the air pollution analysis we will consider only the urban-dwelling cohort members for whom pollution measures are available.

For this step we will use ordinary least-squares regression to estimate mediator and multiple-mediator models.

Variables Needed at Which Ages (names and labels):

Study: E-Risk Study & Community Strength Project

*please see attached list of variables requested versus on-hand from the Community Strengths Project (e.g., NDVI scores)

Predictors:
Normalized difference vegetation index (NDVI) at age 5, 7, 10, 12
Number of green spaces at 12 from Google earth aerial count (NumGreen)

Primary outcomes, <u>at age 18</u>:
IQ, self control, and ADHD
Pro-rated IQ and subtests (IQ, Matrix Reasoning, Information, Digit Symbol Coding)
Big 5 personality – informant and self-reported
ADHD scales
Highest educational achievement

Physical health
Asthma screener
Reports of problems with asthma
BMI, waist-hip ratio
Sleep quality

Wellness / satisfaction
Life satisfaction

Secondary outcomes, <u>at age 10 & 12</u>:
Pro-rated childhood IQ, with component tests at age 12
Continuity of asthma / had asthma - age 5 & 10
Hyperactivity scales at age 12
Total mum and teacher ADHD scales

Covariates:

Neighborhood factors:

Urbanicity (Community Strengths / SCL variable with three levels, rural, suburban, urban)
Belsky et al (in preparation) 4 D's: deprived, dilapidated, dirty, disconnected neighborhoods.
ACORN category, age 5, 7, 10, 12

Family factors:

Family SES
State of the home (homec12)

Mediators:

Air pollution: NO2, PM2.5, O3
Physical activity (On the job / leisure / overall activity)

References cited:

Bowler, D. E., Buyung-Ali, L. M., Knight, T. M., & Pullin, A. S. (2010). A systematic review of evidence for the added benefits to health of exposure to natural environments. *BMC Public Health*, 10, 456.

Berman M. G., Kross E., Krpan K. M., Askren M. K., Burson A., Deldin P. J., et al. (2012). Interacting with nature improves cognition and affect for individuals with depression. *Journal of Affective Disorders*, 140: 300–305.

Collado, S., & Staats, H. (2016). Contact with Nature and Children's Restorative Experiences: An Eye to the Future. *Frontiers in Psychology*, 7: 1885.

Cuvo AJ, May ME, Post TM: Effects of living room, Snoezelen room, and outdoor activities on stereotypic behavior and engagement by adults with profound mental retardation. *Review of Developmental Disabilities*. 2001, 22: 183-204.

Dadvand, P., et al. (2015). Green spaces and cognitive development in primary schoolchildren. *PNAS*, 112(26), 7937–7942.

Groenewegen, P.P. et al. (2006). Vitamin G: effects of green space on health, well-being, and social safety. *BMC Public Healt*h, 6:149.

Richardson, E. A., Mitchell, R., Hartig, T., de Vries, S., Astell-Burt, T., & Frumkin, H. (2012). Green cities and health: A question of scale? *Journal of Epidemiology and Community Health*, 66(2): 160-165.

Ulrich, R.S. (1984) View through a window may influence recovery from surgery. *Science*, 224: 42-423.

Taylor, A. F., & Kuo, F. E. (2009). Children with attention deficits concentrate better after walk in the park. *Journal of Attention Disorders*, 12(5):402-409.
Taylor A.F., & Kuo F.E. (2011). Could exposure to everyday green spaces help treat ADHD? Evidence from children's play settings. *Applied Psycholo*gy 3, 281–303.

Van den Berg A. E., Van den Berg C. G. (2011). A comparison of children with ADHD in a natural and built setting. Child Care Health Dev. 37, 430–439.

Data Security Agreement

Provisional Paper Title	Exposure to greenery and children's physical, psychological and cognitive health
Proposing Author	Aaron Reuben
Today's Date	25/05/17

Please keep one copy for your records
(Please initial your agreement)

__AR_ I am current on Human Subjects Training (CITI (www.citiprogram.org) or training in human subject protection through my post or courses.

__AR_ My project is covered by Duke or King's IRB OR I have /will obtain IRB approval from my home institution.

__AR_ I will treat all data as "restricted" and store in a secure fashion.

__AR_ I will not share the data with anyone, including students or other collaborators not specifically listed on this concept paper.

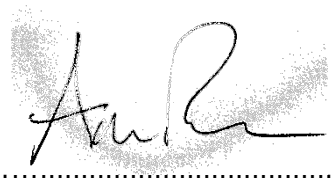
__AR_ I will not post data online or submit the data file to a journal for them to post.
Some journals are now requesting the data file as part of the manuscript submission process. The E-Risk Study cannot be shared because the Study Members have not given informed consent for unrestricted open access. Speak to Terrie or Avshalom for strategies for dealing with data sharing requests from Journals.

