Adolescent Responses to Varying Environments in Virtual Reality Simulations

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Study Protocol

This study is a randomized experiment of the influence of different virtual neighborhoods on emotion and stress reactivity in adolescents and to determine if neighborhood exposures and chronic stress moderate the response to virtual neighborhood conditions. It was approved by the University of Southern California Institutional Review Board.

Enrollment inclusion/exclusion criteria. In order to be eligible for the study youth must be (a) age 14-17, (b) English-speaking, (c) able to use and manipulate a joystick/controller and provide physical and physiological measurements, (d) not pregnant, by self-report, (e) in good physical and mental health, with no self-reported history of hypertension, cardiovascular disease (CVD) or CVD treatment (with associated medication list indicative of treatments that result in exclusion), and (f) have hair at least 1cm in length based on self-report to be able to provide a hair sample.

Informed consent. After recruitment, the consent and assent process was completed, with forms completed securely electronically. We first explained the study to the parents/guardians and adolescent, and if they agreed to participate, parents/guardians provided electronic written consent online. The adolescent completed a brief eligibility screen, and if eligible subsequently provided electronic written assent online.

Pre-session questionnaires. Prior to the study session, youth participants and their primary caregiver were each invited to complete a set of questionnaires using a secure online system, REDCap. If not completed prior to the session, youth first completed these questionnaires during the study session.

Study Session Procedures. Each participant completed one single study session, with no follow-up. At the study session, participants completed additional questionnaires, cognitive tasks, provided a hair sample for analysis of cortisol concentration, and completed measures of height and weight. Participants were then oriented to the virtual reality (VR) task and learned how to navigate in VR. Subsequently participants watched a nature video for approximately 20 minutes to establish a baseline for reactivity assessment. Next, participants navigated the VR neighborhood condition they were randomly assigned to, using a head mounted device. After the VR task, participants completed post-task measures and additional questionnaires, and then a 30-minute recovery period watching a nature video.

Virtual Neighborhood Environment and Task. Two virtual neighborhoods were designed to represent disadvantage and affluence, based on empirical literature highlighting characteristics such as building and business types, signals of social processes, the level of upkeep or deterioration, presence of amenities, green space, and more. They contain background city noise and are populated by human avatars that are walking, standing and conversing. The avatars are held constant across the two neighborhoods, reflect the overall demographics of the U.S., and are balanced to ensure that avatar type (e.g. professional, casual, etc.) is not biased by race/ethnicity or gender. As part of the session participants first learn to navigate the VR environment in a desktop environment. Participants then entered a VR neighborhood, to which they were randomly assigned, that was presented using a head mounted device. Participants are asked to navigate and explore a set route and collect a series of gems that are placed throughout the route. Routes were expected to take approximately 10-15 minutes to navigate on average, though participants time varied as they are allowed to go at their own speed.

Measures: Primary Outcomes

- Emotion: After the VR session, participants rated the emotions they felt while they were in the VR neighborhoods. They rated how strongly they felt positive emotions, such as amusement

and contentment; negative emotions such as fear, disgust, sadness, and anger; complex emotions such as compassion; as well as affect and arousal/alertness.
- HPA-axis function: Cortisol. Participants gave saliva samples by passive drool for assay of salivary cortisol. Samples were provided after baseline, after completion of the VR neighborhood task, after questionnaire completion, after the first 15 minutes of the video during the recovery period, and after the final 15 minutes of the video during the recovery period.
- Psychophysiological reactivity. Electrocardiograph and impedance cardiography signals were recorded continuously, using a standard electrode configuration, allowing for measures such as heart rate variability, pre-ejection period, and cardiac output. Blood pressure was also recorded regularly using standard equipment to support integration with other measures. Recording began just prior to VR orientation to allow time to get used to it. Measures were summarized during baseline, completion of the VR neighborhood task, questionnaire completion, the first 15 minutes of the video during the recovery period, and the final 15 minutes of the video during the recovery period.

Additional post-task measures: Participants completed a brief survey regarding their perceptions and observations of the VR neighborhood, and any feelings of discomfort during VR. In addition, participants rated a set of avatars from the virtual environments on their perception of the avatar's character traits.

Survey measures. Youth and parents completed a demographic questionnaire, and parents completed a residential history for the youth that are geocoded and linked to US census tracts and other sources of neighborhood information. Youth also completed a questionnaire concerning various factors that can influence the quality of saliva and hair samples for cortisol assays. Parents and youth both complete surveys concerning their neighborhood characteristics and pandemic-related stressors. Youth completed surveys to assess current and lifetime exposure to acute and chronic stress, perceived stress and discrimination. Other youth surveys concerned perceptions of parenting, school characteristics, experiences with video games, coping strategies, emotion regulation, health and well-being, and parents and youth report on youth socioemotional functioning.

Additional measures: Executive functions and fluid cognition were assessed using a set of tasks from the NIH Toolbox. Cortisol concentrations in hair will be utilized as a measure of chronic physiological stress, and thus a small hair sample was provided.