Adolescent Peer and Family Relationship Predictors of Adult Health

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6/1/13 – 5/31/18

NIH / NICHD 2R01HD058305-17A1

$ 2,756,492.00

2. SPECIFIC AIMS

The proposed study employs uniquely rich and intensive longitudinal data on adolescent peer and family relationships to test a potentially far-reaching hypothesis—that *relationship qualities* in adolescence ultimately have substantial long-term implications for two of the most important identified domains of adult *physical* health: cardiovascular health and metabolic functioning. To date, almost all public health efforts aimed at primary prevention of cardiovascular and metabolic illnesses have focused on physiological indicators or on specific health behaviors (e.g., smoking). Our proposal builds from growing evidence of links between social functioning and physical health to test the proposition that key relational factors in adolescence may offer a new arena for the early detection—and ultimately the prevention—of long-term physical health problems.

We propose in the following aims to examine hypothesized social developmental pathways by which adolescent relationship struggles may lead to problematic levels of ❶ key physiological indicators that predict long-term health problems, including Cardiovascular reactivity, C-reactive protein levels (CRP), Interleukin-6 levels (IL-6), Central Adiposity:

Aim 1: Direct Prediction of Adult Health Indicators from Adolescent Relational Characteristics - We begin with the most basic, yet important epidemiological task of identifying adolescent relational qualities that may directly predict substantial future risks for health difficulties. We are ultimately also interested in more complex mediated and moderated pathways; however, from a public health perspective, simply identifying relational factors in adolescence that are linked to critical long-term health outcomes would rightly lead to greatly enhanced attention focused on these qualities as keys to physical health across the lifespan. Given that adolescence is a life stage typically marked by relatively few chronic health problems other than obesity, identifying relational qualities during this stage that serve as risk factors for later health outcomes is a potentially critical contribution to guiding both screening practices and preventive efforts.

Aim 2: Intervening Psychosocial Mediators of Links from Adolescence to Adult Health - After identifying key adolescent psychosocial risk factors, we next examine the hypothesized intervening pathways that may explain these risks and that can thus suggest additional potential arenas for intervention. Specifically, we consider pathways: 1. from autonomy struggles when learning to negotiate disagreements in adolescence to hostile conflict in adult relationships to adult health outcomes; and 2. from difficulty establishing supportive relationships in adolescence to adult social isolation to adult health outcomes. To properly temporally assess these hypothesized mediational pathways, we assess both direct predictions from adolescence to adult social functioning and cross-lagged predictions between social functioning and health outcomes in adulthood.

Aim 3: The Role of Temporal and Contextual Effects - We next seek to distinguish the effects of chronic vs. intermittent social functioning difficulties (e.g., are there lingering effects when a prior pattern of social isolation or hostile conflict eventually resolves, or are effects of prior difficulties all mediated via concurrent levels of functioning?). We also consider how key contextual transitions and demographic factors (e.g., marriage, entry into parenthood, SES, and gender) may lead to either continuity or discontinuity from prior periods.

Aim 4: Interplay of Social Functioning, Mental Health, and Physical Health - Finally, we assess the interplay of social functioning and mental health in predicting physical health outcomes both from adolescence to adulthood and within adulthood. Our models will allow us to assess unique effects of relational factors independent of mental health status, and also the conjoint effects of mental health and relational functioning across this part of the lifespan as they work together to predict health outcomes.

We will address these questions using a uniquely intense combination of repeated interviews, sociometric assessments, and observations of interactions with parents, peers, and romantic partners—all obtained from a socio-demographically diverse final sample of 172 individuals (with 98% sample retention to date), followed across a twenty-year span, from age 13 into the early/mid-adult era (ages 28 – 32).

The richness and temporal density of adolescent social relationship data from the proposed sample allows for a uniquely powerful assessment of the adolescent relational roots of critical health outcomes just as these are becoming increasingly salient in the early/mid-adult era. This assessment has the potential: a. to identify an entire new arena for potential interventions to improve lifelong health outcomes; b. to suggest *specific* relational characteristics to target across this period in screening and preventive interventions; c. to provide guidance to parents, educators, and clinicians seeking to distinguish transient adolescent relationship difficulties from difficulties with greatest long-term import for health; and d. to dramatically advance developing theories of the link between adolescent social relationship qualities and major health outcomes into this critical, relatively unexplored portion of the lifespan.

3. RESEARCH STRATEGY

SIGNIFICANCE

❷Cardiovascular diseases have been identified as the single greatest global killer, accounting for 30 percent of all deaths worldwide (World Health Organization, 2011); metabolic diseases follow closely behind, particularly in the United States, where 35% of American adults currently test in the pre-diabetic range (Centers for Disease Control and Prevention, 2011; Institute of Medicine, 2012). Research to date has focused primarily upon physiology and health behavior as potential causal factors and avenues for prevention of these problems. The proposed study, in contrast, tests the novel premise that important roots of these lifelong health problems can also be found in *relational difficulties in adolescence.*

This study builds from the growing recognition that even in terms of physical health, humans are fundamentally social animals. In adulthood, social isolation creates a risk for early mortality as great as cigarette smoking and obesity, and hostility in social interactions has been consistently linked to risk for cardiovascular disease (Holt-Lunstad, Smith et al., 2010; Miller, Smith et al., 1996). The proposed study now uses a uniquely rich, prospective longitudinal data set to identify roots of these relationship difficulties in adolescence and their links to key adult health indices.   We propose to examine two particularly problematic pathways: In the first, adolescent struggles to master autonomy challenges when handling basic conflict negotiations may set the stage for long-term patterns in which hostility becomes a first response when handling disagreements—the type of hostile behavior that is now being linked to problematic adult health outcomes. In the second pathway, adolescent difficulties connecting with parents and peers are tested as predictors of the type of social isolation in adulthood that appears particularly deleterious to adult health. Previously, we and others have examined these adolescent relational difficulties as predictors of *mental* health up through the late adolescent/emerging adult years. The proposed study takes the important new step of suggesting that these adolescent relationship qualities may have far broader implications than we and others have realized, with the potential to explain outcomes in an entirely new domain—physical health—well into the early/mid-adult life phase.

❸ National recommendations targeting children and adolescents for the prevention of future heart disease and metabolic illnesses do not currently address *any* relational factors (Centers for Disease Control and Prevention, 2012; Institute of Medicine, 2012). Recognition that one key to the prevention of adult physical health problems may lie in the realm of adolescent relational functioning could not only alter pediatric screening practices, but may provide a significant new entry point for efforts by everyone from family medicine doctors and public health experts, to parents and school personnel, to reduce lifelong rates of cardiovascular and metabolic illnesses. Beyond simply identifying predictions from adolescence to adult health, identifying *specific pathways and relationship qualities* by which adolescent risk processes unfold into adulthood could provide even more useful guidance in targeting screening and preventive efforts across this period.

❹**Unique features of this age span.** The early/mid-adult era (ages 28-32) sits at the intersection of several developmental trends that make it particularly compelling to consider in this regard. **Numerous social relationship qualities are typically stabilizing into long-term patterns just as a range of critical physiological indicators are becoming increasingly relevant to adult health.** In terms of social functioning, the near continuous social transitions of adolescence and emerging adulthood are concluding. This leads to a stabilization into more crystallized, adult patterns of functioning across a broad array of domains as seen in: marked desistance (for most) from juvenile crime and binge-drinking levels by age 30 (Federal Bureau of Investigation, 2003; Forrest, 2011; McCarty, 2004); transition from financial and residential arrangements that entail significant dependence on parents to true independence (US Census Bureau, 2006); entry into longer term romantic relationships and parenting for the majority of young people (US Census Bureau, 2009, 2010); and completion of education and entry into long-term work venues (Bureau of Labor Statistics, 2012). As the continuous transitions of the prior period subside, underlying continuities from adolescence to more stable early/mid-adult relationship patterns are likely to come into clearer focus. Most importantly, these more crystallized patterns are then likely to become increasingly important in their long-term implications for physical health. Yet, to date we know relatively little about this critical early/mid-adult era in general and we know *virtually nothing* about relational predictors of physical health leading into this period.

