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Author

Schrobenhauser-Clonan, Alexander P

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The Effects of a Classroom-Based Yoga Intervention on Social and
Emotional Functioning in Urban At-Risk Youth

By

Alexander Peter Schrobenhauser-Clonan

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requirement for the degree of

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Committee in charge:

Professor Ronald E. Dahl, Chair
Professor Douglas Jutte
Professor Colette Auerswald

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To my mother and father for gifting me so many
tools that help build happiness.

Acknowledgments

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Background

Self-Regulation and Adolescent Development

As the interface of public health, psychology, and neuroscience has expanded over recent years, a growing consensus in the literature underscores the long-term impact on health and functioning of the timing of particular stressors or interventions along axes of social and neurobiological development[1,2]. Much of the existing research has focused on the development and plasticity of executive functions in early and middle childhood[3-5]. Executive functioning is an umbrella term that refers to a set of cognitive processes used to regulate and manage a multi-tiered (cognitive, emotional and physiological) response to a particular problem in order to achieve certain goals. During childhood, components of executive functioning such as self-control clearly predict short and long-term academic and social success[6,7]. However, gains or setbacks in executive functioning and emotional regulation in childhood are subject to substantial modulation during adolescence, a transitional period between childhood and adulthood characterized by vast changes to brain systems influencing self-regulation and social and motivational dispositions[8-10]. A recent prospective cohort study of one thousand participants followed from birth to 32 years found that preventable setbacks such as high school dropout and teenage pregnancy partly explained the lifespan effects of low self-control and could "ensnare" participants in lifestyles of persistent hardship and ill health[11].

These snares contribute to the *health paradox of adolescence*, whereby one of the healthiest periods of the life span with respect to physical health simultaneously sees overall morbidity and mortality rates increase by 200%. These increases are due in large part to rising rates of accidents, suicide, homicide, depression, substance abuse, unintended pregnancies and sexually-transmitted infections[8]. Most of these outcomes reflect difficulties with control of emotion and behavior, which may manifest as psychiatric disorder. Prevalence rates of adolescent psychopathology closely approximate adult rates, suggesting that many of the most common mental disorders in adults first emerge in childhood and adolescence[12]. Anxiety, mood, behavior and substance use disorders are all common in adolescence, with the overall prevalence of disorders causing severe impairment and/or distress surpassing 20% in a nationally-representative sample of adolescents[12]. Psychopathology in adolescents is likely the manifestation of genetic propensities, early insults of chronic stress and the introduction of new social challenges as adolescents struggle to individuate from peers and parents and become independent, self-regulating adults[13].

For the adolescent student, schools represent a threshold between the family and the wider community into which they are moving. In contexts where families and communities are under considerable stress, schools can become a fault line where these forces shear against one another instead of mutually supporting the integrated development of the learner. Youth raised in poverty, violence and dysfunctional households are exposed to environments of toxic stress that adversely affect their developmental trajectories and self-regulatory capacities. Toxic stress is defined by strong, frequent or persistent activation of the body's stress response systems that disrupts brain architecture, adversely affects other organs and programs mental, emotional and behavioral patterns that exacerbate rather than aid recovery from stress[14,15].

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Although stressors range from material deprivation to emotional neglect, a unifying component of toxic stress is the absence of stable caregiving structures in both homes and schools, thus depriving youth of the scaffolding to model, learn and practice adaptive responses to stress[16]. The consequences of high reactivity to and diminished recovery from stress are captured in the concept of allostatic load, the cumulative detriment of chronic stress on the functioning of multiple systems in the body and brain[17].

Toxic stress and allostatic load may account for a large part of the recognized associations between low socioeconomic status and numerous adverse health and social outcomes[18,19]. Studies of childhood adversity have highlighted its lifelong impact on health and functioning: in adults, a strong dose-response relationship between specific incidents of childhood trauma and numerous domains of physical, mental and behavioral health has been established[20-22]. Childhood exposure to dysfunctional caregiving structures is particularly high in adolescents from urban, ethnically-diverse, socioeconomically-disadvantaged communities and strongly predicts depressive symptoms, antisocial behavior and drug use in this population[23].

In these inner-city communities, violence is often the most conspicuous sign of low social cohesion and chronic stress resulting from economic hardship, discrimination, and lack of educational and occupational opportunities. Experienced or witnessed violence places youth at elevated risk for post-traumatic stress disorder (PTSD), depression, aggression and externalizing disorders[24]. A recent study of a pediatric population in a low-income minority urban area in Northern California found that a majority of participants (67.2%) had experienced trauma related to both household functioning and community violence[25]. In the population from which these study participants were drawn, over a third of adults lacked a high school degree and the leading cause of premature mortality was violence. In this context, youth who were exposed to four or more adverse experiences were an alarming 32 times more likely to have learning and behavior disorders[25]. Results such as this raise the specter that trauma and neglect during development, when combined with realities of widespread school failure and violence, may lead to cognitive and emotional challenges that further predispose to school failure and involvement in risky activities. Yet these downward spirals also suggest their opposite; that targeted interventions to counter stress and enhance emotional well-being may reverse these trends and create upward spirals of success. The cultivation of adaptive stress responses and positive emotions through universal promotion efforts in schools has been advocated as an alternative to the deficit-oriented, punitive emphasis in most school services affecting urban youth[26].

Social and Emotional Functioning during Adolescence

It is not just a cliché that adolescents' feelings are misunderstood; in terms of brain development and psychosocial functioning, affective research in adolescents rebuffs most efforts at simplification, instead pointing to context-specific complexity that can make a risk factor or a strength of the same underlying process[27]. It is clear, however, that adolescence represents an immense swell of emotional reactivity and reward processing, especially in social domains[28,29]. High emotional reactivity is defined by strong and sometimes capricious emotional responses to social interactions. Reward processing

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integrates these emotional inputs and assigns value to certain behaviors and attitudes, both for oneself and others, feeding into concepts of self-worth, social status and group identity. High reactivity and reward processing do not, on their own, confer risk and can even enhance developmental outcomes like academic achievement in contexts with proper scaffolding for emotional regulation[30-32]. As the growing literature on the role of affect in decision-making shows, adolescents do not only stand at the crossroads of childhood and adulthood, their decision-making capacity actively switches between more child-like and more mature modes of thinking. Under conditions of low emotional arousal ('cold' cognition), adolescents are very capable of making decisions that properly weigh the longer-term consequences of an action, yet this capacity erodes with increasing emotional arousal ('hot' cognition)[9,33]. Adolescence is a period of heightened vulnerability as well as opportunity. Linear gains in executive functions occur simultaneously with nonlinear changes in emotional regulation, social competence and sensation-seeking. These "igniting passions" of adolescence can be canalized towards achievements in school, sports, arts and public service or can increase the risk of mental illness, school failure and other impediments in life trajectory[34,35].

Systematic training in the regulation of emotions and stress responses may potentiate adolescent neurological development, leading to healthier goal-directed behaviors and social functioning. Meta-analysis from the field of social and emotional learning (SEL) shows that a heterogeneous group of school-based, universal programs can significantly improve social and emotional skills, attitudes and behaviors[36]. However, despite highlighting successes at all K-12 educational levels, the analysis found that only 13% of studies on SEL programs targeted high school students, compared to 56% for elementary school students, and 31% for middle school students. Several reviews have pointed to the special opportunities afforded in adolescence for training neurobiological functions such as attention and stress reactivity, whose impact on life course and societal benefit may be largest for adolescents with histories of chronic stress and adversity[37,38]. Preventive interventions that leverage adolescents' heightened sensation and status-seeking with age-appropriate, culturally-relevant strategies can take advantage of powerful motivational and reward systems to promote self-regulatory skills formation[37]. Yet, it appears that school activities are failing to sustain attention or ignite passion in many students. By high school, as many as 40% to 60% of students- urban, suburban and rural- report chronic disengagement from school[39]. In this challenging context, school programs that are socially and emotionally rewarding are most likely to succeed.

Contemplative Practices in Children and Youth

Contemplative practices such as mindfulness, yoga and meditation, though millennia old, are novel approaches to promoting self-regulation in children and youth in Western societies. The breadth and diversity of these practices calls for high-quality studies of a variety of programs to build an adequate evidence base[40,41]. More than two decades of research in adults, most notably of the 8-week Mindfulness-Based Stress Reduction (MBSR) program, have shown that systematic training in yoga, meditation and other mindfulness strategies can improve a variety of physical and mental health conditions[42]. Mindfulness practices can induce changes in attention and emotion regulation[43], which improves performance on a number of cognitive tasks that assess

executive functioning[44,45]. These gains are likely to take place in a bidirectional manner, whereby "top-down" executive functions act as a primary mechanism of effortful self-regulation while at the same time arising from "bottom-up," more automatic emotional and physiological stress response systems [3].

As a contemplative practice employing both top-down (mindfulness, meditation) and bottom-up (yogic poses, breathing) strategies for self-regulation, yoga may be particularly well-suited to adolescents, whose neurological and physiological maturation are intimately intertwined through hormonal signaling[8]. There is also preliminary evidence that yoga practices integrating postures, breathing exercises and meditation can buffer the negative effects of prolonged allostatic load[46]. Hence, routine yoga could have neuroprotective effects on the prefrontal cortex and memory-related structures such as the hippocampus, both of which have shown vulnerability to poorly managed stress in adolescence. Stress-induced changes in these areas of the brain may contribute to the large incidence of mood disorders and substance abuse in this age group[47,48].

Results of contemplative practice research in school settings show promise, but point towards variations in outcomes across factors such as age, gender and context. Few school-based studies have looked at yoga-based mindfulness programs in adolescents and none have examined the effects of yoga on chronically stressed urban adolescents. Clinical reviews of the extant literature have pointed to yoga's potential for improving executive functioning, motor control, and specific outcomes in several psychological, behavioral and developmental disorders. However, these results are constrained by the low quantity and quality of controlled trials[40,49,50]. Studies have examined the effects of mindfulness activities throughout the elementary and middle school age range. Flook et al. (2010) and Napoli et al. (2005) completed randomized controlled trials (RCTs) of short meditative practices with elementary school students, both of which suggested improvements in executive, academic and social functioning[51,52]. In a nonrandomized, wait-list control sample of fourth through seventh grades, a classroom-based mindfulness program improved self-reported optimism, positive affect and externalizing behavior[53]. This study also highlighted age-sensitive effects; younger participants (9 and 10 years) had improvements in general self-concept while early adolescent participants (ages 11 and 12) showed none, a finding the authors attributed to heightened self-consciousness and critical appraisal of self and others in adolescence[53]. A recent study of yoga-based mindfulness with fourth and fifth grade girls paradoxically found higher perceived stress alongside greater frequency of positive coping skills in the intervention group; it is unclear whether this finding is gender-specific, if it represents a possible iatrogenic effect in this age group, or if it represents a normal part of training enhanced awareness of emotions and stress reactivity[54,55].

These findings underscore recent calls to strengthen developmental perspectives in contemplative practice research in order to assess differential effects for specific groups of school-aged youth[40,56]. The current study is informed by the strengths and limitations of two recently published evaluations of school-based yoga interventions. Mendelson et al. (2010) undertook the first RCT of contemplative practices geared towards underserved urban youth, utilizing a yoga-based intervention to address social-emotional and behavioral problems in inner-city fourth and fifth grade students[57]. The 12-week pilot program, consisting of 45-minute yoga classes four times weekly, showed high acceptability and feasibility among stakeholders and students, with students

reporting decreases in involuntary stress responses, including rumination, intrusive thoughts and emotional arousal, compared to wait-list controls. In a cluster-randomized trial of rural high school students (grades 11 and 12) that utilized a physical education-as-usual control group, Noggle and Khalsa (2012) found statistically significant differences in outcomes between the two groups. Control students showed worsening measures of negative affect, anxiety, anger, fatigue, and resilience, whereas yoga participants maintained or improved upon their baseline scores in these measures[58,59]. Despite this evidence of the acceptability, feasibility and efficacy of yoga-based prevention strategies in urban preadolescents and rural high school students, there is no published study to date exploring the use of a yoga-based program in an underserved, urban high school setting. Most importantly, there is little research to date on yoga interventions designed to be integrated directly into normal classroom activities. Identifying opportunities and challenges to delivering classroom-based contemplative practices is particularly salient to urban at-risk adolescents, whose schools can be overburdened by the extra space and additional resources needed for universal delivery of extracurricular or PE-time practices.

This unmet need for innovative approaches to address social-emotional and behavioral challenges in students living in environments of chronic stress led prevention researchers from two universities to collaborate with the Niroga Institute. The Niroga Institute (Niroga) is a non-profit yoga service organization, whose mission is to strengthen underserved communities by providing yoga programming, yoga teacher training and other activities to inner-city youth as well as the many stakeholders in their success, such as teachers and law enforcement officials.

Known as Transformative Life Skills (TLS), Niroga's yoga outreach in schools emphasizes self-control and emotional regulation as teachable skills, seeking to bridge a false divide in contemporary education between technical and intellectual abilities and social-emotional aspects underlying character formation and motivation.

The goals of this collaborative research partnership were to help refine a TLS school-based curriculum, facilitate its manualization, and evaluate its strengths-based approach to social-emotional and behavioral problems in urban, at-risk adolescents. Derived from the literature reviewed in the background section, the following logic model demonstrates a model of the hypothesized effects of the intervention.
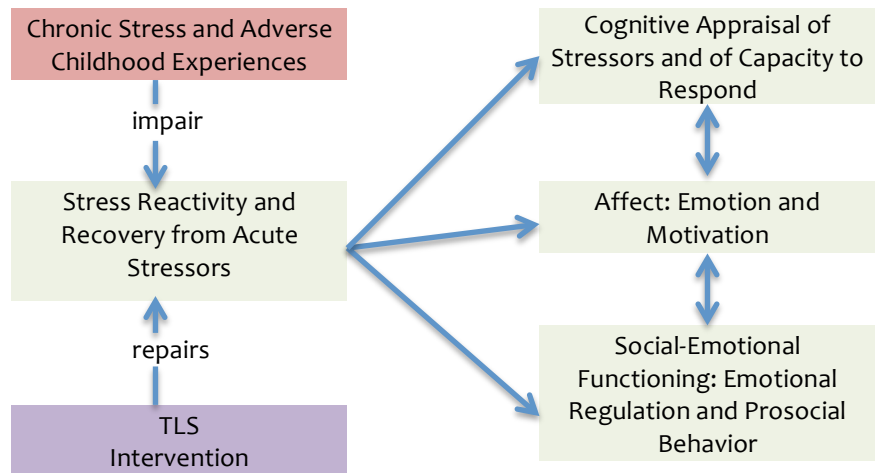
The primary purpose of our research was to examine the effectiveness of the TLS program on high-school adolescents in four domains: involuntary stress responses, positive and negative affect, symptoms of psychological and physical distress, and social-emotional functioning. We hypothesized that adolescents exposed to TLS training would show positive changes over the course of the intervention in all four domains. Our overarching research questions were: (a) Do classroom-based yoga practices help decrease maladaptive stress responses? (b) Can they increase positive emotions in urban teens? (c) Can they be useful as a social-emotional learning technique?

