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Patterns of behavior change in students over an academic term: A preliminary study of activity and sociability behaviors using smartphone sensing methods



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ABSTRACT

The recent arrival of smartphone-sensing methods has made it possible to objectively track consequential everyday health-related behaviors rather than rely on self-reports. To evaluate the viability of using sensing methods to monitor such behaviors in detail, the present research used a smartphone-sensing application to describe the patterns of stability and change that characterize a cohort of students' activity and sociability behaviors over the course of a 10-week academic term. Data were collected from 48 students using a smartphone-sensing application, *StudentLife*, which was designed to track daily durations of activity (via the accelerometer sensor) and sociability (via the microphone sensor). Results showed stability estimates were moderate to high for activity ($r_{mean} = 0.66$) and sociability ($r_{mean} = 0.72$) across the 10 weeks. Students started the term with generally healthy levels of activity ($M = 1.87$ h) and sociability ($M = 4.99$ h), which then dropped (activity by 0.42 h, sociability by 0.90 h) over the first half of the term (i.e., before midterm exams). Over the second half of the term, activity levels did not change but sociability increased (by 0.88 h). Students' ethnicity and academic class predicted variation in the activity and sociability trajectories. Discussion focuses on the implications of our results for designing mHealth interventions to address consequential student outcomes (e.g., mental health, physical health).

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1. Introduction

People engage in a range of routine everyday behaviors that have a significant impact on their health. Two such behaviors, highlighted in the health-research literature as major components of a healthy lifestyle, are engaging in physical activity on a regular basis (e.g., Maher et al., 2013; Warburton, Nicol, & Bredin, 2006) and being socially connected to others (e.g., Cohen, 2004; Shankar, McMunn, Banks, & Steptoe, 2011). A substantial body of research demonstrates that many students experience problems in these behavior domains during the course of their higher education (e.g.,

physical inactivity, loneliness; American College Health Association, 2012; Douglas et al., 1997; Keating, Guan, Piñero, & Bridges, 2005; Mounts, Valentiner, Anderson, & Boswell, 2006). One potential solution to addressing this problem is the development of mobile-health (mHealth) applications to help students improve their health-related behaviors (e.g., Gowin, Cheney, Gwin, & Franklin Wann, 2015; Miller, Chandler, & Mouttapa, 2015). Technological improvements in behavioral assessment using sensors embedded in smartphones have paved the way for mHealth interventions that promote behavior-change at scale (Harari et al., in press; Lathia et al., 2013). However, the technological advances in mHealth have outpaced research on how to implement them effectively (Nilsen, Riley, & Heetderks, 2013). Descriptive research charting the behavioral patterns of students could help target periods of the academic term where mHealth interventions could

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most effectively be deployed to promote healthy levels of activity and sociability. Thus, descriptive research is needed to identify critical periods of normative behavior change during an academic term, and whether there is individual variability in the behavior-change patterns.

1.1. Physical activity behaviors

Health guidelines recommend that students get 2.5 hours of physical activity per week (American College Health Association, 2012). Yet, cross-sectional (Douglas et al., 1997; Keating et al., 2005) and longitudinal (Racette, Deusinger, Strube, Highstein, & Deusinger, 2008) survey studies suggest that many students are physically inactive (estimates range from 30% to 50%). In particular, members of ethnic minorities and older students seem to engage in less physical activity during college than do Caucasian students and younger students (Buckworth & Nigg, 2004; McArthur & Raedeke, 2009). The research to date indicates that the college experience may have a negative impact on students' physical activity but provides only a crude estimate of how such patterns might unfold from week-to-week during a term. Moreover, a meta-analysis of studies on college students' activity behaviors found that many studies used subjective and inconsistent measures of physical activity (Keating et al., 2005), such as self-reports of exercising behaviors or more general activity behaviors (e.g., walking, running), not actual duration of time spent in active movement. Thus, research is needed using objective activity measures, both to plot the normative trajectories of activity levels over time and to identify potential socio-demographic predictors of different activity trajectories.