In terms of physical health, a lifespan approach recognizes that early/mid-adulthood marks the emergence, not so much of full-blown health problems, but rather of key *early-phase prognostic indicators* of future health difficulties (Uchino, 2009). Given the scope, chronicity and ubiquity of cardiovascular and metabolic illness once established, early detection and prevention is key. We identify and focus upon a discrete set of indicators that appear particularly *relevant* to future health problems, that are disturbingly *widespread* in the population by

age 28-32, and that appear most likely to be *predictable* from qualities of adolescent social relationships. These include: high cardiovascular reactivity to stress, impaired immune function (i.e., elevated CRP and IL-6 levels), evidence of impaired metabolic function (i.e., high BMI and Central Adiposity), and poor sleep quality.

Key Indices of Health Status in Early/Mid-Adulthood

❶**Cardiovascular reactivity to stress** (CVR) has been consistently and robustly identified as a precursor of future cardiovascular disease, which is the *single greatest preventable cause of death in the United States* (Chida & Steptoe, 2010; Lloyd-Jones, Adams et al., 2010). Specific pathways of action include connections to future hypertension, immune-mediated disease, greater left ventricular mass, and damage to the endothelial lining of the vasculature (Cacioppo, Berntson et al., 1998; Chida, et al., 2010; Krantz & Manuck, 1984; Treiber, Kamarck et al., 2003).

❶**Inflammation** is assessed via markers including *C-reactive proteins (CRP)* and *Interleukin-6 (IL-6)* in the bloodstream. CRP has received the greatest attention as a robust predictor of future cardiovascular risk (Libby, 2002). IL-6, in turn, is a potent stimulator of CRP production and a predictor of cardiovascular disease risk in its own right (Ridker, 2000). Importantly, these measures along with cardiovascular reactivity appear to have coordinated influences on disease morbidity, in part via sympathetic nervous system activation (Bosch, 2003; Soszynski, 1996; Uchino, 2001).

❶**Metabolic functioning,** assessed in terms of obesity and measured via Central Adiposity and high body mass index (BMI), is predictive of long-term negative health outcomes, including significant risks of both diabetes and cardiovascular disease (Cook, 2003; Poirier, Giles et al., 2006; Rutters, Gerver et al., 2010; Spiegel, Leproult et al., 1999; Van Cauter, Holmback et al., 2007). Obesity has been labeled a global epidemic by the American Heart Association (Poirier, et al., 2006) and is widespread in the early/mid-adult period both nationally and within our sample (Cornier, Despres et al., 2011; Gordon-Larsen, The et al., 2009)(see Progress Report). Although self-reported BMI is useful at the population level, at the individual level it may yield misleading results (e.g., for muscular individuals) (Cornier, et al., 2011). We thus obtain in person assessments of Central Adiposity (i.e., waist measurement) to maximize predictive utility of overweight status (Levitan, Yang et al., 2009; Pischon, Boeing et al., 2008).

Sleep disturbance disrupts a key restorative function of the body and has been linked to hypertension, diabetes, decreased immune functioning, increased body mass index, lower self-rated health, and higher blood pressure and overall mortality rates (Bansil, Kuklina et al., 2011; Cappuccio, D'Elia et al., 2010; Cohen, Doyle et al., 2009; Fung, Peters et al., 2011; Rod, Vahtera et al., 2011; Spiegel, et al., 1999; Steptoe, O'Donnell et al., 2008). The CDC reports that 25% of adults get insufficient sleep at least 15 of every 30 days, results replicated in our sample (Centers for Disease Control and Prevention, 2009)(see Progress report).

Proposed Pathways from Adolescent Psychosocial Functioning to Adult Health Outcomes

The proposed study examines a social developmental model to partly account for the origins of problems in these health domains via two related pathways. For each pathway, we first outline research linking health outcomes and social behaviors within adulthood. We then describe the hypothesized paths by which qualities of adolescent social relationships are expected to predict these adult behaviors and health outcomes.

Pathway 1: Adolescent Autonomy Struggles → Adult Hostile Conflict → Health Outcomes

Adult Hostile Conflict and Health - Hostile conflict in social relationships has long been recognized as a risk factor for cardiovascular disease, likely as a precursor of increased physiological reactivity to interpersonal stress and pathological inflammation processes (Chiang, 2012; Kiecolt-Glaser, 2005; Miller, et al., 1996; Smith, 1992; Smith, Glazer et al., 2004). Hostile relationship conflict undermines the observed physiological benefit of close relationships in reducing cardiovascular response to stress and has been strongly linked to higher blood pressure, increased heart rate, and decreased pre-ejection period (Holt-Lunstad, Smith et al.; Nealey-Moore, Smith et al., 2007; Uno, Uchino et al., 2002; Wright & Loving, 2011). When experimentally induced, negative marital interactions adversely affect a variety of indices of cardiovascular reactivity (Nealey-Moore, et al., 2007). Even simply recalling past marital conflicts raises blood pressure for individuals in poor marriages (Carels, Sherwood et al., 1998). These findings all suggest that cardiovascular reactivity may serve as a potential mechanism to explain the observed link between hostile conflict, lack of social support and problematic cardiovascular functioning (Miller, et al., 1996; Smith, et al., 2004).

These studies of cardiovascular reactivity and inflammation all examine hostility only concurrently or in a laboratory context, however, and often with only transient manipulations of these factors. The cumulative

effects of *long-term and ongoing* (as opposed to transient and experimentally-induced) relationship qualities on cardiovascular reactivity and inflammation processes remain virtually unexplored (Uchino, 2006).

❼**Adolescent Autonomy Struggles and Adult Hostility –** We have found that a uniquely powerful adolescent-era predictor of future hostility lies in failure to master key autonomy challenges. Learning to negotiate conflicts in a way that allows the individual to establish autonomy *without* sacrificing relationships has long been recognized as a key task of adolescent social development (Hill & Holmbeck, 1986). This task is so crucial in part because negotiating relationship disagreements and conflicts is an essential component of adult social functioning. When conceptualized as progress in learning to handle the negotiation of disagreements with parents and peers (*as opposed to conceptualizations in terms of general levels of parental restrictiveness or teen independence*), autonomy development appears broadly relevant to outcomes across racial/ethnic and socioeconomic groups (McElhaney & Allen, 2012). Because this type of competence is difficult to accurately self-report (Nisbett & Wilson, 1977), we have developed a lab-based paradigm and highly reliable observational coding system that captures its critical elements in interactions with parents, peers, and romantic partners (Allen, Hauser et al., 1994; Allen, Porter et al., 2006b)(Appendices C-F).

❼Most importantly, we consistently find future *increases* in hostility to be robustly predicted by adolescent struggles handling autonomy negotiations, even over and above baseline hostility and externalizing behaviors (which we also assess in our models). Lacking adaptive means to establish autonomy, individuals appear to become both stressed and aggressive when negotiating disagreements with important others—a pattern that endures remarkably strongly over time once established: Adolescent autonomy struggles lead not only to increases in observed hostile behavior within the family over a multi-year period (Allen, Hauser et al., 1996c), but to very large continuities from observed behaviors in the family to hostility as reported by peers *a decade later* (i.e., β = .50***), even after accounting for baseline levels of adolescent hostility (Allen, Hauser et al., 2002). Adolescent autonomy struggles also foreshadow broader long-term deficits in functioning with peers, again even after accounting for baseline social competence and psychological symptoms (Chango, McElhaney et al., 2012; Szwedo, Mikami et al., 2011).