Methods

Participants

Participants were 9th-12th grade students at an alternative public high school in Oakland, CA. In general, alternative schools receive students who are referred because they are at risk of educational failure, as indicated by poor grades, truancy, disruptive behavior, suspensions, pregnancy, or similar factors associated with early withdrawal from school[60]. In concordance with this mission, the administration and faculty of the school expressed unanimous interest in helping evaluate contemplative practices that may bolster their efforts to prevent school failure and improve student outcomes. After approval by the UC-Berkeley Institutional Review Board and Oakland Unified School District, TLS instructors described the intervention and research study to students in classroom presentations. During these sessions, parent/guardian permission and student assent forms were provided to students to bring home and share with parents and caretakers, who also received a letter from the principal describing the research and its aims. All enrolled students at the high school were invited to provide assent and parental consent if they wished to participate in the research study. The principal and faculty followed up with students and parents to ensure that all interested students submitted both forms, except for those students over 18 years of age, who provided their own consent to enroll. Community connections fostered by Niroga's outreach efforts and the strong support from the school principal and teachers resulted in a high participation rate. Specifically, 88.8% of students at the school (103 of the total 116 students enrolled in the school at the beginning of the academic year) were enrolled in the study.

Measures

Demographic Information   Students were asked to fill out a basic information form indicating gender, birth date, grade, primary racial/ethnic identification, and household composition.

Positive and Negative Affect   We assessed students' positive and negative affect using the *Affect Valence Scale*, a 9-item scale based on Diener and Emmons' (1984) study of the independence of positive and negative affect. The Affect Valence Scale was utilized by Brown and Ryan (2003) in a study of mindfulness as a predictor of day-to-day self-regulation and well-being[61,62]. It contains nine emotion adjectives (*happy, worried/anxious, frustrated, pleased, angry/hostile, enjoyment/fun, unhappy,*

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depressed/blue, and *joyful*). Participants graded these adjectives on a 100-mm visual analog scale to indicate their emotional state "over the past week." This scale was administered each week of the intervention, except for one week that had a holiday school closure on the regular day of assessment.

Psychological Distress   The *Brief Symptom Inventory-18 (BSI-18)* is a short, highly sensitive, self-report screening index for psychological distress that contains eighteen items that are divided evenly across three dimensions (somatization, depression, and anxiety). Because of the relevance of hostility to adolescent externalizing disorders and aggressive behaviors, five items measuring hostility from the original BSI were added to the standard BSI-18[63]. Students were asked to rate the frequency of experiencing items such as "Feeling fearful" (anxiety subscale) and "Having urges to break or smash things" (hostility) on a five-point Likert-type scale.

Involuntary Stress Responses   The "Involuntary Engagement" factor of the *Responses to Stress Questionnaire* (RSQ) is a 15-item subscale that assesses involuntary responses to stressful situations that include rumination, intrusive thoughts, physiological arousal, emotional arousal and involuntary action. The RSQ was designed specifically for use in adolescence and has been shown to correlate well with a biological measure of heart-rate activity on a laboratory task[64]. Students were asked to rate their agreement with various statements on a 4-point Likert-type scale.

Peer and Teacher Relationships   The *People in My Life (PIML)* questionnaire was used to assess the quality of adolescents' relationships with peers and teachers, utilizing the "friends" and "school" subscales to target social-emotional functioning in school environments[65,66]. The PIML is a self-report measure that demonstrates high comprehension by adolescents and good internal reliability. Students marked their agreement with items on a 4-point Liker-type scale.

Forgiveness   The *Transgression-Related Interpersonal Motivations Scale-12-Item Form (TRIM-12)* is a short inventory assessing the motivations assumed to underlie instances of interpersonal forgiving[67]. The scale includes factors related to avoidance and revenge motivations following an interpersonal transgression; revenge motivations were of particular interest because they are highly associated with involuntary rumination and are likely to perpetuate psychological distress[68]. The TRIM-12 items were rated on a 5-point Likert scale and were preceded by a free-writing prompt asking students to "describe a situation where someone made you angry, hurt you, or betrayed you, and why you think this situation happened."

Teacher-Rated Social-Emotional Competence   In order to seek additional corroboration of potential programmatic effects, classroom teachers were asked to fill out a short assessment of study participants' school behaviors. To minimize participant burden for the teachers, they were only asked to fill out these individualized assessments of participating students' behaviors at pre- and post-intervention. The teacher evaluation instrument was composed of 14 items drawn from the prosocial behavior, emotion regulation and social competence scales of the *Teacher Social Competence Scale (TSCS)*

and the aggressive/oppositional behavior scale of the *Teacher Observation of Classroom Adaptation-Revised (TOCA-R)*[69,70]. Responses were rated on a 6-point Likert-type scale.

Procedure

Four of the school's seven total classrooms were randomly assigned to receive 8-weeks of a TLS modality pilot; the remaining three classrooms served as wait-list controls that received TLS after study completion. Pre-, mid- and post-program questionnaires were administered by research assistants to students who had obtained parental consent and given assent prior to commencement of the TLS program. In addition, a brief "wrap-up" assessment of students' affect (*Affect Valence Scale*) and a free-writing exercise involving prompts related to life stress and the intervention were administered weekly; this data served to add longitudinal information of students' moods as well as qualitative markers of program feasibility and acceptability to the study design. To curb biases due to variability in students' reading proficiency, a research assistant read each item on the questionnaire aloud, and students marked their responses. Students were encouraged to answer the questionnaires honestly and were reminded that none of their answers would ever be shared with teachers, administrators, principals, parents or friends. Pre- and post-intervention, teachers were asked to complete student behavior checklists (*Teacher Social-Emotional Competence Scale*) for each participating student in their class.

The Intervention

Program summary   Transformative Life Skills (TLS) is a classroom-based intervention that draws on multiple secular practices of the yoga tradition to help train students in self-regulation and social-emotional awareness through the practice of physical postures (in Sanskrit, *asana*), breathing techniques (*pranayama*), and quiet centering (*pratyahara*). Through specialized training in yoga instruction for urban minority youth, TLS instructors learn to use age-appropriate and culturally-relevant language to engage youth in practices of

Basic TLS Modality	
Opening- Purpose and Expectations	2 Minutes
Bell and Focused Breathing	2 Minutes
Action: Mindful Movement	5 Minutes
Breathing: Rhythmic and Resonant	2 Minutes
Centering: Silent Sitting	1 Minute
Closing Bell	30 Seconds
Questions	2 minutes
Total Class	15 minutes

mindfulness. Each 15-minute TLS session revolves around the "ABCs" of self-regulation; physical "Action" – asana postures and the purposeful, fluid movements that link them in sequence – help to orient students to present-moment sensations and feelings. This present-moment awareness can then become more focused through attention to the sensations of "Breath" and its synchronization with movement. Awareness and control of body and breath enable students the calm and comfort to engage in "Centering" exercises such as sitting meditations, which might otherwise cause distress. Yoga poses are taught in a sequential manner that builds from the simplest forms to more challenging ones in terms of flexibility, strength and balance. Poses are selected to be accessible and adaptable to all body types and abilities while practicing within the constraints of a normal classroom layout. Breathing techniques focus on rhythmic coordination of in-breaths and out-breaths and resonant breath sound production (*Ujjayi* breathing) that may

help reset the autonomic nervous system, leading to more optimal balance of parasympathetic and sympathetic activation[71,72]. Sitting meditations were short (≤ 5 minutes) and focused on cultivating a non-judgmental, accepting stance towards mental phenomena and sensations. As a whole, the elements of the TLS program aim to provide a repertoire of cognitive and behavioral skills that may broaden student's social-emotional responses to challenges in and outside of school.

Program Implementation   The TLS sessions were integrated into first-period homeroom classes four days per week throughout the first trimester of the school year. Each session was delivered by TLS instructors with students (and willing classroom teachers) performing all activities in regular clothes while sitting at or standing beside their desks. TLS instructors were certified yoga teachers (Yoga Alliance© registered yoga teachers with 200 hours (RYT-200) or more of training at an accredited program) who received additional training in teaching yoga to at-risk youth through the Niroga Institute. The instructors were managed by a head instructor with many years of leading yoga-for-youth classes in the struggling neighborhoods surrounding the school. To minimize class disruption, instructors visited homeroom classes at a specific time during the first period that was worked out in consultation with the teacher and administration. Class subjects included Government, American History, Biology, Algebra, Geometry and English. Assessments were also administered to participants during these specified windows by a TLS instructor and a research assistant. Given these time constraints, assessment questionnaires were completed over the span of two 20-minute sessions occurring on two consecutive days.

Data Analysis

A quasi-experimental control group repeated-measures design was used. Three modes of analysis were performed to explore limitations and strengths of various statistical models given the extant data. The four classrooms that received the TLS program were initially examined via a simple paired t-test analysis using pre- and post-intervention scores only. This uncontrolled analysis was utilized to reveal similarities in findings between this intervention and previous unpublished evaluations of the TLS modality, but was not meant to provide any causal inference. We then examined the effect of the TLS program via a general linear model analysis of covariance (ANCOVA) in which posttest scores served as the dependent variable and pretest scores were factored in as covariates. Lastly, linear mixed models were constructed for each measure to account for clustering and autocorrelation of repeated measures, while allowing full use of less-than-complete data.

Results

Study results are presented in four sections. First, we examine baseline characteristics of TLS participants and control students. In the second section, we report the within-group (paired samples) t-test analysis of outcome measures in the intervention group. Next, we report results from treatment-control ANCOVA analyses examining intervention effects. Lastly, we utilize a mixed model (linear hierarchical model) analysis

of all repeated measures to maximize statistical inference given the constraints of the available data set.

Baseline Characteristics of TLS Students and Controls

Descriptive statistics for the classroom-randomized study sample can be found in Table 1 on the next page. After recruitment, enrollment and classroom randomization, the final study sample consisted of 103 students of the total 116 students in grades 9-12. Of those students who declined participation in the study (13 students), they were split evenly between intervention classrooms (6 declining) and control classrooms (7 declining): there were 2, 2, 1 and 1 declining students in the four intervention classrooms and 3, 2, and 2 declining students in the three control classrooms. The final sample consisted of 22 ninth graders (21.3%), 28 tenth graders (27.2%), 32 eleventh graders (31.1%) and 21 twelfth graders (20.4%). Due to the diversity of the student population and the strong cultural heritage encouraged by the school's philosophy, students were allowed to identify as many race/ethnicity categories as they liked; the largest self-identification categories were Black (35.9%), Latino (40.8%), and Native American (13.6%). Nine percent of students identified primarily as White, Asian or "other". The sample included 49 students in the intervention condition and 54 in the control condition.

We compared intervention and control groups with respect to gender, age, grade, race/ethnicity and baseline scores on all measures using analysis of variance (ANOVA) for continuous variables (age and baseline scores) and Chi-square tests for categorical variables (gender, race/ethnicity, and grade). Gender and race/ethnicity were not significantly different between the two groups. Most students identified as Black or Latino; however, the third largest racial/ethnic identifier was Native American, a fact that reflects both the composition of the surrounding community and the stated mission of the school to foster cultural and political identity. Participants in the intervention condition were more likely than control group students to be in eleventh grade (28 eleventh graders versus 4 eleventh graders; $p < .001$), while control participants were more likely to be in ninth and twelfth grades compared to the intervention group (16 ninth graders versus 6 ninth graders; $p = .032$, and 17 twelfth graders versus 4; $p = .003$). Despite these substantial differences in grade distribution between the two groups, there were no significant differences in age distribution. This discrepancy likely has to do with the structure of classes at the study site: because many students have already failed out of a regular high school context and are held back when they enter the alternative high school, the age range in each grade varies more than in a non-alternative setting where age and grade tend to be fairly collinear. There were no significant differences on any baseline outcome measures at pretest between students in the two study conditions.

Table 1	All participants (*n*=103)	Intervention (*n*=49)	Control (*n*=54)	*P*-value*
Gender				.48
Male	50	22	28	
Female	53	27	26	
Age				.105
13	1	0	1	
14	15	4	11	
15	22	7	15	
16	34	24	10	
17	24	11	13	
$\geq$ 18	5	2	3	
Missing	2	1	1	
Grade				< .001
9th	22	6	16	.032
10th	28	11	17	.303
11th	32	28	4	<.001
12th	21	4	17	.003
Race/Ethnicity				.98
Native American	14	6	8	
Latino	42	20	22	
Black	37	18	19	
Other (White, Asian or Other)	10	5	5	
Baseline Outcome Measures	(Mean ± SD)			
AVS Positive Affect	50.0 ± 22.5	54.1 + 21.7	46.1 + 22.8	.09
AVS Negative Affect	32.4 ± 23.6	32.5 + 23.7	32.3 + 23.7	.97
BSI Somatization	2.0 ± 2.5	1.7 + .8	2.2 + 3.4	.30
BSI Depression	1.7 ± .8	1.8 + .8	1.6 + .7	.15
BSI Anxiety	2.0 ± 2.5	1.8 + 2.5	2.0 + 2.5	.83
BSI Hostility	2.3 ± 2.4	2.4 + 3.2	2.1 + 1.1	.55
BSI Global Severity Index	2.0 ± 1.2			.88
RSQ Involuntary Engagement (IE)	2.0 ± 1.0	1.9 + .7	2.2 + 1.2	.22
Rumination (IE subscale)	2.0 ± .8	2.0 + .8	2.0 + .8	.89
Intrusive Thoughts (IE subscale)	2.1 ± .9	2.0 + .9	2.1 + .9	.67
Physiologic Arousal (IE subscale)	2.1 ± 3.6	1.6 + .7	2.6 + 5.3	.23
Emotional Arousal (IE subscale)	2.1 ± .9	2.1 + .8	2.2 + .9	.54
Involuntary Action (IE subscale)	2.0 ± .9	1.9 + .8	2.0 + 1.0	.48
TRIM Avoidance	3.3 ± 2.1	3.5 + 2.7	3.0 + 1.1	.24
TRIM Revenge	2.9 ± 2.5	2.7 + 1.0	3.0 + 3.3	.63
PML Trust in Friends	3.3 ± 2.0	3.2 + 1.3	3.4 + 2.6	.60
PML Communication with Friends	3.1 ± 2.9	3.4 + 3.9	2.8 + .8	.36
PML Alienation/Dissatisfaction with Friends	1.7 ± 2.7	1.9 + 3.7	1.4 + .4	.43
PML School Bond	2.6 ± .7	2.5 + .6	2.7 + .7	.18
PML Teacher Affiliation	2.7 ± 2.7	2.9 + 3.7	2.6 + .8	.60
PML Dissatisfaction with Teacher	2.3 ± 3.7	2.4 + 5.0	2.1 + .9	.67
TSCS Emotional Regulation	4.0 ± 1.2	4.0 + 1.0	4.1 + 1.3	.65
TSCS Prosocial Behavior	4.0 ± 1.1	4.2 + .9	4.0 + 1.3	.35
TSCS Aggression/Opposition	1.9 ± .7	1.8 + .6	2.0 + .8	.20
TSCS Social-Emotional Competence	3.3 ± .5	3.3 + .5	3.3 + .6	.60

*Continuous variables were analyzed using independent t-tests; categorical variables were analyzed using chi-square. AVS= Affect Valence Scale (visual analog 1-100 score), BSI = Brief Symptom Inventory-18 (5 point Likert), RSQ= Responses to Stress Questionnaire (4 point Likert), TRIM = Transgression-Related Interpersonal Motivations Scale (5 point Likert), TSCS = Teacher-rated Social-Emotional Competence Scale (6 point Likert), PML = People in My Life Scale (4 point Likert).

