Graduate Research Plan

Unlocking success: Neurobiological correlates of grit in adolescents.

Intellectual Merit: During adolescence, the brain undergoes extensive structural and functional development. Specifically, adolescence is characterized by differential development of reward circuitry and cognitive control systems such that cognitive control regions are relatively underdeveloped compared to reward processing regions.[1] Although adolescents are able to reason about risky decision making, they are also vulnerable to social influences. In emotionally salient conditions (e.g., the presence of peers), the maturity of adolescent reward circuitry compared to the less mature prefrontal control system appears to exacerbate risk taking that results in negative outcomes (negative risk taking).[2] However, adolescent differential brain development and vulnerability to social influences may also lead to greater recruitment of cognitive control processes used to engage in risk taking that results in positive outcomes (positive risk taking), like "grit". Grit is defined as the determined pursuit of a superordinate goal in the face of failure.[3] Higher levels of grit are associated, over and above IQ, with objectively measured successes (educational attainment, GPA)[4] and greater well-being.[5] Neurobiological investigations of behavior can corroborate and challenge our assumptions regarding the neural mechanisms underlying motivational, cognitive, and affective components of risk taking. Despite the large body of research investigating negative risk taking, there is a gap in knowledge regarding the neural mechanisms of positive risk taking and whether these mechanisms differ from negative risk taking.

Novelty: The brain-based mechanisms of positive risk taking remain unknown, and the only empirical investigations of grit are through self-report. This study will address gaps in our understanding of the association between negative and positive risk taking in adolescence, provide the first ecologically valid experimental manipulation of grit, and will determine how grit behavior relates to external measures of success (e.g., GPA).

Experimental Design: Participants will consist of 60 adolescents (14-18 yrs).[6] Participants will undergo an MRI desensitization procedure in the Galván Lab mock scanner before completing a novel computer task in an fMRI scanner.

The fMRI task, the "Grit Task", is a money-earning paradigm I created that builds on extensive delay of gratification and delay discounting literature. There are two types of trials, each worth a fixed amount, lower-value trials (LVTs) and higher-value trials (HVTs). Participants must choose to perform either LVTs or HVTs before beginning (path selection). Participants who select the HVT path will be considered "delayers" who have higher grit than those who select the LVT path. If LVTs are selected, money earned will be paid at the end of the session up to $10 max. If HVTs are selected, money earned will be paid in 1 week at a min. of $20, max. $30.[7] In addition to the delay in payment, the HVT path will require completion of a mental rotation task (MR task; participants must mentally rotate two 3-D figures and determine whether they are identical) between each money-earning trial. Requiring completion of the MR task will improve ecological validity compared to delay of gratification measures that traditionally do not require completion of an effortful task to achieve higher-value rewards. For example, college success requires continued goal-oriented pursuit, not simply an initial decision to delay the receipt of reward for a greater reward.

Prior to path selection, all participants will practice the MR task. Participants will be told they must successfully complete (unlimited attempts) the MR task before each money-earning trial if the HVT path is selected. Traditionally, MR tasks are used as a measure of spatial processing, however here the MR task will facilitate manipulation of "failure", an essential element of grit. Participants will be told, regardless of performance, that they have failed at some MR task attempts (randomized). This will require that participants sustain their choice of the HVT path and continue to attempt the MR task to receive the higher reward. Between each money-earning trial delayers will decide whether they want to continue with the HVT path or switch to the LVT path (reward decisions). Path selection and subsequent

reward decisions are proxies for grit. Those choosing to continue on the HVT path and perform the MR task after they have failed will be considered more "gritty" delayers. Delayers who subsequently switch to the LVT path, and participants who select the LVT path at the outset, will remain on the LVT path and will be capped at the LVT max award. Restricting low-to-high switching and setting min/max awards for each path will minimize strategizing. On the LVT path participants will view the MR stimuli before money-earning trials but will not be required to complete the MR task. MR tasks have been successfully used in adolescent fMRI studies and adapted to eliminate gender differences.

Validated survey measures will assess (1) supportiveness of adolescents' home and peer environments,[8] (2) grit and impulsivity,[9] (3) academic achievement, optimism, IQ, self-esteem, performance anxiety, and well-being.[10] The Stoplight Task (ST), a computerized fMRI task in which participants drive a virtual car, will be administered to determine whether gritty individuals are prone to more negative risk taking. In the ST, participants decide whether to brake as the car approaches a yellow light at an intersection. Not braking results in a higher crash risk but also a potentially higher monetary reward for finishing quicker.

Anticipated Findings: On the Grit Task, more gritty individuals will exhibit greater: (1) perseverance on the Grit Task, (2) activation in mesolimbic reward circuitry (ventral striatum) at delayed reward presentation, and (3) activation in regulatory control regions (dorsolateral and ventromedial prefrontal cortices; dlPFC, vmPFC) during reward decisions, compared to less gritty individuals. Ventral striatum activation on the ST and Grit Task are expected to be highly correlated. Gritty individuals are expected to exhibit more PFC activation during both tasks resulting in more gritty behavior and less risky behavior (measured by ST yellow light decisions).

Feasibility: I will work with Dr. Adriana Galván, a developmental neuroscientist with expertise in adolescent brain development and my advisor, to implement this program of research. Dr. Galván has a database of over 400 ethnically diverse adolescents from which to recruit participants, and her affiliation with the UCLA Center for Cognitive Neuroscience gives me access to state-of-the-art neuroimaging facilities. Scanning fees will be paid by Dr. Galvan's unrestricted funds.

Broader Impacts: Identifying the neural correlates of grit will advance our understanding of positive risk taking and inform efforts to improve positive goal-oriented pursuits (e.g., academic achievement) for adolescents. For disadvantaged adolescents who lack external encouragement to engage in positive risk taking, this research is critical. As part of UCLA Psychology in Action (PIA), I will share with educators and policy makers at interdisciplinary symposia how positive risk taking is beneficial for adolescents. I will also engage with lay audiences about the implications of my research through PIA's social media platforms and through community outreach at area schools. I will use my findings to encourage educators and community organizations to provide positive outlets for adolescents. I will advance scientific knowledge by presenting my work in published manuscripts and at conferences, and through transdisciplinary collaboration investigating positive risk taking with the UC Consortium on the Developmental Science of Adolescence. I will directly provide opportunities for adolescents to engage in positive risk taking by conducting leadership workshops at area high schools and will expose underrepresented groups to careers in STEM fields by actively recruiting women and minority research assistants.

References: [1]Casey, B.J., Getz, S., & Galván, A. (2008). *Dev Rev*, *28*, 62-77. [2]Crone, E.A., & Dahl, R.E. (2012). *Nat Rev Neurosci*, *13*, 636-650. [3]Duckworth, A., & Gross, J.J. (2014). *Curr Dir Psychol Sci*, *23*(5), 319-325. [4]Duckworth, A.L., Peterson, C., ... (2007). *J Pers Soc Psychol*, *92*, 1087-1101. [5]Steger, M.F., Kashdan, T.B., ... (2008). *J Res Pers*, *42*, 22-42. [6]Sample size calculated using fmripower.org. [7]Amounts based on intertemporal choice heuristic calculation; Ericson, K.M.M, White, J.M., ... (2015). *Psychol Sci*, *26*(6), 826-833. [8]e.g., NRI-RQV, NRI-SPV. [9] e.g., Grit Scale, DOSPERT, BIS/BAS. [10]e.g., LOT-R , WASI-II, Rosenberg Self-Esteem Scale, LSAS-SR, SWLS.