❾ We recognize, of course, that autonomy processes are not the *only* predictor of future hostility (and we consider baseline levels of hostility as well as other mental health symptoms in our models); ❸ we believe, however, that autonomy struggles reflect an important, surprisingly powerful, and relatively unexamined pathway by which we might understand, and ultimately seek to prevent, long-term social and health problems.

Pathway 2: Lack of Adolescent Social Connection → Adult Social Isolation → Health Outcomes

Social Isolation and Health. Social isolation has been linked to problematic cardiovascular functioning, sleep quality, nutrition quality, body mass index, and immune and metabolic functioning (Caspi, Harrington et al., 2006; Cohen, 2004; Lehman, Taylor et al., 2005; Mahon, 1994; Steptoe, Lundwall et al., 2000; Thorsteinsson & James, 1999; Uchino, 2006). Although isolation has effects even at moderate levels, one in four adults in the U.S. report such severe isolation that they have no one with whom to discuss important issues in their lives (McPherson, Smith-Lovin et al., 2006). Among undergraduates, lack of social support has been found to substantially increase cardiovascular reactivity to stress and to be linked to other health outcomes (Uchino, 2004; Uchino & Garvey, 1997). In adolescence, poor quality peer relationships have been linked to obesity, particularly for females (Griffiths & Page, 2008; Lemeshow, Fisher et al., 2008; Pearce, Boergers et al., 2002).

Adolescent Roots of Adult Social Isolation. The development of peer support processes from adolescence into the early/mid-adult phase has been only minimally studied, ❹ though this is a period of substantial change in support processes, with primary reliance upon parents dropping dramatically (even compared to the mid-twenties) and peers becoming primary sources of support (Berscheid, 2003; Collins, 1997). A number of studies have found predictions from child and adolescent parental and peer relationship qualities to peer and romantic relationships into the early- and mid-twenties (Andrews, Foster et al., 2000; Bagwell, Newcomb et al., 1998; Bagwell, Schmidt et al., 2001; Conger, Cui et al., 2001; Seiffge-Krenke, Shulman et al., 2001; Sroufe, Egeland et al., 2005). Childhood social isolation has been found in one study to predict a single global measure of general health at age 26, although links to specific health indicators and pathways of prediction have not been identified (Caspi, et al., 2006). ❸ At this point, however, we have almost no information about predictors of social support beyond age 26—when peers become primary sources of support—nor of social support predictors of health outcomes beyond age 26, nor of any predictive links to specific health domains (e.g., cardiovascular functioning) that may be responsible for these health outcomes.

The Role of Temporal and Contextual Factors and Mental Health Symptoms

Temporal Factors. A significant limitation to even the small body of extant work on relational predictors of future health status is that it has not yet been able to distinguish between effects of contemporaneous vs. cumulative/chronic social difficulties (Kessler, 1997). Chronic social difficulties may well create enduring stressors (e.g., allostatic load) that take a toll on health over time, an effect quite different from effects that are solely a result of contemporaneous relational difficulties (McEwen, 1998). This distinction has significant implications for preventive efforts, raising the question: Is it sufficient to intervene to improve functioning in early/mid-adulthood, or must interventions come earlier to fully avoid negative health outcomes?

Contextual Factors. During the early/mid-adult period, several contextual transitions (e.g., marriage; entry into parenthood) that may reflect either continuity or discontinuity in development from prior periods also become important to consider. For example, desistance from adolescent-era patterns of hostile and criminal behavior often follows entry into marriage, which in turn may reflect an underlying capacity to form positive social relationships (Roisman, Aguilar et al., 2004; Uggen & Massoglia, 2003). Interactionist models of human development suggest that contextual factors, including gender and various indices of socioeconomic status, may both reflect and influence social functioning (Conger & Donnellan, 2007; Hill, White et al., 2000; Martin, Conger et al., 2010; Melchior, Moffitt et al., 2007; Schofield, Martin et al., 2011), although only a small amount of work has examined the adolescent to adult transition in this regard. Although we recognize that prior research does not yet provide a basis for strong *a priori* hypotheses about specific effects of these contextual factors, we nonetheless carefully examine each of them in our models, recognizing their potential impact.

Mental Health Symptoms. A further limitation to current work on relationship predictors of future health status is that it has typically not taken into account the potentially important role of mental health problems as a co-occurring risk factor. Yet a history of depression and antisocial behavior has been found to predict health difficulties at least into the early twenties (Bardone, Moffitt et al., 1998; Keenan-Miller, Hammen et al., 2007; Pine, Cohen et al., 2006; Richardson, Davis et al., 2003), and in one study to age 32 (Odgers, Moffitt et al., 2008). Although mental health predictors are not the primary focus of this study, we recognize evidence of the potential transactional interplay over time among relational qualities and mental and physical health (e.g., depression predicting physical health problems and future loneliness; hostility predicting health risks, etc. (Bardone, et al., 1998; Herrenkohl, 2010)), and thus include mental health predictors, conceptualized in terms of overall levels of demonstrated internalizing and ❾externalizing symptoms, in our modeling.

Overarching Model

We now have increasingly powerful evidence of the health effects of relational difficulties *within* adulthood.

What we lack is an understanding of the *roots* of these processes in prior developmental eras. We examine these roots and their effects into adulthood as seen in the overarching conceptual model in Figure 1 and as described in the following Aims:

Figure 1 – Overall Conceptual Model

Aim 1: Direct Prediction of Adult Health Outcomes from Adolescent Relational Processes - We begin by seeking to identify relational qualities in adolescence that may herald substantial future health difficulties. We consider predictions from both baseline levels of autonomy and connection in adolescent relationships, and also from developmental trajectories of these relationship qualities (i.e., are relationships improving or deteriorating over the course of adolescence). ❿ In all of our analyses, we account for baseline measures of health risk in adolescence (BMI, and family history of obesity and heart disease), and consider potential contextual moderating factors (e.g., gender, SES, etc.). The overarching goal of this aim is to identify early relational factors that might serve as screening and intervention targets in efforts to reduce health problems across the lifespan.

Aim 2: Intervening Psychosocial Mediators of Links from Adolescence to Adult Health - We next begin to examine the hypothesized pathways by which adolescent risk factors may operate. Specifically, we consider the two primary hypothesized pathways described above: from adolescent autonomy struggles to adult hostility and health outcomes, and from adolescent lack of supportive relationships to adult social isolation and health outcomes. ❺To assess potential mediated pathways, we first examine predictions to adult social and health
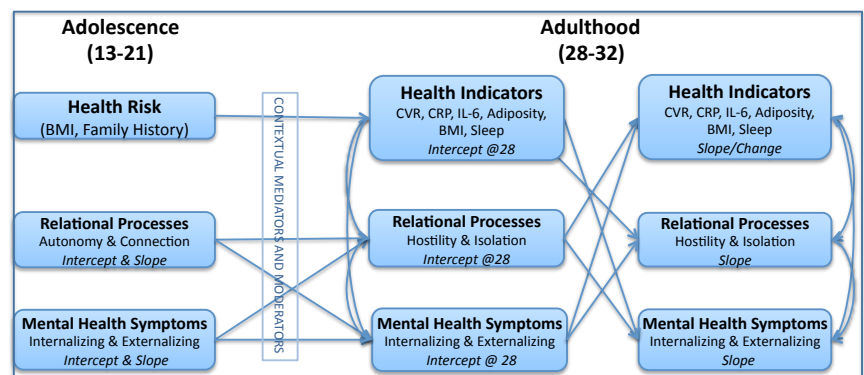
outcomes then use our multiple waves of data in adulthood to examine cross-lagged paths forward from these initial adult assessments. Our goal is to identify specific potential social processes that might be targeted for intervention *across* this twenty-year portion of the lifespan.