Paired T-Test Analysis of Intervention Group

As complete data are needed for general linear models and the percent of missing data was considerable in some measures (outcome measurement items ranged from 0.9% to 26.2% of participants missing pre- or post-intervention data), expectation-maximization imputation was used to complete the data. After imputation, comparable pre- and post-TLS program survey data were available for 49 intervention students. As shown in table 2, TLS program participation was associated with statistically significant ($\alpha \leq .05$) reductions in negative affect ($p = .034$), depressive symptoms ($p=.001$), involuntary engagement with life stressors ($p <.001$), rumination ($p <.001$), intrusive thoughts ($p < .001$), physical arousal ($p <.003$), emotional arousal ($p <.001$), revenge motivations ($p < .001$), and an overall index of distress severity from the BSI-18 ($p <.008$). The only teacher-rated domain to reach significance showed a slight paradoxical increase in aggressive-oppositional behavior ($p=.005$). Other psychological domains of interest such as positive affect and teacher-rated emotional regulation were not found to be significantly different following TLS participation using this within-group analysis.

Table 2	Paired Differences				t-value	Significance (2-tailed)
	Mean Difference (Post-Pre)	Std. Deviation	95% Confidence Interval			
			Lower Limit	Upper Limit		
AVS Negative Affect	-8.17954	26.25955	-15.72216	-.63691	-2.180	.034
AVS Positive Affect	5.95198	24.78205	-1.16626	13.07021	1.681	.099
BSI Somatization	-.20339	1.41421	-.60959	.20282	-1.007	.319
BSI Depression	-.30029	.61447	-.47678	-.12379	-3.421	.001
BSI Anxiety	-.72578	2.71389	-1.50530	.05374	-1.872	.067
BSI Hostility	-.82307	3.07933	-1.70755	.06142	-1.871	.067
BSI Global Severity Index	-.47305	1.20206	-.81832	-.12777	-2.755	.008
RSQ Involuntary Engagement (IE)	-.46590	1.08293	-.77695	-.15484	-3.012	.004
Rumination (IE subscale)	-.69329	.71813	-.89956	-.48702	-6.758	.000
Intrusive Thoughts (IE subscale)	-.70214	.84178	-.94393	-.46035	-5.839	.000
Physical Arousal (IE subscale)	-.67889	1.52564	-1.11711	-.24068	-3.115	.003
Emotional Arousal (IE subscale)	-.70316	.76845	-.92388	-.48243	-6.405	.000
Involuntary Action (IE subscale)	.53361	4.65363	-.80307	1.87029	.803	.426
TRIM Revenge	-.88099	1.48843	-1.30852	-.45346	-4.143	.000
TRIM Avoidance	-.65908	2.41525	-1.35282	.03466	-1.910	.062
PML Trust in Friends	.21952	2.68269	-.55103	.99008	.573	.569
PML Communication with Friends	-.39853	3.53851	-1.41491	.61785	-.788	.434
PML School Bond	1.04967	3.96894	-.09034	2.18968	1.851	.070

| Table 2 | | Paired Differences | | | t-value | Significance (2-tailed) |
| | Mean Difference (Post-Pre) | Std. Deviation | 95% Confidence Interval | | | |
			Lower Limit	Upper Limit		
PML Alienation-Dissatisfaction with School	.50420	5.49836	-1.07511	2.08351	.642	.524
PML Teacher Affiliation	-.47908	3.73484	-1.55185	.59369	-.898	.374
PML Dissatisfaction with Teacher	-.86611	4.59184	-2.18504	.45282	-1.320	.193
TSCS Prosocial Behavior	.06988	.81259	-.16352	.30328	.602	.550
TSCS Aggression-Opposition	.16597	.39547	.05238	.27956	2.938	.005
TSCS Emotional Regulation	.00653	.61373	-.16975	.18281	.075	.941
TSCS Social-Emotional Competence	.08206	.43304	-.04232	.20644	1.326	.191

AVS= Affect Valence Scale (visual analog 1-100 score), BSI = Brief Symptom Inventory-18 (5 point Likert), RSQ= Responses to Stress Questionnaire (4 point Likert), TRIM = Transgression-Related Interpersonal Motivations Scale (5 point Likert), TSCS = Teacher-rated Social-Emotional Competence Scale (6 point Likert), PML = People in My Life Scale (4 point Likert).

ANCOVA Analysis

Intervention effects were assessed using ANCOVA analysis for each outcome, controlling for age, gender, grade, race/ethnicity and baseline score on that outcome. We controlled age and grade because of the aforementioned discrepancy between age and grade in the alternative high school setting in which the study took place. Given its recognized association with multiple domains of psychosocial functioning and stress response[73-75], gender was also entered as a covariate. Lastly, due to the specific import placed on cultural heritage and identity as a means for character formation by the study school, race/ethnicity was also included.

On the next page, table 3 displays adjusted post-intervention means and beta-coefficients for post-outcome variables by study condition. The TLS intervention group showed significant improvement compared to controls on three measures: the self-reported Revenge subscale of the TRIM questionnaire (p=.02) and the teacher-reported Prosocial Behavior (p=.03) and Social-Emotional Competence (p=.04) subscales of the TSCS. Although not statistically significant, adjusted post-intervention means were in the predicted direction for improvement in positive affect (56.69 in intervention group versus 51.18 in the control group on the 100-point Affect Valence Scale (AVS)) and negative affect (26.40 in the intervention group versus 28.48 in the control group on the AVS). There were no significant findings on any subscales of the Brief Symptom Inventory-18 (BSI-18), Responses to Stress Questionnaire (RSQ), or People in My Life (PML), though all of them showed changes in the predicted direction.

Table 3	Adjusted Mean (Standard Error)		Coefficient (B)	P-value
	Intervention	Control		
AVS Positive Affect	56.69 (4.00)	51.18 (3.80)	5.51	.33
AVS Negative Affect	26.40 (3.21)	28.48 (3.05)	-2.08	.65
BSI Somatization	1.67 (.28)	1.99 (.27)	-.320	.42
BSI Depression	1.54 (.10)	1.68 (.09)	-.146	.29
BSI Anxiety	1.39 (.07)	1.44 (.07)	-.051	.50
BSI Hostility	1.69 (.12)	1.88 (.11)	-.187	.26
BSI Global Severity Index	1.58 (.12)	1.70 (.11)	-.125	.46
RSQ Involuntary Engagement (IE)	1.55 (.12)	1.47 (.11)	.078	.64
Rumination (IE subscale)	1.29 (.08)	1.35 (.08)	-.063	.58
Intrusive Thoughts (IE subscale)	1.73 (.05)	1.82 (.10)	-.077	.44
Physiologic Arousal (IE subscale)	1.30 (.07)	1.31 (.06)	-.012	.90
Emotional Arousal (IE subscale)	1.41 (.09)	1.56 (.09)	-.157	.21
Involuntary Action (IE subscale)	2.50 (.49)	1.85 (.47)	.614	.37
TRIM Avoidance	2.80 (.15)	2.73 (.15)	.073	.74
TRIM Revenge	2.00 (.15)	2.48 (.14)	-.482	.02
PML Trust in Friends	3.43 (.28)	2.99 (.26)	.438	.26
PML Communication with Friends	2.72 (.12)	2.60 (.11)	.128	.45
PML Alienation/Dissatisfaction with Friends	2.40 (.49)	2.24 (.47)	.163	.81
PML School Bond	3.48 (.50)	3.31 (.47)	.170	.81
PML Teacher Affiliation	2.42 (.12)	2.32 (.11)	.101	.55
PML Dissatisfaction with Teacher	1.56 (.09)	1.67 (.08)	-.106	.37
TSCS Emotional Regulation	4.16 (.10)	3.92 (.10)	.231	.11
TSCS Prosocial Behavior	4.33 (.12)	3.94 (.12)	.390	.03
TSCS Aggression/Opposition	2.09 (.08)	2.11 (.07)	-.025	.82
TSCS Social-Emotional Competence	3.44 (.06)	3.25 (.06)	.187	.04

* Adjusted scores for gender, race, grade and age. AVS= Affect Valence Scale (visual analog 1-100 score), BSI = Brief Symptom Inventory (5 point Likert), RSQ = Responses to Stress Questionnaire (4 point Likert), TRIM = Transgression-Related Interpersonal Motivations Scale (5 point Likert), PML = People in My Life Scale (4 point Likert), TSCS = Teacher Social-Emotional Competence Scale (6 point Likert).

Linear Mixed Modeling: Accounting for Clustering and Dealing with Missing Data

As a few variables exceeded the 10% missing date rate that is considered the ceiling for valid use of single imputation methods such as expectation-imputation maximization[76], linear mixed modeling was explored because of its capacity to include cases with missing data and thereby avoid the underestimation of standard errors and subsequent inflation of type I errors stemming from inappropriate imputation[77]. Utilizing a mixed model repeated-measures approach, students with complete data for at least two time points on a given outcome measure (seven time points for the Affect Valence Scale; three time points for all other measures) could be analyzed. Another strength of mixed models is their ability to account for clustering of outcomes by such factors as classroom, which would otherwise bias standard errors substantially. In the current study, intraclass correlation coefficients (ICCs) were calculated for baseline measures to estimate the degree of correlation amongst participants' scores in each classroom. Non-zero ICCs suggest clustering of an outcome based on classroom; to control for this clustering, classroom assignment was added as a fixed factor to the model of any measure with a

non-zero ICC. Gender, grade, age and race/ethnicity were included as fixed effect covariates for the same reasons as in the ANCOVA modeling. We also included a gender x treatment condition interaction term to look for gender-specific effects of the intervention, but dropped this term from the adjusted fixed effect estimate if it did not reach statistical significance ($p \leq .05$). Table 4 presents the results of this mixed model analysis, with coefficient estimates of the fixed effect of the TLS intervention on participants' scores. Total number of students with data available from at least two time points ranged from 101 to 75 for each measure.

Several measures were significant using mixed modeling that were not significant in ANCOVA analysis. Compared to controls, TLS participants showed significant improvements in Emotional Arousal (RSQ) ($p=.05$) and teacher-rated Emotional Regulation (TSCS) ($p=.03$). Two measures demonstrated both significant main effects of the TLS intervention and significant gender x treatment interaction terms: Positive Affect (AVS) and Depression (BSI). These measures were stratified by gender and re-analyzed. In repeated-measures analysis over seven possible time points, male students in the intervention group reported significant ($p=.04$) increases in Positive Affect compared to male controls, with an estimated increase of 18.04 points on a 100-point scale over the timespan of the intervention. Female students showed no statistically significant change in Positive Affect, but female gender did account for a substantial drop (-20.30) in Positive Affect score ($p=.001$) in the model when compared to male students. Utilizing data from three time points, male TLS participants also reported a reduction in depressive symptoms (BSI Depression) compared to controls ($p=.02$), with an estimated decrease of -.60 on a 5-point scale. No intervention effect was observed for female participants, but female gender was again associated with a unfavorable change in score compared to male students. Specifically, female gender was associated with an estimated increase of .58 in depressive symptoms ($p=.005$) in the model compared to male gender.

As in ANCOVA analysis, TLS participants also demonstrated improvements in Revenge motivations (TRIM) and teacher-rated Social-Emotional Competence. Teacher-rated Prosocial Behavior, while not reaching significance as it did in ANCOVA modeling, did show a promising trend in the predicted direction ($p=.09$). Intervention and control groups did not differ significantly with respect to changes in other outcomes measures, including overall Involuntary Engagement, relationships with peers and teachers (PML Scale), or Negative Affect (AVS), although there was a downward trend in this measure for intervention students ($p=.10$).

Table 4	Fixed Effect Estimate (Coefficient)		Baseline ICC by Classroom	*n* available
	Unadjusted (*p*-value)	Adjusted (*p*-value)		
AVS Positive Affect	6.16 (.13)	16.45 (.01)	0.00	101
Males		18.04 (.04)		49
Females		-4.94 (.34)		52
AVS Negative Affect	-1.02 (.77)	-7.55 (.10)	0.00	101
BSI Somatization	-.29 (.09)	-.19* (.62)	0.04	101
BSI Depression	.04 (.77)	-.54 (.02)	0.00	101
Males		-.60 (.02)		49
Females		.016 (.95)		52

Table 4	Fixed Effect Estimate (Coefficient)				Baseline ICC by Classroom	n available
BSI Anxiety	-.11	(.34)	-.08	(.76)	0.04	101
BSI Hostility	-.08	(.66)	-.34	(.13)	0.00	101
BSI Global Severity Index	-.15	(.32)	-.27*	(.43)	0.12	101
RSQ Involuntary Engagement (IE)	-.09	(.53)	.49*	(.14)	0.17	97
Rumination (IE subscale)	-.06	(.61)	-.21	(.12)	0.00	97
Intrusive Thoughts (IE subscale)	-.02	(.86)	-.17	(.22)	0.00	97
Physiologic Arousal (IE subscale)	-.05	(.63)	-.14	(.29)	0.00	97
Emotional Arousal (IE subscale)	-.13	(.26)	-.28	(.05)	0.00	97
Involuntary Action (IE subscale)	-.13	(.48)	-.06*	(.88)	0.05	97
TRIM Avoidance	.29	(.15)	.39*	(.42)	0.04	99
TRIM Revenge	-.15	(.42)	-.57	(.01)	0.00	99
PML Trust in Friends	.17	(.40)	.27	(.29)	0.00	96
PML Communication with Friends	.30	(.09)	.60*	(.13)	0.01	96
PML Alienation/Dissatisfaction with Friends	.09	(.57)	.16	(.43)	0.00	96
PML School Bond	-.11	(.44)	-.04*	(.91)	0.04	95
PML Teacher Affiliation	.16	(.34)	.22	(.31)	0.00	95
PML Dissatisfaction with Teacher	-.02	(.87)	.21	(.18)	0.00	95
TSCS Emotional Regulation	.02	(.95)	1.56*	(.03)	0.29	100
TSCS Prosocial Behavior	.43	(.09)	1.07*	(.09)	0.14	75
TSCS Aggression/Opposition	-.23	(.16)	-.39*	(.40)	0.18	75
TSCS Social-Emotional Competence	.04	(.70)	.75*	(.01)	0.06	75

* Non-zero baseline ICC for classroom variable, which was therefore included in adjusted model.
Adjusted scores for gender, race, grade and age. AVS= Affect Valence Scale (visual analog 1-100 score), BSI = Brief Symptom Inventory (5 point Likert), RSQ = Responses to Stress Questionnaire (4 point Likert), TRIM = Transgression-Related Interpersonal Motivations Scale (5 point Likert), PML = People in My Life Scale (4 point Likert), TSCS = Teacher Social-Emotional Competence Scale (6 point Likert).