1.2. Sociability behaviors

Sociability has been defined as a preference for affiliating and being with others (vs. being alone; Cheek & Buss, 1981). Most studies of students' sociability behaviors tend to focus on problematic socializing behaviors, such as binge drinking, drug use, and risky sexual behavior (e.g., Raynor & Levine, 2009). However, the health literature lacks a general understanding of students' general sociability behavior as indexed by the amount of time they spend affiliating with others. There is some debate about the importance of general sociability as a health risk factor, with some researchers claiming that sociability can serve as health buffer (e.g., via a sense of social support; Cohen, 2004), and others claiming that the importance of sociability has been overestimated (Friedman, 2000). In addition, studies that have examined students' sociability tend to use self-report methods that tap into students' sociability-related self-views (e.g., "I like to be with people"; Cheek & Buss, 1981; Mounts et al., 2006), but not actual duration of time spent affiliating with others. Relatively few studies have focused on objectively assessing students' sociability over time. Those that have, suggest that active socializing behaviors (e.g., talking to others) are highly stable over a 4-week period (test-retest reliability of $r = 0.63$), and account for about a third of students' waking hours (Mehl & Pennebaker, 2003). Although previous research suggests students generally retain their relative ranking in their sociability behaviors, it is unclear whether sociability trajectories change (increase or decrease) during an academic term and whether such changes are associated with students' socio-demographic characteristics.

1.3. Objectives of the present research

Past research on students' activity and sociability has focused on major milestones and broad patterns, such as behavior change

during the transition to college or across the four years of college, but little is known about how these behaviors manifest and change on a more nuanced level (e.g., from week-to-week during an academic term). Moreover, it is unclear whether all students experience similar behavioral changes over a term (i.e., show normative changes in their behavior trajectories), or whether students vary in their behavior change patterns (i.e., show individual differences in their behavior trajectories). One reason for the field's focus on broad patterns is the difficulty associated with studying fine-grained patterns of behavior in the real world. As a result of these difficulties, most behavioral research has focused on lab-based proxies of real-world behavior or self-reports of behavior, both of which are subject to range of biases and limitations (Baumeister, Vohs, & Funder, 2007; Block, 1989; Funder, 2001; Furr, 2009; Paulhus & Vazire, 2007). However, recent advances in mobile-sensing technology have revolutionized behavioral assessment by permitting unobtrusive, continuous tracking of behaviors via mobile sensors (e.g., accelerometers, microphones) embedded in smartphones (Gosling & Mason, 2015; Harari et al., in press; Lane et al., 2010; Miller, 2012).

To examine the viability of using mobile-sensing methods to obtain daily estimates of students' behavioral lifestyles, we present a preliminary study using a smartphone-sensing application to objectively measure students' naturally occurring activity and sociability behaviors over the course of a 10-week academic term. In doing so, we address a gap in the existing mHealth literature by providing a descriptive account of the fine-grained patterns of stability and change that characterize students' health-related behaviors during an academic term. We also examine the socio-demographic predictors of students' behavior trajectories, focusing on the characteristics of ethnicity and academic class. Based on past research on this topic, we expected ethnicity and academic class to predict variation in the activity trajectories, such that ethnic minority members and older students would exhibit lower levels of physical activity than would majority members and younger students. We had no expectations regarding the associations between socio-demographic characteristics and the sociability trajectories. We focus on activity and sociability behaviors with the aim of identifying periods in the academic term when mHealth interventions for students may be targeted most effectively. To do so, we estimate (1) the stability of the behaviors across weeks during the term; and use latent growth curve models to examine (2) the patterns of normative and individual-level change in the behaviors across weeks of the term; and (3) the socio-demographic predictors of the observed behavior trajectories.

2. Method

2.1. Participants and procedure

Participants were recruited from a convenience sample of students enrolled in a computer science course at Dartmouth College. The students were informed that participation was voluntary, and that everyone in the course (including those who elected to not participate) would be permitted to use an anonymized subset of the resulting dataset for use in a class project. Forty-eight students volunteered to take part in the study (38 male, 10 female; 30 undergraduates, 18 graduate students). The study lasted a full spring term – 10 weeks – from March to May of 2013. Additional information about the study design and initial results from the study can be found in Wang et al., 2014 and Wang, Harari, Hao, Zhou, & Campbell, 2015.

Participants were informed about the purpose of the study during an entrance interview, before they filled out consent forms. During the entrance interview, they were told that the study aimed

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