Aim 3: The Role of Temporal and Contextual Effects - We next assess the extent to which contemporaneous adult relationships and intervening events may mediate, moderate or override effects of prior relationship qualities. We first seek to distinguish the long-term effects of chronic vs. intermittent social difficulties. For example, we consider what happens when a long-term dysfunctional social pattern improves, e.g., following a successful marriage. ❸ Does this improvement lead to healthy outcomes, or do cumulative residual negative health effects remain from long-term patterns of dysfunction—effects that might indicate a need for interventions to address even problematic social patterns that ultimately resolve? We also then consider mediating and moderating roles of high base-rate contextual transitions (e.g., marriage, parenthood) and demographic factors (e.g., gender, income, ❾educational status) as they may alter these pathways (e.g., marriage disrupting continuities from prior lack of social connection to adult health).

Aim 4: Interplay of Social Functioning, Mental Health, and Physical Health - Finally, we assess the interplay of social functioning and mental health (e.g., internalizing and externalizing symptoms) over time in predicting physical health outcomes both from adolescence to adulthood and within adulthood. We focus upon assessing both unique effects of relational factors (independent of mental health status) and also the conjoint operation of mental health and social functioning across this part of the lifespan in predicting health outcomes.

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INNOVATION

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Long-term Relational Predictors of Key Health Outcomes. <u>We are aware of no prospective studies that have identified long-term relational predictors of early/mid-adult cardiovascular reactivity, immune response, central adiposity/body mass index or sleep status.</u> ❸ If the hypothesized links between adolescent relational factors and future health outcomes exist, identifying and understanding these becomes particularly crucial, as adolescence is a life phase during which routine pediatric screening visits still occur, and broad preventive interventions can still be readily implemented (e.g., via schools, sports teams, etc.). As a result, findings from this study can potentially open up a sizeable array of new venues for enhancing long-term health outcomes.

Sensitivity of Measurement. This study utilizes repeated interviews, sociometric assessments, and direct observations of interactions with parents, peers, and romantic partners in one of the most intensive studies to date of the long-term outcomes of adolescent social development in the family and peer group. <u>Although other studies have utilized similarly in-depth observational methods *or* have tracked participants closely for long periods, virtually none have done both</u>. The social processes being assessed, though potentially quite powerful, are often subtle and lie in domains in which self-reports and retrospective recall are considered least likely to be reliable (Nisbett, et al., 1977): Hostile individuals often do not recognize their hostility; rejection by peers is difficult to acknowledge; and spouse reports of social interaction qualities are more sensitive than self-reports as predictors of coronary artery disease (Kobak & Sceery, 1988; Smith, Uchino et al., 2008). We take an innovative approach to addressing this problem by obtaining repeated direct observations, plus reports from more than *twenty* different individuals about each of our target participants, producing an <u>unparalleled social relationship functioning map across this critical period of the lifespan—a map that maximizes the chance that we will accurately observe sizeable links between adolescent relational functioning and adult physical health.</u>

❺**Time Density of Measurement.** Even if carefully measured, social experiences are less likely to be formative if they are transient. Social interaction qualities change rapidly in adolescence and emerging adulthood; our intensive, repeated-measures approach is designed to provide a uniquely dense picture of both the aggregate and developing quality of these interactions over time. Although larger sample studies come with numerous benefits, <u>we utilize an innovative complementary approach based upon multiple occasions of deep measurement</u>. Nesselroade (1991) has described the 'data box,' a three-dimensional perspective recognizing that developmental assessments can be dense in terms of numbers of individuals, numbers of constructs, and/or number of time points assessed, and ❺*density in terms of time points can dramatically enhance power by yielding far more stable, reliable estimates of key constructs*. Over a 20-year period, we will have 19 assessment time points for our sample—an equivalent data density to a sample size of more than 1600 individuals assessed at just age 13 and age 32. This approach allows in-depth examination of constructs and phenomena that are difficult to examine in large sample designs. The result is a uniquely detailed and robust picture of our target participants' relationship experiences over time. Also, the <u>density of measurement in this design provides one of the only avenues for prospectively addressing certain questions</u> (e.g., the effects of chronic vs. intermittent social dysfunction; the temporal interrelationship between depression, social

functioning, and adult health status, etc.). Given that relationship qualities may change frequently during this period, and that it may be cumulative relationship experience that has the largest impact on health outcomes, such innovative, dense measurement is critical to assessing links of relationship qualities to health outcomes.

Sample Retention and Diversity. Attrition is the bane of longitudinal research and this study has been innovative in keeping attrition to an absolute minimum over a remarkably long period (less than 2% over the first 14 years). Further, this study is innovative in extending this particular type of intensive research to a sample that is diverse and heterogeneous in terms of racial/ethnic identity and SES.

PROGRESS REPORT

Thus far, we have met all major goals from our most recent proposal. We began 14 years ago with a sample of 184 target adolescents and have retained over 98% as active participants in the study in the current phase (a 1% *increase* over the retention rate from the prior 5-year grant). Data collection, coding and entry are all ahead of schedule. We approach dissemination by focusing upon producing broad, high-impact, empirical papers in top-tier journals (e.g., *Child Development, Development & Psychopathology, Journal of Abnormal Psychology*, etc.). In the past 5 years, this grant has yielded over 100 publications, presentations, dissertations, and submitted manuscripts. These include: the publication of **41 papers plus an additional 7 papers under review (Of these 48 papers, 37 are in peer-reviewed journals); two books; 5 doctoral theses; and 56 presentations at national conferences.**

The ongoing study was designed to identify early adolescent predictors of relationship quality and mental health into emerging adulthood (ages 23 - 27). Results from the current funding period provide strong support for our core hypothesis: that adolescent success establishing autonomy while maintaining connections in family and peer relationships sets the stage for adaptive functioning into emerging adulthood—precisely the type of functioning we expect to ultimately predict later health outcomes. These findings demonstrate both the value of the constructs being examined and the power of our design to yield robust, sizeable effects with this sample. All findings below link constructs assessed via different methods, so as to avoid methods confounds and demographic factors are always examined. Effect sizes are presented for previously unpublished findings.

Predictions From Adolescent Autonomy Struggles. We continue to find strong continuities from early autonomy struggles with parents and peers to later hostile and dysfunctional relationship quality. Specifically, we see links from autonomy struggles with parents at 13 to verbal aggression in online interactions with peers at age 20. We also see links from autonomy struggles with peers at 13 to hostile and antisocial behavior, lower close friendship competence, greater depressive symptoms and greater anxiety into the twenties (Allen, Chango et al., 2011a; Chango, Allen et al., 2011; Szwedo, et al., 2011; $\beta_{anxiety}$ = .27***). We have identified a marker of autonomy struggles—low resistance to peer pressure—that predicts *which* adolescents are most likely to be negatively influenced by peers to engage in antisocial acts over time, and find that this marker is in turn predicted by autonomy struggles with mothers (Allen, Chango et al., 2012). ❼Notably, all of these findings are observed across income and racial/ethnic groups in our sample—potential moderating factors that we have explored in-depth both theoretically and empirically (McElhaney, et al., 2012).