Discussion

As one of the first randomized controlled trials of a classroom-based yoga program designed for urban youth, the current study revealed preliminary findings supporting its utility as a strengths-based approach for improving a number of facets of psychosocial and emotional functioning in a population at-risk for school failure and other life adversities.

This study expands upon the methods and builds on the findings of previous reports of the TLS intervention. Ramadoss and Bose (2010) reported a modest but statistically significant decrease in pre-post perceived stress scores for students participating in an 18-week TLS program with varying dose, a finding which was not reproduced in a class-time-as-usual control group (though this control was admittedly much smaller and gender unbalanced compared to the intervention cohort). A measure of self-control, however, did not show significant changes in both within-group and between-group *t*-test analyses[78]. A stratified analysis comparing students receiving daily TLS to those receiving fewer sessions per week suggested an inverse dose-response relationship with perceived stress scores. While no significant differences between these two groups existed at baseline, students receiving TLS every school day showed greater reductions in stress at both mid-point and post-intervention[78]. Self-control did not replicate this dose-response curve.

The present research avails itself of a number of factors that were not previously feasible at the schools that have taken part in TLS yoga programming. First, school administrators and faculty were supportive of randomizing all classrooms to receive the same high-frequency dose (4 days a week) of the TLS modality or a wait-list control over 8 weeks of the school year. This support assured a balanced controlled design that yielded similarly matched intervention and control groups on all demographic factors besides grade (but including age). Second, to adapt to the difficulties of data collection in an inner-city high school environment where absenteeism, unpredictable school events and capricious resistance by students to organized activities may arise, more frequent but shorter data collection time points allowed for more flexibility in obtaining usable data, especially concerning student's weekly reports of Positive and Negative Affect. Lastly, school support allowed for a high study recruitment rate, allowing for stronger inference of school-wide effects of the intervention, which is designed as a universal prevention and promotion strategy. School-wide participation was particularly pivotal for controlling for the nested effect of classroom in the mixed model, wherein this nested effect could be treated as a fixed factor with corresponding parameter estimates rather as a random effect without parameter estimates, which is usually assumed when drawing a sample from a larger population of possible classrooms. This likely increased the internal validity of the study[79].

Structuring the analysis as a sequential examination of amenable statistical models, we were able to track the most statistically durable findings. The uncontrolled pre-post T-test analysis of the intervention found a variety of significant changes, but only the reduction in Revenge motivation (TRIM Revenge) showed reproducible significance in ANCOVA analysis. No other self-report measures achieved significance in ANCOVA modeling; however, promising trends in both Positive and Negative Affect continued to hold, and two teacher-rated measures of students' Prosocial Behavior and Social-Emotional Competence were significant.

Our results from mixed model analysis avoid inappropriate imputation of missing data and take into account all available time points as well as classroom-dependent clustering, which was particularly (and predictably) high for the teacher-rated measures. This method revealed novel gender-dependent effects of TLS participation. A recent

controlled evaluation study of the TLS intervention found that female students showed greater benefit from the intervention in the domain of perceived stress than their male counterparts[80]. In comparison, this current study is the first to find favorable male gender-specific intervention effects.

Gender-Specific and Shared Program Effects

Our results highlight two substantial improvements for male students in affect-related measures, Positive Affect and Depression, whereas improvements in domains of Emotional Arousal and Emotional Regulation were shared across genders. More research is needed to clarify these differing responses in affect-related versus stress-related functions in male and female TLS participants. Although stress and affect are intimately related, physiological stress responses, perceived stress and their relationships with the independent components of positive and negative affect differ substantially across gender[81,82]. We are only aware of one study that assessed gender-dependent effects of yoga in young adults. In a comparison of yoga participation to an active control (swimming), analysis revealed that only males showed greater decreases in stress, anger and fatigue in the yoga condition compared to control[83]. Further research could investigate if these gender discrepancies are simply due to longer response time (greater than our 8-week study period) for affective changes to arise in female adolescents or if they represent gender-differentiated processes of change due to yoga-based mindfulness practice. In order to leverage the cognitive and behavioral flexibility potentiated by adolescent transition, cultural context and its bearing on gender differentiation is likely to be as important as hormonal and neurological changes[27]. We echo and endorse the recommendation by a recent review of mindfulness research in youth for high-quality qualitative research to illuminate processes of change behind contemplative practices' observed effects[40,84].

Regardless of the underlying mechanisms, the reported improvements in social-emotional functioning by both male and female TLS participants and their teachers suggest that yoga-based practices can be effective as a social-emotional learning (SEL) technique in urban classroom environments. Research has shown that self-regulation of emotions mediates the relationship between stress exposure and various youth outcomes, and that school-wide SEL programming can promote resilience to stress and reduce psychological and behavioral difficulties[85-87]. The downstream effects of SEL interventions show considerable promise for educational success. A recent meta-analysis of 213 SEL programs showed an average increase of 11% in standardized measures of academic achievement in participating students compared to controls[36]. Although academic data were not analyzed in this current study, decreased emotional arousal and increased social-emotional competence in the classroom may potentiate learning by reducing disruptions to attention, working memory and information processing[56,88]. For minority adolescents in particular, school performance appears to moderate the influence of neurocognitive deficits on subsequent delinquency[89]. As high self-control plays a central role in school performance and immunity to deviant peer pressure[90], SEL programs in urban minority youth that specifically target the development of self-control through emotional regulation may concurrently enhance educational and crime prevention efforts. In terms of both lost productivity and costs due directly to crimes,

preventing school failure and delinquency in a high-risk 14-year-old (the average age of students beginning high school in the U.S.) has been estimated to save up to \$5.3 million over the lifespan [91]. Long-term longitudinal studies of yoga-based interventions that incorporate objective data of participants' academic and criminal records would be crucial for substantiating this hypothesis.

Implications of the Findings

Though cognitive factors underlying involuntary engagement to stressful stimuli such as rumination did not change in this study, the reduction in Revenge motivations may be particularly sensitive and salient to the lives of youth in environments of chronic stress and violence. The TRIM scale included a writing prompt meant to call to mind a perceived wrong against the respondent. Compared to a standard questionnaire, this was meant to induce a higher and more realistic level of arousal, essential to accurate assessment of adolescents' risk-taking and social motivations, which are substantially altered during "hot" (high-arousal) cognition and decision-making[92,93]. Aggressive or hostile emotions such as revenge are associated with high levels of rumination in adolescents and may inform developmental trajectories that increase the risk of violent behavior[94]. Mindfulness-based practices like TLS yoga, in turn, may be helpful in reducing aggressive tendencies by providing present-moment centered alternatives to ruminative styles of coping[95]. Decreasing retaliatory attitudes in urban youth living in areas of gang influence could help break cycles of violence and recidivism which create toxic stress throughout communities and exact high costs on health, education and criminal justice systems[91,96].

While the improvements in male students' positive affect and depressive symptoms have intrinsic benefit for immediate psychological well-being, the consequences, if any, of these improvements on behavioral outcomes remain unclear. On one hand, considerable evidence from multiple disciplines supports the "broaden-and-build theory"[97] that positive emotions can broaden individuals "though-action repertoires," leading to increased behavioral flexibility that helps build personal resources such as creativity, resilience and even physical health[98]. Laboratory data further support these links by showing that positive emotions speed recovery from the cardiovascular sequelae of negative emotions[99]. "Upward spirals" of causality between vagal tone (an index of autonomic flexibility) and positive affect have also been documented, whereby vagal tone, positive emotions and social connectedness reciprocally and prospectively predict one another[100]. Although tentative, yoga-based practices such as the rhythmic and resonant breathing techniques used in the TLS intervention appear to improve indices of autonomic and cardiovascular function[46]. Moreover, in one active-control study, neurohormonal changes during yoga appear to improve mood above and beyond what can be attributed to normal exercise[101]. There is thus theoretical concordance between the observed increases in positive affect in some TLS participants and the physical practice of yoga.

On the other hand, the assumption that so-called "positive" psychological traits necessarily promote well-being in all contexts has been questioned by some authors[102]. Adolescence may be a period of particular complexity in the relationships between positive emotions and social and behavioral outcomes. One of the first studies to

experimentally investigate the role of affective influences on adolescent risk-taking found that subjects had markedly lower risk perceptions of events such as getting into a fight or riding in a car with a drunk driver under a condition of positive affect compared to neutral affect[92]. Gender-specific patterns further complicate this picture; in a study investigating the link between social and emotional well-being and peer relations in early adolescence, boys' acceptance of peers was predicated on their displaying higher positive affect, lower empathy and lower anxiety, while girls were more likely to accept peers with lower levels of positive affect but higher levels of empathy[103]. A wealth of research shows that social context and emotional arousal structure adolescent risk-taking – and its gender disparities – much more strongly than cognitive and biological factors[104]. Though the effects of positive affect on adolescents' behaviors are inconclusive and require more research, the combination of classroom-based TLS practices that aim to both train emotional regulation and foster positive emotional states may help participants maximize the "upward spirals" of positive socioemotional experiences while avoiding the over-arousal by negative *or* positive experience that leads to poor decision-making. The recent manualization of an 18-week TLS curriculum may scaffold this reciprocity between positive affect and emotional regulation more effectively than the 8-week pilot program used here.

Limitations and Next Steps

This study had several limitations. Although the sample size and high participation rate of students at the study site school bolstered its internal validity, these high numbers strained the limited time and personnel available for data collection, likely adding to the rates of missing data at certain time points. Similarly, randomization by classroom allowed for a degree of control over the nested effect of data in the mixed model analysis, but the number of classrooms (7) may not meet the recommended number of units necessary for inclusion of a higher level factor such as classroom into mixed model analysis[105].

As an alternative school with many at-risk youth, the study site and population was a good fit for the target population of the TLS intervention; however, incidents during the study period such as on-campus fights that required police investigation caused disruptions that were not ideal for testing the efficacy of the intervention. One fight in particular involved a group of female students who incurred numerous suspensions and expulsions, which seemed to adversely affect the general tenor of the trimester, especially for girls at the school. Future studies would benefit from inclusion of measures of implementation fidelity to assess the individual dosage of TLS sessions each student received, the adherence of TLS instructors to program protocols and materials during each session, and the overall quality of program delivery. As some studies have suggested a nonlinear process of change between responses to stress and mindfulness practice[55], analyzing variations in intervention frequency and quality could help determine whether limited exposure to mindfulness may initially increase awareness of stress and emotional experiences before observable benefits accrue, especially in more stress-sensitive females[54]. Longer-term follow-up is crucial to establishing the trajectory and durability of effects across various age and gender groups. Lastly, the use of self-report and non-blinded teacher report to assess functioning may be influenced by social

desirability and other sources of bias. Testing the influence of classroom-based yoga on academic and behavioral functioning requires future multidisciplinary collaboration that draws from various sources of objective and subjective data to map the intersection of prevention outcomes with cognitive, social and affective changes[40]. Direct observation of student behavior, cognitive markers such as grades, test scores, and executive function testing, and physiological measures such as salivary cortisol or heart rate variability would help to elucidate mechanisms of action underlying students' self-reported improvements.

This research supports and expands upon previous research indicating that contemplative practices can be beneficial for adolescents[40,57-59]. The focus on positive youth development and self-regulatory capacities is consistent with recent recommendations from scholars in numerous fields that early adversity and its detriments to brain development may be counteracted by training that strengthens positive mental qualities and socioemotional dispositions[56,106]. As a stepping stone for more rigorous research, this pilot study provides preliminary evidence of the positive effect of a classroom-based contemplative practice on the emotional regulation and social functioning of urban youth, and suggests new lines of questioning to inform the burgeoning developmental perspective of the impact of chronic stress on some of society's most pervasive public health and educational challenges[15,17,35,104,107]. The novel application of classroom-based yoga practice for at-risk and underserved youth demonstrates potential as a universal prevention and promotion scheme that may help move American education in the 21st century to a point proposed by psychologist William James in 1890: "The faculty of voluntarily bringing back a wandering attention, over and over again, is the very root of judgment, character and will… An education which should improve this faculty would be the education par excellence." [108]

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Appendix: Literature Review- Paper 1

Health Disparities, Stress Responses and Contemplative Practices

Alex Schrobenhauser-Clonan
UCB-UCSF Joint Medical Program
5/14/2012

Thesis Committee Members:
Professor Ronald E. Dahl, Chair
Professor Douglas Jutte
Professor Colette Auerswald

Section I. Development of Stress Responses and Self-Regulation Skills Are Critical to Public Health and Health Equity

<u>Social Gradients of Health Find the Fourth Dimension: Why Timing is Important to the Impact of Stress on Neurocognitive Development and Why Race and Class are Not Static Risk Factors</u>

The chief insight of social epidemiology- that non-material factors such as class and autonomy create a social gradient for health conditions such as ischemic heart disease- were brought to light by research like the famous Whitehall study. Whereas a common view in public health circles in the 1970s was that poor people developed diseases of material deprivation while richer people were affected by so-called "diseases of affluence" stemming from rich diets and sedentary lifestyles, Whitehall showed there was a steep inverse relation between the rank of employment of middle-aged men in the British Civil Service and their overall mortality [1]. This social gradient existed even amongst men far above the poverty line. Health inequalities were not limited to the consequences of poverty and conventional risk factors ranging from income to cholesterol levels. Further longitudinal study on the influence of occupation and social position on health (through initiatives such as the Whitehall II) have shown that chronic occupational stress and lack of control over one's workplace environment and activities can lead to common conditions like heart disease, possibly through alterations in neuroendocrine and autonomic nervous system function [2]. These discoveries have, in turn, motivated a reevaluation of the concepts and causal pathways underlying the health disparities of minority communities in urban American.