__AR_ Before submitting my paper to a journal, I will submit my draft manuscript and scripts for data checking, and my draft manuscript for co-author mock review, allowing three weeks.

__AR_ I will submit analysis scripts and new variable documentation to project data manager after manuscript gets accepted for publication.

__AR_ I will return all data files to the Data Manager after the project is complete. Collaborators and graduates of DPPP may not take a data file away from the DPPP office. The data remains the property of the Study and cannot be used for further analyses without express, written permission.

__AR_I will ensure geographical location information, including postcodes or geographical coordinates for the E-Risk study member's homes or schools, is <u>never</u> combined or stored with any other E-Risk data (family or twin-level data)



Signature: ……

CONCEPT PAPER RESPONSE FORM

A. To be completed by the proposing author

Proposing Author:

X☐ I have read the E-Risk data-sharing policy guidelines and agree to follow them

Provisional Paper Title: Exposure to greenery and children's physical, psychological and cognitive health

Potential co-authors: Candice Odgers, Terrie Moffitt, Avshalom Caspi, Dan Belsky, Helen Fisher, Louise Arseneault

Potential Journals: General science or pediatrics journal

Intended Submission Date (month/year): December / 2017

Please keep one copy for your records and return one to Louise (louise.arseneault@kcl.ac.uk)

B. To be completed by potential co-authors:

☐ Approved ☐ Not Approved ☐ Let's discuss, I have concerns

Comments:

Please check your contribution(s) for authorship:

☐ Conceptualizing and designing the longitudinal study

☐ Conceptualizing and collecting one or more variables

☐ Data collection

☐ Conceptualizing and designing this specific paper project

☐ Statistical analyses

☐ Writing

☐ Reviewing manuscript drafts

☐ Final approval before submission for publication

☐ Acknowledgment only, I will not be a co-author

Signature: .....

Variables for the E-Risk greenspace project

Needed from Tim and the E-Risk Data Archive:
Measures where the variable names are unknown

Demographics and identifiers

atwinid
familyid
sampsex
zygosity
rorderp5

Age 18 Measures

Iqe18 – pro-rated IQ at age 18
infe_ss18 – information test age 18
mre_ss18 – matrix reasoning test age 18
dsce_ss18 – digit symbol coding test age 18

educachve18 - Highest educational achievement (based on QCF) - P18 - Elder

bmie18 - BMI age 18
waisthipe18 - Waist Hip Ratio - P18 – Elder

Big 5 personality – informant and self-reported – age 18
ADHD scales – age 18
Asthma screener – age 18
Reports of problems with asthma - 18
Sleep quality scales – 18
Life satisfaction – 18
Physical activity (On the job / leisure / overall) - 18

Age 12 Measures

iqe12 – pro-rated IQ at age 12
infe_ss12 – information test age 12
mre_ss12 – matrix reasoning test age 12
dse_ss12 – digit span test age 12

totadde12 - Total Mum & Teacher ADHD Scale - Elder twin
homec12 - State of the home at age 12

Age 5-10 Measures

Childhood asthma
HadAsthmaE5
HadAsthmaE10
asthmaE510

Family SES
seswq35 - Family SES

Additional Variables:

Green Space
NDVIhome5 - Normalized difference vegetation index at age 5 (Home)
NDVIhome7
NDVIhome10
NDVIhome12
NDVIschool5 - Normalized difference vegetation index at age 5 (School)
NDVIschool7

NumGreen - Number of green spaces at 12 from Google earth aerial count
PerGreen - Percentage of green space from satellite imagery - .5 mile radius age 12

Urbanicity
SCIIurban3 - urbanicity (Community Strengths variable)
ph5urb_cat3 - 3-level ONS age-5 urbanicity. 3=major/minor conurbation, 2=urban cities and town
ph7urb_cat3
ph10urb_cat3
ph12urb_cat3

PopDensity - Number of people in the .5 mile radius - age 12 address

Neighborhood SES and characteristics

P5CACORNCategory - Acorn Category at Age 5
P7CACORNCategory - Acorn Category at Age 7
P10CACORNCategory - Acorn Category at Age 10
P12CACORNCategory - Acorn Category at Age 12

Belsky et al: 4 D's: deprived, dilapidated, dirty, disconnected neighborhoods.
[**ecorisk, zdeprived, zdangerous, zdirty, zdisorg**]

Air pollution: NO2, PM2.5, O3 [request from Fisher]