Predictions from Adolescent Connection Struggles. We are also finding hypothesized continuities from problematic connections with parents to lack of emotional support from peers and to susceptibility to peer pressure in the following years (Allen, Manning et al., 2010; Allen, Porter et al., 2007; Bender, Allen et al., 2007). In turn, not being well-liked by peers, assessed sociometrically in early adolescence, is predicting poor online relationship quality at age 20 and problematic interactions with close friends and romantic partners at age 23 (Allen, et al., 2011a; Mikami, Szwedo et al., 2010). Teens who struggle with peer connections and experience high levels of rejection sensitivity are also at heightened vulnerability for the development of anxiety and depressive symptoms over time (Chango, et al., 2012). In turn, problems that interfere with the development of peer connections in early adolescence, such as high levels of depressive symptoms, have been identified as remarkably strong predictors (i.e., β = .54***) of loneliness and perceived isolation at age 24, even after accounting for concurrent symptoms and baseline levels of social functioning.

Additive Effects of Autonomy & Connection Processes. When examined together, the *combination* of observed autonomy and connection with peers in early adolescence provides the strongest prediction of global adjustment by age 24 as rated by parents (*Multiple R* = .34***).

Predicting Emerging Adult Health Indicators. Initial analyses of partial pilot data (still being collected) on two self-report health indices reveal that fully 49% of our sample has a BMI score above 25, classifying as overweight, and 25% classifies as clinically obese. BMI in emerging adulthood was predictable from both lack

of popularity and lack of mastery of autonomy tasks with peers in early adolescence (*Multiple R* = .40***), and from lack of observed maternal supportive behavior (*β = .29***) with maternal effects partially mediated via peer relationship qualities (Model *Multiple R* = .53***). Similarly, 59% of participants report significant sleep difficulties by age 25, which in turn are predicted by a combination of low peer reported social acceptance and instability of close friendships at ages 13-15 (*Multiple R* = .35***).

Translations and Applications. We have already translated our findings about autonomy and connection processes into a coaching intervention to help secondary school teachers increase student motivation and engagement. The results—published in *Science* (Allen, Pianta et al., 2011b)—show this to be one of the first broad approaches to teacher development to significantly raise actual student achievement test scores. The Autonomy and Relatedness Coding System has now also been translated into both German and Italian (Ingoglia & Allen, 2010) and has been used by more than fifteen other labs internationally, while the Supportive Behavior Task is being used in the adolescent follow-up of the NICHD Early Childcare Study. Our data set has also attracted other researchers to engage in projects utilizing this sample. This includes studies of implicit attitudes toward social rejection (Teachman & Allen, 2007) and separately funded work, led by Co-Investigator Coan (5R01MH80725-3), using fMRI techniques in an experimental paradigm and finding that the degree of social isolation is robustly related to threat reactivity in the brain (e.g., the anterior cingulate cortex)(Coan, 2011).

APPROACH

Design
Target and Collateral Participants. The proposed study will obtain multi-method, multi-reporter data from a final sample of 172 adolescents, their close friends, and romantic partners followed originally from ages 13 to 27 and now from ages 28 to 32. We began with a sample of 184 adolescents (mean age = 13.4) recruited from a seventh and eighth grade public middle school that ❽ served the *entire population* of a socio-economically diverse small Mid-Atlantic city. We had a 63% acceptance rate from teens approached to participate, which is high for studies of this intensity (i.e. initial assessments required 6 hours of in-person interview time). The sample is demographically heterogeneous, including 30% African-American, 8% Mixed-race, and 2% Hispanic-American participants and 33% from families living at less than 200% of the poverty line, ❽rates almost exactly in line with norms from the larger city, and with slightly higher proportions of racial/ethnic minority group members and families in poverty than the state in which it is located (U.S. Census Bureau, 2000). Rates of both internalizing and externalizing symptoms were all well above national norms. Parents, peers, and romantic partners have been repeatedly interviewed and observed interacting with target participants. In all, we have conducted assessments with more than *3200* collateral parties in addition to our target participants thus far.

	Assessment Wave/Age				
Assessment Type	1 (Age 28)	2 (Age 29)	3 (Age 30)	4 (Age 31)	5 (Age 32)
Participant Self-Reports	X	X	X	X	X
Participant Physiological Assessments	X	Spillover		X	Spillover
Participant Sleep, BMI Assessment	X	X	X	X	X
Close-Peer Reports	X	X	X	X	X
Romantic Partner Observation/Reprt	1st Romantic Obs.			2nd Romantic Obs.	

Table 1– Data Collection Plan

Procedure. We recruited adolescents and families via a mailing followed by phone contact. All participants are thoroughly debriefed and written procedures for handling unusual problems (e.g., responding to seriously depressed or suicidal participants) have been established and tested. Although most of our sample is projected to remain nearby in the next five years (see Budget Justification), we have designed procedures for interviewing and collecting physiological data at a distance or compensating travel expenses for participants' return to our locale (i.e., for visits to friends and family of origin).

Data Collection Plan. The plan outlined in Table 1 entails annual paper-and-pencil data collection from target participants and close friends, which also serves to maintain contact and interest among our participants. We allow 'spillover' time to obtain our two physiological assessments for those that we are not able to assess within a 12-month window. Similarly, we have a 2½ year window for romantic partner assessments, leaving sufficient time to identify adults in sustained relationships (i.e., more than 2 months duration).

Measurement Burden & Attrition. Although we assess many constructs, we keep interviews within a 1½ to 2-hour window. We minimize attrition by compensating participants well, making interviews relaxed and enjoyable, having interviewers take the time to develop rapport, and obtaining extensive tracking information. In our last competing continuation, we reported that 3% of participants had not actively participated in the prior period. Several of those participants have since returned, **thus we have obtained data on 98% (i.e., 180 of 184) of our original sample in the current grant period**. Even participants whose data cannot be obtained in a given wave (less than five percent in the most recently completed wave) can frequently be assessed in later

waves. Although our projection of 7% attrition for each of our last two continuation proposals turned out to be overly cautious, we again use this cautious estimate (yielding a projected final sample of 172), although we fully expect that we can keep attrition significantly lower.

Measures

Age at time of data collection and data sources are listed in parentheses for each measure. "Teen" refers to the original participant, even as an adult; measures completed by others are completed about the teen. Extended detail about procedures used, and reliability, and validity of all measures is provided in Appendix A.

Physical Health Assessments

❶*Cardiovascular Reactivity During Acute Psychological Stress* (Teen Ages 28, 31). The cardiovascular reactivity protocol consists of a 10-minute resting baseline, and 12 minutes of mental arithmetic and speech stressors with continuous cardiovascular assessments. These social stressors are widely used, have been found to predict future cardiovascular disease risk, and have been linked to concurrent levels of hostility and social isolation (Cacioppo, Hawkley et al., 2002b; Chida, 2010; Chida & Hamer, 2008). We have developed these stressors to be comparable in their stress-activating effects so as to allow for greater reliability and generalizability through aggregation (Cacioppo, Malarkey, Kiecolt-Glaser, Uchino, et al., 1995). Although there is some stability to cardiovascular reactivity over time, there is also significant variability (e.g., meta-analytic test-retest of reactivity over a 1-year interval is r = .35) which will allow for modeling changes over the proposed 3-year time interval between CVR assessments (Swain & Suls, 1996). For extended detail about assessment procedures, please see Appendix A.

❶*Measurement of Inflammatory Markers* (Teen Ages 28, 31)**.** Approximately 20 cc of blood will be collected and treated with EDTA, to prevent clotting, to determine circulating concentrations of specific inflammatory markers (i.e., CRP and IL-6). Plasma will be separated via centrifugation, aliquoted and stored at -80C and levels of CRP and IL-6 measured by high sensitivity immunoassays. More specifically, **CRP** will be determined by 2-site chemiluminescent immunoassay (limit of detection = 0.02 mg/dL) using the automated Siemens Immulite 2000 System (Siemens Healthcare Diagnostics, Inc., Deerfield, IL). **IL-6** will be measured by ELISA (limit of detection = 0.3 pg/ml; R&D Systems, San Diego, CA). Intra-assay and inter assay coefficients of variation (%CV) are 2.8 and 5.2% for CRP, and 3.6 and 8.6 for IL-6, respectively.