How are the lessons of Whitehall to be applied outside the working population? Specifically, how do these newer perspectives on health disparities impact the study of school-aged individuals and the contexts of unemployment that many minority youth find themselves in after exiting school? Are chronic stress and lack of control less, equally, or more important to outcomes for children and adolescents? Goodman and McEwen (2005) argue that clearer theoretical conceptualization of the differential roles played by race/ethnicity and socioeconomic-status is crucial to understanding stress-related health disparities in adolescents [3]. According to Goodman and colleagues, race/ethnicity and SES comprise different, overlapping dimensions through which social disadvantage and advantage emerge; however, their results show that at the lower end of social hierarchy, amongst inner-city, poor, minority youth, the effects of race/ethnicity and SES on stress are indistinguishable due to their strong covariance, and only become evident as position in a social hierarchy increases [3]. Therefore, according to the authors, "they are not risk factors that can be used to define high-risk groups, but markers of lifelong experience in the social world;" future research must be guided by clearer conceptual frameworks in order to explain the processes through which these social characteristics operate across the life course [3]. While discrimination and poverty-related stressors play a role in negative health outcomes of minority groups [4,5], the new frontiers of social epidemiology and health disparities research will be to operationalize these concepts and integrate them into programmatic and policy-oriented research. *The conceptual framework proposed herein posits that social disadvantage in poor, minority, urban youth results from both increased exposure to uncontrollable stressors and reduced opportunity to modify stress responses and improve recovery from stressful events through environments that train*

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self-control and self-regulation. This hypothesis humanizes the structural injustices of poverty and racial discrimination by postulating the central importance of adult-youth relationships both for the production of stress and suffering in our youth and for the prevention of stress-related outcomes in disease and life success. The following sections unpack the convoluted definition of "stress" into a tripartite model of positive, tolerable and toxic stress, before demonstrating that toxic stress in family and community settings is central to the powerful predictive value of adverse childhood experiences (ACE) on a range of health and life outcomes.

A Tripartite Model of Stress

Psychosocial stress, as well as adaptations to this stress, play a large role in the biological expression of social inequality, which comprises "how people literally embody and biologically express experiences of economic and social inequality, from in utero to death, thereby producing social inequalities in health across a wide spectrum of outcomes" [6]. Since the pioneering work of stress physiologist Hans Selye in the middle of the last century highlighted non-specific, generalized responses to stressful stimuli in animal models, the concept of stress has taken on a more nuanced description. While continuing Selye's seminal investigations into the physiology of stress, stress research has expanded to include contributions from neuroscience, molecular biology, genomics and social sciences. Though this interdisciplinary growth has added crucial insight, variable usage of the term *stress* has lead to confusion and cross-talk in academic dialogues that are otherwise "remarkably convergent" [7]. In reviewing the use of the stress concept in the growing field of stress research, Koolhaas and others (2011) mention that the colloquial usages of *stress* and its formal use in studies of physiological systems can be contradictory: "the physiological 'stress' response to appetitive, rewarding stimuli that are often not considered to be stressors can be as large as the response to negative stimuli" [8]. These researchers propose restricting the term "stress" to situations where an environmental demand exceeds the natural regulatory capacity of an organism, particularly in conditions that are unpredictable or uncontrollable. While this operational definition may be appropriate for basic science and animal research, it loses the important implication that stress is not a wholly separate phenomenon from processes that lead to health, gratification and thriving. Indeed, certain mental and physiological processes that can be harmful in situations of uncontrollable, unpredictable demands and/or low regulatory capacity may be central to productivity, life satisfaction and the rewards of work, hobbies and socializing [9].

This literature review endorses and utilizes the taxonomy proposed by the National Scientific Council on the Developing Child (2005) that categorizes stress responses- rather than the actual stressors themselves- as positive, tolerable and toxic [10] depending on their potential to disrupt healthy neurocognitive and physiologic function. According to Shonkoff (2010), *positive stress* is an important aspect of healthy development characterized by moderate, short-lived increases in a variety physiological and hormonal markers that occurs in response to normative life challenges such as navigating new social settings. Positive stress during development is contingent on stable and supportive relationships that "facilitate adaptive responses that restore the stress response system to baseline" [11]. *Tolerable stress* describes physiological states with the potential to disrupt brain architecture, yet are buffered by these supportive adult

relationships to facilitate restoration of child stress-response systems to baseline, thereby preventing neuronal disruptions that would impair mental, emotional or behavior functioning. Precipitating stressors include death or illness of loved ones, parental divorce, natural disaster and community violence [11].

Toxic stress is characterized by strong, frequent or prolonged activation of the body's stress-response systems that disrupts brain architecture, adversely affects other organs and programs mental, emotional and behavioral reactions to real or perceived stressors that are non-adaptive and pathogenic. The absence of stable adult support to buffer stress responses and facilitate recovery of healthy baseline functions is a cardinal feature of toxic stress. Unfortunately, the main sources of this stress are often the family members and caretakers whose support is most crucial. Many of the major risk factors for toxic stress in U.S. communities arise in the family: recurrent physical and/or emotional abuse, chronic neglect, severe maternal depression, parental substance abuse and family violence [11]. The sequencing of stress response and recovery of physiological steady state in positive or tolerable stress is missing in situations of chronic stress, whose cumulative burden leads to a deterioration of homeostatic regulation known as "allostatic load" [12]. The concepts of chronic stress and allostatic load have been put forward as organizing principles behind the socioeconomic gradients of health, and this formulation may help to account for "the sum total of stressors," ranging from long commutes to violent crime, that accumulate at the lower end of the social hierarchy [13]. However, as the adage in medicine goes that "children are not small adults," so should it follow in public health: the nature, distribution and impact of stressors in pediatric populations require age-sensitive, temporal analysis when considering SES or race/ethnicity [14]. Race and class are likely to structure risk for altered brain development and unhealthy behaviors according to the different environments (whether built, familial, social or academic) that children pass through as they mature. Risk measurement in prospective studies is admittedly complicated by a host of theoretical and practical factors. Innovations such as the adverse childhood experiences (ACE) inventory, while not capable of documenting the "sum total of stressors" of chronic stress, help highlight the chief precipitants of toxic stress and track their effect on disease and health-related behaviors into adulthood.

Adverse Childhood Experiences

Just as the physical sciences were transformed by the quantum revolution, which gave powerful new ways of conceptualizing and measuring energy, life stress, including psychosocial challenges, can be quantized in order to better understand its cumulative effects across the lifespan. In a compelling series of studies, Vincent J. Felitti and colleagues developed the ACE inventory to assess the relationship of adult health risk behaviors, health status and disease states to childhood abuse and household dysfunction [15]. The seven dimensions of childhood adversity are (1) psychological, (2) physical or (3) sexual abuse by a caretaker, household member, or other adult, (4) violence against one's mother or stepmother, and exposure to household members who were (5) substance abusers, (6) mental ill or suicidal, or (7) ever imprisoned. These categories describe specific but often frequent episodes of some of the most distressing experiences possible in childhood, situations uniquely given to prompt toxic stress through the coupling of adversity and absence of stable adult support.

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Results showed compelling evidence for the cumulative effects of childhood stress and trauma on some of the most widely studied risk factors and diseases. The researchers found a strong dose-response relationship between the number of childhood exposures and each of 10 risk factors that account for the leading causes of death in the U.S. Persons who had experienced four or more categories of adversity, compared to those who experienced none, had 4 to 12 times the likelihood (by adjusted odds ratios) for alcoholism, drug abuse, depression, and suicide attempt; a 2- to 4-fold increase in smoking, a history of greater than 50 sex partners, and a history of sexually transmitted disease; finally, those with four or more ACE had a 1.4 to 1.6-fold increase in physical inactivity and severe obesity [15]. This graded relationship was reproduced in an analysis of ACE exposures and adult diseases, which showed significant ($p <. 05$) dose-response relationships between number of ACE and ischemic heart disease, cancer, COPD, history of hepatitis or jaundice, skeletal fractures and poor self-rated health [15].

Documenting adverse childhood experiences as distinct but interrelated instances of profound trauma and stress that may echo throughout the lifespan casts doubt on the common medical reduction that health risk factors and genetics converge to create disease. Studies utilizing ACE or other markers of familial and community-derived stressors beg the question of whether health risk behaviors such as smoking, drug abuse, and overeating "may be properly viewed as a personal solution to problems that are well concealed by social niceties and convention" [16]. It is still taboo in most medical and education systems to make collection of information on histories of sexual child abuse and the like a standard, systematic procedure; it is little surprise, then, that troubled students and medically-challenging patients are often blamed for continuing to engage in unhealthy or risky behaviors while a developmental understanding of toxic stress and its impact on basic neural pathways of behavior is rarely applied in efforts to help them. In the absence of this developmental and neurobiological acumen, these troubled students and patients attempt to cope with their situations with available means. Behaviors such as drinking, smoking and over-eating may even appear as protective factors of mental health in certain populations; both Boardman and Alexander (2011) and Jackson et al. (2010) found that compared to white participants, black adolescents and adults exposed to chronic stress who lead the most "healthy" lives in terms of risk factors like diet, tobacco use and alcohol consumption had the *highest* probability of depression [17,18].

ACE are Common and Interrelated

Although still in its nascence, epidemiological surveillance of ACE suggests that household dysfunction is common during childhood and adolescence but comes in many forms. In the first nationally-representative survey of ACE in 26,229 adults carried out in 2009, the CDC reported that 59.4% of respondents had at least one ACE, while 8.7% reported five or more [19]. Of particular concern was the disparity between adults older than 55 years reporting ACE exposure (9.6%) and young adults aged 18-24 (16.9%), suggesting a mounting toll of childhood trauma in younger generations. Heterogeneity in the prevalence and frequency of various ACE across ethnicity/race categories was striking, and pointed to multiple matrices of adverse experience that can lead to similar outcomes and health disparities in minority groups. Among all racial/ethnic groups, non-Hispanic black respondents reported the lowest prevalence rates in each ACE category with the exception of having an incarcerated family member, parental separation or

divorce, and witnessing domestic violence [19]. Hispanics reported higher prevalence of physical abuse, witnessing domestic violence and having an incarcerated family member compared to their white counterparts. It is possible that self-reporting biases differed amongst groups, while another source of variation could be the need to expand the notion of childhood adversity beyond the household unit into the wider community.

Integrating neurodevelopmental models of stress into surveillance systems and trauma-sensitive service provision by collecting data on ACE requires understanding the high degree of interrelatedness amongst many stressors such as abuse, neglect and domestic violence. In a report on the global public health implications of ACE research, its originators mention the limited utility of single-factor analyses in stress processes where cumulative effects and social contextualization are paramount:

> "Findings suggest that studies of the relationship of single types of ACE
> to public health outcomes are likely to overestimate the contribution of
> these single exposures to outcomes, miss the broader context in which
> they occur, and underestimate the public health impact of a wider array
> of ACE."[20]

Upwards of 90% of people who have experienced one ACE report at least one additional ACE [21]. While the non-independence of ACE certainly makes for more complicated statistics, their study lays a foundation on which the concepts of allostatic load and toxic stress, of which the absence of adequate adult support for stress recovery is paramount, can find practical applications in the fields of education, health care and violence prevention.

<div align="center">Community-level Adversity: Violence</div>

Although a stable, secure and caring household is key to the proper development of stress and emotion regulation, neighborhood and community factors are theorized to play an important role neural development, especially in impoverished settings [22]. Unlike the suburban lexicon, where streets are simply what one drives to get to and from the home, "the street" became an entity unto itself in inner-city and low-income neighborhoods because the impact of surrounding households and their residents is often as palpable and frequent as the noises that emanate throughout crowded low-income housing. Poverty brings with it a range of chronic stressors including material deprivation, income insecurity and instability, interpersonal conflicts related to money, evictions, low-quality housing, and limited health care and other social services [23].

The fraying of social cohesion in some communities due to economic hardship, discrimination and lack of educational and occupational opportunities has created community-level adversity. Community violence is a particularly conspicuous sign, and one that disproportionately affects minority and urban-dwelling youth [24]; Buka and colleagues (2001) estimated that about 1 in 4 urban youths reports having seen someone murdered during childhood [25]. The effects of experiencing or witnessing community violence on children and adolescents include higher rates of post-traumatic stress disorder (PTSD), depression, aggression and externalizing behavior disorders [25]. Besides the direct stress-related effects of being victim, perpetrator or witness to violent events, there appears to be independent associations between perceived neighborhood disorder (self-

<div align="center">33</div>

reported perceptions of one's environment), community cohesion (a measure of perceived social ties) and outcomes such as PTSD [26], depressive symptoms [27], adolescent sexual onset [28], and externalizing and antisocial behaviors [29]. In a study of Mexican-American families, whose findings were replicated in a sample of African-American families, researchers found support for a "transaction model" of neighborhood influence in which children's perception of neighborhood quality fully mediated the association between empirical indicators of neighborhood disorder and child antisocial behavior [29]. Moreover, parent support attenuated the positive association between children's perceptions and their antisocial behavior. Objective markers of community violence such as crime rates, perceptions and symbolic meanings of this community adversity, and interpersonal support structures all make unique contributions to the development of a community's younger generations.

Community violence is not a separate phenomenon from household or family dysfunction when it comes to its impact on psychological and behavioral health; the degree of family conflict, domestic violence, and family support are important moderators of the effects of exposure to community violence [25]. Although the physical fallout of this stress may not manifest till middle age, self-rated health and functioning quickly decline. In an 8-year prospective cohort study of more than 8,000 adolescents ages 12-18, cumulative violence exposures (witnessed gun violence, threat of violence, repeated bullying, perceived safety and criminal victimization) were associated with a graded increase in risk for poor self-rated health. For each additional violence exposure, the risk of poor health increased by 38% [30]. In this nationally representative sample, disparities in self-rated health during the adolescent period were partially attributable to disparities in cumulative exposure to violence, after controlling for SES, alcohol use, drug use, smoking, depressive symptoms, and family and neighborhood characteristics [30].

<u>Individual, Family and Neighborhood Cycles of Adversity and Toxic Stress</u>
This suggests that the confluence of neighborhood violence and disorder with mediating factors such as poverty and household dysfunction may potentiate the negative effects of stressful events on adolescents' developing systems. A recent study of a pediatric population in a low-income, predominately minority urban area in Northern California found that a majority of participants (67.2%) had experienced trauma related to both ACE and community violence [31]. In the population from which study participants were drawn, over a third of adults lacked a high school degree and the leading cause of premature mortality was violence. In this context, youth that were exposed to four or more adverse experiences in childhood and adolescence had double the odds of being overweight or obese, but were an alarming 32 times more likely to have learning and behavior disorders [31]. Results such as this raise the specter that pre-adult trauma and neglect, when mixed into a milieu of widespread school failure and violence, may lead to cognitive and emotional challenges that further predispose to school failure and subsequent involvement in dangerous, possibly violent, activities. In a review of psychobiological and brain maturation studies of children with histories of abuse or neglect, De Bellis (2001) describes this this toxic stress as an "environmentally-induced complex developmental disorder" with patterns of intergenerational transmission [32]. The failure to develop proper systems for self-regulating emotion and behavior in one generation, according to De Bellis, may lead to poor parenting skills and account for the

well-studied increases in risk of substance abuse, domestic violence and child maltreatment in the next generation. Recent findings by Gapen and colleagues (2011) add a community-level layer on this perspective by showing that "near-epidemic levels of civilian PTSD with impoverished inner-city communities" may be attributable not just to trauma exposure, but to perceptions of high neighborhood disorder and low community cohesion [26].

Adolescent Mental Health as an Outcome of Development Stress

Mental-health related disorders of mood and behavior appear to not only originate in pre-adult experiences, but also emerge before adulthood as well. Prevalence rates of mental disorders in U.S. adolescents closely approximate rates in the adult population, suggesting that the majority of these disorders present before adulthood, but often go undiagnosed and untreated [33]. One in four to five adolescents experience disorders that result in severe impairment in daily activities such as socialization or learning; the median age of the onset of symptoms for these adolescents is 6 for anxiety disorders, 11 for behavior disorders, 13 for mood disorders and 15 for substance use disorders [33]. Although the prevalence of these severe emotional and behavioral disorders is higher than the most frequent major diseases of adolescence such as asthma and diabetes, half of all adolescents with these disorders never receive mental health treatment, with Hispanic and black youth much less likely to receive treatment than Whites [34].

Timing is Everything: An Example of Adolescence as a Sensitive Period in Neurobiological Development

In addition to the cumulative effects of stressful events on later health and functioning, there is rapidly growing consensus that the impact of any particular stress is intimately related to its timing along axes of social and neurobiological development. Due to its connections to well-studied pharmacological processes as well as its later onset, greater incidence and socially-mediated patterns during adolescence [35], substance abuse is a prime example of how adolescence is a sensitive period in neurobiological development. Reviewing the current state of epidemiological, brain imaging, molecular biology and genetics research on substance use, Andersen and Teicher (2009) describe "how the timing of stress exposure interacts with normal maturational processes to enhance vulnerability to abuse substances" [36]. Chronic stressors such as dysfunctional relationships or lack of safe environments for normal childhood activities to take place may alter the organization and activity of the brain by numerous mechanisms; in the case of drug abuse, it seems that stress during early and middle childhood (ages 11 and below) manifests later in adolescent and adult life as decreased density of neurons and synapses in the memory-storing hippocampus and abnormal responses to dopamine in the nucleus accumbens (part of the brain's "reward" system). On their own, these subcortical changes may enhance an individual's susceptibility to addictive reward and behavior, but stress during adolescence appears to blunt the higher-level control exerted by the prefrontal cortex on these structures and their functions. Unlike the delayed effects of traumatic stress on the hippocampus and other subcortical areas of the brain, stress seems to exert maximal and immediate effects on the prefrontal cortex during adolescence [36]. The prolonged development of the prefrontal cortex, whose normal maturation extends even into adulthood, seems to render it particularly vulnerable to the effects of adolescent

stress. Stress exposure during adolescence, including social isolation and sexual abuse, is associated with decreased prefrontal gray matter and synaptic density, with little to no change in other brain regions [37,38]. These neural changes cause dysregulation in stress and reward systems that predisposes to compulsive drug use, while mood disorders during adolescence further exacerbates the dependence on drugs for pleasure and stress-relief. Andersen and Teicher (2008) also describe a model for the pathogenesis and increased frequency of depression in adolescence in which alterations to the prefrontal cortex due to adolescent stress bring the latent effects of earlier stressors into full expression as the anhedonia, sleep disturbances, decreased cognitive abilities and suicidality often seen in depressed adolescents [39].

In an apropos allusion to an adolescent rite of passage, some researchers employ the metaphor of driving a car to illustrate the vulnerabilities and opportunities of the adolescent period on brain and behaviors. Dysregulation of stress reactivity through childhood adversity, coupled with interference in normal prefrontal development by adolescent stressors, may create a situation where teens are prone to gun their engines by partaking in risky behaviors with little ability to apply the brakes that allow them to calm themselves and control these drives. This shortfall in self-regulatory capacity can have dire consequences for adolescents and young adults when they are put behind the wheel of an actual car; in the United States, the leading single cause of deaths among youth aged 10-24 is motor vehicle crashes (30%). Along with driving deaths, other unintentional injuries (16%), homicide (16%) and suicide (12%) make up nearly three quarters (74%) of mortality in this age group [40]. These sobering statistics are the dark silhouettes of a multidimensional picture of adolescent health; the same affective and motivational upsurges that account for the lability of adolescent emotional responses- the adolescent "angst" often popularized in media portrayals of teens- also create opportunities for powerful transformations during this time. Although puberty can be explained in evolutionary terms as the actuation of full sexual ability, this view alone fails to account for social, ethical, and- what might be even be deemed in some circles- spiritual effects of the intensity of feeling in adolescents. In reference to the metaphor of adolescents possessing "turbo-charged" emotions without a trained set of "driving skills," or cognitive abilities, to modulate them, Dahl (2004) writes:

"This metaphor is one way to capture the relatively earlier timing of these "igniting passions" at puberty- passions that refer not only to romantic and sexual interests, but also to the intensification in many kinds of goal-directed behaviors that emerge in adolescence. Early adolescence is a time when many teenagers become passionate about a particular sport, hobby, music, art or literature. It is also a time of passionate commitments to idealistic causes." [41]

Adolescence as an Integral Piece of the Executive Function Debate

Transition and training are inherent to adolescence. As a passage from the structures of childhood, whereby parents and other adults such as teachers monitor and assume partial control of many aspects of behavior, to that of adulthood, where autonomous behavior is expected, adolescence is the full-stage debut of skills that are rehearsed throughout childhood. Much research into skills acquisition during childhood has focused on the "executive" functions that undergird goal-directed behaviors and complex tasks. These include working memory, inhibitory control over non-relevant

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thoughts and impulses, and the cognitive flexibility to adjust to new information and demands.

As the building blocks of any mentally demanding activity, executive functions are transferable and durable facets of individual performance throughout a variety of contexts. Showing clear and consistent correlations, Mischel et al. (1988) compared the results of a delayed gratification task in 95 preschoolers (ages 4-5) to personality (rated by parents) traits of these individuals over a decade later [42]. Children who were able to delay eating one marshmallow while alone in a room for 15 minutes, and hence were rewarded with an extra marshmallow, were reported to be more academically and socially competent, verbally fluent, attentive, goal-oriented and able to deal with frustration and stress as adolescents [42]. In an available sub-sample of these subjects, both quantitative and verbal SAT scores as teenagers were significantly related to the amount of time they were able to delay gratification as a preschooler [43]. More recently, Duckworth and Seligman (2005) reported that self-discipline (as measured by multiple delay-of-gratification tasks as well as self, parent, and teacher reports) in eighth-graders at the start of the school year accounted for more than twice as much variance as IQ in subsequent academic performance, selection into a competitive high school and school attendance [44]. Self-control and executive functioning appear to take root and bear fruit throughout different phases of childhood and adolescence. Although variably defined in different fields of study, stress responses, emotion regulation and executive function merge onto related brain structures and neural circuitry that are susceptible to toxic stress [45].

The effects of childhood executive functioning also extend far forward in time. Moffitt et al. (2011) found considerable independent effects of childhood self-control on 30-year follow-up results of adult physical health, substance dependence, personal financial markers, and criminal history [46]. Investigating the idea that "children with poor self-control were more likely to make mistakes as adolescents, resulting in "snares" that trapped them in harmful lifestyles," the scholars found that lower self-control was inversely proportional to the number of "snares" experienced, like early smoking (<15 years), high school drop-out, and unplanned teenage parenthood [46]. These snares attenuated a substantial portion of the effect of self-control on health (32%), substance dependence (63%), attained SES level (35%), income (29%), single-parent child rearing (61%) and crime (42%), although the direct effect of childhood self-control remained statistically significant for almost all categories. As in the neurobiological models of adolescent substance abuse and depression, adolescent experiences moderate, for better or worse, the effects of childhood adversity. With this perspective, however, we see the changes wrought by adolescent adversity are not confined to unseen alterations in prefrontal cortex, but become social and interpersonal phenomena as dramatic as unwanted childbirth and school failure.

Training is Everything: No Great Trade-Offs when Adolescent Interventions Target the Right Skills

Compared with research on the effectiveness and economics of early childhood investment in cognitive, linguistic, social and emotional competencies, large-scale training programs for adolescents and young adults have more narrowly approached certain cognitive and linguistic abilities. Vocational training, adult literacy and criminal

rehabilitation generally have poor track records and returns [47], but these interventions have not struck the substrates of motivation and emotion that seems to account for much of the success of early childhood programs.

Federal child development programs like Head Start and No Child Left Behind have focused on cognitive test score outcomes to measure their success and have been deemed by many as failures; yet social experiments such as the Perry Preschool Program (started in 1962) that sought to enrich poor children's early years- while failing to change IQ scores- nonetheless showed surprisingly durable impacts in follow-up to age 40: treatment groups show higher rates of high school graduation and home ownership and higher salaries concomitant with lower rates of welfare assistance, out-of-wedlock births and fewer arrests [48]. Other early childhood enrichment programs are showing similar effects on life trajectory, although cohorts are still in early stages of their adult life cycles and therefore do not have long earnings and investment histories [49]. Though more clinical and laboratory studies are needed to disclose the exact nature of the underlying neurobiological changes that early childhood interventions elicit, it is already clear that the skills conferred affect learning and life success less through purely cognitive tracks then through social and emotional stimulation. This stimulation strengthens self-mastery of emotion and attention and assigns personal utility to these strengths that further motivates learning and goal attainment in all realms of life [50].

In terms of human capital, early childhood enrichment can be seen as a long-term investment opportunity that awards big socioeconomic returns many years later. Some economic analyses point to the paramount importance of intervening in the earliest developmental timeframes, stating that the most successful interventions for brain development occur before the age of three, and that perhaps antenatal interventions with mothers hold the greatest impact across the lifespan [51]. Springing from the landmark study commissioned by the Institute of Medicine and the National Research Council, *From Neurons to Neighborhoods: The Science of Early Childhood Development,* a consensus has begun to emerge amongst scientists and policymakers that is based on four principles of human development [22]:

(1) brain development and skill formation are based on interactions between genetics and life experience

(2) the neural pathways that underlie mastery of these skills and are essential for economic success follow hierarchical rules whereby later attainments build on foundations laid down earlier

(3) cognitive, linguistic, social and emotional competencies are interdependent and all are powerfully shaped by experiences of the developing child

(4) although adaptation to life experience is continuous, skills are formed in a predictable sequence of sensitive periods, during which the development of specific neural circuits and the behaviors that mediate them are most receptive to environmental influences. [adapted from [50]]

This consensus is right to highlight early childhood as a sensitive period when skills promotion may have its broadest benefit on all the interdependent competencies, but these discussions should not reduce the importance of a life cycle perspective on the rapidly-evolving evidence of neuroplasticity in humans [52]. Though the seeds of life success are most definitely sowed earliest, true neighborhood transformation will require that the network of neurons we call a community be given proper nutrients and maintenance at every life stage. While a cognitive marker such as IQ may stabilize in middle childhood, other measures of personality, such as conscientiousness, do not reach peak stability in the population until after the age of 50 [53]. Although doing well in an activity such as music performance often favors early practice and training, doing good in society may allow for a more diverse array of approaches that draw on skills that can be strengthened at any age.

The teenage years stand out as an opportune time when skills formed in childhood can be integrated into the adolescent project of identity formation. The highly charged media and peer-related inputs of most adolescents' self-image may be leveraged to cement a sense of personal efficacy that can help adolescents avoid risky behaviors while still taking the risks needed to achieve dreams [54]. Moffitt and colleagues (2011), discussing their 30-year study of self-control, state that "with respect to timing of programs to enhance self-control, our findings were consistent with "one-two punch" scheduling of interventions during both early childhood and adolescence... [as] low self-control's capacity to predict health, wealth, and crime outcomes from childhood to adulthood was, in part, a function of mistakes our research participants made in the interim adolescent period" [46].

This "one-two" punch may be particularly powerful for those most in need. The greatest returns on investment can occur with those programs targeted at disadvantaged youth because their home and neighborhoods are most lacking in neuro-stimulating environments [55]. While returns in many domains tend to diminish with age- English language proficiency, for example, shows a precipitous drop if age of arrival in the U.S. is after puberty rather than before [56]- it does not necessarily follow, as Heckman (2006) maintains, that "a serious trade-off exists between equity and efficiency for adolescent and young adult skill policies" [50]. Indeed, Heckman later qualifies this generalization with analyses showing that while there are substantial trade-offs for investment in cognitive skills of disadvantaged adolescents, "the trade off is much less dramatic for investment in the noncognitive skills of adolescents" [57]. The greater malleability of noncognitive capabilities, such as emotion regulation and stress responses, is associated with the slowly developing prefrontal cortex, which creates opportunities for alterations to personality and emotional profiles in adolescence and beyond [53].

The optimal time to deliver an intervention will depend on the target outcomes of interest and the nature of adversity in a child's early years. Disadvantaged and non-disadvantaged populations may maximally benefit from the same intervention at different stages; recent analyses of data from the National Longitudinal Survey of Youth show that successful adolescent remediation strategies for children faced with early adversity focus on noncognitive skills and may be the most cost-effective strategy for preventing certain outcomes like crime [57,58].

<u>Self-regulation Training as Secondary Prevention and Stress Inoculation</u>

Before discussing modes of training self-regulation, their place in both disease prevention and health promotion schemes should be established. In evaluating the impact of chronic and traumatic stress from the antenatal period to adulthood, interventions or their specific components may qualify as primary, secondary and tertiary prevention. Primary prevention would entail curtailing the occurrence of adverse childhood experiences and other stressful exposures at both household and community levels. Secondary prevention might seek to avert the adoption of health risk factors and behaviors that stress-exposed individuals are more prone to take up. Lastly, tertiary prevention would seek to change adopted health risk behaviors, reduce the risks of engaging in them, or minimize the burden of morbidity and mortality attributable to these risks (considerable overlap exists between tertiary prevention as such and "treatment"). Although toxic stress before adolescence poses a detriment to subcortical brain development, strengthening the still plastic prefrontal cortex during adolescence represents secondary prevention of the sequelae of subcortical impairment, whether they are drug abuse, depression or school dropout.