❶*Central Adiposity & Body Mass Index* (Teen Ages 28-32). These will be assessed by trained personnel during both the health and the romantic partner assessments. Central adiposity will be measured in cm right above the iliac crest following normal exhalation as recommended by the National, Heart, Lung, and Blood Institute. BMI will be calculated based on height and weight assessed via a medical scale (BMI=weight in kg/height in meters^2).

Sleep Quality (Teen Ages 28-32)*.* The *Pittsburgh Sleep Quality Index (PSQI)* is comprised of 19 items, which yield scores for sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, sleep medication, daytime dysfunction, and overall quality, with good reliability and demonstrated strong relations to both health and social functioning (Buysse, Reynolds III et al., 1989; Cacioppo, Hawkley et al., 2002a).

❿*Health History & Family History* (Teen: Age 32). We will obtain BMI at age 13 from local medical records of required school exams. Family history of cardiovascular and metabolic disease and obesity will be assessed as recommended by the American Medical Association. Assessments include health histories for parents, siblings, and immediate relatives (e.g., mother's siblings, grandparents). Such assessments have been found to be relatively accurate and consistently linked to health outcomes (Wilson, Qureshi et al., 2009).

Autonomy Assessments

Verbal Autonomy – Observed Conflict/Autonomy Task (coded for Observed Autonomy and Relatedness) (Allen, Hauser et al., 1996b)(Teen and Parent: Ages 13, 16, 18; Teen and Peer: Ages 13-19, 21, 26; Teen and Romantic Partner: Ages 18, 21, 24, 26, 29, 31). Participants and partners first separately identify their greatest areas of conflict. They then come together and take 8 minutes to discuss and try to resolve the conflict. Video recordings of the interaction are coded with the well-validated Autonomy and Relatedness Coding System (❼see Appendices C-F) (Allen & Hauser, 1996a; Allen, et al., 1994; Allen, Insabella et al., 2006a; Marsh, McFarland et al., 2003).

Relationship Maintenance During Autonomy Negotiations - Observed Conflict/Autonomy Task (Allen, et al., 1996b) (Teen and Parent: Ages 13, 16, 18; Teen and Peer: Ages 13-19, 21, 26; Teen and Romantic Partner: Ages 18, 21, 24, 26, 29, 31). Behavior enhancing vs. undermining relatedness in the midst of conflict negotiations is coded from the Observed Conflict/Autonomy task described above.

Previously Collected Autonomy Assessments *(described further in Appendix A) (Teen: Ages 13-19; Parent:*
*Ages 13, 16, 18)****: Parental Psychological Control*** *– Child Report of Parenting Behavior Inventory*
(Schludermann et al., 1970); ***Parent/Peer Influence Inventory*** (Allen, et al., 2006b).

Social Support Assessments

Supportive Behavior Interaction Task (Allen, Porter et al., 2005; Allen, et al., 2007) (Teen with: Parent: Ages
13, 16, 18; with Peer: Ages 13-20, 21, 26; with Romantic Partner: Ages 18, 21, 24, 26, 29, 31). Participants
are video-recorded spending 8 minutes discussing "a problem about which they would like some help or
advice" with a parent, peer or partner. The task is coded (see Appendix A for manual) for instrumental and
emotional support, overall warmth and engagement.

Network of Relationships Inventory (Furman & Buhrmester, 1985) (Teen re: Parents, Peers and Romantic
Partner: Ages 17-32; **Peer**: Ages 20-32; Romantic Partner: Ages 18, 21, 24, 26, 29, 31) This 30-item measure
yields a reliable and valid index of relationship quality with peers and romantic partners (Furman, et al., 1985;
Patterson, Kupersmidt et al., 1990).

Relationship Assessment Scale (Hendrick, 1988)(Teen: Ages 23-32; Romantic Partner: Ages 24, 26, 29, 31)
This 7-item measure yields a single index of overall relationship satisfaction within romantic relationships with
strong links to multiple qualities of relationships (Hendrick, Dicke et al., 1998).

Social Support Questionnaire (Sarason, Levine et al., 1983) (Teen Ages 28-32). This widely used, well-
validated 27-item questionnaire yields both an overall support score and an overall satisfaction score (Sarason,
Sarason et al., 1986; Sarason, Sarason et al., 1987).

Social Acceptance (Harter, 1988; Messer & Harter, 1986) (Self-Perception Profile for Adolescents; Adult Self-
Perception Profile) (Teen & Peer: Ages 13-32; Romantic Partner Ages 29, 31). The 5-item social acceptance
and close friendship competence scales are obtained via teen self-report. They have also been modified to
collect reports from peers and romantic partners *about* target participants and found to be valid and reliable
across raters (Allen, et al., 2006b).

Previously collected measures (described further in Appendix A): ***Overall Support -*** *Friendship Quality*
Questionnaire (Parker & Asher, 1993); ***Trust/Communication*** *- Inventory of Parent and Peer Attachment*
(Armsden & Greenberg, 1989); ***Peer Popularity*** *– Sociometric* (Peer: Ages 13-17); ***Acceptance*** *- Child Report*
of Parenting Behavior Inventory (CRPBI) (Schaefer, 1965; Schludermann & Schludermann, 1970) (Teen:
Ages 13-19; Parent: Ages 13, 16, 18).

Hostile Conflict Assessments

Hostility – Supportive Behavior Task (Allen, et al., 2006a; Allen, et al., 2007; Denton & Zarbatany, 1996;
Dishion, Andrews et al., 1995) (Teen and Parent: Ages 13, 16, 18; Teen and Peer: Ages 13-19, 21, 26; Teen
and Romantic Partner: Ages 18, 21, 24, 26, 29, 31). Hostility is coded in the midst of efforts to obtain support
from a parent, peer, or romantic partner. Described above under "Social Support Assessments."

Verbal Abuse *- Psychological Maltreatment Experience Scale* (Petretic-Jackson, Betz et al., 1995). (Teen
Ages 17-32; Peer: Ages 17-27; Romantic Partner: Ages 18, 21, 24, 26, 29, 31). The well-validated 16-item
verbal abuse/attacks on self-worth scale assesses participants' experiences of and perpetration of verbal
abuse in relationships with peers and romantic partners.

Hostility - Buss/Durkee Hostility Inventory (Buss & Durkee, 1957) (Teen: Ages 23-32)*.* This well-validated
24-item measure assesses general tendencies toward hostile behavior and affect in relationships, and is linked
to outcomes ranging from personality disorders and depression to risk of coronary artery disease (Miller, et al.,
1996; Moreno, Selby et al., 1994; Selby & Neimeyer, 1986; Sinha & Watson, 2006).

Relationship Negativity *-* ***Network of Relationships Inventory*** (Teen re: Parents**,** Peers and Romantic
Partner: Ages 17-27; Peer: Ages 20-27; Romantic Partner: Ages 18, 21, 24, 26, 29, 31) Described above
under "Social Support Assessments."

Previously collected measures *(described further in Appendix A):* ***Conflict/Betrayal*** *- Friendship Quality*
Questionnaire (Teen & Peer: Ages 13-19).

Social Isolation Assessments

UCLA Loneliness Scale (Russell, Peplau et al., 1980) (Teen: Ages 23-32). This 20-item measure assesses
loneliness and is linked to prior lack of social involvement and to outcomes ranging from lower life satisfaction
to attachment insecurity (Goswick & Jones, 1982; Kobak, et al., 1988; Moore & Schultz, 1983).

Social Withdrawal is assessed from the withdrawal scales on the well-validated *Adult Self-report and Adult*

Behavior Checklist (Teen: Ages 18-32; Peer: Ages 18-32; Romantic Partner: Ages 23-27, 29,31, Parent: Ages 23, 25) (Achenbach & Rescorla, 2003).

Social Relationships Index (Campo, Uchino et al., 2009) (Teen Ages 28-32). This 6-item (per relationship) measure assesses positivity and negativity of specific relationships and the broader social network.

Previously collected measures (described further in Appendix A): **Alienation** - Assessed via the *Inventory of Parent and Peer Attachment* (Teen, Peer: Ages 13-22) (Armsden & Greenberg, 1989).

Mental Health Symptom Assessments

Depressive Symptoms We assess depressive symptoms with the **Childhood Depression Inventory** (Teen: Ages 13-17) (Kovacs, 1992) & the **Beck Depression Inventory** (Beck, Rush et al., 1979)(Teen: Ages 18-32).

❾**Anxiety Symptoms** – We assess anxiety symptoms with the **Beck Anxiety Inventory** (Beck, Epstein et al., 1988; Beck & Steer, 1987; Clark, Beck et al., 1990) (Teen: Ages 15-17); and the **State-Trait Anxiety Inventory** (Spielberger & Diaz-Guerrero, 1982; Spielberger, Sydeman et al., 1999) (Teen: Ages 18-32), and the **Social Phobia and Social Interaction Scales** capturing DSM-IV criteria for specific and generalized social phobia (Mattick & Clarke, 1998).

Internalizing Symptoms - *Adult Self-report and Adult Behavior Checklist* (Teen: Ages 18-32). Described under "Social Isolation Assessments."

❾**Externalizing Symptoms -** *Adult Self-report and Adult Behavior Checklist (*Teen: Ages 18-32; Peer: Ages 18-32; Parent: Ages 24,26; Romantic Partner: Ages 24, 26).* We utilize the **externalizing scale** from this measure, described further under "Social Isolation Assessments." We also use the **Monitoring the Future Survey** (Teen: Ages 13-32). The core measure from this survey assesses use both annually and within the past 30 days of several different categories of alcohol and drugs on a 7-point scale, including information on total use and bingeing, with extensive evidence of reliability and validity of the resulting indices (Johnston, O'Malley et al., 1987; Johnston, O'Malley et al., 2006).

Contextual Assessments

Parenting Stress Index *(Teen ages 28-32, if applicable).* This well-validated and widely-used 120-item measure assesses a wide variety of social stressors related to the parenting role (Abidin, in press).

Socio-economic and Demographic Status *(Teen ages 13-32)***.** We assess parental and marital status, ❾college attendance, final education level, current income, work history, and perceived economic pressure using the Life Experiences Survey and specific demographic questions selected from similar measures (Conger, Wallace et al., 2002; Frederick, 2010; Sarason, Johnson et al., 1978; Spilman & Peng, 2009).

Statistical Analyses

Our primary analytic approach employs latent growth curve (LGC) modeling in the context of structural equation (SEM) modeling (Duncan, Duncan et al., 2006; McArdle & Hamagami, 2004; McArdle, 2001; McArdle & Nesselroade, 2003). Autoregressive SEM models (Biesanz, Deeb-Sossa et al., 2004) will also be used independently of LGC models with repeated measures to assess stability of predictive relationships over time. We also utilize relatively new applications of latent difference score models and dynamical systems modeling approaches to estimate the direction and strength of longitudinal coupling between multiple systems (Boker, in press; Boker & Laurenceau, 2007; Montpetit, Bergeman et al., 2010) (see Appendix B for an example). Mediated relationships will be assessed using bootstrapping procedures to determine confidence bands around point estimates for indirect effects (MacKinnon, Fairchild et al., 2007; Preacher, Zyphur et al., 2010). Moderated relationships will be assessed as outlined by Preacher, Curran, and Bauer (2006). We handle *missing data* with full information maximum likelihood estimation which is known to produce less biased estimates than listwise deletion, even when missing-at-random assumptions are not strictly met (Rubin & Little, 2002), and with multiple imputation procedures within Mplus 6.12 (Muthén & Muthén, 2011).

Data reduction. ❻We employ both traditional (e.g., factor analytic, SEM) and recently developed advanced data reduction techniques (e.g., idiographic filtering (Zhang, Browne et al., in press); see Appendix B for further detail) to create a limited number of well-measured latent constructs for our analyses. We recognize, for example, that specific health outcomes might serve as components of a latent health factor (Uchino, 2001). We will also consider whether sufficient overlap exists among relational and mental health factors at some points in the lifespan to allow some of these to be combined into more powerful latent markers of functioning.

❺We present exemplar analyses below, *using selected constructs as examples,* to illustrate our primary analytic approach for each of our Aims. Final construct identification and model selection will be empirically
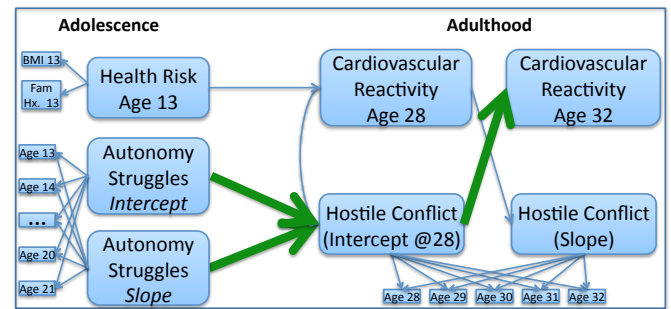
guided so as to utilize *non-redundant* approaches to maximize measurement precision and power while minimizing Type I and II error rates. Respecting our sample size, hypothesis-testing is based *not* on building broad models, but on evaluation of discrete, pre-specified pathways within models (the bold green arrows in each model below). Similarly, when we employ multiple approaches to address a given question, we will report results that converge *across* analytic techniques so as to minimize Type I error rates for that question.

Aim 1: Exemplar Question: Are autonomy struggles a marker of future health risk? We begin by assessing simple predictions from adolescent autonomy struggles (assessed both in terms of baseline levels and developmental trajectories across adolescence) to health outcomes as illustrated in the Figure. Although we test mediated models below, for the purposes of this Aim we use health outcomes aggregated across time (at two or five data collection points) to obtain the most robust, reliable indices. We account for prior health status, gender, and past and current socioeconomic status in all analyses.
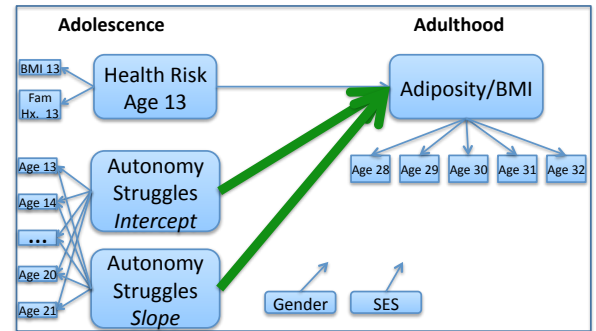

Aim 1 - Direct Prediction of a Single Health Outcome

Aim 2: Exemplar Question: Are the effects of adolescent autonomy struggles mediated by adult hostile conflict? We first assess prediction from adolescence to hostile conflict at age 28 using LGC models, then examine pathways by which hostility predicts relative change in health indices over the succeeding period (along with assessment of the concomitant lagged pathway in which health predicts the development of hostility over time). For indices measured only twice, as in the Figure, lagged predictions will be assessed. ❺For health indices measured more than twice (i.e., Adiposity/BMI, Sleep) we can also employ dynamical systems and latent difference score models (McArdle & Hamagami, 2001)(described in detail in Appendix B) that simultaneously account for growth curve parameters and multiple lagged pathways to maximize our ability to understand the interplay of health

Aim 2 – Example of Mediated Path from Autonomy to Adult Health

and relational functioning within adulthood. ❺These approaches represent a substantial advance over 'mediation' analyses in which measures of the final pathway are only assessed concurrently at age 28 and are thus temporally confounded. Together, these analyses will permit some of the first tests of *bidirectional* pathways between health and relational factors assessed longitudinally.