Equally as instructive, the analogy between an inoculation schedule and self-regulation skills promotion during sensitive development windows can be drawn. This avoids the assumption of latent defect present in the concept of secondary prevention. Instead, sensitive periods of brain development become windows for deploying resources to optimize brain maturation. Protective factors and resiliency are best amplified by introducing specialized practices and experiences that anticipate and help youth respond optimally to possibly harmful exposures. As in immunization, not only do the same self-regulation and stress response capabilities need "boosting" at critical moments throughout development, but different interventions must be introduced sequentially and staged appropriately to induce maximal benefit and avert specific outcomes like crime or substance abuse. This analogy also hints at the possibility of herd immunity for mental and behavioral health disorders and of contagion-like spread of self-regulation in communities. Although these implications are unfounded, recent innovations in social network analysis using data from the Framingham Heart Study suggests that personal happiness may diffuse through networks and reach people with up to three degrees separation, as has been already been noted for obesity and smoking behavior [59].

Section II. Social-Emotional Learning and Contemplative Practices as 21st Century Educational and Health Paradigms

Supporting disadvantaged youth to achieve educational and health-related milestones will require programs and policies that understand and leverage the burgeoning applications of neuroplasticity and the effects of toxic stress. Under the rubric of social-emotional learning (SEL), research on executive function, self-regulation and self-control are central to some well-publicized efforts to improve school readiness, reduce school failure and prevent negative mental and physical health outcomes. These programs usually begin in preschool or early elementary grades and are designed to reduce problematic classroom behaviors while enhancing learning environments by emphasizing social-emotional competencies.

A prominent example, the Promoting Alternative Thinking Strategies (PATHS) program [60], provides teachers with systematic, developmentally appropriate lessons, materials and instructions for teaching a variety of social-emotional competencies such as emotional literacy (properly identifying and naming emotions in oneself and others to manage them properly). As part of both the federal preschool Head Start program and large elementary school cohorts, single and multi-year PATHS implementation have shown modest to strong effects on aggression reduction, prosocial behavior and academic engagement [61,62].

SEL interventions are still understudied and many are still in their infancy in terms of programmatic standardization. PATHS is one of only a few classroom-based social-emotional curricula that has been evaluated and shown reproducible success in randomized clinical trials using multiple sources of data. In one study, intervention children were better at identifying facial expressions and were significantly less likely than control to misidentify them as angry [61]. Given that humans have a special area of cortex responsible for processing and identifying faces, the social importance of accurately assessing facial expressions is not trivial. Moreover, emotional discrimination of facial expressions, executive functioning and social skills may be all correlated, although their causal relationships are still unknown [63].

An initiative that more specifically targeted components of executive function (EF), the Tools of the Mind curriculum demonstrated that 4 and 5 year-old children in a low-income, urban school district could improve EF through 40 core activities, such as actively and silently listening as a peer reads a picture book [64]. Many of these activities scaffold children's learning through "shared activity" in which one child does while the other monitors their progress, an idea which is based on development psychologist Lev Vygotsky's principle that children gradually internalize mental "tools" that first exist in a "shared" or "distributed" state [65]. The significant improvements of executive function in preschoolers enrolled in Tools of the Mind were therefore entrained not only by specific tasks but through, or at least alongside, social-emotional competencies.

<u>Is a Gram of Promotion Worth An Ounce of Prevention?</u>

Studies such like Tools of Mind and PATHS, and the epidemiological and observational research that informed their priorities, has created a shift in accepted applications and theories of health promotion. A 1994 Institute of Medicine report on the prevention of mental disorders concluded that there was not enough evidence to endorse mental health promotion [66]. The authors of a follow-up report, *Preventing Mental, Emotional and Behavioral Disorders Among Young People* (2009), stated explicitly that "the committee has embraced mental health promotion as an integral component of the continuum of [prevention and treatment] that warrants attention." [67].

Mental health promotion through SEL, EF training, and other forms of self-regulation, however, remains heavily weighted towards the first decade of life. Much of the work with adolescents, especially poor or otherwise disadvantaged youth, is remedial, targeting problem behaviors rather than protective factors. Despite highlighting successful programs at all education levels, a recent meta-analysis of 213 school-based universal SEL interventions found that 56% were delivered to elementary school students, 31% to middle school students, and only 13% to high school students [68].

The dearth of continuing mental health promotion likely contributes to dissatisfaction of teachers and school psychologists with the deficit-oriented, "refer-test-place" model of mental health in which children with learning and behavioral issues are passed down a pathology-reinforcing line into special and remedial education [69]. Universal, strengths-based approaches to psychological well-being in adolescence avoid the "self-fulfilling prophecy" of pathology-based approaches. Whether studied among health care providers, teachers, or coaches, there is considerable evidence that low expectations of an individual's functioning set in motion a series of "covert communications" between people in these positions of power and the individual that increases the likelihood that performance will actually reflect those expectations [70,71]. Increases in rumination and self-reflective thought in adolescents may potentiate these "interpersonal expectancy" effects, and may push adolescents with maladaptive stress responses (low distress tolerance) toward risk-taking behaviors [72].

The movement away from "categorical" prevention programs, which contribute to the fragmentation of efforts to meet students' mental, emotional and behavioral needs, to more inclusive, integrated frameworks is led by organizations such as the Collaborative for Academic, Social, and Emotional Learning (CASEL). Researchers from various institutes established CASEL to investigate the prospect that "SEL programming could address underlying causes of problem behavior while supporting academic achievement" [73]. In years of research, they have found that, despite a wide-variety of methods for improving social-emotional competencies, effective programs and approaches are typically sequenced, active, focused, and explicit (S.A.F.E.) [68], meaning they:

S: use a **S**equenced set of activities to achieve skill objectives
A: use **A**ctive forms of learning
F: include at least one program component **F**ocused on developing personal or social skills
E: **E**xplicitly target particular personal or social skills for development.

Contemplative Practices as Systematic SEL Training

Although not common in most SEL programs to date, there is increasing interest in contemplative practices such as yoga, meditation and mindfulness as complements to or even core components of mental health promotion. The consonance between the S.A.F.E. criteria above and four common elements of "integrated contemplative practices" identified by Oman (2010) is notable: systems of contemplative practices emphasize *setting aside time* for specific *mental centering/stabilizing practices* which target *virtues and character strengths* which are *modeled* by other individuals, both living and dead [74]. These elements dovetail with the sequenced, active, focused and explicit goals of personal and social development in SEL programs.

Although there has been explosive growth in research in the psychology, neuroscience and clinical applications of contemplative practices in adult populations, their efficacy and possibly differential effects in children and adolescents is limited. This small evidence base is often disproportional to the enthusiasm for promoting contemplative practice in children and youth [75]. This enthusiasm may be the consequence of many adults who discovered the benefits of these practices later in life, and "wished they had learned mindfulness skills decades earlier" [76]. The next section will review the state of research into contemplative practices with adults with some discussion of

underlying neurological and physiological processes before discussing the emerging field of contemplative education.

<u>Mindfulness-Based Therapies Show Success In Physical and Mental Health</u>

High-quality clinical research on contemplative practices began with studies in adult chronic pain patients [77,78], but soon grew to encompass research on a number of conditions. Developed at the University of Massachusetts Medical Center, the Mindfulness-Based Stress Reduction Program (MBSR) demonstrated that chronic pain caused by a number of etiologies could be treated with the self-regulation skills of mindfulness meditation. Kabat-Zinn (1982, 1985) hypothesized that in comparison to traditional treatment protocols, large reductions in reported pain, negative body image, mood disturbances, and inhibition of daily activity by pain were attributable to greater ability to maintain a "detached observer" stance. This attentional training created the possibility of "uncoupling" the sensory dimension of pain from a subsequent affective/evaluative stress reaction, which helped reduce patient's discomfort through cognitive reappraisal. This "uncoupling" of sensory and affective systems may also be accompanied by a more general "decentering" that allows practitioners to build new meaning-based coping systems for a variety of life circumstances and relationships [79,80]. Gains accrued from these cognitive-affective shifts may be remarkable durable. On 15-month and 3-year follow-up, the majority of subjects provided a 10-week stress reduction training reported continued high compliance with a consistent meditation practice and stability of a number of the outcomes described [81].

As any chronic condition can potentially reduce quality of life and well-being, mindfulness as a form of self-regulation and cognitive reappraisal has been investigated in a variety of mental and physical conditions: cancer [82,83], psoriasis [84], anxiety disorders [81], depression [85], substance use [86,87], and rheumatoid arthritis [88] to name a few. Meta-analysis of the MBSR program covering a wide spectrum of clinical populations as well as nonclinical groups found consistent and relatively strong effect sizes (*Cohen's d* approximately 0.5 ($p<.0001$)) across a spectrum of standardized health measures including psychological and functional quality of life scales, depression, anxiety, coping style, and medical symptoms [89,90]. As a treatment for anxiety and mood disorders, mindfulness-based therapy has been found to have large and robust effect sizes for improving symptoms [91]. Less attention has focused on MBSR's effects in healthy adults, although a recent review and meta-analysis of 10 studies in healthy populations found a positive nonspecific effect on stress levels compared to wait-list controls [92].

<u>Mind-Body Interactions Gain Scientific Credibility</u>

There are still methodological weaknesses in the majority of published studies on mindfulness, including the lack of agreement over appropriate active controls and varying operational definitions of the mindfulness construct [90]. Newer studies utilizing biomarkers and neuroimaging have hinted at physiological changes correlated with the well-described psychological benefits of routine contemplative practice. In a randomized, controlled study involving 25 healthy employees undergoing work-based mindfulness training, Davidson et al. (2003) reported significant increases in activity in the anterior left hemisphere of the brains of participants (measured by EEG), a pattern previously associated with positive affect [93]. Furthermore, intervention subjects showed increased

antibody titer to influenza vaccine compared to the wait-list control group, and the magnitude of this antibody titer "boost" was predicted by the magnitude of participants' left-sided brain activation [93].

Research on another mind-body training method (integrative mind-body training, IMBT) found that even short-term training with a qualified instructor (20 minutes a day for 5 days) could positively influence volitional control of attention, as well as lower cortisol-mediated stress response and improve immunoreactivity (higher antibodies) to a stressful activity [94,95]. Further investigation also showed that this short-term training could alter the functioning of brain regions such as anterior cingulate cortex (which has been implicated as a key player in attention-demanding tasks), and the autonomic nervous system (measured by physiological markers like heart rate variability (HRV)) [96].

Mix and Match Your Mindfulness; Yoga as the Common Ancestry

Besides MBSR and IBMT, mindfulness training has been incorporated into numerous other clinical programs, including dialectical behavior therapy (DBT) for borderline personality disorder [97], mindfulness-based cognitive therapy for generalized anxiety disorder and prevention of depression relapse (MBCT; [98-100]), and acceptance and commitment therapy (ACT; [101]). Although DBT and MBSR have a weight of evidence to prove their efficacy, the hybrid nature of their therapeutic components, combining among other things, cognitive-behavioral techniques and mindfulness in DBT, and Hatha yoga and seated meditation in MBSR, does not allow for specificity in evaluating the relative contributions of these components to program effects [90].

Though contemplative practices such as mindfulness, breathing techniques and various moving, static and meditative postures were first developed in ancient Indo-Tibetan traditions known collectively as "yoga," yoga research outside of India has been limited and has tended to focus on physiological aspects of the posture-based component of yoga called *asana*. Perhaps because many of the more than 15 million practitioners of yoga in the U.S. are engaged primarily in exercise-based yoga classes, most Western research has evaluated physical benefits of the practice, finding results similar to those of other comparable forms of exercise on cardiopulmonary and musculoskeletal function [102,103]. Moreover, unsubstantiated and exaggerated claims in the popular literature about the effects of yoga has likely discouraged some would-be researchers.

Besides the incorporation of gentle *asana* sequences into the MBSR protocol, domestic research into yoga as a therapeutic intervention for chronic stress is meager. A bibliometric analysis of yoga in biomedical journals over the past three decades found that a majority of research was conducted by Indian investigators and published in Indian journals, particularly yoga specialty journals- though the past decade has seen a recent trend of increasing contributions from U.S. and UK-based researchers [104]. The types of conditions most evaluated in yoga therapy studies have been psychiatric conditions, cardiovascular disorders and respiratory disorders, with depression, anxiety, heart disease, hypertension, diabetes and asthma being the most common discrete disorders [104].

Available high-quality research on yoga, however, supports the common belief that yoga can improve health by boosting psychological and physical resilience to stress. Studies have shown that practicing yoga can have immediate down-regulating effects on the response of both the sympathetic nervous system and the hypothalamic-pituitary-adrenal (HPA) axis to stress and stressful stimuli. Evidence points to yoga's salutary influence on salivary cortisol [105], blood glucose [106,107], as well as plasma rennin levels,

and urine norepinephrine and epinephrine (catecholamine) levels [108]. Some of these biochemical changes may underlie the significant decreases in heart rate and systolic and diastolic blood pressures found in yoga intervention participants [109]. Researchers have now begun to examine yoga's potential modulation of nitric oxide levels and oxidative stress and its applications to cardiovascular and metabolic functions [110]. Besides the hormonal effects of cortisol and catecholamines on brain functioning, neurochemical changes, including substantial increases brain levels of the inhibitory neurotransmitter GABA after hour-long yoga practice, may account for specific alterations in mood and cognitive ability [111]. The GABAnergic neurotransmitter system plays a prominent role in regulating neuronal excitability and its dysfunction is a factor in mood disorders and epilepsy. Research also points to yoga's effect on neurocognitive functioning. In a study of 36 yoga-naïve, healthy men, 6-months of routine practice produced significant improvement in measurements of both short- and long-term memory [112].

Based on preliminary results, some researchers hypothesize that yoga-based practices correct the underactivity of the parasympathetic nervous system and GABA systems in stress-related disorders partly through stimulation of the vagus nerve (i.e. vagal tone), the main peripheral pathway of the parasympathetic system; these pathways, and possibly others which have yet to be pinpointed, may reduce the harmful effects of chronic stress and allostatic load [113]. Compared to the benefits of regular exercise, which are undoubtedly legion [114], the more tightly aligned synchrony of respiratory control, muscle tone, body awareness and executive attention produced by certain yoga practices may be of particular merit in the treatment and prevention of mood disorders and recovery from conditions brought on by toxic or traumatic stress such as post-traumatic stress disorder [115].