Aim 3a: Exemplar Question: Are the effects on adult health of adolescent relational struggles and subsequent isolation based on accumulated effects of a chronic state, or are effects fully mediated via concurrent levels of isolation? To address this question, we compare two pathways to health outcomes: 1.) a direct path (Path "A" in figure) from prior social problems, independent of effects of current problems; and 2) an indirect path (Path "B") in which effects of prior problems are fully mediated via concurrent social difficulties in early/mid-adulthood.
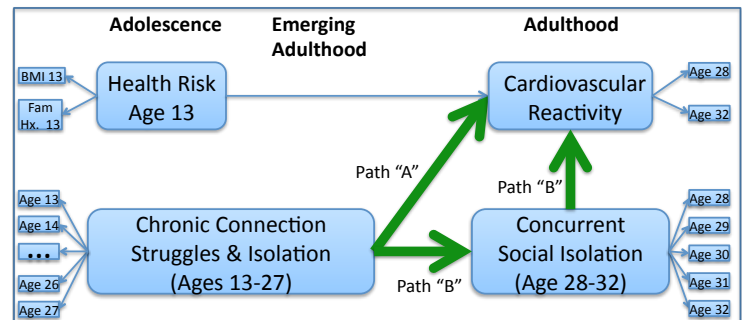
Aim 3a - Cumulative v. Contemporaneous Paths to Health Outcomes

Aim 3b: Exemplar Question: To what extent are effects mediated and/or moderated by major social contextual factors (e.g., marriage, parenthood, educational history, current income) and moderated by demographic factors (e.g., gender, SES)? We address these questions in two ways as illustrated with marriage as *one* example of a key contextual change. First, we enter marriage as a mediator in our models (solid green lines) to see whether, for
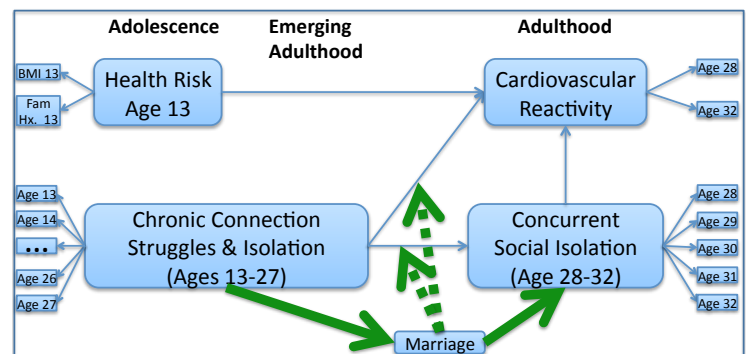

Aim 3b – Mediated and Moderating (dotted arrow) Marriage Effects

example, adolescent connection struggles predict absence of a marital relationship in adulthood, which in turn partially explains adult social isolation. We then consider marriage as a potential turning point (dotted lines) that may moderate continuities and discontinuities from prior patterns of functioning. We apply this same approach to assessing other contextual factors in this and other Aims of the study.

Aim 4: Exemplar Question: What are the Unique/Additive vs. Overlapping Effects of Autonomy Struggles and Externalizing Symptoms in Predicting Physical Health Outcomes? We first consider the extent to which predictions from relational factors in prior Aims are overlapping vs. unique with respect to multiple indicators of mental health in adolescence (illustrated using externalizing symptoms and an Aim 2 analysis). Where significant overlap is found, we consider creation of potentially more powerful aggregate measures of functioning that consider mental health and relational factors together as predictors, subject of course, to empirical confirmation. We also consider the interplay over time among relational and mental health factors using the approaches described above.
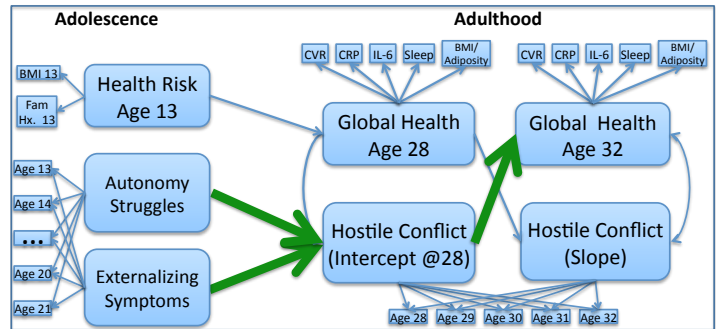
Aim 4 – Conjoint Predictions with Mental Health Symptoms

Effect Sizes, Power, & Type I Error Rates. An ongoing tradeoff with our intensive, multi-method approach is that it becomes inordinately expensive to conduct with very large samples. Even to obtain data on our target 184 participants has thus far required data collection from over *3,200* collateral reporters. Although our data density significantly reduces error variance in our measures (e.g., ❺ for growth curve analyses, each additional wave of data increases statistical power equivalently to adding an additional sample of similar size (Molenaar, 2004; von Oertzen & Boker, 2010), we recognize that sample size will always be a limit in research of this intensity. This intensity yields a worthwhile trade-off, however, in allowing us to very accurately assess highly subtle social interaction processes over time that are often impossible to assess within larger sample designs. Our record of publishing results in top tier journals provides a degree of face valid evidence of the likely power of this study to detect important effects within this dataset, by showing that we have *already* been detecting similar effects with this design and sample. As noted above, our approach is not to test grand models (which we see as premature in any case given the current state of research in this area) but to assess important *discrete* questions that may ultimately contribute to our understanding of broader processes.

Although we are able to detect effect sizes in the small range, our results to date regarding relationship continuities suggest that the majority of effect sizes likely to be obtained will fall between the small-to-medium and medium-to-large range, even after accounting for demographic and contextual covariates. For physiological outcomes, extensive prior research with small samples (e.g., *N* < 90) has reported medium and larger effect sizes in predicting cardiovascular outcomes even when using more transient social predictors (Bongard, Al'Absi et al., 1998; Larson & Langer, 1997; Nausheen, Gidron et al., 2007; Schwerdtfeger & Schlagert, 2011). ❺Use of robust, repeatedly assessed measures can reasonably be expected to yield larger effect sizes than assessments based upon brief, one-time experimental manipulations—one of the major advantages of our intensive measurement approach, and a critical counterweight to our moderate sample size.

Although we have many measured variables, we have a relatively small number of critical estimated paths, which helps tremendously with power issues. ❻We use a Monte Carlo approach to estimate power for the models proposed (Muthén & Muthén, 2002). Data are generated from a population with hypothesized parameter values, a large number of samples is drawn, a model is estimated for each sample, and parameter values and standard errors are averaged across the samples. Using this approach and reasonably conservative assumptions (please see Appendix B for a detailed description of assumptions and results), we find power for key models to be comfortably above .90 for detecting paths with β's of .25 or greater. These Monte Carlo estimates are also consistent with more general longstanding guidelines regarding power for models of the complexity proposed (MacCallum, Browne et al., 1996)(as also described in Appendix B).

Even in cases where power is more marginal (i.e., detecting small effects), we balance traditional Type II error rates, which reflect the *possibility* that we will fail to detect effects due to lack of power, against the *near certainty* that such effects will not be examined nor found by ourselves nor by anyone else in the near future unless they are pursued in studies such as this. This discussion is not meant to imply that we see ourselves as having *carte blanche* to develop broad models with our approach. Rather, it shows that our approach is completely feasible for the type of tightly specified, discrete hypotheses upon which we focus.

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