Yoga prioritizes study of the transactional nature of body and mind through direct experience. As such, it may be amenable to the "bidirectional model of executive functions and self-regulation" proposed by Blair and Ursache (2010). The authors propose that executive functions serve a deliberate and therefore "critical higher-level or top-down role in behavior regulation and act as a primary mechanism of effortful self-regulation, but are to some extent as much a consequence as a cause of reactivity and regulation in lower-order, more automatic emotion, attention and stress response systems" [116]. If yoga can retrain automatic processes like vagal tone that compose the body's response to stress-related stimuli, then its bottom-up approach may impact the top-down role of executive function in novel ways. The distribution of GABA-releasing neurons in the thalamus, insular cortex, amygdala and hippocampus, as well as the projections of these neurons from the prefrontal cortex to the amygdala, make them possible candidates for yoga's effect on working memory and other executive functions [113].

Extending a bidirectional model to the social sphere, Kok and Fredrickson (2010) found that vagal tone (as an index of the flexibility and responsiveness of the autonomic nervous system), positive emotions and social connectedness may display a reciprocal causality; individuals with higher vagal tone appear to reap the benefits of an "upward spiral," whereby they more easily and readily capitalize on social and emotional opportunities of everyday life, resulting in more positive emotions and closer relationships that actualize further gains in vagal tone [117]. This is the first study of its kind to provide physiological correlates to Fredrickson's broaden-and-build theory (1998, 2001), which posited the positive feedback loops which link positive emotions to a range

of cognitive, physical and social resources [118,119]. Future research may show how individuals with enhanced vagal tone, who tend to demonstrate superior performance on a number of indices of cognitive flexibility including working memory, directed attention and inhibition of dominant responses to experimental stimuli, employ this flexibility to flourish in personal and professional domains [117]. Yoga, which has elaborated many targeted practices for consciously influencing autonomic function through the use of breathing exercises known as *pranayama* [120,121], may provide systematic instructions for setting in motion these upward spirals of human flourishing.

For proponents of mind-body integration, the complexity of human nature that somehow springs from our evolutionarily-derived, animal bodies warrants a valuing of the body's role in the creation even of high-level concepts and emotions such as hope and hate. Thomas Hanna, who pioneered and coined the word "somatics" to describe a "field of study dealing with somatic phenomena, i.e., the human being as experienced by himself (or herself) from the inside," writes in the *The Body of Life,*

"We cannot hate or be angry without an organism that hates and is angry. We cannot love and hope and expect without actively, movingly, physiologically loving and hoping and expecting. Hate, anger, love and hope are not "psychological states," existing in some "mental" vacuum; they are somatic states that exist in the entirety of a living organism."[122]

Section III. Pediatric and School-Based Mind-Body Training for Social-Emotional Learning

The shared characteristics of secularized contemplative practices variously labeled as mindfulness, meditation and yoga generally relate to their use of structured activities that "require individuals to exercise volitional control over their physical and mental activity" [123]. Although the outward manifestations of these practices may vary from silent, sitting meditation to walking meditation to audible breathing and dynamic body movement, each emphasizes sharpening attention in order to become aware of moment-to-moment changes in consciousness. Accessed through a broadened awareness of the interplay of environment, body and thought, gains in emotional regulation skills and knowledge of the basic workings of self and other are central to the social-emotional learning inherent in contemplative practices.

The Basic Levels of Self (BLoS) model presented by Roeser and Peck (2009) integrates William James' distinction between the *I* dimension of self that is the subject of phenomenal awareness and the constant change inherent in that awareness, and the *Me* self (or selves) that is an object of our experience, primarily contained in long-term memory, and provides "relatively fast and automatic evaluative feedback concerning the presence of self-relevant benefits and harms" [124]. The authors theorize that contemplative practices may impact *I* processes in ways that elude educational systems that primarily focus on the content knowledge of subjects like math and English; as such, contemplative practices may be a means to achieving what James himself highlighted as the consummate goal of education:

"The faculty of voluntarily bringing back a wandering attention, over and over again, is the very root of judgment, character, and will… An

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education which should improve this faculty would be *the* education *par excellence*. But it is easier to define this ideal than to give practical directions for bringing it about." [125]

Steeped in Western philosophical and psychological traditions as he was, James illustrates the disregard of the wealth of practical directions for this "education *par excellence*" provided by millennia of Asian scholarship and practice. As has been shown previously, these directions have been secularized and codified for numerous clinical applications in adults. These same efforts are only recently beginning to emerge for children and adolescents. When enacted in non-clinical settings, they form the burgeoning field of contemplative education. These projects are likely to require even more interdisciplinary dialogue and collaboration than the East-meets-West fusion of research with adults. They will require a Brain-meets-Society paradigm of mutual engagement between the sciences of the developing nervous system and the study of social contexts that envelop the nervous system as surely as the body does. The nature of pre- and post-pubertal development, which comprise fundamental shifts in emotional complexity and interpersonal relationships that move from complete caretaker dependence in early childhood to negotiations for autonomy in adolescence, require adapting contemplative practices for use with children and youth [124].

The State of Research on Contemplative Practice in Pediatric Populations

Four systematic reviews of research on contemplative practices in pediatric populations, two focused on meditation and two on yoga, were released in 2008 and 2009. The two reviews examining sitting meditation and mindfulness-based practices [126,127] found that in addition to methodological limitations of most of the studies, which were small and designed to evaluate feasibility and acceptability rather than causality, adaptations based on the age or development stage of participants were given short thrift. According to one of the reviews, these modifications require sensitivity to "age-related developmental needs (attention span, cognitive capacities, language, physicality, relevant content), and issues arising from the fact that children are somewhat embedded within their family (and school) system, and varyingly reliant on adults" [127]. Given these caveats, there are nevertheless promising results in the small pool of available studies on mindfulness-based practices with children and youth.

Several studies indicate that mindfulness-based strategies may influence self-regulation and executive function. Using parent and teacher report, a school-based randomized controlled trial (RCT) of mindful awareness practices (MAPs) in 64 second- and third-grade children (ages 7-9) demonstrated executive function (EF) gains, which were particularly pronounced in children who started out with poor EF [128]. Similarly, Napoli et al. (2005) report an RCT with 228 first through third graders who were taught sitting and moving mindfulness exercises by experienced instructors; significant improvements in self-rated test anxiety, teacher-rated attention and social skills and an objective measure of selective visual attention were reported [129]. In a randomized, wait-list controlled study of MBCT in 25 children ages 9-13, program participants who completed the program showed fewer attention problems (Cohen's d=.42, p=.025) at three months follow-up and these decreases accounted for 46% of the variance in changes in problem behaviors, suggesting a mediating effect of attention on behavior [130].

Participants in this MBCT study were a non-clinical sample of predominately ethnic minorities from low-income, inner-city households, who "enthusiastically accepted" the structured 12-week intervention [130].

In the adolescent age range, there are few RCTs exploring mindfulness practices. One of the strongest in terms of methodology and size, Biegel et al (2009) completed an RCT of an MBSR intervention with 102 adolescents ages 14-18 who were under current or recent psychiatric outpatient care. Compared to a control group receiving treatment as usual (TAU) for their particular disorder, intervention subjects showed significant improvements in self-reported perceived stress and anxiety (p's < .05, effect sizes ranging from d= .28-.92) at 3-month follow-up; these findings received corroboration by concurrent improvements in a blinded clinician-rated assessment of psychopathology [131]. Additionally, this study documented a dose-response relationship between logged hours of mindfulness practice that predicted increases in both self-report measures and clinician-rated functioning. Mindfulness-based strategies have not been rigorously evaluated in non-clinical adolescent populations, however, so their utility as a universal health promotion and social-emotional learning programs is still unknown.

The two systematic reviews of yoga in pediatric populations ([132,133] reveal a more heterogeneous compilation of applications and outcomes than in the reviews on sitting meditation and mindfulness-based practices. In thirty-four controlled studies published between 1979 and 2008 (19 of which were RCTs), areas of investigation ranged from cardiorespiratory function, motor skills and strength, and gastrointestinal health to psychological disorders and mental health [132]. In regards to yoga for pediatric mental health promotion, research is scant. In a comparison of Hatha yoga to an active control group (swimming), analysis revealed gender-dependent effects on outcomes, with only males showing greater decreases in stress, anger and fatigue in the yoga condition compared to swimming [134]. In a more recent comparative study of the effects of Hatha yoga and African dance on perceived stress, affect, and salivary cortisol (compared to a third nonactive control group), West et al. (2004) documented an interesting interaction effect whereby changes in positive affect and cortisol were inversely correlated in the yoga condition but directly correlated in the African dance group [135]. The authors suggest that even in interventions that produce similar positive psychological effects, their impact on and origins in physiological stress processes may vary widely. Both of these preceding studies, however, involved young adults (18-24) in college and therefore are not generalizable to the context and characteristics of high-school adolescents.

Only in the past few years have studies of school-based and/or urban/minority-focused contemplative practice interventions begun to appear in the literature. An RCT [136] of 121 11th and 12th graders in a rural, predominately white high school assigned students to either regular physical education classes or to 30-40 minute yoga sessions two to three time per week for a semester. Preliminary results reveal statistically significant differences between groups for only a few self-report outcome measures: anger (Anger Control Subscale), resilience (Resilience Scale) and fatigue/inertia (Profile of Mood States- short form). In the dimensions of anger and resilience, there were relatively small positive effects in the yoga group but marked declines in the control group. This may suggest either that yoga can play a protective role in maintaining equanimity throughout the stressful school year or that results represent a more transient protective effect in the run-up to final exams when the post-assessments were completed. Although

only suggestive of possible effects, this study is the first of its kind on yoga in a secondary school setting and points to some overlap with the positive role of yoga for stress management that has been demonstrated repeatedly in adult studies [105,137].

Only two studies thus far have targeted contemplative practices to low-income, urban or at-risk youth. Sibinga et al (2011) report an acceptability and exploratory analysis study of an MBSR program for HIV-positive and at-risk urban youth [138]. Program completers included 26 thirteen to twenty-one-year old African-American youth who were recruited from a hospital-based pediatric primary care that serves one of the poorest areas of Baltimore, with high rates of crime, drugs and sexually-transmitted infections. Quantitative data shows that these participants had significant reductions in self-reported hostility ($p=0.02$), general discomfort ($p=0.01$), and emotional discomfort ($p=0.02$). In a subsample (n=10) of participants from whom qualitative data was gathered using semi-structured interviews, Kerrigan et al (2011) substantiated and enriched these quantitative findings; interviewees generally described a process of deepening self-awareness through which they learned to identify and more fully accept thoughts and feelings, which contributed to reductions in stress and hostility [139]. Findings indicate, however, that there is a wide range of psychological and behavioral changes for individuals. For some participants, MBSR course work created transformational shifts in their overall sense of self and life orientation. Similar to the internal somatic experience of life written about by Thomas Hanna, one participant said, "*We were supposed to get to know our inner body… and she* [the MBSR instructor] *told us to put our hand on our stomach, and see how slowly we breathe, or fast. And I thought it was, like, crazy at first, but then I was like, 'I'm getting to know my inner self'. Because I didn't even know I had as much stress built up. Knowing me, don't pay attention. But once I did that, I was like, 'Oh, my goodness, I know my inner body.*" [139]. Although the small sample size and uncontrolled design limits these findings, they prove that mind-body training with urban and at-risk youth is acceptable and feasible and may have positive benefits on their well-being.

In the first school-based contemplative intervention with underserved, urban youth, Mendelson, Greenberg and others (2010) looked at a mindfulness and yoga program specifically designed to counter chronic stress of inner-city life and promote affective and social-emotional adjustment. In a school-randomized waitlist control of four Baltimore public elementary schools, fourth and fifth-graders (*n*=97) completed a 12-week program (consisting of 45-minute session four times per week) that integrated yoga-based physical activity, breathing techniques and guided mindfulness practices in a sequential manner. Results show significant improvements in domains of the Responses to Stress Questionnaire (RSQ; [140]) for the participants compared to students at control schools; specifically, students in the intervention scored better on a measure of Involuntary Engagement to stressful stimuli ($p<0.001$), an index score composed of question items related to Rumination, Intrusive Thought and Emotional Arousal [141]. The authors state that though the findings are preliminary, they show promise that self-regulation can be trainable in middle childhood. Shifts in stress reactivity factors such as emotional arousal may remediate the over-sensitization of the stress response system that occurs in environments of adversity and chronic exposure to stress [36].

<u>Future Aims of Contemplative Practice Research in Youth</u>

As social and emotional learning technique, contemplative practices have yet to be investigated thoroughly. In the preceding study by Mendelson, Greenberg and colleagues (2010), significant group differences were not detected in the study's measures of mood or relationships with peers and teachers (although scores were generally in the predicted direction for mood variables). This implies either a longer response-to-treatment time than a 12-week intervention or the need for programmatic revision to target these factors. Moreover, the complex question of identifying the optimal times in child development to influence various affective, motivational and social-emotional facets of well-being remains open until underlying mechanisms are illuminated and enough evidence accrues to warrant comparisons between different age groups' responses to specific contemplative practices. Though research to date has rarely analyzed for age-specific effects, Schonert-Reichl and Lawlor (2011) found that a mindfulness program for students in 4th to 7th grades showed more positive benefits on measures of self-concept, such as perceived self-efficacy, for preadolescents than for early adolescents [142]. Findings like this could help compel further linking of stages of brain development with programmatic aims at various grade-levels.

Calls for the integration of social context and biological processes of stress, coping and childhood development have received mounting popular and academic attention [7,143-145]. Although quality of parenting and community environment are key components of healthy neurocognitive development and stress response, contemplative practices may help to boost these processes, especially in disadvantaged areas that tend to be low-income, minority and urban. Research with long-term practitioners of certain meditative and yogic traditions has revealed neural and physiological changes that may generate the reported mood, attention, memory and empathic enhancement of the practices. Only a few studies published to date have evaluated the potential impact of systematic contemplative practice on social-emotional learning and mental health promotion in nonclinical populations. Future research must be directed towards providing high-quality evidence on clearly described, reproducible programs through high-powered RCTs and qualitative work to identify "age-appropriate" practices [75]. Adolescence, despite being a defining period for many personality traits and coping styles, has not seen the resources or research that are now being channeled into social-emotional health of children in earlier periods. Research on mood, social-emotional competencies in peer and teacher relationships, automatic and voluntary responses to stress, and mental disorders may benefit from the practical application of mindfulness and yoga-based therapies, especially in underserved or disadvantaged youth.

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